KINGS HILL DEVELOPMENT

Species Impact Statement

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Kings Hill Development
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GLOSSARY OF TERMS

BMP	Biodiversity Management Plan
CEEC	Critically endangered ecological community
CERs	Chief Executives Requirements
CKPoM	Comprehensive Koala Plan of Management
EEC	Endangered ecological community
EP&A Act	*Environmental Planning and Assessment Act* 1979
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
KHD	Kings Hill Development
KHURA	Kings Hill Urban Release Area
LEP	Local Environment Plan
LGA	Local Government Area
Locality	The area within a 5 km radius of the study area
OEH	NSW Office of Environment and Heritage
PCT	Plant community type
PSC	Port Stephens Council
Proposal	Proposed development of the subject site
SEPP	State Environmental Planning Policy
SIS	Species Impact Statement
Study area	The area including the subject site and any areas affected by the proposal, either directly or indirectly.
Subject site	The area subject to the Proposal, as shown in Figure 1.2.
TEC	Threatened ecological community
TSC Act	*Threatened Species Conservation Act* 1995
VMP	Vegetation Management Plan
VPA	Voluntary Planning Agreement

EXECUTIVE SUMMARY

This Species Impact Statement (SIS) has assessed the impacts of a Proposal described as a Concept Development Application for future Residential Subdivision and Stage 1 Subdivision Works (Initial Site Preparation Works), inclusive of biodiversity restoration and mitigation works and the establishment of a managed in-perpetuity Conservation Area for the protection of biodiversity in areas of ecological significance. The Proposal is contained within lands described as Lot 41 DP1037411 and Lot 4821 DP852073, 3221 Pacific Highway, Kings Hill in the Port Stephens Council (PSC) local government area (LGA).

The Proposal

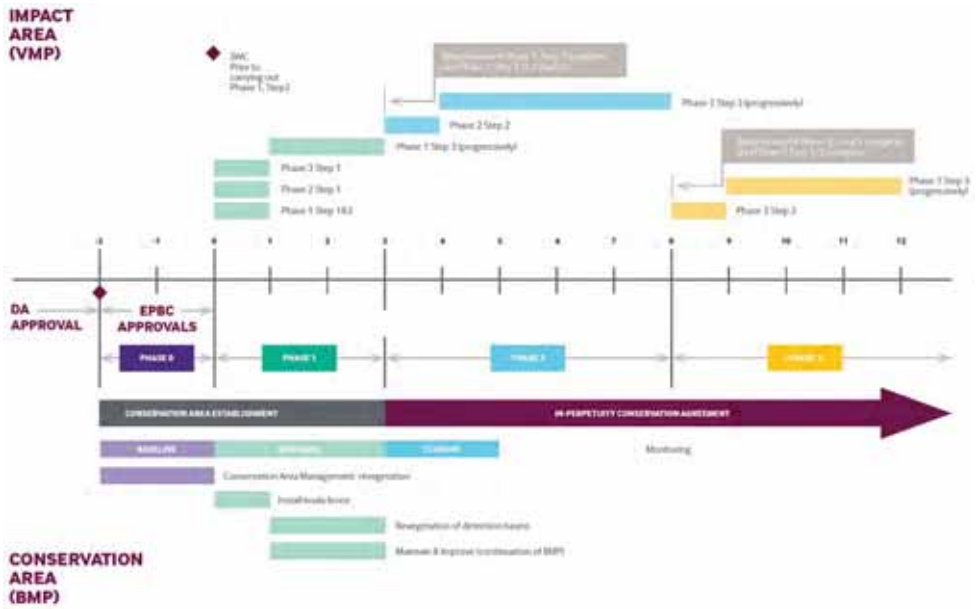
The Proposal involves the use of former rural zoned land generally disturbed by a history of logging and quarrying, and weed and pest invasion associated with uncontrolled grazing activities. The assessment provides for the consideration of local, long-term sustainable, biodiversity restoration and mitigation measures tailored to restore and improve the habitat of affected threatened species and ecological communities, managed and funded under an in-perpetuity agreement, in addition to species impact and habitat loss. The Proposal assessed by this SIS is for land uses that broadly reflect those that are permitted for zones described by the 2010 gazettal, these being:

- R1: Residential Zone - General Residential
- B2: Business Zone - Local
- B4: Business Zone – Mixed Use
- E2: Environment Protect Zones – Environmental Conservation

The initial site preparation works includes the following elements:

- Progressive (Phased) clearing of vegetation and habitat over an 8+ year period;
- Use of sensitive clearing procedures in accordance with a Vegetation Management Plan (VMP);
- Establishment of a Conservation Area including implementation of mitigation works in accordance with a Biodiversity Management Plan (BMP); and
- Implementation of a Voluntary Planning Agreement (VPA) to provide an in-perpetuity conservation mechanism/ agreement for the protection of biodiversity values within the Conservation Area.

The chart below outlines the sequence of these events over time.



The Proposal design has integrated the five key recommendations provided in the PSC commissioned biodiversity assessment for the 2010 rezoning (EcoBiological 2009), which was endorsed by the NSW Department of Environment, Climate Change and Water endorsed, for the express purpose of providing improved environmental outcomes (i.e. impact avoidance, minimisation and mitigation). The EcoBiological (2009) recommendations are listed below together with the response by the Proponent [i.e. Kings Hill Development (KHD)].

EcoBiological (2009) recommendation	KHD Response
Establish three corridor zones (100-150 m wide) two in the south and one in the north-east. These corridors need to be enhanced with Koala-friendly vegetation (loss of 20-30 ha)	KHD impact avoidance outcomes amounting to 38.47 ha have contributed to the development of enhanced wildlife corridors that meet and/ or exceed the width recommendation where relevant to KHD land. In addition to excluding 38.47 ha of land from the impact area, 19.40 ha of revegetation works are proposed to support these outcomes. Note - the third recommended corridor location in the north east of the urban release area does not involve KHD lands.
Provide a wildlife overpass (suitable for the Koala) to cross the Pacific Highway at the distal end of the corridor	KHD to provide an underpass at the distal end of the main north – south corridor and improve corridor linkages leading to the underpass. This underpass, which is to use the old Irrawang Spillway, has the purposes of facilitating the safe east west movement of wildlife across the Pacific Highway. The underpass is to be modified and furnished suitable for the Koala.
Retain additional preferred Koala habitat along the western ridge (loss of 5-10 ha)	KHD has allowed for a 17.58 ha impact avoidance outcome along the western ridge with the area avoided assessed to be of high value to the Koala. The avoidance area substantially broadens the wildlife corridor that extends downslope to wetland 803. Revegetation works incorporating Swamp Mahogany, Forest Redgum and Tallowwood around wetland 803 are proposed to provide primary Koala habitat.
Avoid as far as possible areas of high-value Brush-tailed Phascogale habitat and known Grey-crowned Babbler breeding areas	KHD has identified, avoided and integrated high-value Brush-tailed Phascogale habitat and known Grey-crowned Babbler breeding areas into the in-perpetuity Conservation Area
Avoid the removal of Freshwater Wetland habitat within three key wetland locations	KHD has avoided the removal of Freshwater Wetland habitat, protected it through sensitive stormwater management principles and incorporated into an in-perpetuity Conservation Area

The impact avoidance, minimisation and mitigation measures incorporated into the Proposal has substantially reduced the impact of the Proposal on threatened species identified by EcoBiological (2009).

Investigations

The SIS and Proposal has been informed by the completion of conventional methodologies required under the Chief Executive Requirements (CERs) and innovative and comprehensive survey methods for species like the Koala. The information base for preparing the SIS assessment incorporates detailed recent investigations for subject species with investigations performed since 2003 (HWR 2004; EcoBiological 2009). Assessments for the Koala have included results from dog detection (i.e. scats), population genetics, foliage nutrient analysis and the conventional SAT method (Phillips and Callaghan 2011). The investigations performed are regarded as adequate for the assessment of impacts on affected species and ecological communities.

Impacts

A total of 212.14 ha of native vegetation comprising threatened species habitat and 59.87 ha of cleared lands will be progressively impacted by the Proposal for future urban use over an 8+ year timeframe. The site preparation works involved in this process are to be Phased and managed in a sensitive manner in accordance with a VMP. The works under the VMP will encourage the gradual transition of affected species in impacted areas into a 244.25 ha Conservation Area comprising ‘like for like’ native vegetation and threatened species habitat which will be restored and improved under a BMP in a timely manner to ensure a

long term, resilient, and sustainable habitat. Restoration and improvement works under the BMP will commence prior to impacts managed under the VMP to enable species transition where desirable.

This impact is countered by the establishment of a 244.25 ha Conservation Area comprising 'like for like' native vegetation and threatened species habitat. Mitigation that forms part of the Proposal (**Section 7**), and detailed in the BMP, is listed below:

- Revegetation works in cleared lands to benefit the Koala and winter-spring nectar dependent species;
- Habitat enrichment works for the Koala;
- Habitat enhancement (i.e. installation of hollows, fauna fencing and emplacement of fallen logs);
- Weed management (e.g. removal of Lantana and African Olive);
- Feral animal control (e.g. wild dogs, feral cats and deer);
- Fencing of Conservation Areas to:
  - curb and deter illegal and uncontrolled activities (e.g. illegal dumping, timber getting, hunting)
  - manage existing rural activities that impact on native plants and weed dispersal (e.g. grazing by cattle, horses, goats)
- Habitat protection for threatened species; and
- Use of a conservation mechanism to locally protect threatened species and their habitat from future development.

A VPA is to be executed for the purposes of delivering an in-perpetuity conservation agreement for the Conservation Area. The establishment and in-perpetuity protection of the Conservation Area under a VPA is consistent with the options outlined in the CERs.

Feasible Alternatives

Two feasible alternatives have been considered being the 'Do Nothing' and 'Zone based development scenario' with the latter representing a higher lot yield at the expense of impact avoidance outcomes and the subdivision of E2 zoned lands for private sale. Key highlights of these alternatives are as follows:

- The 'Do Nothing' alternative results in considerable socio-economic loss and is inconsistent with the objectives of the Greater Newcastle Metropolitan Plan 2036, which identifies the Kings Hill Urban Release Area as the largest and most important housing release area in this time horizon for the Port Stephens local government area.
- The 'Zone based development scenario' will reduce the amount of impact avoidance outcomes proposed in pursuit of higher residential lot yield. The increased development footprint will place greater pressure on locally occurring threatened species such as the Koala and Brush-tailed Phascogale. The subdivision of and subsequent use of E2 lands will potentially erode the effectiveness and certainty of threatened species management and delivery of local outcomes (i.e. fragmented land holdings and reduced conservation management efficiencies). The greater development yield at the expense of biodiversity protection is generally inconsistent with the EcoBiological (2009) recommendations.

Assessment Conclusion

The Proposals impact includes sequenced and managed habitat loss over an 8+ year timeframe coupled with the delivery of restoration, mitigation and conservation works designed to attain localised ecological benefit for affected threatened species and ecological communities within the adjacent Conservation Area. The Conservation Area is of sufficient size and character to retain local viable populations of affected threatened species and ecological communities, with in-perpetuity funding and management delivering certainty in the outcome.

A nett gain in preferred Koala feed trees is expected through the revegetation of cleared lands and intra-forest enrichment. Koala habitat protection measures such as fencing, road underpasses, grids and bridges are also proposed to prevent mortality. These measures, in addition to the managed protection of Koala habitat within the Conservation Area satisfy the requirements specified in the PSC Comprehensive Koala Plan of Management.

On balance, it is concluded that the habitat loss and ecological benefit of the Proposal will deliver a local outcome for affected threatened species and ecological communities that is not likely to have a significant impact on these matters.

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1 INTRODUCTION

1.1 Overview

RPS was commissioned by APP Corporation on behalf of Kings Hill Developments (KHD) to prepare a Species Impact Statement (SIS) to assess a Proposal described as a Concept Development Application for future Residential Subdivision and Stage 1 Subdivision Works (Initial Site Preparation Works), inclusive of biodiversity mitigation works and provision of a biodiversity Conservation Area, for lands within Lot 41 DP1037411 and Lot 4821 DP852073 (hereafter referred to as the 'subject site') as shown in **Figure 1.1**. The subject site comprises two precincts broadly described as:

- The Proposal 'impact footprint'. This delineates Stage 1 Subdivision Works (Initial Site Preparation Works) and is 272.88 ha in area comprising 212.14 ha of native vegetation and 60.74 ha of cleared lands; and
- The 'Conservation Area'. This delineates an area for the managed conservation and protection of affected biodiversity values. It comprises 244.25 ha incorporating E2 zoned lands and impact avoidance areas zoned R1 and B4, which contain high biodiversity values.

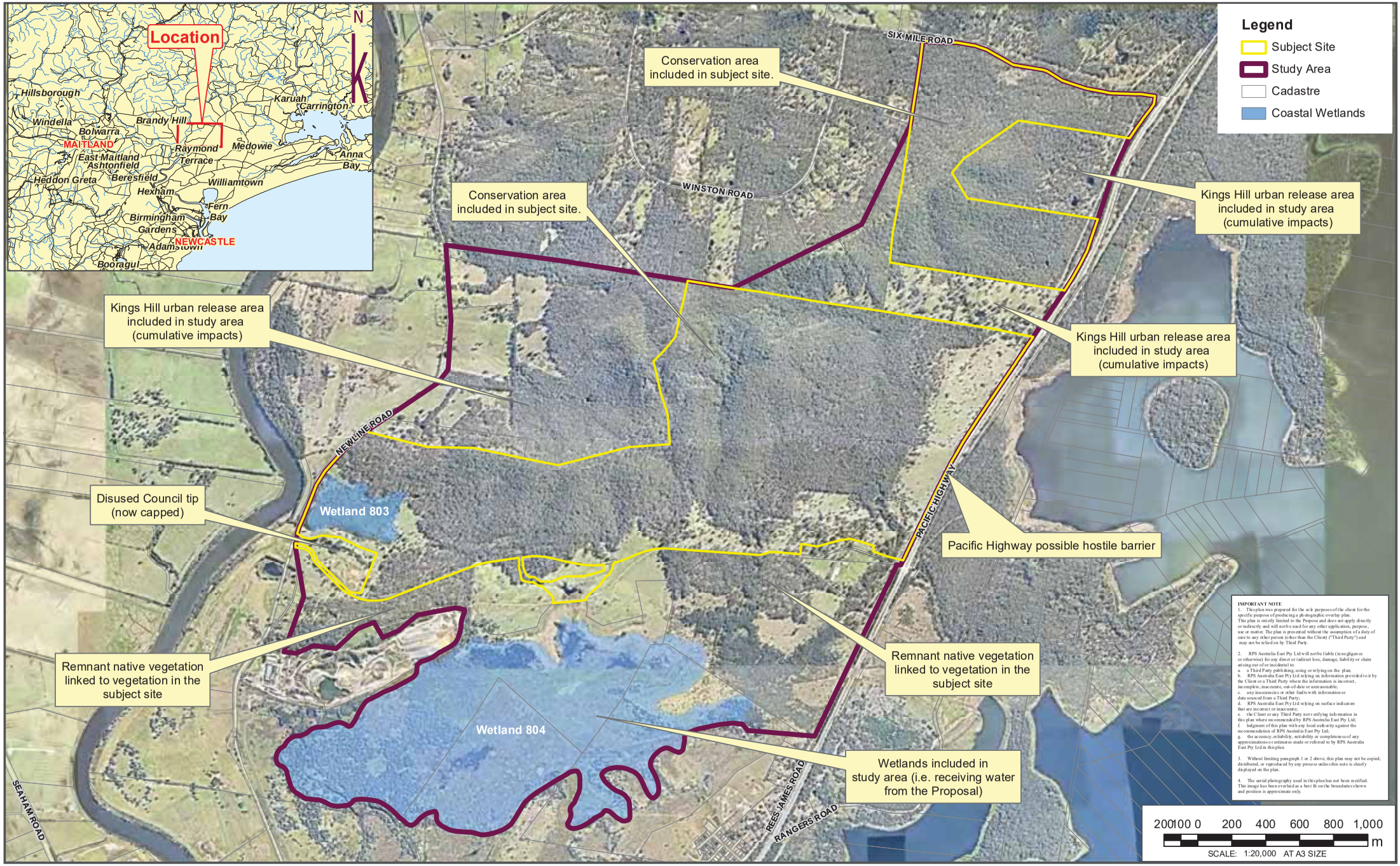
The subject site is located at 3221 Pacific Highway, Kings Hill in the Port Stephens Council Local Government Area (LGA). A description of the Proposal, as shown in **Figure 1.1**, is provided in **Section 2.1** and the accompanying Statement of Environmental Effects (SEE) (JW Planning 2020).

1.1.1 Regulatory Context

This SIS has been prepared in accordance with Section 109 and 110 of the *NSW Threatened Species Conservation Act 1995* (TSC Act) and Office of Environment and Heritage (OEH) Chief Executive requirements (CERs) dated 9 September 2018, which are provided in **Appendix A**. The main objectives of this SIS are to:

- Identify threatened species issues and provide appropriate amelioration for adverse impacts resulting from the Proposal;
- Provide an appropriate level of background information and assessment to facilitate determinations and licensing processes;
- Assist consent and determining authorities in the assessment of the development application under Part 4 under the *Environmental Planning and Assessment Act* 1979 (EP&A Act);
- Assist Port Stephens Council in forming a view (as per the CERs and EP&A Act) as to whether OEH concurrence is required;
- If OEH concurrence is sought by Council, assist the Chief Executive of the OEH in deciding whether or not concurrence should be granted for the purposes of Part 4 of the EP&A Act; and
  - Assist the Chief Executive of the OEH or the Minister for the Environment if consulted for the purposes of Part 4 of the EP&A Act; and
  - Assist the Chief Executive of the OEH in the assessment of Section 91 Licence applications lodged under the NSW TSC Act.

This document has been structured to comply with the CERs. Throughout the SIS at the start of each major section the relevant parts of the CERs are reproduced in italics in order to demonstrate how each SIS section complies with statutory requirements. A compliance table is also included in **Appendix B**.



TITLE : FIGURE 1.1: LOCATION OF THE STUDY AREA AND SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): E A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 1.1 Location of the study area and subject site E A3 20200719.mxd

CLIENT: **PM NO 1 PTY LIMITED**

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1.1.2 Key Elements of the Proposal

The Proposal design and description incorporates the principles of the 'mitigation hierarchy' being impact avoidance, minimisation and mitigation. EcoBiological (2009) provided recommendations for the consideration of future development within the Kings Hill Urban Release Area (KHURA), as supported by the former NSW Department of Environment, Climate Change and Water (now NSW Biodiversity Conservation Division), have formed a primary consideration in defining the Proposal. These are:

- Establish three corridor zones (100-150 m wide) two in the south and one in the north-east. These corridors need to be enhanced with Koala-friendly vegetation (loss of 20-30 ha);
- Provide a wildlife overpass (suitable for the Koala) to cross the Pacific Highway at the distal end of the corridor;
- Retain additional preferred Koala habitat along the western ridge (loss of 5-10 ha);
- Avoid as far as possible areas of high-value Brush-tailed Phascogale habitat and known Grey-crowned Babbler breeding areas; and
- Avoid the removal of Freshwater Wetland habitat within three key wetland locations.

The demarcation of impact avoidance outcomes has been demonstrated through the process of identifying and including developable lands comprising high biodiversity values within the Conservation Area. The Conservation Area, which comprises E2 lands with known high biodiversity values (EcoBiological 2009) plus areas of impact avoidance, is to be managed and protected in perpetuity following establishment through the implementation of a Biodiversity Management Plan (BMP) (**Appendix C**). The BMP is to be applied to the Conservation Area for the benefit of affected threatened species and ecological communities. Impact minimisation, which forms part of the Proposal description and is to apply to the Proposal impact footprint, is described in a Vegetation Management Plan (VMP) (**Appendix D**).

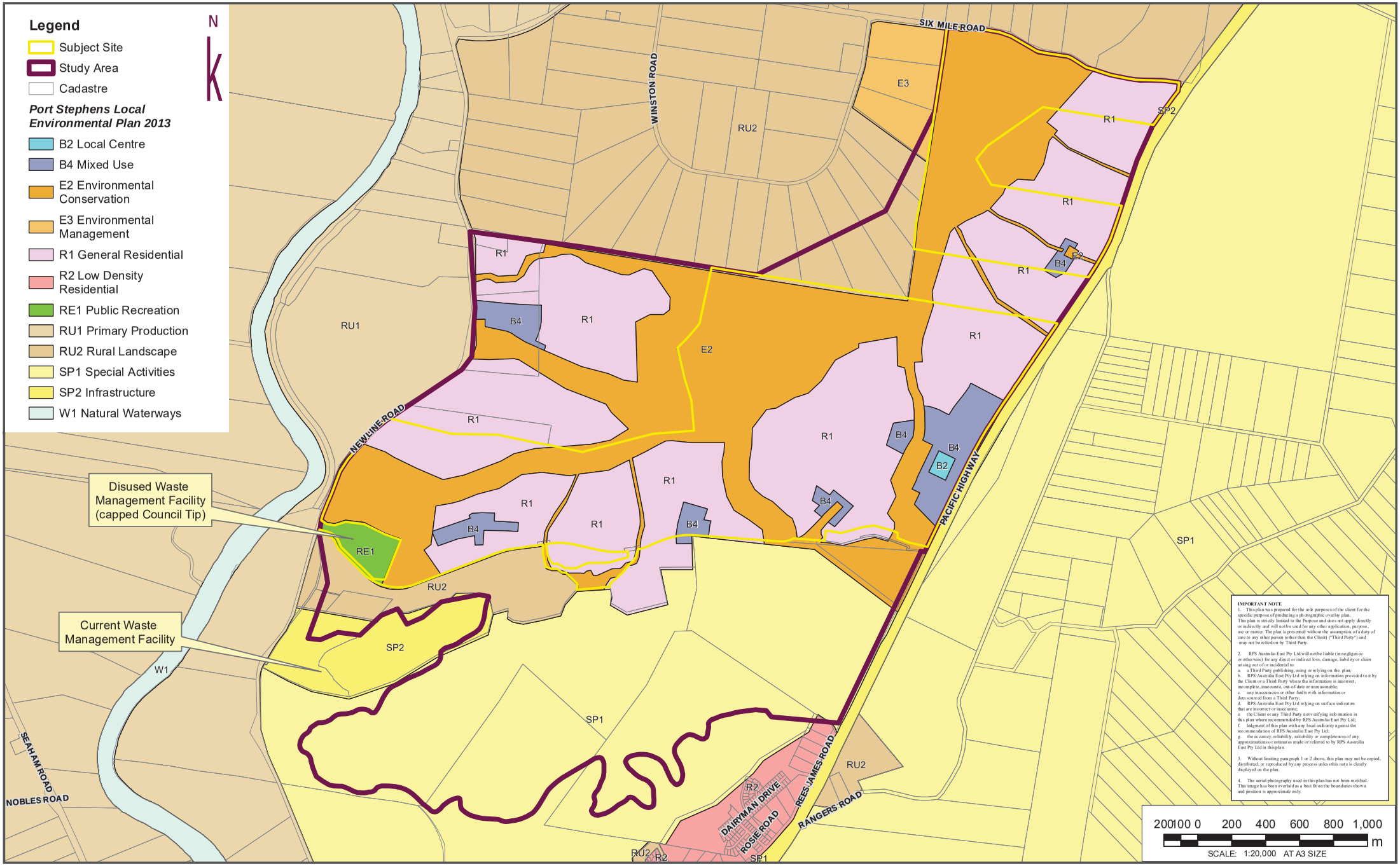
A number of studies additional to those reported in Section 4 of this SIS were performed to define the biodiversity values of the subject site and aid in the application of the mitigation hierarchy including the following investigations:

- Hydrobiology of coastal wetland [Alluvium (2019) **Appendix E**];
- Preliminary flora and fauna studies [Cumberland Ecology (2019) **Appendix F**];
- Koala studies [BioLink (2019a,b,c) **Appendix G**; OWAD (2019a,b) **Appendix H**];
- Eucalypt foliar nutrient investigations [Marsh and Youngentob (2019) **Appendix I**]; and
- Targeted winter bird surveys [Biodiversity Conservation Monitoring (2018) **Appendix J**].

1.2 Background

The subject site, as generally defined by the boundary of Lot 41 DP1037411 and Lot 4821 DP852073, comprises an area of 517.13 ha as shown in **Figure 1.1**. In 2010, approximately 50% of the subject site was rezoned from rural 1A zone to E2 zone while the remainder was rezoned mixed urban purposes as shown in **Figure 1.2**.

The consideration of biodiversity values in the 2010 gazetted rezoning was based on information provided in the PSC commissioned biodiversity assessment for the KHURA (EcoBiological 2009). The gazetted rezoning broadly resembles the 'Option 2' scenario described in EcoBiological (2009), which indicated that development for this option would require the preparation of an SIS. EcoBiological (2009) recommendations for avoiding/ minimising impacts on threatened species and ecological communities for this option, as listed in **Section 1.1.2**, formed a primary consideration in designing and defining the Proposal.



TITLE : FIGURE 1.2: LAND ZONING OF THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 1.2 Land Zoning of the study area D A3 20200719.mxd

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1.3 Need for a Species Impact Statement

Preliminary assessments of the development to the full extent of lands zoned for residential and commercial uses (as shown in **Figure 1.2**) show that the development will impact on threatened biodiversity listed under the TSC Act. This included impacts on the Koala and Brush-tailed Phascogale, both listed as vulnerable under the TSC Act. The EcoBiological (2009) recommendations for avoiding and minimising impacts on threatened biodiversity, as outlined in **Section 1.2**, have been used as important terms of reference in the preparation of the SIS.

Initial Assessments of Significance prepared for these species by EcoBiological (2009) indicated there could potentially be a significant impact on habitat for these species, and as such, the CERs were sought from OEH. Impact avoidance, amelioration and compensatory measures have been developed (**Section 7**) and form part of the Proposal description. The preliminary Assessment of Significance has been revised to include the consideration of impact avoidance, minimisation and mitigation measures and is presented in **Section 8** of this SIS.

1.4 Legislative Requirements

1.4.1 Threatened Species Conservation Act 1995

This SIS has been prepared in accordance with Sections 109, 110 and 111 of the TSC Act, which describes the form and content of an SIS, with the exception of those matters limited or modified in the CERs as listed in **Section 1.5** below. The requirements of the Director-General of the OEH were sought pursuant to Section 111 of the TSC Act. Revised CERs for the Proposal were issued on 8 September 2018.

All fauna and flora work performed by RPS was carried out under the following licences:

- NSW National Parks and Wildlife Service Scientific Investigation Licence S100536 (Valid 31 December 2020);
- Animal Research Authority (Trim File No: 16/361) issued by NSW Department of Primary Industries (Valid 21 March 2020);
- Animal Care and Ethics Committee Certificate of Approval (Trim File No: 16/361) issued by NSW Department of Primary Industries (Valid 21 March 2020); and
- Certificate of Accreditation of a Corporation as an Animal Research Establishment (Trim File No: 01/1522 & Ref No: AW2001/014) issued by NSW Agriculture (Valid 22 May 2020).

1.4.2 State Environmental Planning Policy 44: Koala Habitat Protection

Port Stephens Comprehensive Koala Plan of Management (CKPoM) 2002 supersedes SEPP 44. Section 5.3 of the Port Stephens CKPoM provides performance criteria for development applications as listed below:

a. Minimise the removal or degradation of native vegetation within Preferred Koala Habitat or Habitat Buffers;

b. Maximise retention and minimise degradation of native vegetation within Supplementary Koala Habitat and Habitat Linking Areas;

c. Minimise the removal of any individuals of preferred koala food trees, where ever they occur on a development site. In the Port Stephens LGA these tree species are Swamp Mahogany (*Eucalyptus robusta*), Parramatta Red Gum (*Eucalyptus parramattensis*) and Forest Red Gum (*Eucalyptus tereticornis*). An additional list of tree species that may be important to koalas based on anecdotal evidence is included in Appendix 8 of the Port Stephens Council CKPoM (as recommended by the CKPoM Consultative Committee);

d. Make provision, where appropriate, for restoration or rehabilitation of areas identified as Koala Habitat including Habitat Buffers and Habitat Linking Areas over Mainly Cleared Land. In instances where Council approves the removal of koala habitat (in accordance with dot points 1-4 of the above waive clause), and where circumstances permit, this is to include measures which result in a "net gain" of koala habitat on the site and/or adjacent land;

e. Make provision for long term management and protection of koala habitat including both existing and restored habitat;

f. Not compromise the potential for safe movement of koalas across the site. This should include maximising tree retention generally and minimising the likelihood that the proposal would result in the creation of barriers to koala movement, such as would be imposed by certain types of fencing;

g. Be restricted to identified envelopes which contain all buildings and infrastructure and fire fuel reduction zone; and

h. Include measures to effectively minimise the threat posed to koalas by dogs, motor vehicles and swimming pools by adopting minimum standards for these threats.

Information that is to accompany applications on sites that contain preferred or supplementary habitat, habitat buffers or habitat linking areas is provided in **Section 5.1.4** together with a section reference in the SIS where the matter has been addressed in detail. This was guided by information obtained from the application of the "Guidelines for Koala Habitat Assessment" (Section 5.5 of the CKPoM).

Surveys completed had reference to the "Guidelines for Koala Habitat Assessment" (Section 5.5 of the CKPoM) and were performed by a number of skilled experts as listed below (with their roles):

- Dr Steven Phillips [SAT survey and Koala habitat utilisation assessment (BioLink 2019a), offset advice/ habitat area calculation (BioLink 2019b) and mitigation advice (BioLink 2019c) see **Appendix G**];
- Mr Mark Aitkens [vegetation and tree mapping; GIS analysis (contained within this report)];
- Ms Olivia Woosnam [detection dogs (OWAD 2019a,b) see **Appendix H**];
- Dr Fiona Hogan [Koala genetics analysis in OWAD (2019a,b) see **Appendix H**];
- Dr Kara Youngentob [nutrient foliage analysis (Marsh and Youngentob 2019) see **Appendix I**];
- Ms Karen Marsh [nutrient foliage analysis (Marsh and Youngentob 2019) see **Appendix I**]; and
- Dr Robert Clark (statistical analysis: survey design for the nutrient foliage analysis).

The addressing of matters pertaining to Port Stephens Comprehensive Koala Plan of Management (i.e. Information to Accompany Applications), as required by the CERs, is provided in **Section 5.1.4**.

1.5 CER Matters Which Have Been Limited or Modified

The following Section 110 matters of the TSC Act need not be addressed by this SIS:

- Section 110(2)(g) and 110(3)(d).

The matters raised in these sections of the TSC Act have been clarified by the requirements below.

The following Section 110 matters need only be addressed where relevant:

- All reference to threat abatement plans;
- All reference to recovery plans;
- All reference to key threatening processes; and
- All reference to critical habitat. At the time of printing, the areas of declared critical habitat are not relevant to this proposal.

1.6 Consultation

The following consultation was performed during the preparation of the SIS.

OEH

- 17 April 2018 – Consultation Meeting (Hunter Central Coast Branch attended by Steve Lewer & Steven Cox from OEH), APP, JWP discussed process related to:
  - Treatment of DGRs (seek amendment to include Lot 4821)
  - Offsetting approach / SIS
  - Approach for all future DAs (include LEP changes & alignment with PSC KPoM)
  - Approach to Koala impact
- 2 August 2018 – Pre-SIS Consultation (Hunter Central Coast Branch attended by Steve Lewer & Steven Cox from OEH), APP, CE and JWP.
- 7 Feb 2019 – Pre-lodgement Consultation Meeting (Hunter Central Coast Branch attended by Steven Cox from OEH), Port Stephens Council (Ms Natalie Nowlan and Mr Duncan Jinks), OWAD, RPS, JWP and ANU representatives.

Council

- 9 Feb 2018 - Approval from Council (Les Seddon) on Koala HUB Assessment Scope and engagement with Stephen Phillips.
- 18 September 2018 – Pre-lodgement DA Meeting (as per minutes attached – scope later amended to vary Stage 1 to specifically enable preliminary subdivision works within the development footprint).
- 21 Feb 2019 – Meeting (Council Administration Building attended by Natalie Nowlan and Duncan Jinks) with Kara Youngentob from ANU and RPS. Topics discussed included:
  - Koala habitat polygon
  - Wetlands impact
  - Corridors
  - Cumulative impacts
  - DNA work
  - SIS submission
- 17 May 2019 – Meeting (Council Administration Building attended by Natalie Nowlan and Mark Aitkens) Topics discussed included:
  - Changes to the Proposal study area, subject site boundaries,
  - Informed of wetland investigation performed by Alluvium
  - Changes to the Proposal impact footprint including impact avoidance
  - Mitigation and Offsetting
  - Lodgement, Assessment and Referral Process

Specialist Consultation

Stephen Phillips

- 20 September 2017 – Arcadis, KHD, JWP, Biocm (attended by Stephen Phillips and Grant Brearley)

  - Existing Environment
  - Koala Objectives for the area
  - Management Frameworks, Policies and Guidance Docs
- 21 March 2018 – Meeting at Biolink (Uki) to discuss HUB Assessment Outputs and Recommendations
- 2 May 2018 – Telecon KHD, JWP, Biocm (attended by Stephen Phillips)
  - Koala Corridor / HUB Assessment Update
- 11 April 2019 – Meeting with BioLink (Stephen Phillips) to discuss approach taken in assessing the Koala at Kings Hill
  - Outlined methods used to locate Koalas and their activity
  - Outlined nutrient study performed by ANU
  - Presented maps displaying results including the extent of foliage nutrients across the subject site
  - Showed how the information was used to identify important impact avoidance outcomes
  - Outlined commitments to improving connectivity and Koala safety (fencing)

1.7 SIS Production

This SIS has been produced by RPS with contributions made by Cumberland Ecology, BIOCM, OWAD and ANU (see below). A draft SIS produced by Cumberland Ecology (April 2017) was prepared in parallel with peer review support from RPS (i.e. vegetation typing and mapping). Due to short regulatory timeframes and Cumberland Ecology's' limited capacity of to accommodate this timeframe constraint, RPS was commissioned to finalise the SIS.

OWAD and WildDNA

Olivia Woosnam and Alex Dudkowski worked tirelessly and were very supportive through their contributions made with their Koala dog detection work and DNA analysis as performed by Dr Fiona Hogan and Dr Faye Wedrowicz at WildDNA (Federation University).

Alluvium

Mark Wainwright and David Carew provided considerable expert knowledge and assistance in the evaluation of hydrological impacts on Wetlands 803 and 804.

ANU Experts

The following staff at the Australian National University are acknowledged for their invaluable assistance in the investigation of Koala habitat values within the subject site:

- Professor Kara Youngentob - Research Fellow in Ecology and Evolution at the Australian National University.
- Professor Robert Clark - Research School of Finance, Actuarial Studies and Statistics.
- Dr Karen Ford - POSTDOCTORAL FELLOW - Foley Group - Animal-Plant interactions.

BioLink

Dr Steve Phillips and Dr Grant Brearley are acknowledged for their ongoing assistance in providing expert advice as to the evaluation of Koala activity using the Spot Assessment Technique (SAT) and the various intricacies associated with the application of this activity measure.

Dr Mark Clements (Centre for Australian National Biodiversity Research)

Dr Mark Clements is acknowledged for his invaluable contribution to the understanding of taxonomy, habitat requirements and population definitions for the two threatened orchids found within the subject site. He is an authority in the ecology and taxonomy of orchids across the world with emphasis on the Australasian region. His current research projects are to study the biodiversity of the Australian Orchidaceae in relation to those of related floras and to carry out systematic, biological and molecular studies of these plants to elucidate their phylogenies. The project also involves compilation of photographic indices of Australian Orchidaceae and of Orchidaceae types.

Dr Frank Lemckert (EcoLogical)

Frank has been a professional scientist since 1992, specialising in understanding and managing the ecology and management of threatened species in forest environments. Frank has conducted ecological work through eastern Australia targeting the impacts of forestry and human activities and established long-term research and monitoring programs in managed forests to better understand the longer term impacts of forest harvesting practices. He has worked extensively with the NSW state and federal Governments on varying issues of fauna and flora management including the preparation of a draft NSW/National recovery plan for *Heleioporus australiacus* and providing expert advice for Impact Assessment Guidelines. Frank has prepared reports on endemism and representation in reserves of flora and fauna for the Commonwealth, represented the NSW Forestry Commission in license negotiations for the Comprehensive Regional Assessment process (2000), provided expert ecological advice on illegal land clearing for the NSW and Commonwealth Governments and authored over 90 peer-reviewed publications. Frank is a research associate with the Australian Museum and University of Newcastle and convenor of the NSW Declining Frog Working Group.

Frank's specific history in regards to forest management practices and Koala management includes:

- Completing expert workshops on prescriptions for the coastal Threatened Species License for DPIE in 2017. This required evaluating current forestry logging practices and developing new strategies to maintain current timber quotas whilst improving conservation outcomes for fauna.
- Undertaking expert reviews on species management plans for four threatened fauna species for the NSW Natural Resources Council in 2019. This included assessing the value of the data collected to date, the effectiveness of the projects in evaluating and achieving their stated goals and changes that should be made to the strategies to allow them to be more effective in meeting those goals, as required.
- Completing and publishing research on the impacts of forestry practices on fauna in eastern NSW. This included complex multi-factorial analysis of species and community relationships with disturbance history along with undertaking before and after impact assessment of fire disturbances.
- Undertaking a review of harvesting practices in areas of redgum on native fauna for the Riverina Forestry EIS. This covered thinning trials and their value in improving fauna habitat.
- Targeted surveys for a range of threatened species including the large forest owls, Yellow-bellied Gliders, threatened insectivorous bats, Koalas, all of the threatened frogs in NSW, Stephens Banded Snakes, Earless Dragons, Glossy Black Cockatoos Regent Honeyeaters and other woodland birds.
- Reviewing Koala management plans for Mary's Mount, Koala conservation strategies for the Pacific Highway at Urunga, reviewing reports for Koala research programs for a road upgrade at Port Stephens.
- Targeted monitoring and reporting for threatened species for road projects including several locations along the Pacific Highway, the Princes Highway between Gerringong and South Nowra and Mona Vale Road. Species covered include the Green and Golden Bell Frog, Giant Burrowing Frog, Red-crowned Toadlet, Green-thighed Frog, Giant Barred Frog, Yellow-bellied Glider, Brush-tailed Phascogale, Squirrel Glider, Glossy Black Cockatoo, Southern Myotis and Bentwing-bats.

- Research into the value of planted areas as fauna habitat at Albury and on the Liverpool Plains of NSW to understand the role that plantings can play in restoring habitats for fauna in agricultural landscapes.
- Assisting with radio-tracking of Koalas at research programs at Nowendoc and the Liverpool Plains and reviewing the ethics of tracking programs at Coffs Harbour.

2 CONTEXTUAL INFORMATION

This chapter covers the following Chief Executive Requirements:

DGR 2. CONTEXTUAL INFORMATION

2.1.1 Description of the Study Area

DGR 2.1.2 Definition of SIS study area

DGR 2.1.3 Description of SIS study area

Overview

Investigations performed for the Kings Hill Urban Release Area (KHURA) have been performed over a period of at least 16 years (e.g. HWR 2004; EcoBiological 2009 and current investigations). These investigations have been used to define the study area for the evaluation of indirect impacts and cumulative impacts. Recent investigations performed in addition to recent RPS works provided in this SIS are listed below:

- Alluvium (2019): Assessment of the Kings Hill development impacts on the hydrology and vegetation of Irrawang Swamp and Coastal Wetland 803 (**Appendix E**);
- Cumberland Ecology (2019): Kings Hill Development Ecological Survey Summary Report (**Appendix F**);
- BioLink (2019a): Kings Hill Koala Habitat Assessment (**Appendix G**);
- BioLink (2019b): Kings Hill Developments (KHD): Offsetting Advice (**Appendix G**);
- BioLink (2019c): Kings Hill Developments (KHD): Infrastructure Advice (**Appendix G**);
- OWAD (2019a): Raymond Terrace Koala Survey Report (**Appendix H**);
- OWAD (2019b): Port Stephens LGA Koala Genetic Sampling Report (**Appendix H**);
- Marsh and Youngentob (2019): Report on Nutritional Analysis of Eucalypt Leaves collected from Kings Hill (**Appendix I**);
- BIOCM (2018): Winter Bird Surveys for Kings Lands 2018 (including historical threatened species records from 2003 to 2018) (**Appendix J**); and
- Dr Mark Clements (2020): Conservation genomics of an Australian orchid complex with implications for the taxonomic and conservation status of *Corybas dowlingii* (**Appendix K**).
- Dr Frank Lemckert (2020): Review of Management Actions for the Koala at the King Hill (**Appendix L**).

The following sections define and describe the study area.

2.1.2 The Study Area

2.1.2.1 Direct and Indirect Impacts

The study area is defined as the subject site (i.e. area of direct impacts) and adjoining lands where indirect impacts may occur (as required by the CERs). This area is bounded by the Pacific Highway in the east, Newline Road to the west, Six Mile Road and private rural lots to the north and Irrawang Wetland in the south as shown in **Figure 1.1**. The study area is approximately 1,170.63 ha with approximate dimensions of 3.7 km wide (east to west) and 5.4 km (north to south).

The assessment of the Proposals direct impacts in this SIS included the consideration of results obtained from detailed subject site investigations where property access was readily available. Indirect impacts have considered some detailed datasets and supplementary data sources (e.g. grey literature, databases, regional vegetation mapping) where property access generally limited information availability.

2.1.2.2 Cumulative Impacts

The assessment of the Proposals cumulative impacts encompasses an area larger than the study area to account for broader non-project related land use considerations. The broader area considered in evaluating cumulative impacts is shown in **Figure 2.1**. The cumulative impact area is defined as the study area and additional lands to the north and east as is generally reflective of the land area occupied by the Kings Hill Koala hub (BioLink 2019d) (i.e. a land area comprising habitat able to support at least 50 Koala individuals). The cumulative impact area boundary is delineated to the:

- West by the predominantly cleared Williams River floodplain, which represents a barrier to most wildlife movement in that direction;
- North by the Balickera channel, which acts to narrow most north – south wildlife movement pathways to a ~1.1 km wide corridor coincident with Italia Road (i.e. doesn't prevent wildlife movement but serves to influence movement efficiency); and
- East by the western shoreline of Grahamstown Dam north from the Irrawang Spillways to the Balickera channel.

The cumulative impact assessment area was extended east of the Pacific Highway into the Grahamstown Dam precinct to allow for the consideration of the KHURA infrastructure works proposed adjacent to the Grahamstown Dam shoreline; a decision based on local Koala genetics, which shows individuals either side of the Pacific Highway form part of the same population (OWAD 2019b).

2.1.2.3 Regional Context

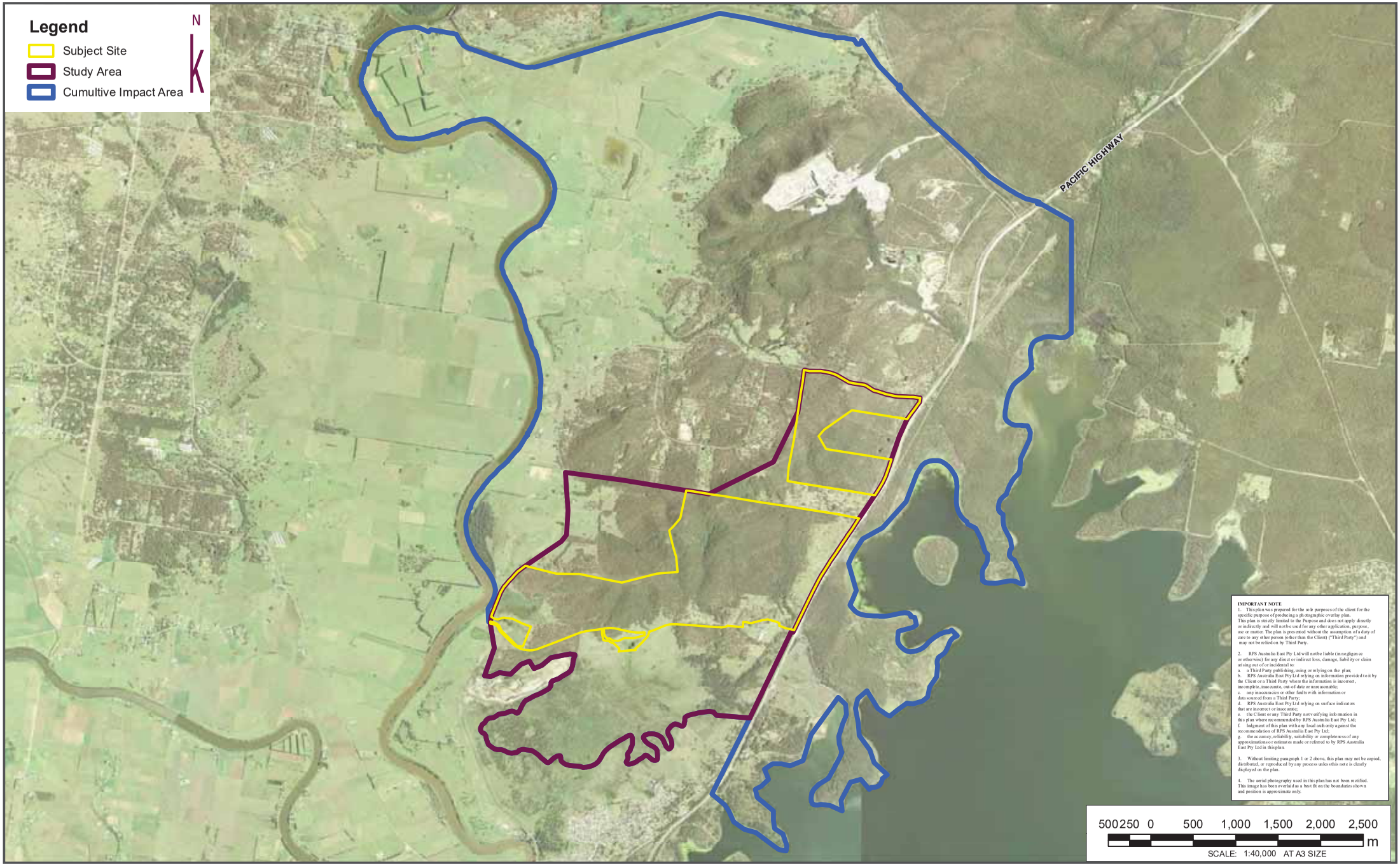
The study area is situated within the:

- Hunter-Central Rivers major catchment area and NSW North Coast IBRA region near the northern boundary of the Sydney Basin Bioregion;
- Karuah Manning IBRA subregion and adjacent to the Hunter and Upper Hunter IBRA subregions, with 16% of the Karuah Manning IBRA subregion occurring within conservation reserves; and
- Newcastle Coastal Ramp Mitchell Landscape (OEH 2017).

The Newcastle Coastal Ramp Mitchell Landscape comprises an area of native vegetation cover that is not classed as overcleared (i.e. currently 54% cleared). Most of the uncleared native vegetation remaining within this Mitchell landscape occurs within nearby conservation reserves including Medowie State Conservation Area (2,851 ha ~3.5 km to the east), Wallaroo National Park (2,780 ha ~5.0 km to the north), Wallaroo State Forest (6,200 ha ~3.0 km to the north), Karuah National Park (3,534 ha ~5.3 km to the north-northeast), Karuah Nature Reserve (823 ha ~17.3 km to the east-northeast) and Columbey National Park (868 ha ~11.8 km to the north-northwest). All these conservation reserves contain native vegetation and habitat found within the subject site and study area (OEH 2016c).

The vegetation within the Newcastle Coastal Ramp Mitchell Landscape is generically described as follows:

"Undulating lowlands and low to steep hills on complex patterns of faulted and gently folded Carboniferous conglomerate, lithic sandstone, felspathic sandstone, and mudstone, general elevation 50 to 275m, local relief 40 to 150m. Stony red texture-contrast soils on steep slopes, yellow and brown texture-contrast soils on lower slopes and deep dark clay loams along streams. Woodland of spotted gum (*Corymbia maculata*), forest red gum (*Eucalyptus tereticornis*), red ironbark (*Eucalyptus sideroxylon*), white mahogany (*Eucalyptus acmenoides*), large-fruited grey gum (*Eucalyptus canaliculata*), with sub-tropical rainforest elements in sheltered gullies. Similar eucalypts with forest oak (*Allocasuarina torulosa*) and grasses on lower slopes, merging to forest of smooth-barked apple (*Angophora costata*), red bloodwood (*Corymbia gummifera*), blackbutt (*Eucalyptus pilularis*) with bracken (*Pteridium esculentum*) and grasses nearer the coast" (DECC 2002).



TITLE : FIGURE 2.1: BOUNDARY OF THE SUBJECT SITE, STUDY AREA AND CUMULATIVE IMPACTS ASSESSMENT AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): F A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 2.1 Bdy of the subject site and Study Area F A3 20200719.mxd

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2.1.2.4 Soil Landscapes

Soil types are known to influence vegetation types. Soil landscapes located within the study area include Ten Mile Road, Birdsview, Wallalong and Hexham Swamp landscapes. The Ten Mile Road soil landscape occupies most of the study area, with the Birdsview landscape occurring in the north-western corner, the Wallalong landscape along the east and Hexham Swamp landscape in the west (**Figure 2.2**).

The Ten Mile Road landscape is described as 'gently undulating to undulating low hills on Carboniferous sediments' with slope gradients of 5-10% (Matthei 1995). Soils are moderately deep to deep, well to imperfectly drained brown soloths, yellow soloths, and shallow, well-drained bleached loams/ lithosols (Matthei 1995). A variant of this soil landscape, variant a, is located along the western portion of the landscape (**Figure 2.2**). It is characterised by rolling low hills and slope gradients of 10-20%, with all other landscape features similar to that of the Ten Mile Road soil landscape (Matthei 1995).

Vegetation associated with the Ten Mile Road soil landscape is uncleared open-forest consisting of *Corymbia maculata* (Spotted Gum), *Eucalyptus acmenoides* (White Mahogany), *Eucalyptus globoidea* (White Stringybark), *Eucalyptus paniculata* (Grey Ironbark), *Eucalyptus tereticornis* (Forest Red Gum) and *Eucalyptus punctata* (Grey Gum). Lower slopes see an occurrence of *Angophora costata* (Smooth-barked Apple), *Eucalyptus gummifera* (Red Bloodwood) and *Allocasuarina littoralis* (Black She-oak) (Matthei 1995).

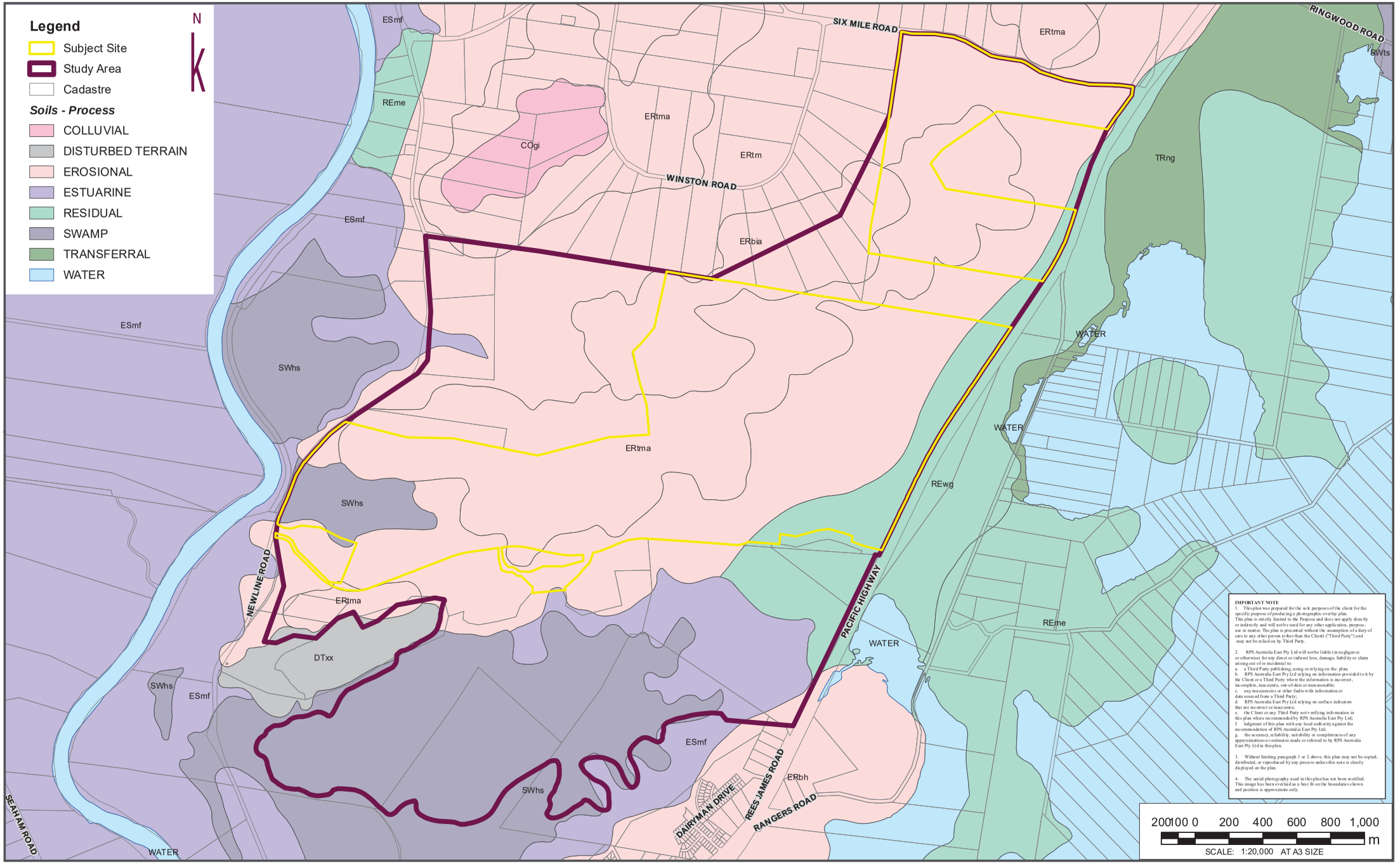
The Birdsview soil landscape (variant bia) is characterised by rolling hillcrests and midslopes on Carboniferous sediments, with a slope of 10-20% (Matthei 1995). Soils are moderately deep, well-drained yellow podsolic soils with shallow, well-drained bleached loams and lithosols on stony ridge crests and deep, well-drained red podsolic soils where siltstone and deeply weathered polymictic conglomerate outcrop (Matthei, 1995). Vegetation generally associated with this soil landscape is cleared tall open forests on crests and steep upper slopes, and uncleared closed forest on sheltered slopes and gullies. Open forest consists of *Eucalyptus seeana* (Narrow-leaved Cabbage Gum), Spotted Gum, Grey Ironbark, *Eucalyptus crebra* (Narrow-leaved Ironbark), *Eucalyptus punctata* (Grey Gum), *Brachychiton populneus* (Kurrajong) and *Acacia implexa* (Hickory) (Matthei 1995).

The Wallalong Soil Landscape located along the eastern side of the study area is characterised by undulating low hills on sediments of the Permian Dalwood Group (Matthei 1995). Soils are moderately deep to deep yellow soloths and black soloths and shallow lithosols, shallow to moderately deep brown podsolic and yellow podsolic soils (Matthei, 1995). Vegetation is extensively cleared tall open forest comprising Spotted Gum, Narrow-leaved Ironbark, *Eucalyptus glaucina* (Slaty Red Gum) and Grey Box (Matthei 1995).

The Hexham Swamp Soil Landscape is characterised by broad, swampy, Quaternary estuarine backplains on the Lower Hunter delta with slope gradients less than 1% (Matthei 1995). Vegetation is comprised of sedgeland with predominantly cleared open woodland on swamp margins (Matthei 1995).

The Wallalong Soil Landscape located along the eastern side of the study area is characterised by undulating low hills on sediments of the Permian Dalwood Group (Matthei 1995). Soils are moderately deep to deep yellow soloths and black soloths and shallow lithosols, shallow to moderately deep brown podsolic and yellow podsolic soils (Matthei, 1995). Vegetation is extensively cleared tall open forest comprising Spotted Gum, Narrow-leaved Ironbark, *Eucalyptus glaucina* (Slaty Red Gum) and Grey Box (Matthei 1995).

The Hexham Swamp Soil Landscape is characterised by broad, swampy, Quaternary estuarine backplains on the Lower Hunter delta with slope gradients less than 1% (Matthei 1995). Vegetation is comprised of sedgeland with predominantly cleared open woodland on swamp margins (Matthei 1995).



TITLE : FIGURE 2.2: SOIL LANDSCAPES WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 2.2 Soil landscapes within the SA C A3 20200719.mxd

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2.1.2.5 Hydrology

The subject site comprises three main catchments each draining to separate receiving environments. Kings Hill South drains to Irrawang Swamp (Wetland 804) which is located between Newline Road and the Pacific Highway. Kings Hill West drains to wetland 803, which is also referred to as Irrawang Swamp, is located adjacent to Newline Road within the Conservation Area. Kings Hill East currently drains to Grahamstown Dam. The Proposal aims to divert this runoff away from this catchment into Irrawang Swamp via a constructed channel to protect water quality in the dam. Irrawang Swamp (Wetland 804) and Coastal Wetland 803 are both mapped coastal wetlands under SEPP (Coastal Management) 2018 (SEPP 2018).

Alluvium (2019) provides a detailed account of the hydrology and vegetation that characterises Wetlands 803 and 804 including a historical (formation) perspective. The following sections briefly outline this detailed description, which can be further understood in their report as provided in **Appendix E**.

2.1.2.5.1 Wetland 803

Wetland 803 comprises a Swamp Oak Woodland with areas of submerged vegetation and open water. The wetland is a shallow water body, with a small volume relative to its catchment, which fills readily from the catchment and tidal inflows. Livestock have had historic access to the wetland (Alluvium 2019).

The mature *Casuarina glauca* (Swamp Oak) are growing on pedestals of their own roots indicating that they have been growing under elevated water levels for a significant period of time. The healthiest *Casuarina glauca* are seen in the north-western corner - which is a shallower area on the wetland and less “pedestaling” is seen in this area. The extent and density of the Casuarina has changed over time with a historic reduction of up to 30% between 1954 and 2019 (Alluvium 2019).

The shallow gradient banks of Wetland 803 have a mixture of herbs, grasses and sedges including: *Paspalum distichum* (Water Couch), *Cotula coronopifolia* (Water Buttons), *Samolus repens* (Creeping Brookweed), *Triglochin* sp (Water Ribbons), *Juncus* sp, *Bolboschoenus caldwellii* (Marsh Club Rush). In some areas a sharply stepped bank (at the high water level) reduces vegetation extent (Alluvium 2019).

Extensive emergent macrophytes stands, as seen in Irrawang Swamp (Wetland 804), are not present. However, emergent species such as *Carex appressa* (Tall Sedge), *Eleocharis equisetina* (Spike Sedge), *Bolboschoenus caldwellii* (Sea Club-rush), *Juncus continuus* (Rush), *Ranunculus inundata* (River Buttercup) and *Ludwigia peploides* (Water Primrose) are present at low cover abundance. This may reflect the hydrology which draws down and then rapidly refills possibly drowning any new emergent macrophyte species. Historic grazing by cattle will have impacted emergent vegetation with ongoing impact expected from water-fowl grazing. The lack of *Typha orientalis* indicates periodic drying (Alluvium 2019).

Areas of submerged vegetation dominated by *Thyridia repens* (Syn *Mimulus repens* - Monkey face) were present during the site visit. This species often occupies areas of sub-saline seasonal mudflats indicating the wetland water level varies through a cycle of complete drying in most years. Other seasonal aquatic species are present including *Callitriche stagnalis* (Common Star-wort), *Potamogeton sulcatus* and *Triglochin* sp. (Water-ribbons) (Alluvium 2019).

Wetland 803 has a number of saline tolerant species including *Cotula coronopifolia*, *Mimulus repens* and *Samolus repens*. Their presence is an indicator of saline influence in the wetland. They are particularly abundant in the areas near the outlet where frequent inflow of saline water occurs. The banks which undergo frequent wetting and drying (which will accumulate salts) are also dominated by these species. However, other non-saline tolerant aquatic plants such as *Callitriche stagnalis* and *Potamogeton sulcatus* were present during the site visit. The presence of these varying tolerance species indicates that inflow from the estuary occurs and that seasonal winter inflow must lower the salinity level significantly. Maintaining these conditions will enable the diversity of flora in the wetland to persist (Alluvium 2019).

2.1.2.5.2 Wetland 804 (Irrawang Swamp)

The hydrology of Irrawang Swamp has changed significantly from natural conditions due to historical land management practices associated with catchment development, land clearing, pasture irrigation, grazing and drainage channel construction. Under natural conditions, surface runoff from local catchments would have drained to a series of swamps including the Grahamstown Moors, Campvale Swamp and Irrawang Swamp. The hydrology of these swamps would have also been influenced by groundwater from the catchment. Although, clay soils are dominant in the local Irrawang Swamp catchment and it is expected that groundwater inflows to this swamp would be relatively low. The western extents of Irrawang Swamp were regularly inundated by tidal flows and it is envisaged that salt marsh and other salt tolerant species would have previously inhabited these areas (Alluvium 2019).

Construction of the Grahamstown Dam wall across the natural outlet from the Grahamstown Moors resulted in Campvale Swamp and Irrawang Swamp being separated. The natural hydrology of Irrawang Swamp was significantly altered by the dam construction due to catchment flows now being stored in the dam and extracted for water supply. Diversion of river flows from the Williams River to the dam has also modified the Irrawang Swamp hydrology. Surface water flows from the east of the wetland are now limited to infrequent periods when the dam capacity is exceeded initiating spillway discharges to Irrawang Swamp. The dam construction has also modified groundwater flows (Alluvium 2019).

Increasing residential development on the southern side of Irrawang Swamp has altered the hydrology for these catchments with the increased imperviousness in these catchments now contributing more regular pulses of stormwater runoff volume discharges into the southern area of Irrawang Swamp. In addition, the construction of rural dams and water holding dams associated with the waste recycling and recovery site on the northern side of the swamp has altered the hydrology in these areas (Alluvium 2019).

Irrawang Swamp naturally would have received tidal inflows and been inundated during large overbank flooding events from the Williams River. Construction of the Newline Road embankment and flood gates on pipes under Newline Road has resulted in tidal inflows to the swamp and low flows from the swamp now being controlled through these gates. During large spillway events from Grahamstown Dam, water can rapidly fill Irrawang Swamp. To control flooding in these large events, a levee was constructed within the western extents of the swamp parallel to Newline Road to controls overflows from the swamp to the Williams River. A large multi-cell culvert was also constructed under Newline Road just south of the flood gates to convey spillway flows from Grahamstown Dam in a controlled manner to the Williams River (Alluvium 2019).

A large open channel, Pennington Drain, was constructed centrally through Irrawang Swamp in the 1970's as a component of the initial Grahamstown Dam construction to efficiently convey spillway flows through the swamp to the Williams River. Pennington Drain was formed by excavating a trapezoidal-shaped channel from just downstream of the original spillway to the floodgates. A number of other minor interconnected lateral drains were also constructed in the wetland by landowners to enable efficient draining of the land for cattle grazing and to grow pasture grasses. Many of these drainage channels were connected to the Pennington Drain (Alluvium 2019).

The vegetation in Irrawang Swamp is a mosaic of wetland marsh and woodland communities. These occupy areas of the swamp which experience different hydrological regimes (wetting/drying cycles and depth of inundation). These have developed depending upon the elevation and drainage patterns in the different areas of the Swamp (Alluvium 2019).

The Irrawang Swamp vegetation was significantly modified after the 1950s to enable agricultural uses. This involved the cutting of drains through the central areas of the swamp and the clearing of some of the Swamp Oak (Casuarina glauca) woodland areas to enable pasture management. The Irrawang Swamp Plan of Management (Hunter Water, 2012a) outlines the following historical changes:

Irrawang Swamp has been subjected to a range of anthropogenic disturbances, all aimed at improving the area for agricultural activities, particularly grazing. This disturbance history has resulted in a degraded

wetland system with a highly altered hydrological regime affecting inundation frequency, duration and extent, as well as salinity.

Past land management practices that have altered the natural vegetation include:

- Clearing of native vegetation;
- Livestock grazing; and
- Introduction of exotic pasture species.

The swamp vegetation is adjusting to the current flow regime which includes maintenance practices that are allowing the drainage channels to infill reducing their hydraulic efficiency. This will see water retained in the central areas of the swamp for longer periods and increased inundation for tolerant plant species. The Irrawang Swamp Plan of Management (HWC 2012) describes past human disturbances as:

Irrawang Swamp has been subjected to a range of anthropogenic disturbances, all aimed at improving the area for agricultural activities, particularly grazing. This disturbance history has resulted in a degraded wetland system with a highly altered hydrological regime affecting inundation frequency, duration and extent, as well as salinity. Past land management practices include:

- *Clearing of native vegetation;*
- *Livestock grazing;*
- *Introduction of exotic pasture species;*
- *Construction of Pennington Drain which conveys water from the old spillway to the Williams River, essentially bypassing the swamp;*
- *Excavation of an extensive network of drainage channels to increase surface water outflows from the swamp;*
- *Installation of floodgates on Pennington Drain at the southern end of the swamp to prevent tidal inundation from the Williams River;*
- *Construction of 1.8 km long bund adjacent to New Line Road.*

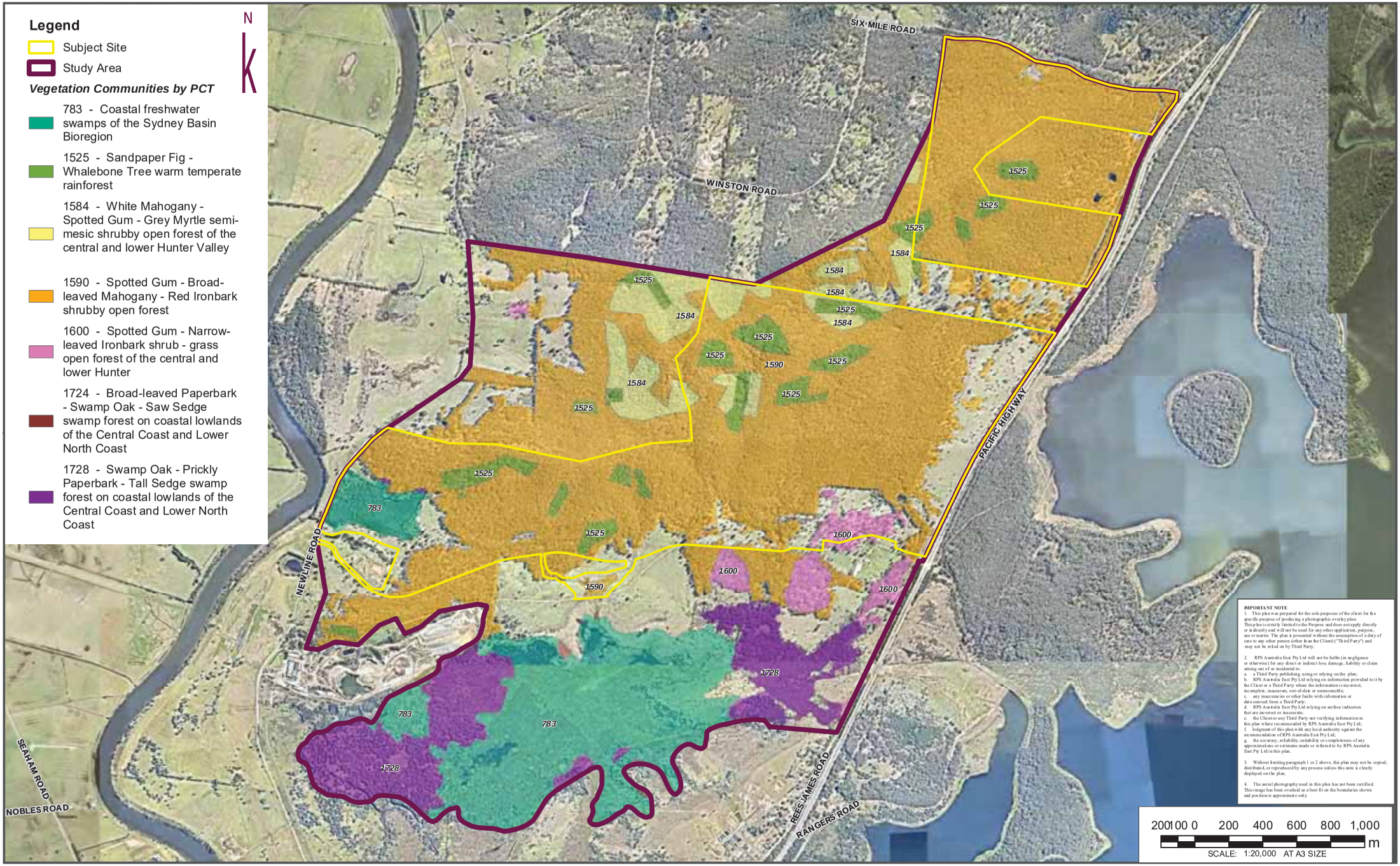
The Plan of Management for Irrawang Swamp (HWC 2012) established the following objectives in light of the past and future impacts on this wetland:

- To restore the wetland to a desired state and eliminate, or at least manage, existing threats.
- To manage the restored wetland for the long-term to address any potential degradation of the system in the future.

HWC (2012) define 'desired state' as *a state which is considered to be that in which the wetland system is functioning effectively (eg. providing habitat for flora and fauna, supporting regenerating native vegetation.)*.

2.1.2.6 Native Plant Community Types

Seven native plant community types (PCTs) are mapped within the study area (NPWS 2003) (with minor modifications made for the subject site as recommended by BioLink 2017). These are listed in **Table 2.1** and shown in **Figure 2.3.**



TITLE : FIGURE 2.3: PLANT COMMUNITY TYPES (PCTS) WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 2.3 Plant Community Types PCT withihn SA DA3 20200719.mxd

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Table 2.1 PCTs of the study area including extent

PCT	TEC	PCT Name	Study Area (ha)
783	Yes [1]	Coastal freshwater swamps of the Sydney Basin Bioregion	158.68
1525	Yes [2]	Sandpaper Fig - Whalebone Tree warm temperate rainforest	42.01
1584	No	White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	49.24
1590	No	Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	572.93
1600	Pre [3]	Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	26.50
1724	Yes [4]	Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast	1.23
1728	Yes [5]	Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast	89.43
TOTAL			**940.02**

2.1.2.7 Land and Soil Capability

The study area comprises land use zones (see **Section 2.1.2.8**) ranging from urban (i.e. residential zones) to non-urban zones where permitted land uses are co-dependent on land capability (e.g. rural zones and agricultural activity). From an agricultural perspective, land soil capability mapping, as shown in **Figure 2.4**, identifies land and soil capability classes between 4 and 8 and are described in **Table 2.2**.

Table 2.2 Land and Soil Capability Classes

LSC Class
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)
4 - Moderate capability land: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
5 - Moderate–low capability land: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)
6 - Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation
Land generally incapable of agricultural land use (selective forestry and nature conservation)
7 - Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8 - Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

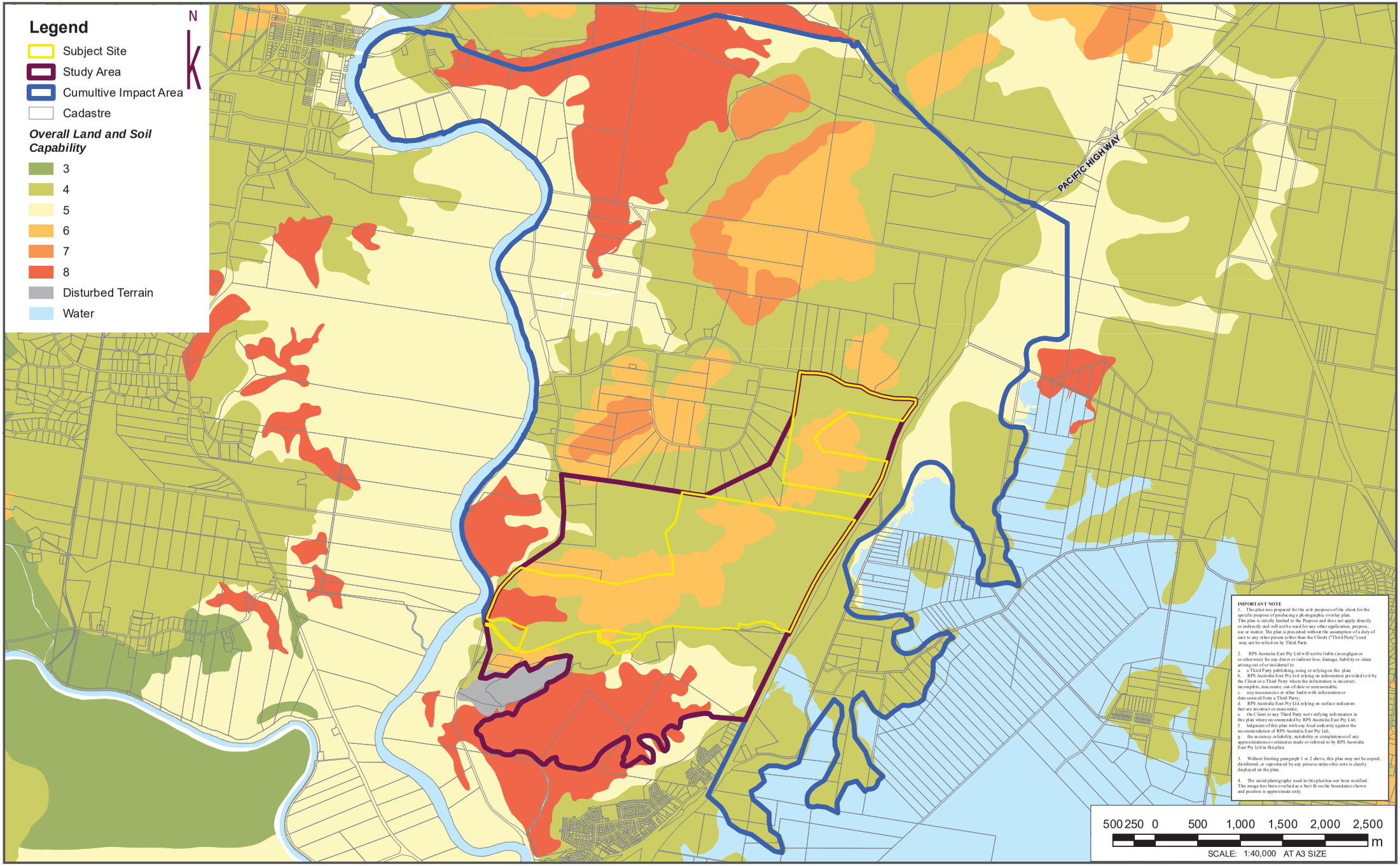
[1] *Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* EEC

[2] *Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions* VEC

[3] Preliminary determination for *Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin and North Coast Bioregions* EEC

[4] *Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* EEC

[5] *Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions* EEC



TITLE : FIGURE 2.4: LAND AND SOIL CAPABILITY WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): A A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 2.4 Land and Soil Capability within the SA A A3 20200721.mxd

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In general, land uses in the study area and locally accurately reflect the land and soil capability classes listed in **Table 2.2**. Intense agricultural activity is generally restricted to floodplains, which are largely cleared, with partial clearing and use of the adjoining hills restricted to less steep lands with localised soil fertility. Consequently, much of the local area remains naturally vegetated.

2.1.2.8 Previous land uses and events

Notable disturbances evident within the subject site and more broadly operating in the local area include:

- Historical land clearing and logging;
- Track constructions within native vegetation;
- Quarrying;
- Construction of turkey nest and inline dams;
- Past and current livestock grazing; and
- Firewood collection.

The extent and influence of these disturbances varies across the study area and is largely determined by access (i.e. changes in terrain). Steeper, rockier lands have no discernible evidence of past/ current livestock grazing as the suitability and access to these areas is poor.

Similarly, there is limited evidence of feral deer grazing in these areas owing to the ground conditions (i.e. lands generally less suitable for this species). These areas do exhibit signs of past selective logging (i.e. tree stumps) and associated high weed cover. The extent of weed cover in these areas is likely attributed to the combined influence of past selective logging and absence of livestock/ feral deer grazing that would otherwise inhibit weed growth/ spread.

The more arable forested parts of the subject site typically coincide with the Proposal impact footprint, where it is comparatively grassier with lower weed densities. Past logging is also evident in these areas as is firewood collection. The presence of turkey nest and inline dams is likely associated with more extensive historical livestock grazing practices, with the majority of livestock grazing now restricted to the predominantly treeless and lightly wooded parts of the eastern and western parts of the subject site. Feral deer activity is relatively high in these parts of the study area, with the associated herbivory of this species likely to be influencing understorey structure (i.e. simplified shrub and grassier groundcover stratum).

A general description of the vegetation in the heavily used parts of the study area [i.e. treeless parts of the site and closed depressions (i.e. farm dams)] is provided in the following sections.

2.1.2.8.1 Exotic Grasslands

Vegetation no longer resembling a formally recognised and naturally occurring PCT occur through the southern and eastern parts of the study area. In the south, vegetation contains sparse occurrences of trees of the canopy species as described above, in some areas, though is predominately comprised of open grasslands only (**Plate 2.1** and **Plate 2.2**), with no tree or shrub layer and grazed by livestock.

Grasslands are highly degraded and dominated by exotic species such as *Cenchrus clandestinum** (Kikuyu), *Paspalum dilatatum*, Cynodon dactylon* (Couch), and *Axonopus fissifolius**. Other exotic grasses such as *Vulpia bromoides** (Squirrel Tail Fescue), *Poa annua** (Winter Grass), and *Briza minima** are common, though not dominant. Exotic forbs such as *Senecio madagascariensis*, Soliva sessilis** (Bindyi), *Hypochaeris radicata** and *Gamochaeta americana** are also common.

Plate 2.1 Exotic grassland within the southern central parts of the subject site

The dominant native species recorded in a 400m^2 quadrat was the native grass *Microlaena stipoides* which covered approximately twenty percent of the quadrat. Other native grasses such as *Sporobolus creber* (Rat's Tail Grass), *Chloris truncata* (Windmill Grass) and *Dichelachne micrantha* are present, though with scattered distributions. Common native forbs such as *Dichondra repens, Pratia purpurascens*, and *Veronica plebeia* (Trailing Speedwell) are also present, generally scattered through the grassland areas, along with native sedges such as *Juncus usitatus* and *Fimbristylis dichotoma* (Common Fringe-sedge).

Plate 2.2 Example of exotic grassland within the eastern part of the subject site

In the east this exotic grassland occurs on Permian soils (Wallalong Landscape) with the occurrence of scattered regrowth of species such as *Eucalyptus moluccana, Eucalyptus tereticornis* and *Melaleuca* spp.. The grassland has historically been cleared for grazing and has scattered regrowth of juvenile trees of the species *Eucalyptus tereticornis, Eucalyptus moluccana,* and *Corymbia maculata.* It is dominated by exotic

grass species, the most abundant including *Axonopus fissifolius**, *Paspalum dilatatum*,* and *Cynodon dactylon*. Other species include *Briza minor** (Lesser Quaking-grass), *Andropogon virginicus** (Whiskey Grass) and *Sporobolus africanus** (Parramatta Grass). Common exotic herbs include *Romulea rosea** (Onion Grass), *Plantago lanceolata*, Verbena bonariensis** (Purpletop), and *Linum trigynum** (French Flax).

Despite the dominance of exotic weed species, some native grasses and other herbs are common throughout the grassland. Grasses include *Bothriochloa macra, Sporobolus creber*, and *Poa sieberiana*. Other herbs include *Carex longebrachiata, Carex inversa, Asperula conferta* (Common Woodruff), and *Dichondra repens.*

2.1.2.8.2 Closed depressions (i.e. farm dams)

The vegetation of several dams within natural creek lines in the southern half of the study area (**Plate 2.3**) are typically characterised by *Typha orientalis*, with tall sedges such as *Schoenoplectus validus* also occurring in deeper areas, with a shorter layer of aquatic herbs underneath and on the margins. Species present in the lower layer include native species such as *Ludwigia peploides* subsp. *montevidensis* (Water Primrose), *Utricularia gibba* (Floating Bladderwort), *Alternanthera denticulata* (Lesser Joyweed), *Persicaria decipiens* (Slender Knotweed), and the grass *Paspalum distichum* (Water Couch). The threatened aquatic herb *Maundia triglochinoides* (Small Water-ribbons) has been recorded in some of these dams.

Exotic species are common to dominant in the lower layer with the most prevalent species occurring including the Weeds of National Significance (WoNS) *Alternanthera philoxeroides** (Alligator Weed) and *Eichhornia crassipes** (Water Hyacinth), which dominate the lower layer of many areas of the community, and *Isolepis prolifera**. Other exotic species are predominately grasses and occur in the more elevated, less frequently inundated, fringing areas of the community. Species include *Cynodon dactylon* (Couch), *Axonopus fissifolius** (Carpet Grass) and *Paspalum dilatatum**.

Plate 2.3 Aquatic vegetation in the central southern area of the subject site

The vegetation within the constructed dams do not occur on the floodplain and, on this basis, does not form part of the *Swamp Oak Forests on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions* EEC as listed under the NSW TSC Act (NSW Scientific Committee 2004).

2.1.2.9 Fire History

The fire history of the study area is unknown prior to 2012 (RFS 2019). A small isolated fire event was recorded in the north-western part of the study area in July 2016 (RFS 2019). No wildfire or hazard reduction burns have been recorded within the subject site since 2012. Further, field surveys indicate there is no evidence of any recent fire events (e.g. last 15 years). Indications are that the study area comprises vegetation with influence from fire events.

2.1.2.10 Land Zoning and Tenure

Land tenure across the study area, as defined by land zones, comprises 10 categories with one of these (Special Purposes Infrastructure) comprising two separate land uses as outlined in **Table 2.3**.

Table 2.3 Land Zoning, Tenure and Current Uses

Land Zone	Land Ownership	Current uses
B2	KHD and other private owners	Passive and rural activities
B4	KHD and other private owners	Passive and rural activities
E2	KHD and other private owners	Passive and rural activities
E3	Private ownership	Passive and rural activities
R1	KHD and other private owners	Passive and rural activities
R4	Private ownership	Passive and rural activities
RE1	Private ownership	Passive and rural activities
RU2	Multiple private ownership	Passive and rural activities
SP1 (Hunter Water Corporation)	Hunter Water Corporation	Passive and water management activities
SP2 (waster or resource facility)		Waste management
SP2 (Classified Road – Pacific Highway)	State Government	Transport

Hunter Water Land

Land in the southern part of the study area (owned by Hunter Water) is zoned SP1 Special Activities pursuant to Port Stephens Local Environmental Plan (LEP) 2013. Aquaculture is permitted with consent on this land as well as development that is ordinarily incidental or ancillary to development for that purpose. The objectives of the zone are:

- To provide for special land uses that are not provided for in other zones.
- To provide for sites with special natural characteristics that are not provided for in other zones.
- To facilitate development that is in keeping with the special characteristics of the site or its existing or intended special use, and that minimises any adverse impacts on surrounding land.
- To ensure the protection of water catchment areas to safeguard the quality and quantity of groundwater and surface water.
- To facilitate the provision of infrastructure provided by Hunter Water Corporation.

The current SP1 zoning therefore affords a good level of ongoing environmental protection to the land by virtue of the limited activities which can occur. Hunter Water Corporation are examining the feasibility of placing large tracts of this land into a biodiversity stewardship site agreement as a conservation measure for protecting the associated biodiversity values.

RU2 Rural Landscape Land

A small parcel of land north of the Hunter Water land and land in the area of Winston Road is zoned RU2 Rural Landscape pursuant to PSLEP 2013 and has a minimum lot size of 40ha. The objectives of the zone are:

- To encourage sustainable primary industry production by maintaining and enhancing the natural resource base.
- To maintain the rural landscape character of the land.
- To provide for a range of compatible land uses, including extensive agriculture.

The following uses are permitted with consent in the RU2 zone:

Agriculture; Airstrips; Animal boarding or training establishments; Aquaculture; Boat launching ramps; Boat sheds; Building identification signs; Business identification signs; Camping grounds; Cellar door premises; Cemeteries; Community facilities; Correctional centres; Crematoria; Dual occupancies; Dwelling houses; Eco-tourist facilities; Environmental facilities; Environmental protection works; Extractive industries; Farm buildings; Flood mitigation works; Forestry; Group homes; Helipads; Home-based child care; Home businesses; Home industries; Information and education facilities; Jetties; Landscaping material supplies; Plant nurseries; Recreation areas; Roads; Roadside stalls; Rural industries; Tourist and visitor accommodation; Turf farming; Veterinary hospitals; Water recreation structures; Water supply systems

The current RU2 Rural Landscape zoning provides a good level of ongoing environmental protection. The potential to subdivide the land is limited by the 40 ha minimum lot size. Uses permitted with consent in the zone would also be subject to the provisions of part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), generally requiring a development application to be lodged with Port Stephens Council. Any proposed land clearing would be subject to the provisions of the Biodiversity Conservation Act 2016.

KHD Owned Land

The majority of the remainder of the study area (Kings Hill Urban Release Area) is zoned a mixture of R1 General Residential (with pockets of B4 Mixed Use and a small portion B2 Local Centre) interspersed with land zoned E2 Environmental Conservation. The objectives of the E2 zone are:

- To protect, manage and restore areas of high ecological, scientific, cultural or aesthetic values.
- To prevent development that could destroy, damage or otherwise have an adverse effect on those values.

The extent and configuration of the E2 zone was determined through the process of zoning the land from its former Rural zoning to include urban land uses and conservation outcomes. That process occurred between 2002 and 2010 and was based on environmental studies under applicable provisions at the time by Council approved consultants (EcoBiological 2009).

The following uses are permitted with consent in the E2 zone:

Bed and breakfast accommodation; Building identification signs; Business identification signs; Dual occupancies; Dwelling houses; Eco-tourist facilities; Environmental facilities; Flood mitigation works; Home-based child care; Home businesses; Information and education facilities; Oyster aquaculture Recreation areas; Research stations; Roads; Water recreation structures; Water supply systems

The E2 land would enjoy a moderate level of ongoing environmental protection by virtue of the 40 ha minimum lot size and limited permissible uses. The irregular configuration of the E2 land however, and its proximity to land zone R1 means that, without properly informed mitigation measures, it is likely to be negatively impacted by the future development of the R1 land.

Uses permitted with consent in the E2 zone would also be subject to the provisions of Part 4 of the EP&A Act, generally requiring a development application to be lodged with Port Stephens Council. Any proposed land clearing would also be subject to the provisions of the *Biodiversity Conservation Act 2016*.

Land zoned R1 General Residential, B2 Local Centre or B4 Mixed Use is likely to be subdivided and developed for urban purposes and would have a low level of ongoing environmental protection.

It should also be noted that the land is also subject to the provisions of Port Stephens Council Development Control Plan 2014 Section D14 Kings Hill – Raymond Terrace (Port Stephens Council, 2015).

2.1.2.11 State Environmental Planning Policies

The following State Environmental Planning Policies (SEPP) are applicable to the study area:

- State Environmental Planning Policy – Coastal Management 2018; and
- State Environmental Planning Policy No 44 – Koala Habitat Protection.

2.1.2.11.1 State Environmental Planning Policy – Coastal Management 2018

The subject site comprises three main catchments that drain into Wetlands 803 and 804. These are mapped wetlands and are regulated under the SEPP 2018. A general description of these wetlands is provided in **Section 2.1.2.3**.

The Proposal acknowledges and accepts the EcoBiological (2009) recommendations including "*a 50 m buffer around the southern wetlands*". This buffer specification has been applied around wetland 803. Other recommendations made by EcoBiological (2009) that relate to the protection of wetlands, which are also incorporated into the Proposal, are as follows:

- Rehabilitation of two zones to enhance Koala movement within the subject area (see **Appendix C**);
- Initiate rehabilitation actions in the SEPP 14 wetland area (see **Appendix C**);
- All areas identified for conservation should be fenced off and grazing excluded (see **Appendix C**);
- A weed management plan should be implemented to control the spread and dominance of weed species (particularly Lantana) in the areas marked for conservation and rehabilitation and along the edge of remnant forest patches (see **Appendix C and D**); and
- Any replanting or introduction of seed bank stocks should utilise only local endemic species from areas of similar habitat (see **Appendix C and D**).

2.1.2.11.2 State Environmental Planning Policy No 44 – Koala Habitat Protection

The PSC CKPoM operates for the entire PSC LGA. All development having an impact on koala habitat is to be assessed in accordance with this management plan to avoid, minimise and mitigate any impacts on the Koala. The subject site comprises lands mapped by PSC as having Koala habitat and therefore requires consideration, which was considered in the 2010 rezoning process by EcoBiological (2009) through the inclusion of high value habitat within the E2 zone. Additional investigations and evaluation of protecting Koala habitat is provided in **Section 5.1.4**.

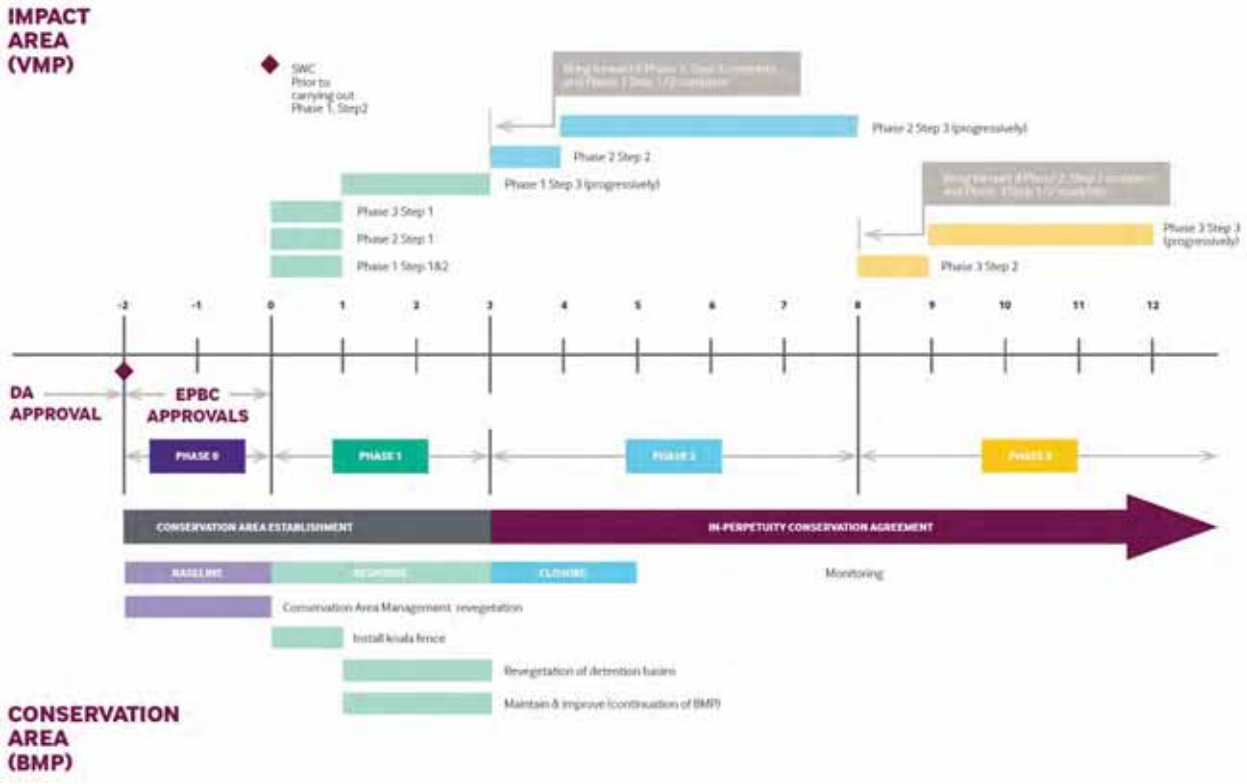
2.2 Description of the Proposal, Subject Site and Study Area

A species impact statement must include a full description of the action proposed, including its nature, extent, location, timing and layout (Section 110 (1)).

DGR 2.1.1 Description of proposal

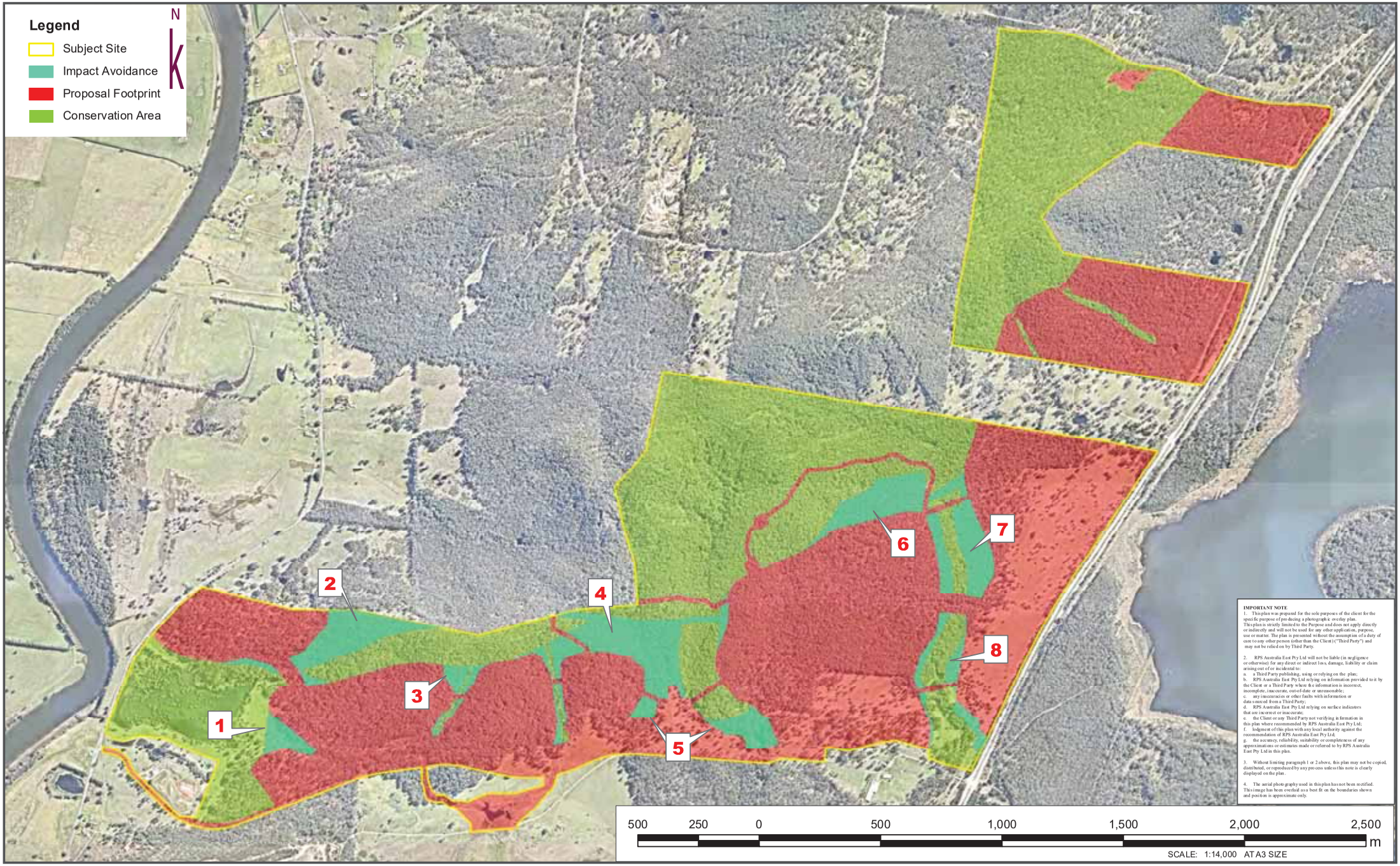
2.2.1 Description of the Proposal

The Proposal is described as a Concept Development Application for future Residential Subdivision and Stage 1 Subdivision Works (Initial Site Preparation Works), inclusive of amelioration measures described in **Section 7** of this SIS as detailed in the Biodiversity Management Plan (BMP) (see **Appendix C**) and Vegetation Management Plan (VMP) (see **Appendix D**). The Proposal is to occur within the area defined as the subject site, as shown in **Figure 1.1**, over a period of 8+ years involving multiple Phases. The following chart outlines how the Proposal is to be performed in accordance with the phasing.



The area to which the Proposal applies comprises the Proposal impact footprint for future urban development and the Conservation Area for in-perpetuity biodiversity management and protection. Four key principles were used to define the Proposal description as listed below:

- Impact avoidance (see **Figure 2.5**);
- Impact minimisation through implementation of a Phased site preparation sequence involving progressive and clearing over an 8+ year timeframe (see **Figure 2.6**);
- Impact mitigation including habitat retention, restoration and protection, as described in **Appendix C**, for implementation within a biodiversity protection area referred to as the 'Conservation Area' (see **Figure 2.7**); and
- Implementation of a three-step vegetation clearing procedure to further minimise impacts on affected threatened biodiversity, which is to be regulated in accordance with a VMP (see **Appendix D**).



TITLE : FIGURE 2.5: IMPACT AVOIDANCE OUTCOMES

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **24/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (mark.aitkens)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 2.5 Impact Avoidance Outcomes C A3 20200719.mxd

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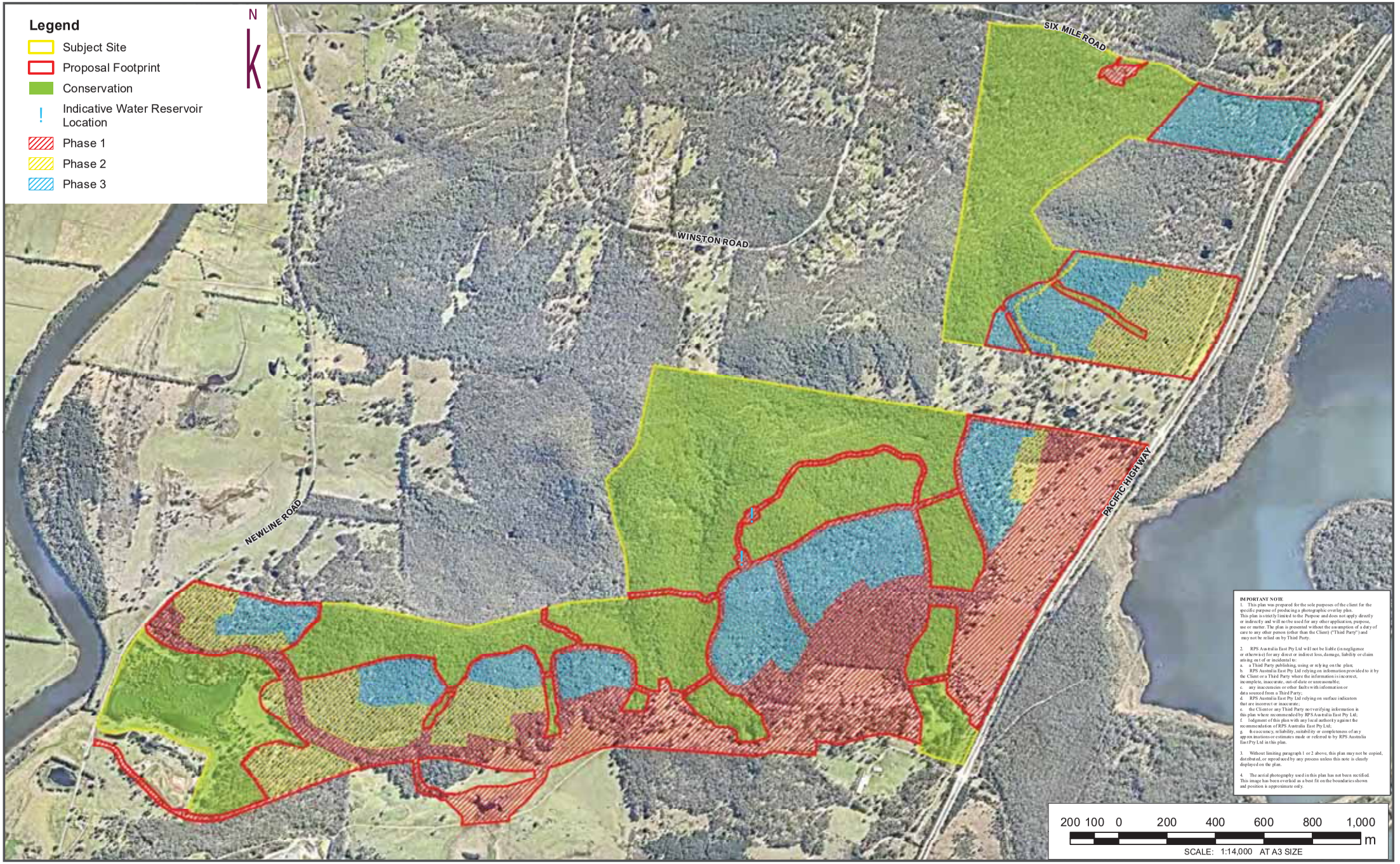

TITLE : FIGURE 2.6: SITE PREPARATION SEQUENCE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 2.6 Site Preparation Sequence B A3 20200719.mxd

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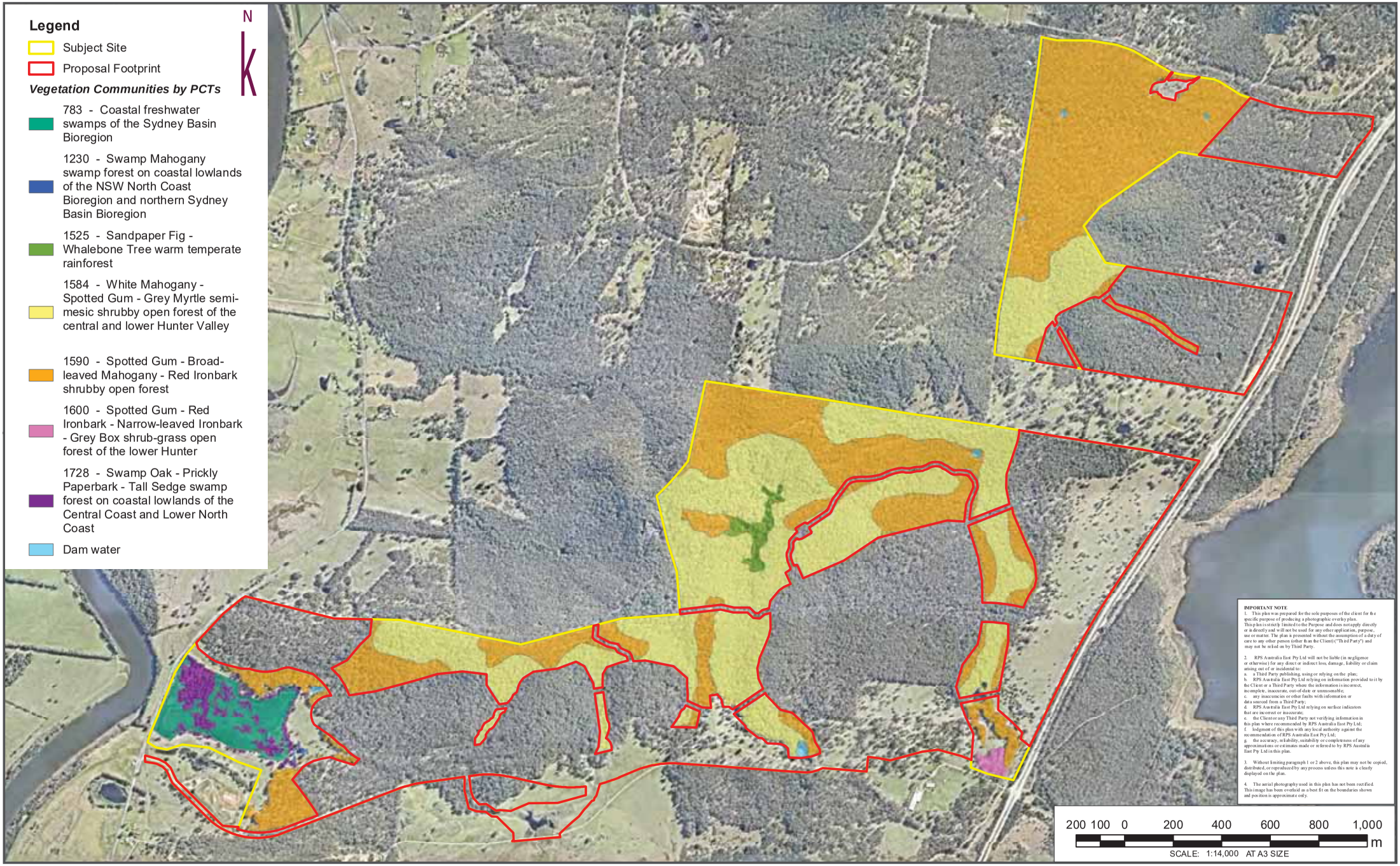

TITLE : FIGURE 2.7: CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 2.7 Conservation Area B A3 20200719.mxd

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The principles applied in the process of describing the Proposal are outlined in the following sections.

2.2.1.1 Impact Avoidance

Impact avoidance outcomes in favour of protecting threatened biodiversity and their habitats in the local area were investigated and have been documented in the body of this SIS. The refined Proposal footprint made allowances for the avoidance of preferred Koala feed trees (PKFTs), areas if high habitat complexity (i.e. distribution and density of hollow-bearing trees, fallen logs, eucalypt flowering phenology and forest maturity), the incidence of threatened species and protection of lands that would improve the functionality of wildlife corridors. A focus was placed on the protection of habitat for the following species:

- Koala;
- Grey-headed Flying Fox;
- Brush-tailed Phascogale;
- Large Forest Owls;
- Grey-crowned Babbler;
- Squirrel Glider;
- *Corybas x dowlingii*; and
- *Pterostylis chaetophora.*

Relative to the existing approved zone boundaries, allowances made by KHD to avoid impacts on threatened biodiversity have resulted in the protection of 38.47 ha of high value habitat for inclusion in the Conservation Area. **Section 7.1** provides a detailed description of the rationale supporting the identification of impact avoidance areas shown in **Figure 2.5**.

In relation to Area 6 on **Figure 2.5**, which constitutes 5.36 ha of R1 zone land, it is important to note that the impact avoidance outcome was derived from several contributing factors as listed below:

- Avoid area with high foliage nutrient value for the Koala and area actively used by the Koala including breeding female activity;
- Substantially increase patch integrity by limiting edge to area ratio (i.e. reduce edge effects);
- Avoid area with high hollow-bearing tree density; and
- Avoid the majority of habitat occupied by *Corybas* × *dowlingii.*

During the preparation of the SIS, and after the finalisation of the Proposal footprint, the taxonomy of the endangered species referred to as *Corybas dowlingii* was revised and was consequently no longer recognised as a species. Wagner et al (2020) (**Appendix K**) revised the taxonomic classification from a species to ‘stable hybrid’ between *Corybas aconitiflorus* and *Corybas barbarae* (i.e. *Corybas* × *dowlingii*), with the conservation status of this stable hybrid assessed by as being of least concern. Wagner et al (2020) recommended this conservation status assessment be reflected in the Australian legislation at State and Commonwealth level, indicating that the endangered species listing is no longer warranted.

Since *Corybas* × *dowlingii* is not a species, and has a ‘least concern’ conservation status, it is considered that the weighting applied to this taxon in determining impact avoidance outcomes is no longer relevant. Accordingly, it is considered that a review and re-evaluation of the land use opportunities in this area of impact avoidance is appropriate noting that other constraints still occur and would require due consideration. Potential for permissible low impact R1 zone land uses may be considered for this area should appropriate and reasonable impact minimisation and mitigation measures be provided for other threatened species that may utilise this area.

2.2.1.2 Habitat Retention and Protection

The Proposal binds the E2 lands and areas of impact avoidance (**Figure 2.5**) into a Conservation Area, as shown in **Figure 2.7**, which is the subject to an in-perpetuity conservation agreement (the Agreement) for the protection of biodiversity values in the local area. The establishment of the Conservation Area and the mechanism used to provide ongoing protection is described in the following sections.

2.2.1.2.1 Establishment of Conservation Area

The key principles that underpin the value of the Conservation Area for protecting local biodiversity, hence its role in maintaining local viable populations of affected threatened species, are:

- Patch size and integrity: Larger patches with proportionally reduced edge length increase the resilience of retained habitat thus allow for sustained biodiversity outcomes. Importantly, the Conservation Area is of suitable size and configuration to cater for species with larger home ranges and minimise the risk of adverse outcomes from external threatening processes.
- Habitat condition: Preferential incorporation of areas with higher biodiversity value (e.g. areas of relatively high hollow-bearing tree and fallen log density and PKFTs) to minimise impacts at the landscape scale, thereby allowing for ongoing local persistence of threatened species.
- Movement pathways: Local and regional movement pathways/ corridors are important for genetic flow and population viability. While the original zone boundaries made allowance for the protection of this important landscape scale function, the Proposal made additional provisions to further improve the wildlife corridors functionality by:
  - widening narrowed vegetated movement paths and shortening their length; and
  - using revegetation works to restore and improve access to habitat including plantings around wetland 803.

The Conservation Area will be established following completion of the BMP (see **Appendix C**), which also serves as the principle mechanism for the delivery of amelioration works described in **Section 7**, with the impact of these works on biodiversity having been considered in the SIS. The Agreement is founded on the satisfactory completion of these establishment works to an extent that will allow for the implementation of maintenance management regimes.

The establishment works specified within the BMP are expected to take five years to complete and is pre-requisite to the execution of the in-perpetuity conservation outcome specified in the Agreement. By this time, the management demands of the proposed Conservation Area will have shifted from establishment works to a maintenance management regime in line with the achievement of key performance goals for biodiversity conservation.

Certain works specified in the BMP aim to restore, embellish, enhance and enrich habitat for the benefit of local biodiversity. Such works include weed and feral animal management and the planting of native vegetation. These works do not require development consent or a Subdivision Works Certificate prior to commencement. Such works can commence at any time, provided the actions do not adversely impact listed threatened species and ecological communities.

In addition to these works (i.e. weed and feral animal management, and the planting of native vegetation), other necessary logistical works are also required to enable permitted establishment works such as the construction of tracks and fences. These works, which will have some impact on the natural environment, are necessary to provide access for the effective implementation of management works involved in the establishment and long term maintenance of the Conservation Area. Tracks will have a dual purpose with the primary use being the prevision of access for the implementation of management works and bush fire management.

Tracks within the established Conservation Area comprise existing and proposed tracks, with some extending from an existing track that is to be used as a service road to access the HWC water reservoir. Trail categories used within the Conservation Area are listed below and described in the BMP (**Appendix C**):

- Category 1;
- Category 7;
- Category 9; and
- Dormant.

Existing tracks are already formed and are traversable across the Conservation Area. As existing tracks, their use and ongoing maintenance is permitted under existing use rights with allowances for vegetation clearing to maintain these tracks to be exercised under Clause 8(3) of the State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017.

The design specifications for the service road used to access the HWC water reservoir falls within the 'Category 1' classification for bush fire trails and, as such, this track will have dual management application on this basis. This road is to be permanent, all weather (Section 7.9 of HWC Water and Sewer Design Manual Section 7 – Tank / Reservoir standards) and will require the following standard to be applied:

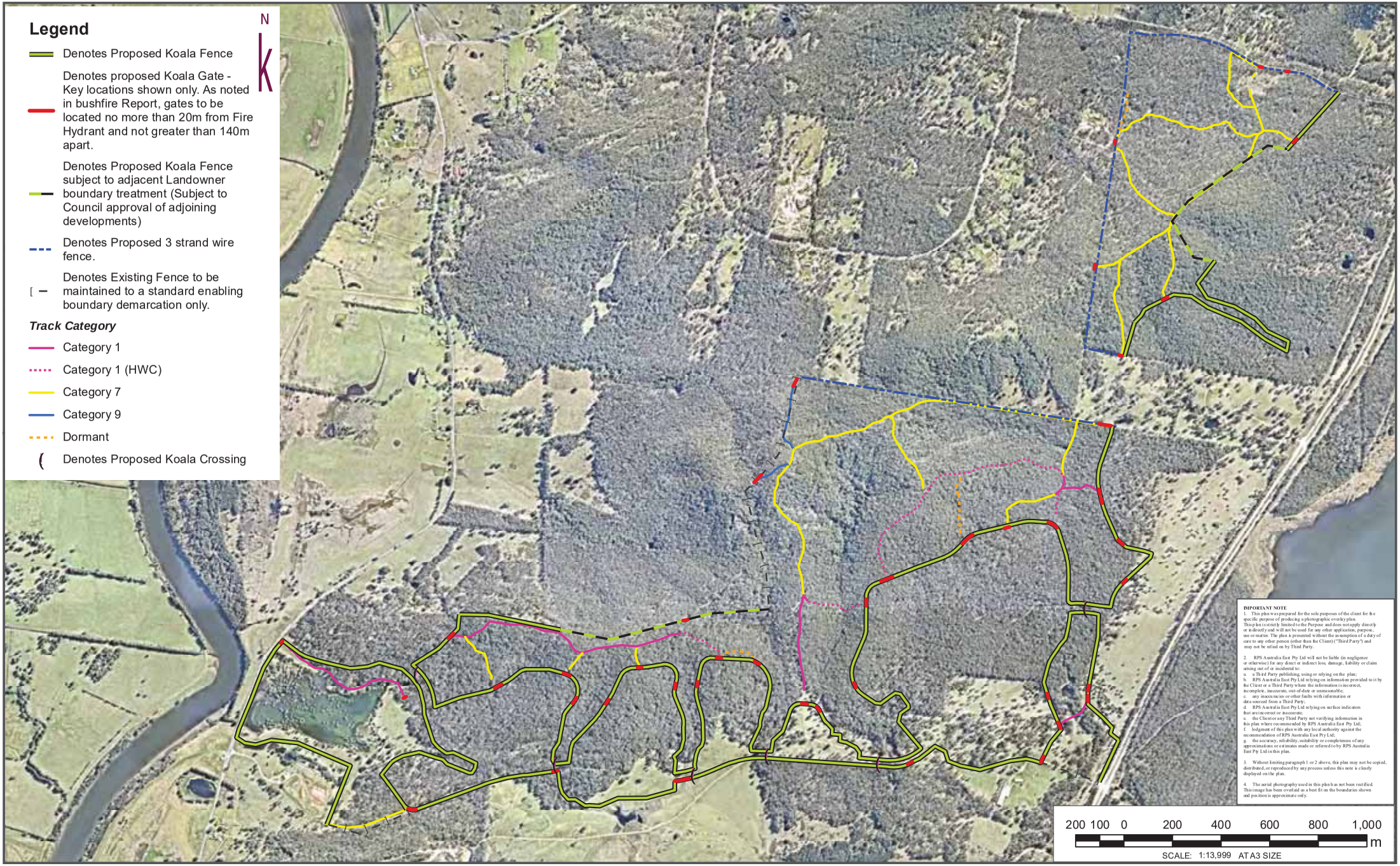
- 3m wide;
- Desirable max 12.5%;
- Pavement to be flexible with AC or concrete; and
- >15% will require concrete pavement.

Proposed unformed tracks are to be installed as part of the establishment works. A summary of these and existing tracks within the Conservation Area is provided in **Table 2.4** and shown in **Figure 2.8**.

Table 2.4 Track Classification, Purpose, Status and Length within the Conservation Area

Classification	Purpose	Status	Length (m)
Category 1	Support the safe transit of a 'Category 1' type bush fire fighting appliance being a vehicle typically of length 8200 mm, width 2400 mm, height 3700 mm (including 600 mm for aerials), Ground clearance 310 mm, Approach angle 35º, Departure angle 25º, Wheelbase 4700 mm, turning circle – wall to wall 22m diameter, Weight 14200kg, Maximum axle loading 9,000kg.	Existing	2,411
Category 7	Support the safe transit of a 'Category 7' type bush fire fighting appliance being a vehicle typically of length 6200mm, width 2040mm, height 3050mm (including 600 mm for aerials), Ground clearance 230mm, Approach angle 35º, Departure angle 30º, Wheelbase 3395mm, turning circle – wall to wall 17m diameter, Weight 7500kg, Maximum axle loading 5,600kg.	Existing	4,778
		Proposed	2,357
Category 9	Support the safe transit of a 'Category 9' type bush fire fighting appliance being a vehicle typically of length 5300mm, width 1750mm, height 2600 mm (including 600 mm for aerials), Ground clearance 220mm, Approach angle 35º, Departure angle 30º, Wheelbase 3180mm, turning circle – wall to wall 16m diameter, Weight 3700 kg, Maximum axle loading 2000kg	Existing	440
Dormant	Dormant fire trails are designated if they don't facilitate a principle land management objective. These trails have no construction standards of management schedules, are allowed to be over-grown and will only be re-opened when needed as control lines for bush fire and/ or weed management operations. Following use, erosion control measures are implemented and allowed to regenerate naturally.	Existing	330
		Proposed	267

The SIS has allowed for 2.4 ha of native vegetation clearing for the purposes of establishing the proposed tracks. Opportunities to avoid and minimise impacts that may arise in the course of establishing these proposed tracks, with the method for delivering these reduced impacts outlined in the VMP (**Appendix D**).



TITLE : FIGURE 2.8: TRACKS AND FENCES OF THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **24/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): A A3 (mark.aitkens)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 2.8 Tracks and Fences AA3 20200721.mxd

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Fences with adjoining rural lands have the purpose of excluding livestock from the Conservation Area. These are to be constructed with minimal impact on the environment (i.e. without complimentary tracks where appropriate). The fence is to be three strand with the central strand being barbed to prevent harm to fauna passing beneath and over the fence. Fence construction is to pass along the property boundary and installed/ maintained without the need to clear vegetation. Fences adjoining E2 zoned land are to be of minimal specification and have the sole purpose of demarcating the property boundary. Existing and proposed 'rural' fencing is shown in **Figure 2.8**.

The Koala fence, which has the primary purpose of preventing koala movements into the urban environment from the Conservation Area, is to be constructed along the urban interface with the Conservation Area. This fence is contained within the Proposal footprint and is therefore ancillary and complimentary to the works occurring within the Conservation Area. Some sections of the Koala fence are notional such as sections along boundaries in common with adjoining private landholders. The final location/ specification is subject to Council's wider consideration of the KHURA. The extent of the proposed Koala fence is also shown in **Figure 2.8**.

2.2.1.2.2 In-perpetuity Conservation Mechanism

To properly secure, in-perpetuity, the proposed Conservation outcomes, KHD has formally submitted an Offer to Port Stephens Council dated 3 February 2020 (and since matured) seeking to enter a VPA which proposes as follows:

- *The Developer, at its own cost, will implement the Biodiversity Management Plan (BMP) and Vegetation Management Plan (VMP) submitted with the Species Impact Statement for the Concept DA. The Developer's obligations under the BMP and VMP will commence upon the issue of a Subdivision Works Certificate relating to the DA.*
- *Once the Conservation Area has been established by the Developer through implementation of the BMP and VMP (measured against the Key Performance Criteria in the BMP, to the satisfaction of Council), the Developer will transfer the Conservation Area to Council for active management of the land.*
- *At the time of Concept DA Approval, Council will be satisfied with the terms of the VPA detailing the funds (Conservation Area Fund) required to be paid by the Developer to Council to manage the Conservation Area into perpetuity, and including a Biodiversity Conservation and Management Plan (BCAMP) detailing management of the land required to preserve the conservation principles. Following transfer of the*
- *Conservation Area Fund by the Developer to Council, and following transfer of the Conservation Area to Council, Council will commence management of the land in alignment with the BCAMP.*
- *The Developer's obligations in maintaining the Conservation Area will cease upon transfer of the Conservation Area to Council. After that point, the BCAMP will operate to ensure biodiversity conservation of the Conservation Area in perpetuity. The VPA can be removed from title at this point.*

2.2.1.3 Site Preparation Sequence

The Phased site preparation sequence, as shown in **Figure 2.6**, is detailed in **Table 2.5**.

Table 2.5 Site Preparation Sequence: Project Phasing

Phase	Objective	Notional Timeframe (years)	Land Area (ha)	Non-vegetated land (ha)	Native Vegetation Cover (ha)	
					Retained	Removed
0	Implement mitigation measures to generate ecological benefit within the Conservation Area prior to Phase 1-3 impacts	-2 to 1	244.25[6]	13.06[7]	231.19 12.38[8]	-
1	Focused site preparation works on relatively low biodiversity value (i.e. cleared to partially cleared lands, vegetation with low condition)	1 to 3	131.97	56.09	6.63[9]	75.88
2	Progressive site preparation works occurring within areas of increasing biodiversity value	3 to 8	52.09	3.38	-	48.71
3	Finalisation of site preparation works within areas of higher biodiversity value	8 +	88.85	1.30	-	87.55

The establishment of mitigation measures include the following:

- Phase 0: Revegetation of currently cleared treeless lands surrounding Wetland 803 with PKFTs, which are also beneficial for nectar dependant species such as the Squirrel Glider and Grey-headed Flying Fox. See **Figure 2.9** for guidance on where these revegetation works are proposed;
- Phases 0 and 1: Installation of natural and artificial hollows (i.e. nest boxes) for hollow-dependent species such as the Brown Treecreeper, Squirrel Glider and Brush-tailed Phascogale;
- Phase 1: Emplacement of logs to improve ground habitat complexity for small mammals including the Brush-tailed Phascogale and non-threatened species suitable as prey species for Large Forest Owls;
- Phases 0 to 3: Weed management to improve vegetation structure, floristic composition and natural regeneration potential, including;
  - Feral fauna management to reduce the effects of herbivory on native vegetation and predation on species such as the Koala; and
  - Forest enrichment through inter-forest plantings of PKFTs to improve the carrying capacity of the Conservation Area for the Koala.

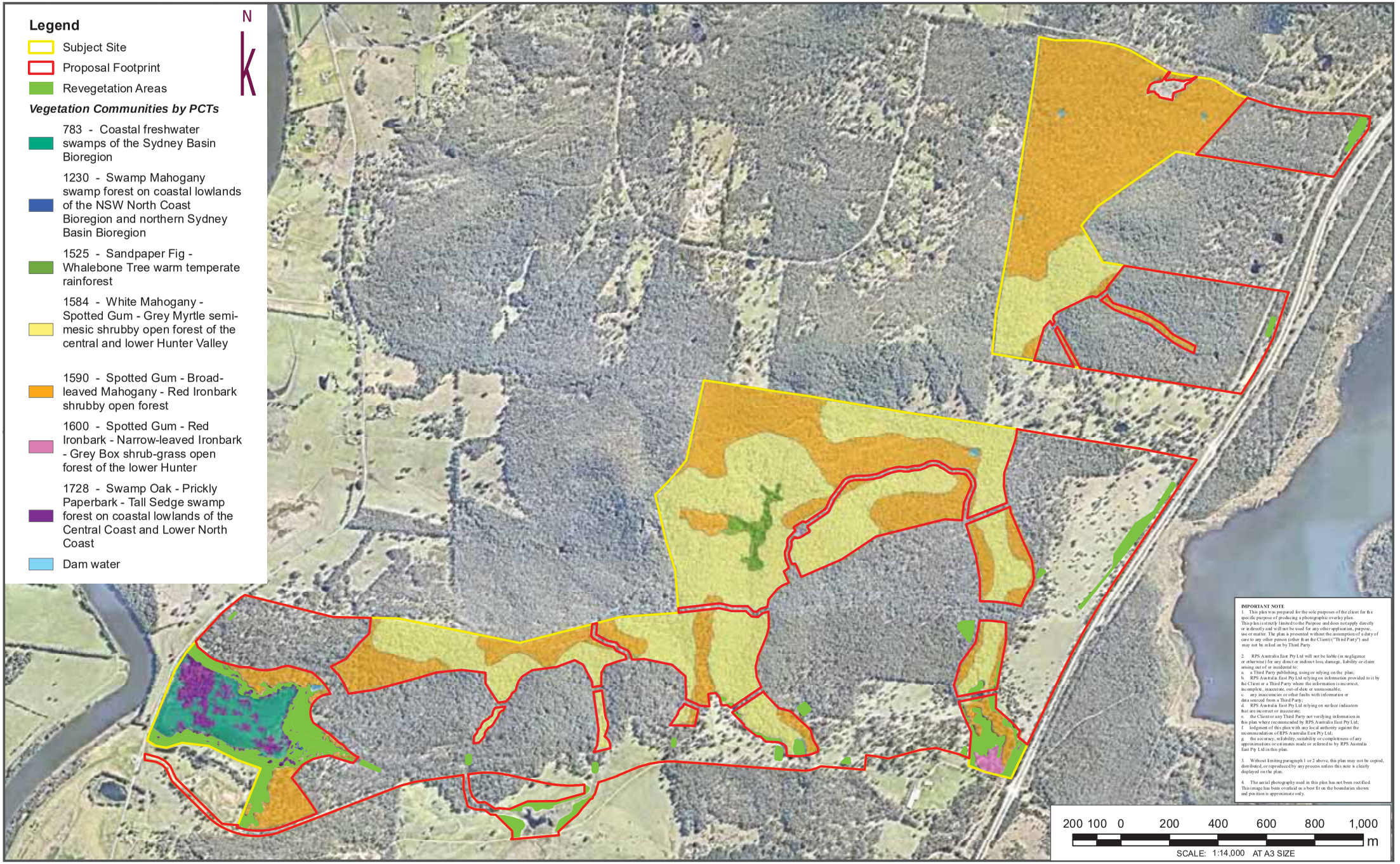
In accordance with the BMP, most of these works will start prior to Phase 1 to account for the lag in attaining ecological benefit from activities such as revegetation works (e.g. Kavanagh and Stanton 2012). More detail on the mitigation works is provided in **Section 7.1.1** of this SIS and the BMP (**Appendix C**).

[6] Incorporates E2 lands (**Figure 1.2**), impact avoidance areas (**Figure 2.5**), cleared lands and areas of water

[7] Includes treeless cleared lands (12.38 ha) that are subject to revegetation works and farms dams (0.68 ha), which are to be retained

[8] Represents area of revegetation works of non-vegetated lands contained within the Conservation Area

[9] Revegetation of detention basins within Proposal footprint



TITLE : FIGURE 2.9: PROPOSED REVEGETATION WORKS

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 2.9 Proposed Revegetation Works B A3 20200719.mxd

CLIENT: **PM NO 1 PTY LIMITED**

JOB REF: **PR130430**

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
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MAKING COMPLEX EASY

2.2.1.4 Stormwater Management

Downstream waterways comprise environments including wetlands (i.e. wetland 803 and 804) and biodiversity dependant on those habitats. To manage impacts on these systems, stormwater treatment devices including swales, constructed wetlands, infiltration basins, media filters and permeable paving, depending on the treatment scale, were considered as per guidance provided by BMT WBM Pty Ltd (2014). These devices were investigated as part of the Proposal design process, however many were not integrated for a number of reasons:

- In general, slopes within the Proposal impact footprint are generally too steep to accommodate road side swales with further consideration expected during the more detailed design processes;
- Soil properties do not lend themselves to infiltration, especially concentrated at locations immediately downstream of roadways and other infrastructure; and
- It is the preference of the NSW Department of Industry - Water to have water quality treatment devices offline which reduces the potential for constructed wetlands to be incorporated as part of the development.

McManus et al (2007) indicates for Catchments above Wetlands strategies associated with new developments in the catchments upstream of natural wetlands need to include Water Sensitive Urban Design (WSUD) measures that preserve the pre-development drying and flooding hydrology characteristics in order to protect the wetland ecology. Bio-filtration basins in combination with Gross Pollutant Traps (GPTs) are considered the most efficient and economical treatment devices for the Kings Hill development at a precinct scale. Rain water tanks at a lot scale have also been included as the first step in the treatment train. These treatments are to be applied to address water quality and quantity concerns.

It is expected that flows from the minor events are to enter the basins and flows from the major event will bypass. This will be achieved by a “splitter pit” immediately upstream of the bioretention basin. Flows up to and including the 1 in 2 year event, deemed “low flows” will be diverted to the bioretention basin, while larger flows will be directed to the downstream detention basin, channel or existing creek. Assessment of the effect of these treatments on the downstream wetlands indicates a small but negligible impact on the hydrology and biodiversity values of these wetlands (Alluvium 2019; **Appendix E**).

2.2.1.5 Vegetation Clearing Sequencing and Procedure

A clearing procedure that considers the spatial and temporal impacts on affected species is proposed to minimise impact by allowing for readjustments to occur in habitat occupancy. Three steps have been defined in order to deliver a sequenced clearing outcome sensitive to the habitat needs of affected species, these being:

- Step 1: Exotic flora removal;
- Step 2: Partial vegetation removal; and
- Step 3: Complete vegetation removal.

These steps are outlined below and in the associated chart:

- Step 1: Targeted removal of exotic species where a duty under Section 21 of the *Biosecurity Act* 2015 is required. Species with a biosecurity duty are to be eliminated and/ or minimised to an extent that is consistent with prescribed control measures. Such activities apply to the whole subject site (i.e. both Proposal and Conservation Area) with notable species with a biosecurity duty including:
  - African Olive (*Olea europaea* subsp. *cuspidata**);
  - Lantana (*Lantana camara**);
  - Ground Asparagus (*Asparagus aethiopicus**);
  - Blackberry (*Rubus fruticosus** species aggregata);

  - Alligator Weed (*Alternanthera philoxeroides**); and
  - Water Hyacinth (*Eichhornia crassipes**).
- Step 2: Partial vegetation removal where the purpose of this intermediate step is to:
  - Gradually establish areas proposed for future urban purposes (impact areas), to:
    - Provide adequate time for impact mitigation measures to be established in or at the interface with the Conservation Area (e.g. fencing); and
    - Minimise impact intensity on native flora and fauna in lieu of a future complete clearing event (i.e. minimise the temporal effects by delaying the clearing of important habitat thereby provide opportunity for displaced fauna to gradually relocate to improved habitat in the adjoining Conservation Area).
  - Provide an opportunity for the recovery of habitat resources for use in mitigation works performed within the Conservation Area (i.e. recover logs, bushrock, and natural hollows); and
  - Provide separation between the bushfire threat and development through the construction of bushfire Asset Protection Zones (APZ) for all staged clearing and development as outlined in Section 3.2.1 “Staged Development” of Planning for Bushfire Protection 2018.

  The partially cleared state is, at all times, required to demonstrate sufficient landform stability (e.g. negligible evidence of erosion) to maintain satisfactory water quality standards at the catchment scale.
- Step 3: Complete native and exotic vegetation removal with the exception of trees deemed suitable by an arborist and bushfire consultant for inclusion in urban landscape, subject to compatibility with engineered structures. Consideration should be given to the integration of suitable tree species into the urban landscape. Soil and erosion management procedures are to be applied in this step to ensure satisfactory water quality standards at the catchment scale, with specific details of these management specifications to be provided in the approved subdivision works certificate for the corresponding construction activities. Manage harm to fauna through observance of preclearance surveys and clearing supervision.

This vegetation clearing sequence and procedure outlined above does not preclude the carrying out of initial development enabled by the State Planning Agreement (i.e. initial east west road link and associated early stages of subdivision) to the extent that it remains within the areas of Phase 1. A more detailed prescription for these clearing procedures is provided in the VMP (see **Appendix D**) and the BMP (**Appendix C**).

To ensure impact minimisation, to prevent premature and indiscriminate clearing, and to facilitate the movement of fauna into adjoining vegetation:

- Step 1 can occur at any time in accordance with the *Biosecurity Act* 2015;
- Step 3 in any Phase can only occur to the extent that consent is granted for development within that Phase, thereby preventing indiscriminate clearing. This requires the satisfactory competition of Steps 1 and 2, each having the purpose of minimising impacts over time on affected species. By way of example:
  - Step 2 of Phase 2 cannot proceed until Step 3 of Phase 1 is completed for all areas contained within Phase 1 (i.e. a process facilitating the movement of fauna into adjoining vegetation).
  - Similarly, Step 2 of Phase 3 cannot proceed until Step 3 of Phase 2 is completed.

2.2.1.6 Water Reservoirs

Two water reservoirs are proposed to service the future development area, these referred to as the ‘low level’ and ‘high level’ reservoirs. The current level of design has made allowance for these future infrastructure requirements. The indicative locations for the installation of these reservoirs is shown on **Figure 2.6**.

An allowance of 0.6 ha is provided for the clearing of native vegetation at these indicative locations. While it is likely that the clearing works will coincide with these indicative locations, it is possible that following detailed design and consultation with HWC that the final location of these water reservoirs may differ. It is expected that the revised location(s) would be generally consistent with the current indicative locations. Any vegetation clearing proposed with an amended location would be 'like for like' in area and vegetation type with verification of this outcome to be determined through an appropriate assessment and approvals processes (e.g. Review of Environmental Factors under Part 5 of the EP&A Act).

2.2.1.7 Koala Fence, Gates and Grids

The interface between the Proposal and Conservation Area is to be characterised by a Koala proof fence with 'furniture' specifications for culverts' and Koala bridges and grids, which all have the purpose of:

- Excluding free ranging Koala's from the urban area to prevent mortality from domestic dog attack and vehicle strike;
- Excluding domestic dogs from the Conservation Area to prevent mortality from domestic dog attack and enable wild dog management; and
- Aiding the efficient movement of Koalas within/ through the Conservation Area along designated habitat corridors.

Specifications for these design features are taken from advice provided by BioLink (2019c) (**Appendix G**).

While good arguments exist for enabling the free movement of Koalas through friendly perimeter fencing (i.e. allow unlimited movement into the urban precinct to access remnant foraging resource), it is considered that the threats identified in the PSC CKPoM (i.e. domesticated dog attack, motor vehicle strike and drowning in swimming pools) collectively represent serious unmanageable threats outweighing the small benefit. It is for this reason that such fencing is not proposed in this circumstance and that a hard barrier between the development and known koala habitat is recommended.

The fence is to be readily visible from the perimeter roadside environment (i.e. to minimise the incidence of vandalism and loss of primary function) and constructed in a manner so as to allow access for recreational uses (e.g. bush walking) and biodiversity management (e.g. implementation of ecological burns and management of edge effects). One potential effective fence design is shown in **Plate 2.4**, which shows a colourbond style strip at the top of the fence to prevent Koalas from climbing over the fence (and has similar effect as floppy top style fences).

Plate 2.4 Example of Koala Fence

Access for recreation and land management activities such as bush fire management works is to be facilitated by an internal track and regular locked access points through the Koala fence, with the track width enabling the free movement for the efficient implementation of management actions (e.g. fence maintenance and weed management). Fencing will also protect the Conservation Area from undesirable activities (such as illegal dumping, 4wd and motorbike activities, logging) and from existing rural activities (grazing by cattle, horse and goats).

Pictorial details showing Koala bridge and grid designs are provided in **Figures 2.10** and **2.11** respectively. These have the purpose of preventing Koala movements into the urban environment where KTPs may result in harm or mortality. The furniture used in culverts to aid Koala movements is shown in **Figure 2.12**, which has the purposes of facilitating Koala movement beneath roads to and from habitat areas. The proposed Koala fence is shown in **Figure 2.8**.

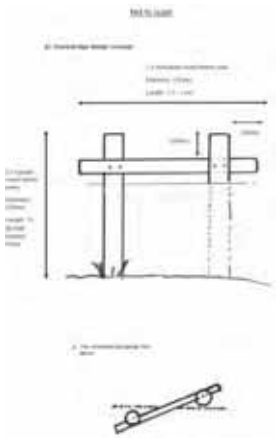

Figure 2.10 Koala bridge

Figure 2.11 Koala grid

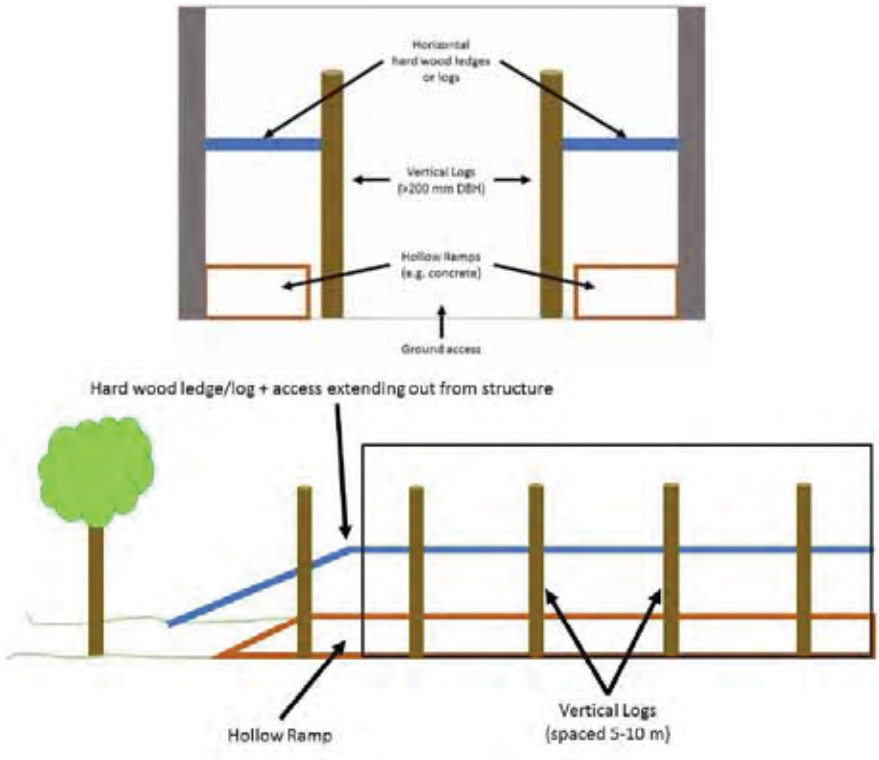

Figure 2.12 Culvert Furniture for Koala Road Underpasses

2.3 Provision of relevant plans and maps

DGR 2.2 Provision of relevant plans and maps

The following maps are provided at the end of each chapter within the SIS:

Section 1

Figure 1.1 Location of the study area and subject site

Figure 1.2 Land zoning of the study area

Section 2

Figure 2.1 Boundary of the subject site, study area and cumulative impacts assessment area

Figure 2.2 Soil landscapes within the study area

Figure 2.3 Plant Community Types (PCTs) within the study area

Figure 2.4 Land and Soil Capability within the study area

Figure 2.5 Impact Avoidance Outcomes

Figure 2.6 Site Preparation Sequence

Figure 2.7 Conservation Area

Figure 2.8 Tracks and Fences within the Conservation Area

Figure 2.9 Proposed Revegetation Works

Figure 2.10 Koala Bridge

Figure 2.11 Koala Grid

Figure 2.12 Culvert Furniture for Koala Road Underpasses

Section 3

Figure 3.1 Threatened Ecological Communities within the locality

Section 4

Figure 4.1 BAM survey locations within the subject site (RPS)

Figure 4.2 Rapid Data Points (RDPs) within the subject site (RPS)

Figure 4.3 Tree Canopy Nearest Neighbour Survey within the subject site

Figure 4.4 Systematic Threatened Flora Survey (winter 2018) within the subject site

Figure 4.5 Targeted threatened flora survey (spring 2018) within the subject site (RPS)

Figure 4.6 Targeted threatened flora survey (summer 2019) within the subject site (RPS)

Figure 4.7 Targeted threatened flora survey (spring 2019) within the subject site (RPS)

Figure 4.8 Mammal trapping locations within the subject site (RPS)

Figure 4.9 Infra-Red Camera Trap locations within the subject site (RPS)

Figure 4.10 Koala and Spotted-tail Quoll Detection Dog Surveys within the subject site (OWAD)

Figure 4.11 Bird Census Survey Locations within the subject site (RPS)

Figure 4.12 Bat Census Survey Locations within the subject site (RPS)

Figure 4.13 Nocturnal Survey Locations within the subject site (RPS)

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Figure 4.33 Modelled Distribution of Grey Gum (*Eucalyptus punctata*) within the subject site
Figure 4.34 Modelled Distribution of Small-fruited Grey Gum (*Eucalyptus propinqua*) within the subject site
Figure 4.35 Modelled Distribution of Grey Box (*Eucalyptus moluccana*) within the subject site
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Figure 4.37 Modelled Distribution of Broad-leaved Ironbark (*Eucalyptus fibrosa*) within the subject site
Figure 4.38 Modelled Distribution of Northern Grey Ironbark (*Eucalyptus siderophloia*) within the subject site
Figure 4.39 Modelled Distribution of White Stringybark (*Eucalyptus globoidea*) within the subject site
Figure 4.40 Modelled Distribution of White Mahogany (*Eucalyptus acmenoides*) within the subject site
Figure 4.41 Modelled Distribution of Broad-leaved White Mahogany (Eucalyptus umbra) within the subject site
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Figure 4.49 Potential habitat and recorded locations of the Brown Treecreeper within the study area
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Figure 4.51 Potential habitat and recorded locations of the Little Lorikeet within the study area
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Figure 4.53 Potential habitat and recorded locations of the Square-tailed Kite within the study area
Figure 4.54 Potential habitat and recorded locations of the Osprey within the study area
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Figure 4.56 Potential habitat of the Australasian Bittern within the study area
Figure 4.57 Potential habitat of the Black Bittern within the study area
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Figure 4.84 Grey-headed Flying Fox Nectar Sources: February to March within the study area
Figure 4.85 Grey-headed Flying Fox Nectar Sources: April to May within the study area
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Figure 4.90 Potential habitat and recorded locations of the Eastern Freetail-bat, Eastern False Pipistrelle and Greater Broad-nosed Bat species within the study area
Figure 4.91 Potential habitat of the Yellow-bellied Sheath-tail Bat species within the study area
Figure 4.92 Potential habitat of the Southern Myotis within the study area
Figure 4.93 Potential habitat of the Green and Golden Bell Frog within the study area
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Section 5

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Figure 5.4 Native Vegetation and Habitat loss: Phase 3
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Figure 5.7 Kings Hill West: Wetland 803 water level modelling 1989 – 2008 (Alluvium 2019)
Figure 5.8 Kings Hill South: Dry Spell Curves 1989 – 2008 (Alluvium 2019)
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Section 7

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Figure 7.15 Recommended 'off site' improvement measures
Figure 7.16 Monitoring Grid within the Conservation Area
Figure 7.17 Sensitive Vegetation in Wetland 804
Figure 7.18 Proposed Water Monitoring Locations for Wetland 804

2.4 Land Tenure Information

The study area is part owned by Kings Hill Developments (KHD), with the areas to the south leased by Riding for the Disabled (Hunter Water Corporation land), Newline Resources and Hunter Water Corporation. The subject site is wholly owned by KHD.

3 INITIAL ASSESSMENT

This chapter covers the following Chief Executive Requirements:

DGR 3 INITIAL ASSESSMENT

A general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action (Section 110 (2)(a)).

3.1 Identifying Subject Species, Populations and/or Ecological Communities

DGR 3.1.1 Assessment of available information

Database analyses and review of the current literature for records of threatened species occurring within the locality were examined for the likelihood of threatened species to occur in habitats present within the study area. Database analysis was undertaken using the OEH Atlas of NSW Wildlife Database (OEH 2019a) and the Biodiversity Assessment Method Credit Calculator (accessed 20 November 2018). The Atlas of NSW Wildlife Database search was used to generate records of threatened flora and fauna species and populations listed under the TSC Act within the locality of the study area.

Mapping prepared by NSW Vegetation Information System (VIS) and Lower Hunter & Central Coast Regional Environmental Management Strategy (LHCCREMS) vegetation mapping (LHCCREMS, 2003), as well as the Lower Hunter Vegetation Mapping prepared for the Commonwealth (Cockerill, 2013), was reviewed when determining ecological communities to be included within the list of subject species.

The abundance, distribution and age of records generated within the search area also provided supplementary information for the assessment of likelihood of occurrence of those threatened species within the study area. Consideration was also given to those threatened species listed in the CERs.

3.1.1 Threatened species and populations

The threatened species that occur or have the potential to occur in the study area were identified as candidate 'subject species'. This list includes those specified in the CERs as requiring consideration as 'subject species'. Candidate species considered for inclusion as 'subject species' in this SIS are listed below.

1. Threatened flora

- *Asperula asthenes* (Trailing Woodruff);
- *Callistemon linearifolius* (Netted Bottlebrush);
- *Corybas dowlingii* (Red Helmet Orchid);
- *Cynanchum elegans* (White-flowered Wax Plant);
- *Dendrobium melaleucaphilum* (Spider Orchid);
- *Diuris arenaria* (Sand Double-tail);
- *Diuris pedunculata* (Small Snake Orchid);
- *Diuris praecox* (Rough Doubletail);
- *Eucalyptus camfeldii* (Camfield's Stringybark);
- *Eucalyptus parramattensis* subsp. *decadens* (Parramatta Red Gum);
- *Gallium australe* (Tangled Bedstraw);
- *Genoplesium baueri* (Bauer's Midge Orchid);
- *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea);

- *Maundia triglochinoides* (Small Water-ribbons);
- *Melaleuca biconvexa* (Biconvex Paperbark);
- *Melaleuca groveana* (Grove's Paperbark);
- *Persicaria elatior* (Tall Knotweed);
- *Pomaderris queenslandica* (Scant Pomaderris);
- *Pterostylis chaetophora*;
- *Rulingia prostrata* (Dwarf Kerrawang);
- *Rutidosis heterogama* (Heath Wrinklewort);
- *Senna acclinis* (Rainforest Senna);
- *Syzigium paniculatum* (Magenta Lilly Pilly);
- *Tetratheca juncea* (Black Eyed Susan); and
- *Zannichellia palustris* (Horned Pondweed).

2. Threatened fauna

- Green and Golden Bell Frog (*Litoria aurea*);
- Wallum Froglet (*Crinia tinnula*);
- Pale-headed Snake (*Hoplocephalus bitorquatus*);
- Stephens's Banded Snake (*Hoplocephalus stephensii*);
- Magpie Goose (*Anseranas semipalmata*);
- Regent Honeyeater (*Anthochaera phrygia*);
- Bush Stone-curlew (*Burhinus grallarius*);
- Gang-gang Cockatoo (*Callocephalon fimbriatum*);
- Glossy Black-cockatoo (*Calyptorhynchus lathami*);
- Spotted Harrier (*Circus assimilis*);
- Brown Treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*);
- Barred Cuckoo-shrike (*Coracina lineata*);
- Varied Sittella (*Daphoenositta chrysoptera*);
- White-fronted Chat (*Epthianura albifrons*);
- Black-necked Stork (*Ephippiorhynchus asiaticus*);
- Black Falcon (*Falco subniger*);
- Little Lorikeet (*Glossopsitta pusilla*);
- Painted Honeyeater (*Grantiella picta*);
- White-bellied Sea Eagle (*Haliaeetus leucogaster*);
- Little Eagle (*Hieraaetus morphnoides*);
- Swift Parrot (*Lathamus discolor*);
- Square-tailed Kite (*Lophoictinia isura*);
- Black-chinned Honeyeater (*Melithreptus gularis* subsp. *gularis*);

- Hooded Robin (*Melanodryas cucullate* subsp. *cucullata*);
- Scarlet Robin (*Petroica boodang*);
- Flame Robin (*Petroica pheonicea*);
- Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*);
- Wompoo Fruit-dove (*Ptilinopus magnificus*);
- Rose-crowned Fruit-dove (*Ptilinopus regina*);
- Superb Fruit-dove (*Ptilinopus superbus*);
- Speckled Warbler (*Pyrrholaemus sagittatus*);
- Diamond Firetail (*Stagonopleura guttata*);
- Barking Owl (*Ninox connivens*);
- Powerful Owl (*Ninox strenua*);
- Masked Owl (*Tyto novaehollandiae*);
- Sooty Owl (*Tyto tenebricosa*);
- Grass Owl (*Tyto capensis*);
- Eastern Pygmy-possum (*Cercartetus nanus*);
- Spotted-tailed Quoll (*Dasyurus maculatus*);
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*);
- Little Bentwing-bat (*Miniopterus australis*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*);
- Eastern Freetail-bat (*Mormopterus norfolkensis*);
- Southern Myotis (*Myotis macropus*);
- Squirrel Glider (*Petaurus norfolcensis*);
- Brush-tailed Phascogale (*Phascogale tapoatafa*);
- Koala (*Phascolarctos cinereus*);
- Grey-headed Flying Fox (*Pteropus poliocephalus*);
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*); and
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

A likelihood of occurrence analysis was prepared to aid in the refinement of the 'subject species' list for consideration in the SIS. Five 'likelihood of occurrence' categories have been attributed to identified threatened biodiversity; a process that had regard for:

- Habitat descriptions as provided in the TSPD (BCD 2019b);
- The recency of threatened species observations (i.e. recent being less than five years) and proximity to the study area (i.e. application of landscape factors such as patch size and connectivity);
- Habitat value and condition as determined through the site inspection;
- The results of targeted surveys (where performed); and
- The effect of existing key threatening process (KTPs).

The five likelihood of occurrence ratings are described in **Table 3.1**.

Table 3.1 Likelihood of occurrence criteria

Likelihood Rating	Description
None	Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the investigation area. The investigation area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2 km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Low	Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The investigation area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2 km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs.
Moderate	Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the investigation area. The investigation area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy.
High	Habitat values within the investigation area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy.
Known	Species observed and habitat values within the investigation area are generally consistent with descriptions provided in the BCD TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Habitat occupancy is likely to be associated with important life cycle processes; however, the reliance on this habitat would depend on additional factors (e.g. size and extent of local population, effect of KTPs).

The likelihood of occurrence analysis is provided in **Table 3.2**. Species denoted with a 'grey shade' are 'subject species' for the purposes of this SIS. Species **Table 3.1** that are not confirmed as 'subject species' have been excluded on the basis of one or more of the following reasons:

- Nil to low habitat value; and
- Site survey results (Section 4) have not identified occurrence within the subject site; and
- There are no known occurrences within the study area; and
- Consideration of known distribution ranges; and
- Historical investigations have failed to detect the species within the subject site;
- Information gained from database records (i.e. species with no recent and/ or few historical observations).

A justification for species not confirmed as subject species is provided in **Table 3.3**.

Table 3.2 Subject Species Likelihood of Occurrence Analysis: Threatened Species

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
Litoria aurea (Green and Golden Bell Frog)	E	V	Inhabits a very wide range of water bodies including marshes, dams and streams, particularly those containing emergent vegetation such as bullrushes or spikerushes. It also inhabits numerous types of man-made water bodies including quarries and sand extraction sites. Optimum habitat includes water-bodies that are un-shaded, free of predatory fish such as Plague Minnow, have a grassy area nearby and diurnal sheltering sites available.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Litoria brevipalmata (Green-thighed Frog)	V	-	This species is distributed from south-east Queensland to the NSW Central Coast. It occurs in a range of habitat types including rainforest, moist eucalypt forest, dry eucalypt forest and heath, but is most closely associated with wetter forest types in the southern part of its range. Calling and breeding is highly correlated with heavy rainfalls that lead to the formation of large ephemeral pools in a range of sites, but always in association with some native vegetation. Calling occurring only for one or two nights at a time anywhere between September and May.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Crinia tinnula (Wallum Froglet)	V	-	Wallum Froglets are found in acid paperbark swamps and sedge swamps of the coastal 'wallum' country. Their tadpoles are adapted to acid conditions and may be outcompeted by the Common Froglet. Males call from the base of vegetation in and around the breeding site and are almost impossible to locate. Calling occurs from Autumn to Spring, being most strongly associated with flooding following rainfall. Its range extends from SE QLD to the Kurnell Peninsular of Sydney.	5	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Recently observed in the locality (NSW BioNet records) with nearest being ~9 km to the southeast.
Uperoleia mahonyi (Mahony's Toadlet)	CE	CE	Current observations indicate Mahony's Toadlet inhabits ephemeral and semi-permanent swamps and swales on the coastal fringe of its range. Known records occur in heath or wallum habitats almost exclusively associated with leached (highly nutrient impoverished) white sand. Commonly associated with acid paperbark swamps, Mahony's Toadlet also	11	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
			is known to occur in wallum heath, swamp mahogany-paperbark swamp forest, heath shrubland and Sydney red gum woodland. Recent studies suggest intact vegetation adjacent to and within water bodies is an important habitat feature for this species		unlikely to depend on available habitat for important life cycle processes such as reproduction. Recently observed in the locality (NSW BioNet records) with nearest being ~9 km to the south.
Hoplocephalus bitorquatus (Pale-headed Snake)	V	-	The Pale-Headed Snake has a patchy distribution from north-east Queensland to north-east NSW. In NSW it occurs from the coast to the western side of the Great Divide as far south as Tuggerah and out to the western plains. It is found mainly in dry eucalypt forests and woodlands, cypress woodland and occasionally in rainforest or moist eucalypt forest where it favours streamside areas, particularly in drier habitats. They shelter during under loose bark or in hollows and have preference for frogs as prey, although lizards and small mammals are also taken. This species breeds and shelters in hollows in live and dead trees and in and under fallen timber. It is best detected from mid spring to mid autumn and is mostly nocturnal.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Hoplocephalus stephensii (Stephens' Banded Snake)	V	-	The Stephens Banded Snake is found through the coast and adjacent ranges of NSW from the Central Coast northwards and into SE Queensland. It is most commonly found living in wet sclerophyll and rainforest areas, but can be found in taller dry forest areas and even in some areas of dry forest where there is significant rock outcropping. They spend the majority of the time in tree tops, either in large hollows or in dense vegetation, coming to the ground for forage for a range of vertebrates.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Circus assimilis (Spotted Harrier)	V	-	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. Occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
Haliaeetus leucogaster (White-bellied Sea-Eagle)	V	M	Inhabits coastal and near coastal areas, building large stick nests, and feeding mostly on marine and estuarine fish and aquatic fauna.	8	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest offsite record being ~3 km to the west.
Hieraaetus morphnoides (Little Eagle)	V	-	Most abundant in lightly timbered areas with open areas nearby. Often recorded foraging in grasslands, crops, treeless dune fields, and recently logged areas. May nest in farmland, woodland and forest in tall trees.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Lophoictinia isura (Square-tailed Kite)	V	-	Typically inhabits coastal forested and wooded lands of tropical and temperate Australia. In NSW it is often associated with ridge and gully forests dominated by Eucalyptus longifolia, Corymbia maculata, E. elata or E. smithii. Individuals appear to occupy large hunting ranges of more than 100km2. They require large living trees for breeding, particularly near water with surrounding woodland -forest close by for foraging habitat. Nest sites are generally located along or near watercourses, in a tree fork or on large horizontal limbs.	2	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Recently observed in the locality (NSW BioNet records) with nearest being ~6 km to the west southwest.
Pandion cristatus (Osprey)	V	-	Ospreys are found right around the Australian coast line, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. Favour coastal areas, especially the mouths of large rivers, lagoons and lakes. Feed on fish over clear, open water.	0	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Not recently observed in the locality (NSW BioNet records).

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
Anseranas semipalmata (Magpie Goose)	V	-	Mainly found in shallow wetlands less than 1 m deep, with a dense growth of rushes or sedges.	1	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Recently observed in the locality (NSW BioNet records) with nearest being ~3 km to the south.
Botaurus poiciloptilus (Australasian Bittern)	E	E	The Australasian Bitterns is widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent Swamp Oak Forests with tall, dense vegetation, particularly bullrushes and spikerushes.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Ixobrychus flavicollis (Black Bittern)	V	-	Usually found on coastal plains below 200 m. Often found along timbered watercourses, in wetlands with fringing trees and shrub vegetation. The sites where they occur are characterized by dense waterside vegetation.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Artamus cyanopterus cyanopterus (Dusky Woodswallow)	V	-	The Dusky Woodswallow is widespread in eastern, southern and southwestern Australia. In New South Wales it is widespread from coast to inland, including the western slopes of the Great Dividing Range and farther west. It is sparsely scattered in, or largely absent from, much of the Upper Western region. The Dusky Woodswallow is often reported in woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including regenerating forests; very occasionally in moist forests or rainforests. At sites where Dusky	0	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). While evidence of activity by this species was observed during surveys for the SIS, this species has not been recently observed in the locality (NSW BioNet records).

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
			Woodswallows are recorded the understorey is typically open with sparse eucalypt saplings, acacias and other shrubs, including heath. The ground cover may consist of grasses, sedges or open ground, often with coarse woody debris (Higgins and Peter 2002). Birds are also often observed in farm land, usually at the edges of forest or woodland or in roadside remnants or wind breaks with dead timber.		
Burhinus grallarius (Bush Stone-curlew)	E	-	The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range. Inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber. Largely nocturnal, being especially active on moonlit nights.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Callocephalon fimbriatum (Gang-gang Cockatoo)	V	-	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. Also occur in subalpine snow gum woodland and occasionally in temperate or regenerating forest. In winter, occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas. It requires tree hollows in which to breed.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Calyptorhynchus lathami (Glossy Black-Cockatoo)	V	-	Inhabits forest with low nutrients, characteristically with key Allocasuarina spp. Tends to prefer drier forest types with a middle stratum of Allocasuarina below Eucalyptus or Angophora. Often confined to remnant patches in hills and gullies. Breed in hollows stumps or limbs, either living or dead. Endangered population in the Riverina.	0	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). While evidence of activity by this species was observed during surveys for the SIS, this species has not been recently observed in the locality (NSW BioNet records).

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
Coracina lineata (Barred Cuckoo-shrike)	V	-	Rainforest, eucalypt forests and woodlands, clearings in secondary growth, swamp woodlands and timber along watercourses. They are usually seen in pairs or small flocks foraging among foliage of trees for insects and fruit. They are active birds, frequently moving from tree to tree.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001 Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Ephippiorhynchus asiaticus (Black-necked Stork)	E	-	Mainly found on shallow, permanent, freshwater terrestrial wetlands, and surrounding marginal vegetation, including swamps, floodplains, watercourses and billabongs, freshwater meadows, wet heathland, farm dams and shallow floodwaters, as well as extending into adjacent grasslands, paddocks and open savannah woodlands. They also forage within or around estuaries and along intertidal shorelines, such as saltmarshes, mudflats and sandflats, and mangrove vegetation.	1	Moderate. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~8 km to the east southeast.
Climacteris picumnus victoriae (Brown Treecreeper (eastern subspecies))	V	-	Found in eucalypt woodlands (including box-gum woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and river red gum forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains.	0	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). While observed during surveys for the SIS, this species has not been recently observed in the locality (NSW BioNet records).
Ptilinopus magnificus (Wompoo Fruit-dove)	V	-	Distributed north of the Hunter River in NSW on the coast and coastal ranges. Inhabits rainforest, monsoon forest, adjacent eucalypt forest and brush box forest.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
					or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Ptilinopus regina (Rose-crowned Fruit-dove)	V	-	Coast and ranges of eastern NSW and Queensland, from Newcastle to Cape York. Vagrants are occasionally found further south to Victoria. Rose-crowned Fruit-doves occur mainly in sub-tropical and dry rainforest and occasionally in moist eucalypt forest and swamp forest, where fruit is plentiful.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Ptilinopus superbus (Superb Fruit-dove)	V	-	The Superb Fruit-dove occurs principally from north-eastern in Queensland to north-eastern NSW. It is much less common further south, where it is largely confined to pockets of suitable habitat as far south as Moruya. There are records of vagrants as far south as eastern Victoria and Tasmania. Inhabits rainforest and similar closed forests where it forages high in the canopy, eating the fruits of many tree species such as figs and palms. It may also forage in eucalypt or acacia woodland where there are fruit-bearing trees.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Falco subniger (Black Falcon)	V	-	The Black Falcon is found along tree-lined watercourses and in isolated woodlands, mainly in arid and semi-arid areas. It roosts in trees at night and often on power poles by day.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Anthochaera phrygia (Regent Honeyeater)	CE	E, M	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. The distribution of the species has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three	1	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
			known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests.		or degraded habitat. Recently observed in the locality (NSW BioNet records) with nearest being ~10 km to the south southwest (Hunter Botanic Gardens August 2018).
Epthianura albifrons (White-fronted Chat)	V	-	Low vegetation in salty coastal and inland areas and crops. Runs along ground and is found in local flocks in winter.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Grantiella picta (Painted Honeyeater)	V	-	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution. Inhabits boree, brigalow and box-gum woodlands and box-ironbark forests.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Melithreptus gularis (Black-chinned Honeyeater (eastern subspecies))	V	-	Eucalypt woodlands within an approximate annual rainfall range of 400-700mm. BioNet records indicate the species is absent from coastal habitats east of a line between Clarencetown and Gosford, this being broadly consistent with average annual rainfall limitations.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Daphoenositta chrysoptera	V	-	Inhabits wide variety of dry eucalypt forests and woodlands, usually with either shrubby under storey or grassy ground cover	3	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
(Varied Sittella)			or both, in all climatic zones of Australia. Usually in areas with rough-barked trees, such as stringybarks or ironbarks, but also in paperbarks or mature Eucalypts with hollows.		occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~3 km to the west.
Chthonicola sagittata (Speckled Warbler)	V	-	The Speckled Warbler lives in a wide range of eucalypt dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy. BioNet records indicate the species is generally absent from coastal habitats.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Stagonopleura guttata (Diamond Firetail)	V	-	Feeds exclusively on the ground, on ripe and partly-ripe grass and herb seeds and green leaves, and on insects (especially in the breeding season). Found in grassy eucalypt woodlands, including box-gum woodlands and snow gum woodlands. Also occurs in open forest, mallee, natural temperate grassland, and in secondary grassland derived from other communities.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Melanodryas cucullata cucullata (Hooded Robin (south-eastern form))	V	-	Occupy a wide range of eucalypt woodlands, Acacia shrublands and open forests.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Petroica boodang (Scarlet Robin)	V	-	The Scarlet Robin is found from SE Queensland to SE South Australia and also in Tasmania and SW Western Australia. In	0	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
			NSW, it occurs from the coast to the inland slopes. The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs.		occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). While observed during surveys for the SIS, this species has not been recently observed in the locality (NSW BioNet records).
Petroica phoenicea (Flame Robin)	V	-	Flame Robins are found in a broad coastal band from southern Queensland to just west of the South Australian border. The species is also found in Tasmania. The preferred habitat in summer includes eucalyptus forests and woodland, whilst in winter prefers open woodlands and farmlands. It is considered migratory. The Flame Robin breeds from about August to January.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Pomatostomus temporalis (Grey-crowned Babbler (eastern subspecies))	V	-	In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Balranald. It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW. It may be extinct in the southern, central and New England tablelands. Inhabits open box-gum woodlands on the slopes, and box-cypress-pine and open box woodlands on alluvial plains.	13	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~2 km to the south.
Glossopsitta pusilla (Little Lorikeet)	V	-	Distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range in NSW, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri. Mostly occur in dry, open eucalypt forests and woodlands. They feed primarily on nectar and pollen in the tree canopy. Nest hollows are located at heights of between 2 m and 15 m, mostly in living, smooth-barked eucalypts. Most breeding records come from the western slopes.	1	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~10 km to the northwest.
Lathamus discolor (Swift Parrot)	E	CE	The Swift Parrot occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt nectar, pollen and	1	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study

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			associated insects. The Swift Parrot is dependent on flowering resources across a wide range of habitats in its wintering grounds in NSW. This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability.		area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Recently observed in the locality (NSW BioNet records) with nearest being ~6 km to the north.
Neophema pulchella (Turquoise Parrot)	V	-	The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland. Nests in tree hollows, logs or posts, from August to December. It lays four or five white, rounded eggs on a nest of decayed wood dust.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Ninox connivens (Barking Owl)	V	-	Generally found in open forests, woodlands, swamp woodlands and dense scrub. Can also be found in the foothills and timber along watercourses in otherwise open country.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Ninox strenua (Powerful Owl)	V	-	Occupies wet and dry eucalypt forests and rainforests. Can occupy both un-logged and lightly logged forests as well as undisturbed forests where it usually roosts on the limbs of dense trees in gully areas. It is most commonly recorded within red turpentine in tall open forests and black she-oak within open forests. Large mature trees with hollows at least 0.5 m deep are required for nesting. Tree hollows are particularly important for the Powerful Owl because a large proportion of the diet is made up of hollow-dependent arboreal marsupials. Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm.	2	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being off site observation ~9 km to the east southeast.

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Turnix maculosus (Red-backed Button-quail)	V	-	Red-backed Button-quail inhabit grasslands, open and savannah woodlands with grassy ground layer, pastures and crops of warm temperate areas, typically only in regions subject to annual summer rainfall greater than 400 mm. In NSW, said to occur in grasslands, heath and crops. Said to prefer sites close to water, especially when breeding. Observations of populations in other parts of its range suggest the species prefers sites near water, including grasslands and sedgelands near creeks, swamps and springs, and wetlands.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Tyto longimembris (Grass Owl)	V	-	Found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Tyto novaehollandiae (Masked Owl)	V	-	Inhabits a diverse range of wooded habitat that provide tall or dense mature trees with hollows suitable for nesting and roosting. Mostly recorded in open forest and woodlands adjacent to cleared lands. Nest in hollows, in trunks and in near vertical spouts or large trees, usually living but sometimes dead. Nest hollows are usually located within dense forests or woodlands. Masked owls prey upon hollow-dependent arboreal marsupials, but terrestrial mammals make up the largest proportion of the diet.	3	High. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). If present, the species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~5 km to the south.
Tyto tenebricosa (Sooty Owl)	V	-	Often found in tall old-growth forests, including temperate and subtropical rainforests. In NSW mostly found on escarpments with a mean altitude less than 500 metres. Nests and roosts in hollows of tall emergent trees, mainly eucalypts often located in gullies. Nests have been located in trees 125 to 161 centimetres in diameter.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified

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					or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Cercartetus nanus (Eastern Pygmy-possum)	V	-	Inhabits rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source. Will often nest in tree hollows, but can also construct its own nest. Because of its small size it is able to utilise a range of hollow sizes including very small hollows. Individuals will use a number of different hollows and an individual has been recorded using up to 9 nest sites within a 0.5ha area over a 5 month period.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Dasyurus maculatus maculatus (Spotted-tailed Quoll)	V	E	Spotted-tailed Quoll are found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline.	2	High. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). If present, the species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~2 km to the south.
Phascogale tapoatafa (Brush-tailed Phascogale)	V	-	The Brush-tailed Phascogale has a patchy distribution around the coast of Australia. In NSW it is mainly found east of the Great Dividing Range although there are occasional records west of the divide. Prefer dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter. Also inhabit heath, swamps, rainforest and wet sclerophyll forest.	10	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest off site record being ~1 km to the northwest.
Planigale maculata (Common Planigale)	V	-	Common Planigales inhabit rainforest, eucalypt forest, heathland, marshland, grassland and rocky areas where there is surface cover, and usually close to water. The female builds a nest lined with grass, eucalypt leaves or shredded bark. BioNet records indicate this species reaches its southern limit of distribution at Fern Bay (one record), with the majority of records for this species occurring north from Taree.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle

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					processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Saccolaimus flaviventris (Yellow-bellied Sheathtail-bat)	V	-	Roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. When foraging for insects, flies high and fast over the forest canopy, but lower in more open country. Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory.	2	High. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). If present, the species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~2 km to the northeast.
Macropus parma (Parma Wallaby)	V	-	Once occurred from north-eastern NSW to the Bega area in the southeast. Their range is now confined to the coast and ranges of central and northern NSW from the Gosford district to the Queensland border. Preferred habitat is moist eucalypt forest with thick, shrubby understorey, often with nearby grassy areas, rainforest margins and occasionally drier eucalypt forest.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Petrogale penicillata (Brush-tailed Rock-wallaby)	E	V	Found in rocky areas in a wide variety of habitats including rainforest gullies, wet and dry sclerophyll forest, open woodland and rocky outcrops in semi-arid country. Commonly sites have a northerly aspect with numerous ledges, caves and crevices.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Mormopterus norfolkensis (Eastern Freetail-bat)	V	-	Most records are from dry eucalypt forests and woodlands to the east of the Great Dividing Range. Appears to roost in trees, but little is known of this species' habits.	10	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of

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					local population). Recently observed in the locality (NSW BioNet records) with nearest off site record being ~1 km to the northwest.
Pseudomys gracilicaudatus (Eastern Chestnut Mouse)	V	-	In NSW the Eastern Chestnut Mouse mainly occurs north from the Hawkesbury River area as scattered records along to coast and eastern fall of the Great Dividing Range extending north into Queensland. There are however isolated records in the Jervis bay area. In NSW the Eastern Chestnut Mouse is mostly found, in low numbers, in heathland and is most common in dense, wet heath and swamps. In the tropics it is more an animal of grassy woodlands. Optimal habitat appears to be in vigorously regenerating heathland burnt from 18 months to four years previously. By the time the heath is mature, the larger Swamp Rat becomes dominant, and Eastern Chestnut Mouse numbers drop again.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Petaurus australis (Yellow-bellied Glider)	V	-	Occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. forest type preferences vary with latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Petaurus norfolcensis (Squirrel Glider)	V	-	Generally occurs in dry sclerophyll forests and woodlands but is absent from dense coastal ranges in the southern part of its range. Requires abundant hollow bearing trees and a mix of eucalypts, banksias and acacias. There is only limited information available on den tree use by Squirrel gliders, but it has been observed using both living and dead trees as well as hollow stumps. Within a suitable vegetation community at least one species should flower heavily in winter and one species of eucalypt should be smooth barked.	13	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Recently observed in the locality (NSW BioNet records) with nearest being ~4 km to the west.
Phascolarctos cinereus (Koala)	V	V	Inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall.	73	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km

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					(IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~0.5 km to the north.
Aepyprymnus rufescens (Rufous Bettong)	V	-	The original range from Coen in north Queensland to central Victoria has been reduced to a patchy distribution from Cooktown, Queensland, to north-eastern NSW as far south as Mt Royal National Park. In NSW it has largely vanished from inland areas but there are sporadic, unconfirmed records from the Pilliga and Torrington districts. Rufous Bettongs inhabit a variety of forests from tall, moist eucalypt forest to open woodland, with a tussock grass understorey. A dense cover of tall native grasses is the preferred shelter. They sleep during the day in cone-shaped nests constructed of grass in a shallow depression at the base of a tussock or fallen log. At night they feed on grasses, herbs, seeds, flowers, roots, tubers, fungi and occasionally insects.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Potorous tridactylus tridactylus (Long-nosed Potoroo)	V	V	Inhabits coastal heath and wet and dry sclerophyll forests. Generally found in areas with rainfall greater than 760 mm. Requires relatively thick ground cover where the soil is light and sandy.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Pteropus poliocephalus (Grey-headed Flying-fox)	V	V	This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Bats commute daily to foraging areas, usually within 15 km of the day roost although some individuals may travel up to 70 km.	35	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest off site record being adjacent the site.

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
Syconycteris australis (Common Blossom-bat)	V	-	Often roost in littoral rainforest and feed on nectar and pollen from flowers in adjacent heathland and paperbark swamps. They have also been recorded in a range of subtropical forest types, rainforest, wet sclerophyll forest and coastal eucalypt forest. They generally roost individually in dense foliage and vine thickets of the sub-canopy, staying in the same general area for a season. They change roost sites daily, but each roost site is generally only 50m or so away from other recent roosts.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Chalinolobus dwyeri (Large-eared Pied Bat)	V	V	Located in a variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range. Can also be found on the edges of rainforests and in wet sclerophyll forests. This species roosts in caves and mines in groups of between 3 and 37 individuals.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Falsistrellus tasmaniensis (Eastern False Pipistrelle)	V	-	Inhabit sclerophyll forests, preferring wet habitats where trees are more than 20 m high. Two observations have been made of roosts in stem holes of living eucalypts. There is debate about whether or not this species moves to lower altitudes during winter, or whether they remain sedentary but enter torpor. This species also appears to be highly mobile and records showing movements of up to 12 km between roosting and foraging sites.	1	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Recently observed in the locality (NSW BioNet records) with nearest being ~7 km to the southwest.
Kerivoula papuensis (Golden-tipped Bat)	V	-	Distributed along the east coast of Australia in scattered locations from Cape York Peninsula in Queensland to Bega in southern NSW. Found in rainforest and adjacent sclerophyll forest. Roost in abandoned hanging Yellow-throated Scrubwren and Brown Gerygone nests located in rainforest gullies on small first- and second-order streams.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
Miniopterus australis (Little Bentwing-bat)	V	-	Coastal north-eastern NSW and eastern Queensland. Little Bent-wing Bat is an insectivorous bat that roost in caves, in old mines, in tunnels, under bridges, or in similar structures. They breed in large aggregations in a small number of known caves and may travel 100s km from feeding home ranges to breeding sites. Little Bent-wing Bat has a preference for moist eucalypt forest, rainforest or dense coastal banksia scrub where it forages below the canopy for insects.	15	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest off site record being ~0.5 km to the west.
Miniopterus schreibersii oceanensis (Eastern Bentwing-bat)	V	-	Eastern Bent-wing Bats occur along the east and north-west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young.	4	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest off site record being ~0.5 km to the northwest.
Myotis macropus (Southern Myotis)	V	-	The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage.	3	High. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). If present, the species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~7 km to the southwest.
Nyctophilus corbeni (South-eastern Long-eared Bat)	V	V	The South-eastern Long-eared Bat has a limited distribution that is restricted around the Murray-Darling Basin in south-eastern Australia. Even in this region its distribution is scattered and it is rarely recorded. It occurs in far eastern South Australia, in areas north of the Murray River, east of Canegrass Station and south of the Barrier Highway. These areas include the Riverland Biosphere Reserve, Danggali Conservation Park and the Birds Australia Gluepot Reserve. It is distributed throughout inland NSW except in the north-west area which is dominated by	0	None. Suitable 'vegetation formation level' habitat surrogates are absent from the study area. Species incidence is not expected and, if present, would represent atypical habitat usage. Not recently observed in the locality (NSW BioNet records).

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
			treeless plains. It can be found in the Hunter Valley, extending from central NSW to the eastern Hunter Valley coast.		
Scoteanax rueppellii (Greater Broad-nosed Bat)	V	-	Prefer moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. They are only found at low altitudes below 500 m. In dense environments they utilise natural and human-made opening in the forest for flight paths. Creeks and small rivers are favoured foraging habitat. This species roosts in hollow tree trunks and branches.	2	High. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). If present, the species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~7 km to the east southeast.
Vespadelus troughtoni (Eastern Cave Bat)	V	-	The Eastern Cave Bat is found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT. A cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Cynanchum elegans (White-flowered Wax Plant)	E	E	Recorded from rainforest gullies scrub and scree slopes from the Gloucester district to the Wollongong area and inland to Mt Dangar.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Not recently observed in the locality (NSW BioNet records).
Rutidosis heterogama	V	V	Grows in heath on sandy soils and moist areas in open forest, and has been recorded along disturbed roadsides.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
					unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Monotaxis macrophylla	E	-	Grows on rocky ridges and hillsides. Displays the properties of a fire ephemeral species in many ways.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Acacia bynoeana (Bynoe's Wattle)	E	V	Grows mainly in heath and dry sclerophyll forest in sandy soils. Mainly south of Dora Creek-Morisset area to Berrima and the Illawarra region, west to the Blue Mountains, also recorded from near Kurri Kurri in the Hunter Valley and from Morton National Park.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Senna acclinis	E	-	Grows in or on the edges of subtropical and dry rainforest.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Species not recently observed in the locality (NSW BioNet records).
Maundia triglochinoides	V	-	Grows in swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients in association with wetland species such as *Triglochin procerum*. Flowering occurs during warmer months.	2	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
					this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest off site record being ~9 km to the south.
Angophora inopina	V	V	Endemic to the Central Coast region of NSW. The known northern limit is near Karuah where a disjunct population occurs; to the south populations extend from Toronto to Charmhaven with the main population occurring between Charmhaven and Morisset. Occurs most frequently in red bloodwood – scribbly gum woodland, wet heath, red mahogany – paperbark sedge woodland and stringybark – red bloodwood forest.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Callistemon linearifolius	V	-	Recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. Recorded in 2000 at Coalcliff in the northern Illawarra. For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River. Grows in dry sclerophyll forest on the coast and adjacent ranges.	1	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Recently observed in the locality (NSW BioNet records) with nearest being ~7 km to the southeast.
Eucalyptus camfieldii	V	V	Restricted distribution in a narrow band with the most northerly records in the Raymond Terrace Area south to Waterfall. Localised and scattered distribution includes sites at Norah Head (Tuggerah Lakes), Peats Ridge, Mt Colah, Elvina Bay Trail (West Head), Terrey Hills, Killara, North Head, Menai, Wattamolla and a few other sites in Royal National Park. Poor coastal country in shallow sandy soils overlying Hawkesbury sandstone. Coastal heath mostly on exposed sandy ridges. Occurs mostly in small scattered stands near the boundary of tall coastal heaths and low open woodland of the slightly more fertile inland areas.	2,260	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Recently observed in the locality (NSW BioNet records) with nearest being ~6 km to the south.
Eucalyptus glaucina (Slaty Red Gum)	V	V	Found only on the north coast of NSW and in separate districts: near Casino where it can be locally common, and farther south, from Taree to Broke, west of Maitland. Grows in grassy	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of

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			woodland and dry eucalypt forest. Grows on deep, moderately fertile and well-watered soils.		occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Eucalyptus parramattensis subsp. decadens	V	V	Generally occupies deep, low-nutrient sands, often those subject to periodic inundation or where water tables are relatively high. It occurs in dry sclerophyll woodland with dry heath understorey. It also occurs as an emergent in dry or wet heathland. Often where this species occurs, it is a community dominant.	426	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Recently observed in the locality (NSW BioNet records) with nearest being ~7 km to the southwest.
Eucalyptus pumila (Pokolbin Mallee)	V	V	The single known population occupies north-west-facing slopes derived from sandstone. Present as a mid-canopy species to a height of 6 m within dry sclerophyll woodland which has a canopy comprising Eucalyptus fibrosa, Callitris endlicheri and Corymbia maculata.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Melaleuca biconvexa (Biconvex Paperbark)	V	V	Grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects. Scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).

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Melaleuca groveana	V	-	Grows in heath and shrubland, often in exposed sites, at high elevations, on rocky outcrops and cliffs. It also occurs in dry woodlands.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Syzygium paniculatum (Magenta Lilly Pilly)	E	V	Found only in NSW, in a narrow, linear coastal strip from Bulahdelah to Conjola State forest. On the south coast the species occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral rainforest. On the central coast it occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Species not recently observed in the locality (NSW BioNet records).
Corybas dowlingii	E	-	Sheltered areas such as gullies and southerly slopes in tall open forest on well-drained gravelly soil at elevations of 10-200 m.	1	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~7 km to the east southeast.
Cryptostylis hunteriana (Leafless Tongue-orchid)	V	V	Does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. The larger populations typically occur in woodland dominated by Scribbly Gum (Eucalyptus sclerophylla), Silvertop Ash (E. sieberi), Red Bloodwood (Corymbia gummifera) and Black Sheoak (Allocasuarina littoralis); appears to prefer open areas in the understorey of this community and is often found in association with the Large	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Species not recently observed in the locality (NSW BioNet records).

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
			Tongue Orchid (C. subulata) and the Tartan Tongue Orchid (C. erecta).		
Dendrobium melaleucaphilum	E	-	An orchid which grows on other plants (sometimes on rocks). Occurs in coastal districts and nearby ranges, extending from Queensland to its southern distributional limit in the lower Blue Mountains. In NSW, it is currently known from seven recent collections. There has been no subsequent confirmation from the locations of three earlier (pre-1922) collections and it is possible that these are now extinct.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Species not recently observed in the locality (NSW BioNet records).
Diuris arenaria (Sand Doubletail)	E	-	Known from the Tomaree Peninsula near Newcastle. This species occurs in coastal heath and dry grassy eucalypt forest on sandy flats. Grows in gently undulating country in eucalypt forest with a grassy understorey on clay soil.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Diuris pedunculata (Small Snake Orchid)	E	E	Confined to NSW. It was originally found scattered from Tenterfield south to the Hawkesbury River, but is now mainly found on the New England Tablelands, around Armidale, Uralla, Guyra and Ebor. Grows on grassy slopes or flats, often on peaty soils in moist areas. Also known from shale and trap soils, on fine granite, and among boulders.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Species not recently observed in the locality (NSW BioNet records).
Diuris praecox (Rough Doubletail)	V	V	Occurs between Ourimbah and Nelson Bay. Grows on hills and slopes of near-coastal districts in open forests which have a grassy to fairly dense understorey. Exists as subterranean tubers most of the year. It produces leaves and flowering stems in winter.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle

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					processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Genoplesium baueri (Bauer's Midge Orchid)	E	E	Grows in dry sclerophyll forest and moss gardens over sandstone. Flowers February to March. Has been recorded between Ulladulla and Port Stephens. Currently the species is known from just over 200 plants across 13 sites. The species has been recorded in Berowra Valley Regional Park, Royal National Park and Lane Cove National Park and may also occur in the Woronora, O'Hares, Metropolitan and Warragamba Catchments.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Pterostylis chaetophora (Taree Rusty Greenhood)	V	-	The preferred habitat is seasonally moist, dry sclerophyll forest with a grass and shrub understorey. Flowers from September to November. Vegetative reproduction is not common in this group of Greenhoods, but some species may form more than one dropper annually. Fails to flower in dry seasons. Plants are deciduous and die back to the large, underground tubers after seed release. New rosettes are produced following soaking autumn and winter rains.	4	Known. Habitat values generally consistent with description provided in the OEH TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001). The species is likely to depend on the habitat it occurs within for important life cycle processes; however, the importance of this habitat would depend on additional factors (e.g. size and extent of local population). Recently observed in the locality (NSW BioNet records) with nearest being ~1 km to the northeast.
Persicaria elatior	V	V	This species normally grows in damp places, especially beside streams and lakes. Occasionally in swamp forest or associated with disturbance.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Grevillea parviflora subsp. parviflora (Small-flowered Grevillea)	V	V	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	1	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
					unlikely to depend on available habitat for important life cycle processes such as reproduction. Recently observed in the locality (NSW BioNet records) with nearest being ~6 km to the east.
Pomaderris queenslandica	E	-	Rare in N.S.W. Specimens have been recorded from Mount Danger and Gloucester district. Species more widespread in Queensland. Recorded in moist eucalypt forest or sheltered woodlands with a shrubby understorey.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Asperula asthenes (Trailing Woodruff)	V	V	This small herb occurs only in NSW. It is found in scattered locations from Bulahdelah north to near Kempsey, with several records from the Port Stephens-Wallis Lakes area. Damp sites, often along river banks.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence' and area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Species not recently observed in the locality (NSW BioNet records) despite there being a historical record adjacent to the subject site. Surveys have not relocated the species.
Galium australe	E	-	Widespread in Victoria and is also found in South Australia and Tasmania. Once regarded as presumed extinct in NSW, this species is now known from the Towamba Valley near Bega, Lake Yarrunga near Kangaroo Valley, Cullendulla Creek Nature Reserve near Batemans Bay, Conjola National Park, Swan Lake near Swanhaven, and the Big Hole in Deua National Park. Grows in moist gullies of tall forest, Eucalyptus tereticornis forest, coastal Banksia shrubland, and Allocasuarina nana heathland. In other States the species is found in a range of near-coastal habitats, including sand dunes, sand spits, shrubland and woodland.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Commersonia prostrata	E	E	Occurs on sandy, sometimes peaty soils in a wide variety of habitats: snow gum woodland at Rose Lagoon; blue leaved	2	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
			stringybark open forest at Tallong; and in brittle gum low open woodland at Penrose; scribbly gum - swamp mahogany ecotonal forest at Tomago.		of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Recently observed in the locality (NSW BioNet records) with nearest being ~8 km to the south.
Tetratheca juncea (Black-eyed Susan)	V	V	Confined to the northern portion of the Sydney Basin bioregion and the southern portion of the North Coast bioregion in the local government areas of Wyong, Lake Macquarie, Newcastle, Port Stephens, Great Lakes and Cessnock. It is usually found in low open forest-woodland with a mixed shrub understorey and grassy groundcover. The majority of populations occur on low nutrient soils associated with the Awaba Soil Landscape. Cryptic species that requires survey in September-October.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Zannichellia palustris	E	-	Grows in fresh or slightly saline stationary or slowly flowing water. NSW populations behave as annuals, dying back completely every summer.	0	Moderate. Typical habitat types, important habitat features and/ or known habitat surrogates (e.g. PCTs) are present within the study area. Habitat is located within known 'extent of occurrence'; however, is outside its known area of occurrence (i.e. standard grid size of 2x2km (IUCN 2001). Incidence may be supplementary to occurrence in proximal areas of higher value habitat or associated with modified or degraded habitat. Species not recently observed in the locality (NSW BioNet records).

Species not considered likely to occur are listed in **Table 3.3**. Notwithstanding, the methods and timing of targeted surveys performed for species identified in **Table 3.2** as likely to occur are considered adequate for the detection of the species listed in **Table 3.3**. Species are deemed to be absent on this basis.

Table 3.3 Species not likely to occur in Subject Site and exclusion from Subject Species list

Scientific Name (Common Name)	TSC Act	EPBC Act	Comment
Litoria brevipalmata (Green-thighed Frog)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Uperoleia mahonyi (Mahony's Toadlet)	CE	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. Recent records in the locality are associated with leached (highly nutrient impoverished) white sand, a key habitat feature that is are absent from the site.
Hoplocephalus bitorquatus (Pale-headed Snake)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Hoplocephalus stephensii (Stephens' Banded Snake)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Circus assimilis (Spotted Harrier)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Hieraaetus morphnoides (Little Eagle)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Burhinus grallarius (Bush Stone-curlew)	E	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Callocephalon fimbriatum (Gang-gang Cockatoo)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Species possibly outside its natural range. Habitat conditions generally unsuitable.
Coracina lineata (Barred Cuckoo-shrike)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Ptilinopus magnificus (Wompoo Fruit-dove)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Ptilinopus regina (Rose-crowned Fruit-dove)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Ptilinopus superbus (Superb Fruit-dove)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Falco subniger (Black Falcon)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Epthianura albifrons (White-fronted Chat)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.

Scientific Name (Common Name)	TSC Act	EPBC Act	Comment
Grantiella picta (Painted Honeyeater)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Melithreptus gularis (Black-chinned Honeyeater (eastern subspecies))	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Chthonicola sagittata (Speckled Warbler)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Stagonopleura guttata (Diamond Firetail)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Melanodryas cucullata cucullata (Hooded Robin (south-eastern form))	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Petroica phoenicea (Flame Robin)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Ninox connivens (Barking Owl)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Turnix maculosus (Red-backed Button-quail)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Tyto longimembris (Grass Owl)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Tyto tenebricosa (Sooty Owl)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Cercartetus nanus (Eastern Pygmy-possum)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Planigale maculata (Common Planigale)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Macropus parma (Parma Wallaby)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Petrogale penicillata (Brush-tailed Rock-wallaby)	E	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Pseudomys gracilicaudatus (Eastern Chestnut Mouse)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Petaurus australis (Yellow-bellied Glider)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Aepyprymnus rufescens (Rufous Bettong)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.

Scientific Name (Common Name)	TSC Act	EPBC Act	Comment
Potorous tridactylus tridactylus (Long-nosed Potoroo)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Syconycteris australis (Common Blossom-bat)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Chalinolobus dwyeri (Large-eared Pied Bat)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Kerivoula papuensis (Golden-tipped Bat)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Nyctophilus corbeni (South-eastern Long-eared Bat)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Vespadelus troughtoni (Eastern Cave Bat)	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Cynanchum elegans (White-flowered Wax Plant)	E	E	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Rutidosis heterogama	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Monotaxis macrophylla	E	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Acacia bynoeana (Bynoe's Wattle)	E	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Senna acclinis	E	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Angophora inopina	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Callistemon linearifolius	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. Recent record is within a vegetation type that does not occur within the subject site. Habitat conditions generally unsuitable.
Eucalyptus camfieldii	V	V	The subject site is north and outside of the species known area of occurrence and extent of occurrence. Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. Recent records are within a vegetation type that does not occur within the subject site. Habitat conditions generally unsuitable.
Eucalyptus glaucina (Slaty Red Gum)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Eucalyptus parramattensis subsp. decadens	V	V	The subject site is north and outside of the species known area of occurrence and extent of occurrence. Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. Recent records are within a

Scientific Name (Common Name)	TSC Act	EPBC Act	Comment
			vegetation type that does not occur within the subject site. Habitat conditions generally unsuitable.
Eucalyptus pumila (Pokolbin Mallee)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Melaleuca biconvexa (Biconvex Paperbark)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Melaleuca groveana	V	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Syzygium paniculatum (Magenta Lilly Pilly)	E	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Cryptostylis hunteriana (Leafless Tongue-orchid)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable (Bell 2019).
Dendrobium melaleucaphilum	E	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Diuris arenaria (Sand Doubletail)	E	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Diuris pedunculata (Small Snake Orchid)	E	E	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Diuris praecox (Rough Doubletail)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Genoplesium baueri (Bauer's Midge Orchid)	E	E	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Persicaria elatior	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Grevillea parviflora subsp. parviflora (Small-flowered Grevillea)	V	V	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks. Occurs in Lower Hunter Spotted Gum Ironbark Forest and is not associated with Seaham Spotted Gum Ironbark (NSW Scientific Committee 2019) Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. Recent record is to the north near Italia Road in a different vegetation type. Habitat conditions generally unsuitable. Comprehensive surveys performed with none found.
Pomaderris queenslandica	E	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Asperula asthenes (Trailing Woodruff)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. Nearest record to the north of the site in a creek line characterised by

Scientific Name (Common Name)	TSC Act	EPBC Act	Comment
			Tall Alluvial Forest, which is absent from the subject site (EcoBiological 2009). Habitat conditions generally unsuitable.
Galium australe	E	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Commersonia prostrata	E	E	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. Recent records associated with vegetation on sand masses on Tilligerry peninsular. Habitat conditions generally unsuitable.
Tetratheca juncea (Black-eyed Susan)	V	V	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.
Zannichellia palustris	E	-	Species not previously observed within the subject site (HWR 2004; EcoBiological 2009; Cumberland Ecology 2019) or during this study. No recent records. Habitat conditions generally unsuitable.

3.1.2 Endangered Populations

No endangered populations have been identified for consideration in the SIS as 'subject species' as indicated in the likelihood of occurrence analysis provided in **Table 3.4**.

Table 3.4 Subject Species Likelihood of Occurrence Analysis: Endangered Populations

Scientific Name (Common Name)	TSC Act	EPBC Act	Habitat	Recent Records (OEH 2019a)	Likelihood of Occurrence
Dromaius novaehollandiae (Emu population in the New South Wales North Coast Bioregion and Port Stephens local government area)	EP	-	The species was formerly widespread in north-eastern NSW, but that population is now isolated and largely restricted to coastal and near-coastal areas between Ballina - Evans Head and Red Rock, extending west to the Bungawalbin area. There have also been recent records from the Port Stephens area. On the NSW north coast, Emus occur in a range of predominantly open lowland habitats, including grasslands, heathland, shrubland, open and shrubby woodlands, forest, and swamp and sedgeland communities, as well as the ecotones between these habitats.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Not recently observed in the locality (NSW BioNet records).
Cymbidium canaliculatum (*Cymbidium canaliculatum* population in the Hunter Catchment)	EP	-	Typically grows in the hollows, fissures, trunks and forks of trees in dry sclerophyll forest or woodland, where its host trees typically occur on Permian Sediments of the Hunter Valley floor. It usually occurs singly or as a single clump, which can form large colonies on trees, between two and six metres from the ground.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).
Leionema lamprophyllum subsp. obovatum in the Hunter Catchment - endangered population listing	EP	-	There is currently only one known location in the Hunter Catchment where *L. lamprophyllum* subsp. *obovatum* is found. The Hunter Catchment population of *L. lamprophyllum* subsp. *obovatum* is currently known to occur in Pokolbin State Forest where it is found on a rocky cliff line in a dry eucalypt forest. There are no records of *L. lamprophyllum* subsp. *obovatum* from a conservation reserve in the Hunter Catchment.	0	Low. Typical habitat types are absent from the study area; however, formation level vegetation habitat surrogates are present. Irrespective of proximity to the species known 'extent of occurrence' and 'area of occurrence' (i.e. standard grid size of 2x2km (IUCN 2001), the presence of this species would likely be incidental or random and generally inconsistent with natural occurrences. The species is unlikely to depend on available habitat for important life cycle processes such as reproduction. Species not recently observed in the locality (NSW BioNet records).

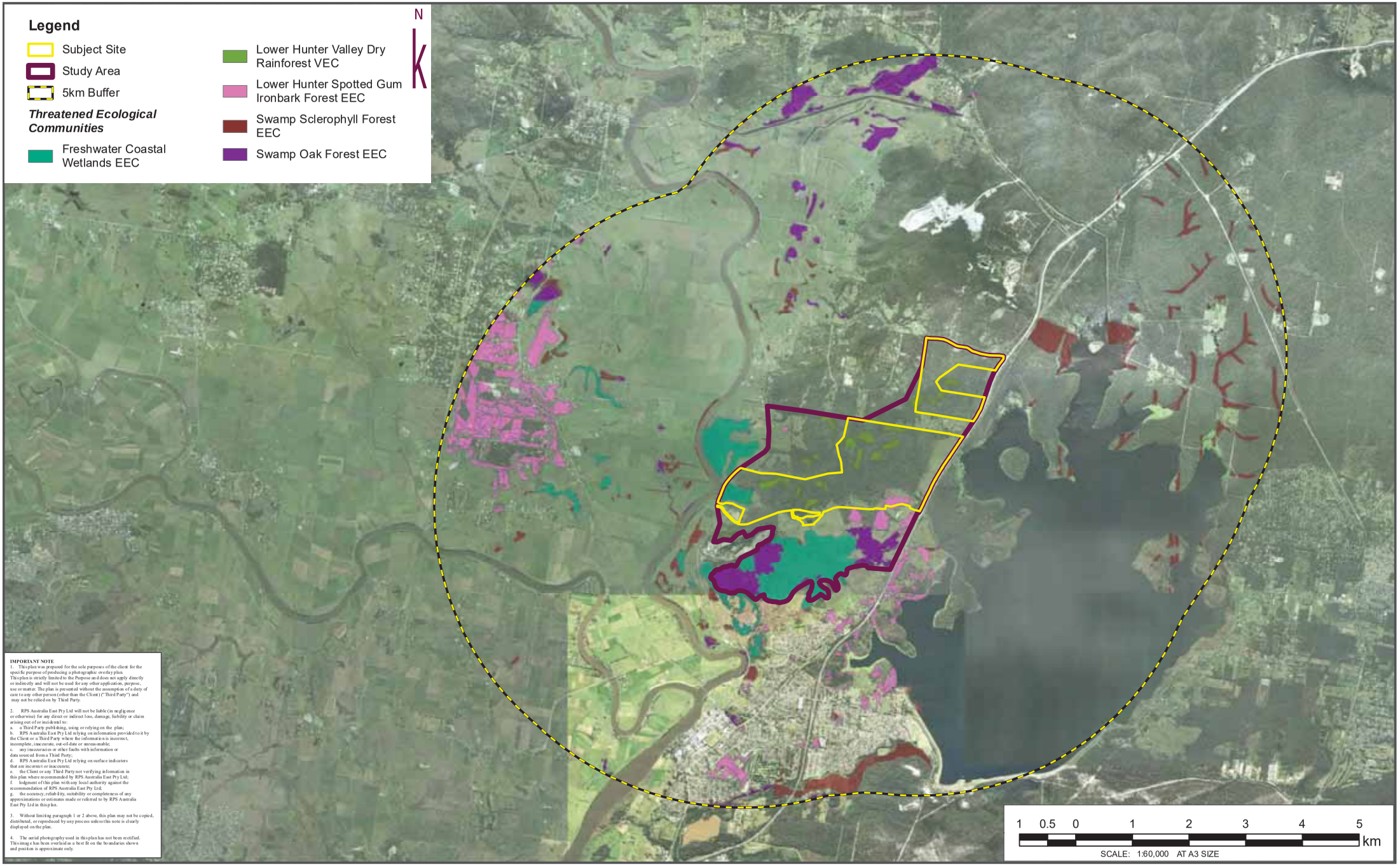
3.1.3 Endangered and Critically Endangered Ecological Communities

The CERs and database searches indicate the occurrence of the following endangered ecological communities (EECs), critically endangered ecological communities (CEECs) and vulnerable ecological communities (VEC) within the locality:

- Lower Hunter Spotted Gum-Ironbark Forest in the Sydney Basin and North Coast Bioregions EEC;
- Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions VEC;
- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions;
- Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions EEC;
- Lowland rainforest of the NSW North Coast and Sydney Basin Bioregions EEC;
- Lowland rainforest on floodplain of the NSW North Coast Bioregion EEC;
- Hunter Valley Vine Thicket in the NSW North Coast and Sydney Basin Bioregions EEC;
- River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC;
- Subtropical coastal floodplain forest of the NSW North Coast Bioregion EEC;
- Swamp Oak Forests on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC; and
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC.

Mapped occurrences within the study area are shown in **Figure 3.1**. Of these communities the following have been identified for consideration as ‘subject species’ in the SIS:

- Lower Hunter Spotted Gum-Ironbark Forest in the Sydney Basin and North Coast Bioregions EEC;
- Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions VEC;
- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC;
- Swamp Oak Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC; and
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC.



IMPORTANT NOTE

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TITLE : FIGURE 3.1: THREATENED ECOLOGICAL COMMUNITIES WITHIN THE LOCALITY

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): E A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 3.1 TECs within the location E A3 20200719.mxd

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4 SURVEY

This chapter covers the following Chief Executive Requirements:

DGR 4 SURVEY

4.1 Requirement to Survey

DGR 4.1 Requirement to survey

Recent flora and fauna surveys, including targeted threatened species surveys within the study area, have been performed by Cumberland Ecology, BioLink, Biodiversity Conservation Monitoring and RPS. Survey dates are as follows:

- Cumberland Ecology (2019): 3-5 March 2014, 11-14 October 2016, 20 October 2016, 9-13 January 2017, 23-25 January 2017 and 16-17 and 23-24 August 2018 (Cumberland Ecology 2019) (**Appendix F**);
- BioLink (2018): Kings Hill Koala Habitat Assessment (**Appendix G**);
- OWAD (2019): Raymond Terrace Koala Survey Report (**Appendix H**);
- Marsh and Youngentob (2019): Report on Nutritional Analysis of Eucalypt Leaves collected from Kings Hill (**Appendix I**);
- Biodiversity Conservation Monitoring (2018): 28-31 July 2018, 1-3 August 2018 and 8-10 August 2018 (**Appendix J**); and
- RPS: 27-31 August 2018, 3-7 September 2018, 17-20 September 2018, 5 October 2018, 8-12 October 2018, 15-19 October 2018, 29-31 October 2018, 1-2 November 2018, 25 October – 19 November 2018 (Anabat and IR Cameras), 21 December 2018 – 22 February 2019 (Anabat and IR Cameras), 11-15 February 2019, 19-21 August 2019, 26-28 August, 11-12 September 2019, 14, 17-18 and 23 October 2019 and 25 November to 11 December 2019.

Additionally, previous studies conducted within the locality since 2003 provided a useful dataset that supplemented the surveys undertaken within the subject site and understanding of long term patterns (pers coms John-Paul King 2019).

Flora and fauna surveys were conducted, where appropriate, in accordance with guidelines provided in the OEH (then DEC) Threatened Biodiversity Survey and Assessment Guidelines for Development and Activities (Working Draft) (DEC 2004). Each of the methods utilised by RPS is described in detail in **Sections 4.2** and **Section 4.3** below.

4.1.1 False Absences and Imperfect Detection

As indicated in the CERs, species detection is challenged by a variety of factors such as (Tyre *et al*. 2003):

- The species in question (e.g. species with large home ranges and cryptic behaviours);
- Climatic conditions;
- Experience of surveyors; and
- Survey methods employed.

A range of techniques were adopted to mitigate these challenges to species detection through the use of:

- Expert/ experienced surveyors (e.g. Koala);
- Methods to objectively quantify habitat (e.g. eucalypt foliage nutrient analysis);
- Comprehensive systematic survey designs to minimise observer bias (i.e. grid and parallel transect surveys);

- Appropriate survey timing for seasonal species (e.g. ground orchids); and
- Appropriate survey timing for weather dependant species (e.g. Green-thighed Frog).

While residual risk remains in determining presence/ absence of a species, it is considered that the methodological measures deployed in this assessment have greatly minimised the chances of a false absence or imperfect detection. Notwithstanding, the precautionary principle has been appropriately considered in circumstances where reasonable uncertainty remains, with the expression of this uncertainty provided in a conservative estimation of habitat extent and occupancy.

4.1.2 Stratifying the Site

Broad-scale existing vegetation mapping of the study area was used as a basis for the ground-truthing of vegetation within the study area. This included vegetation mapping for the Greater Hunter Native Vegetation mapping project (OEH 2012b) and the Lower Hunter Vegetation Mapping project (Cockerill 2013). Previous vegetation mapping produced prior to this investigation was also considered (EcoBiological 2009; PEA Consulting 2012; PEA Consulting 2014; Cumberland Ecology 2019). Stratification units were initially based on Keith (2004) vegetation formations. Additional stratification units were generated based on the following factors:

- Land accessibility (i.e. surveys limited to the subject site);
- Relevant environmental factors; and
- Direct impact (i.e. Proposal impact footprint) and Conservation Area (i.e. land within the ownership of KHD comprising E2 lands plus areas of impact avoidance zoned R1).

4.1.2.1 Vegetation and Flora Surveys

Vegetation classification and mapping conforming to the OEH VIS Plant Community Types (PCTs) standard was performed using flora plots, transect data and rapid data points (RDPs). Vegetation formations (Keith, 2004) were used by Cumberland Ecology (2019) to stratify the field survey and were initially obtained from available regional vegetation mapping for the study area (see **Figure 2.7**). Four stratification units were initially identified as listed below:

- Dry Sclerophyll Forests (Shrub/grass sub-formation);
- Forested Wetlands;
- Rainforest; and
- Wet Sclerophyll Forests (Grassy sub-formation).

Additional factors used to stratify the location of additional survey methods/ effort was applied by RPS. Environmental factors considered in the further stratification of the study area are listed below:

- Aspect;
- Slope;
- Soils;
- Topography (e.g. riparian zones, ridges);
- Vegetation structure, as determined from aerial photograph interpretation, as a proxy for condition; and
- Estimates of foliage projected cover as calculated from an analysis of recent satellite imagery (i.e. Enhanced Vegetation Index 2 from Sentinel – 2 data).

Stratification units for targeted threatened flora species surveys were performed in the spring and summer of 2018 and 2019 following the completion of a comprehensive threatened flora species survey of the subject site in winter 2018 and analysis of information obtained from the systematic RDPs obtained during the winter 2018 survey.

Details on the survey design are provided in **Section 4.1.4**. Survey methods are described in **Section 4.2**.

4.1.2.2 Fauna Surveys

The fauna survey was performed with reference to the DEC (2004) guidelines and was stratified using the vegetation formations listed in **Section 4.1.2.1**. Additional to the methods specified in these guidelines, a systematic approach was taken for the Koala and Large Forest Owls. These are outlined below.

4.1.2.2.1 Koala

Koala investigations included spotlighting, scat searches, dog detection, foliage nutrient analysis, feed tree surveys as outlined in BioLink (2019a) and BioLink (2019b) (**Appendix G**), OWAD (2019a) and OWAD (2019b) (**Appendix H**), Marsh and Youngentob (2019) (**Appendix I**) and this document. The investigations performed are consistent with methods outlined in *A review of koala tree use across New South Wales* (OEH 2018). The survey of preferred feed tree species was performed in accordance with a recommendation from BioLink (2019a) (**Appendix G**) to aid the net gain analysis as required by the CKPoM (PSC 2002).

4.1.2.2.2 Large Forest Owls

Large forest owls were surveyed using standard techniques (i.e. spotlighting and call playback) by multiple surveyors since 2003 (HWR 2004; Cumberland Ecology 2019) in addition to recent surveys performed for this SIS. More recently, stag watches were performed in August 2019 for hollow-bearing trees located within the Proposal impact footprint to determine if these hollows were being utilised by breeding pairs. Trees with potential were selected using relevant criteria and surveyed on at least two nights involving 1.5 hrs of silent watching from dusk. Stag watching post was established 20 minutes beforehand to minimise disturbance and to collect additional diurnal bird survey data.

4.1.2.3 Limitations

Field surveys were conducted for the purposes of describing the biodiversity values of the study area, the targeting identified 'subject species' included in the SIS and species listed in **Tables 3.1** and **3.4** that were not identified as 'subject species'. A combination of suitable sampling methods and survey timing has been used to minimise the likelihood for false absences and/ or imperfect detection.

Access limitations were evident (e.g. detailed survey only possible on lands owned by KHD); thus preventing surveys from being performed in certain parts of the study area. Vegetation mapping for these areas represents existing published maps of the locality.

4.2 Documentation of Survey Effort and Technique

DGR 4.2.1 Description of survey techniques and survey locations

DGR 4.2.2 Documenting survey effort and results

4.2.1 Survey Techniques and Survey Locations

Survey methods applied in this investigation had reference to the following survey guidelines:

- Threatened Biodiversity Survey and Assessment (DEC 2004);
- Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna - Amphibians (DECC 2009);
- Guide to surveying Threatened Plants (OEH 2016a);
- Survey guidelines for Australia's threatened birds. (DEWHA 2010);
- Survey guidelines for Australia's threatened bats (DEWHA 2010);
- Survey guidelines for Australia's threatened reptiles (DEWHA 2011);

- Survey guidelines for Australia's threatened frogs (DEWHA 2010); and
- EPBC Act referral guidelines for the vulnerable koala (DotE 2014).

The following sections describe the methods used in this investigation.

4.2.1.1 Vegetation Mapping

All available vegetation mapping of the site was collated and analysed in order to stratify the site for targeted flora survey conducted by RPS in 2018 and 2019. This included the consideration of broad scale vegetation mapping (NPWS 2003; Cockerill, 2013), as presented in **Figure 2.7** as modified (BioLink 2017), to reflect site specific data obtained from recent and prior detailed surveys (EcoBiological 2009; HWR 2004; PEA Consulting 2012; PEA Consulting 2014; BIOCM 2018; Cumberland Ecology 2019; additional plot surveys and analysis were performed in 2018 and 2019 by RPS).

Data analysis was performed in PRIMER version 6.1.13 with PERMANOVA version 1.0.3 (Plymouth Marine Laboratory, Plymouth, United Kingdom and see Clarke and Gorley 2006). SIMPROF analyses were also performed to test for statistically significant evidence of genuine clusters in samples (i.e. groupings of plot data), which are a priori unstructured (i.e. single samples from each of a number of sites). A SIMPER analysis using SIMPROF generated groups were used to describe vegetation classifications.

The resultant information was synthesised using Geographical Information Systems (GIS) (ArcGIS 10.6.1) to update vegetation mapping for accessible parts of the study area (i.e. the subject site).

4.2.1.2 Flora Survey

Vegetation classification and descriptions were aided by the analysis of data from flora plot surveys performed in accordance with the:

- BioBanking Assessment Methodology (2009) (BBAM 2009) (DECC 2009);
- BioBanking Assessment Methodology (2014) (BBAM 2014) (OEH 2014); and
- Biodiversity Assessment Method Order (2017) (BAM 2017) (State of NSW 2017).

Vegetation mapping was aided by the dual consideration of flora plot data analysis, RDPs and a tree canopy species surveys. These methods are further described in the following sections.

4.2.1.2.1 Flora Plots

Earlier investigations included surveys by a botanist and an ecologist on 3-5 March 2014 and on the 11-14 October 2016 by two botanists (Cumberland Ecology 2019; **Appendix F**). A total of 76 flora plots and transects were performed, as shown in **Appendix F**, comprising:

- 31 BBAM (2009) plots; and
- 45 BBAM (2014) plots.

The following data was collected for each plot and transect:

- Native species richness recorded within each stratum of a 20 m x 20 m plot;
- Native over-storey projected foliage cover recorded at 10 points along a 50 m transect;
- Native mid-storey projected foliage cover recorded at 10 points along a 50 m transect;
- Native groundcover projected foliage cover recorded at 10 points along a 50 m transect for three life forms (shrubs, grasses and other);
- Weed species projective foliage cover expressed as a percentage of over-storey, mid-storey and ground cover along a 50 m transect;
- Number of trees with hollows where entrance width is over 5 cm and hollow are at least 1 m above ground within the 20 m x 50 m plot;

- The percentage of regenerating canopy species within the vegetation zone; and
- The total length in metres of fallen logs over 10 cm in diameter within the 20 m x 50 m plot.

Table 4.1 provides the number of plots completed by Cumberland Ecology within each stratification unit.

Table 4.1 Plots required and completed per stratification unit[10] (Cumberland Ecology 2019)

Stratification Unit	Study Area (ha)	Number of Plots	
		Required[11]	Completed
Dry Sclerophyll Forests (Shrub/grass sub-formation)	298.75	6	19
Forested Wetlands	5.88	3	4
Rainforest	2.42	2	2
Wet Sclerophyll Forests (Grassy sub-formation)	130.48	6	7
Total	**440.53**	**17**	**30**

Subsequent BAM plot surveys performed in accordance with OEH (2017) were completed by RPS on 17 October 2018, 24-25 October 2018, 30-31 October 2018, 1 November 2018, 7-9 November 2018. A total of 28 BAM plots were collected from within the subject site as shown in **Figure 4.1**. **Table 4.2** provides the number of plots completed by RPS within each stratification unit.

Table 4.2 Plots required and completed per stratification unit[12] (RPS)

Stratification Unit	Study Area (ha)	Number of Plots	
		Required[11]	Completed
Dry Sclerophyll Forests (Shrub/grass sub-formation)	276.63	7	17
Forested Wetlands	5.65	3	0
Rainforest	2.42	2	0
Wet Sclerophyll Forests (Grassy sub-formation)	149.30	6	11
Total	**437.00**	**18**	**28**

4.2.1.2.2 Rapid Data Points (RDPs)

A total of 888 Rapid Data Points (RDPs) were sampled every 100 m along the winter transect survey as shown in **Figure 4.2**. Data collected at each RDP used to map various important habitat features includes:

- Tree species presence within a 10 m radius of the RDP including OEH (2017) diameter at breast height (DBH) classes;
- Weed cover (measured as projected foliage cover);
- Hollow-bearing tree count; and
- Fallen log length.

The hollow-bearing tree count and fallen log length recorded at each RDP represents observations made in the preceding 100 m transect (i.e. distance traversed between two RDPs) for an effective sampling area of ~1,000 m^2 (i.e. visual 10 m wide swathe achieved between two observers for the traversed distance).

[10] Refers to Cumberland Ecology (2019) vegetation mapping that predates RPS revised mapping

[11] BBAM (OEH 2014)

[12] Revised vegetation mapping prepared by RPS subsequent to additional analysis of Cumberland Ecology (2019) preliminary mapping

TITLE : FIGURE 4.1: BAM SURVEY LOCATIONS WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.01 BAM survey locations within SS (RPS) B A3 20191205.mxd

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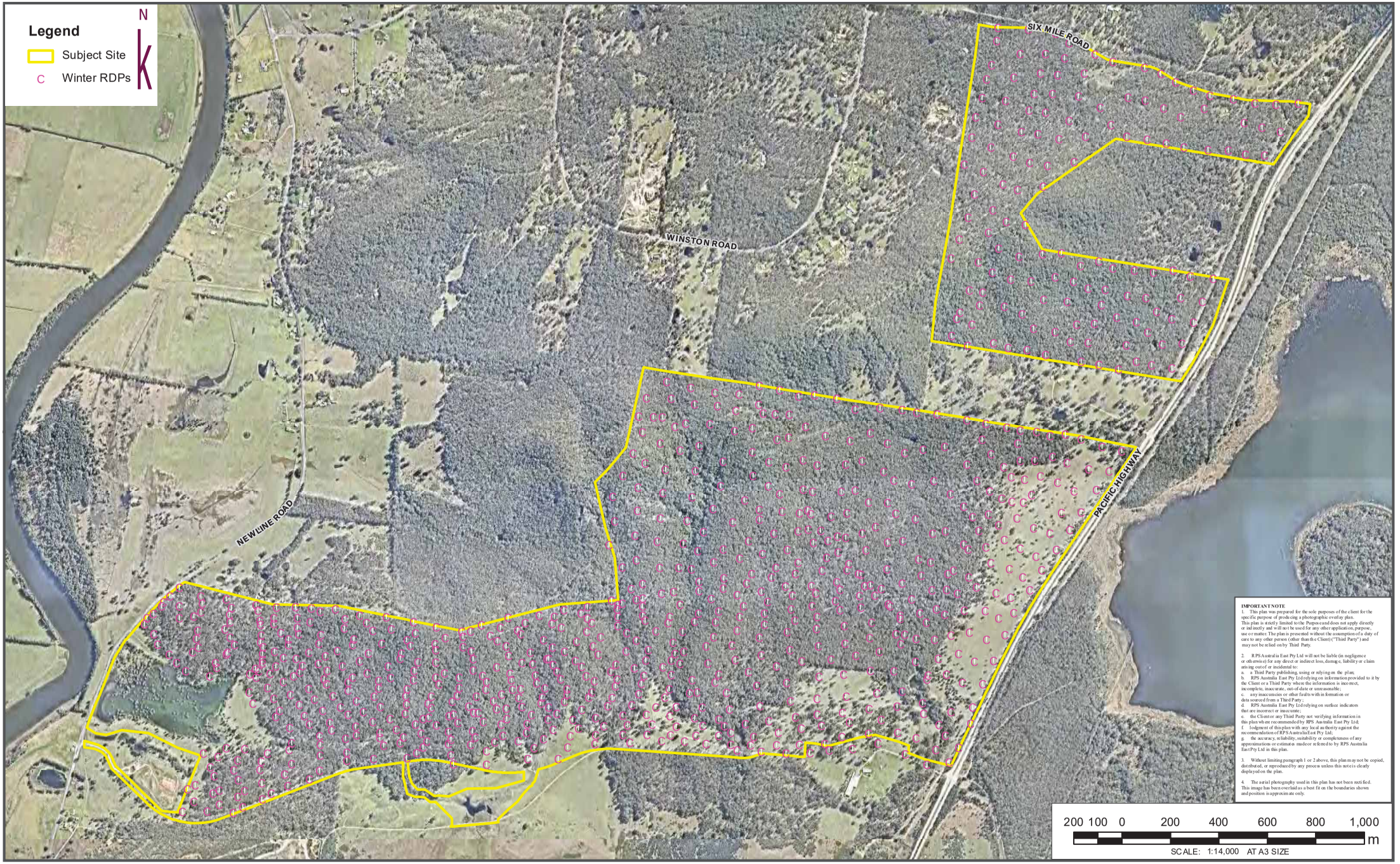

TITLE : FIGURE 4.2: RAPID DATA POINTS (RDPS) WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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4.2.1.2.3 Tree Canopy Nearest Neighbour Survey

RPS performed a survey of tree canopy species across the subject site in February 2019 using a systematic grid as shown in **Figure 4.3**. Nearest neighbour tree data was obtained at each sample location included the identity of 30 trees that are > 0.2 m dbh. The dataset comprised the central tree (i.e. tree 1) and the surrounding 29 trees. The distance from tree 1 to each surrounding tree was estimated. The data was collected to assist with the modelling of foliar nutrient value and vegetation mapping.

4.2.1.2.4 Tree Species Modelling

Kriging, a geostatistical interpolation method based on statistical models that include autocorrelation (i.e. the statistical relationships among the measured points) was used to map tree species across the subject site. Compositional data includes the RDP obtained during winter 2018 (see **Section 4.2.1.2.2**) and tree canopy nearest neighbour survey (see Section **4.2.1.2.3**). The purpose of this interpolation is to model the distribution of certain tree species independent of vegetation boundary mapping to explore variation in habitat for species reliant on certain tree species [e.g. Koala (OEH 2018), Grey-headed Flying-fox (Eby and Law 2008)], habitat features (e.g. hollows and logs for Brush-tailed Phascogale), forest maturity (e.g. large forest owls and other hollow-dependent birds) or habitat roughness (e.g. scansorial species such as the Brush-tailed Phascogale and Varied Sittella).

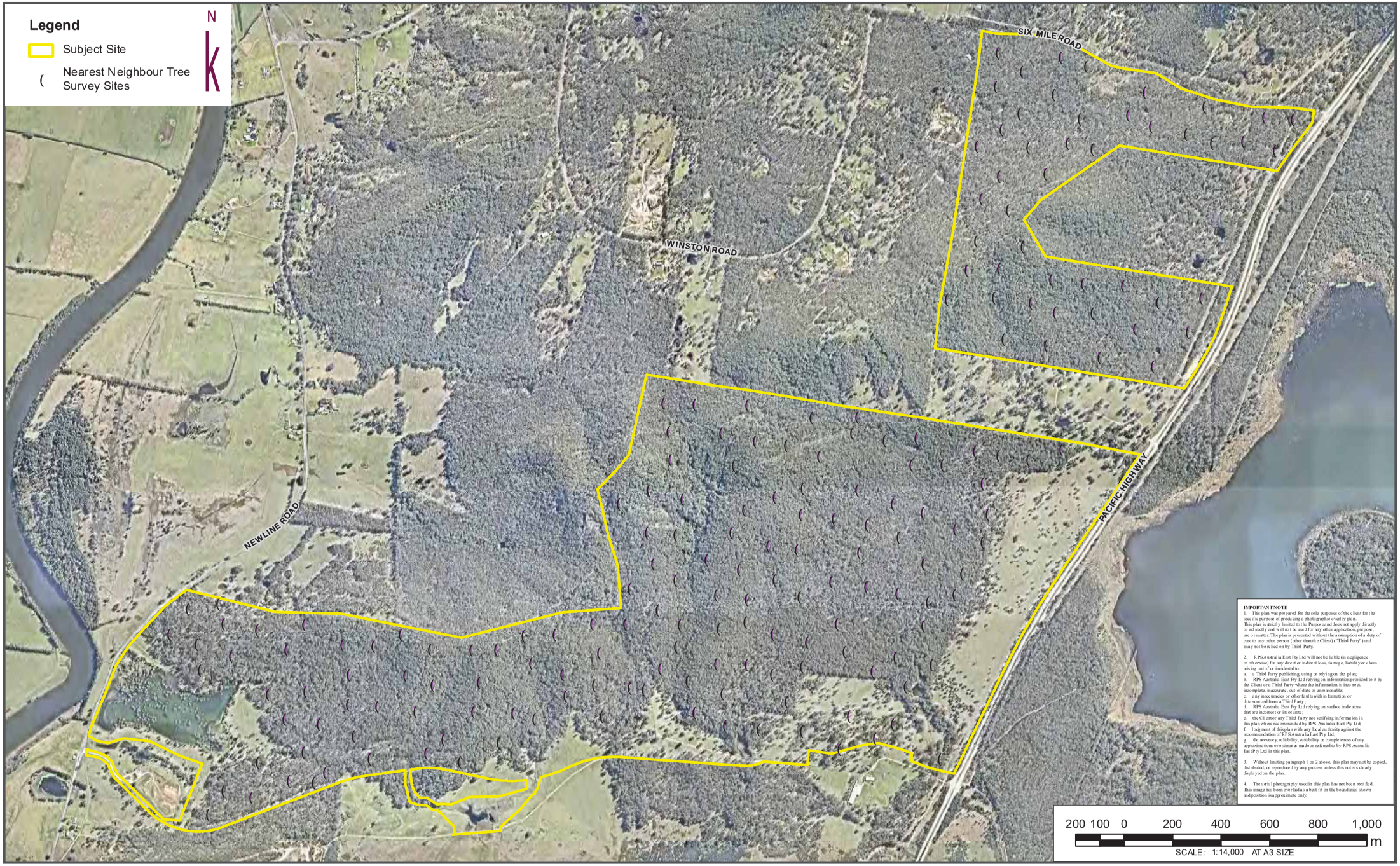
Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. The Kriging tool fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. Kriging is a multistep process; it includes exploratory statistical analysis of the data, variogram modelling, creating the surface, and (optionally) exploring a variance surface. Kriging was performed in ArcGIS 10.6.1 using the following properties:

- Method: Ordinary
- Semivariogram model: Spherical
- Advanced parameters
  - Lag size:60
  - Major Range: 150
  - Partial Sill: 0.8
  - Nugget: 0.2
- Output cell: 10m
- Search radius: 120m
- Search radius settings:
  - Number of points: 8
  - Maximum distance: unspecified

The resultant raster was ‘snapped’ to a standard grid for ease of handling in the raster calculator. Multi-species distribution models were built using the raster calculator. A ‘total native vegetation cover’ polygon, as derived from the PCT mapping, was used as a mask to constrain the modelling to the subject site.

4.2.1.2.5 Preferred Koala Feed Tree Survey

BioLink (2019a) recommended the completion of a stadia-metric survey of preferred koala feed trees (PKFTs) ≥ 300 mm DBH within the Proposal impact footprint to better understand the impacts on koalas within the subject site. PKFTs are defined by BioLink (2019a) as *Eucalyptus tereticornis*, *Eucalyptus moluccana*, *Eucalyptus punctata*, *Eucalyptus propinqua* and *Eucalyptus microcorys*. This survey was performed using DBH tapes and hand held GPS to record locations. Data duplicates were obtained through species and location records on written data sheets.



TITLE : FIGURE 4.3: TREE CANOPY NEAREST NEIGHBOUR SURVEY WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.03 Tree Canopy Nearest Neighbour Survey within SS B A3 20191205.mxd

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4.2.1.3 Targeted Threatened Flora Surveys

Targeted surveys for threatened flora species were conducted as follows:

- Cumberland Ecology (**Appendix F**): 23-25 January 2017 and 16-17 and 23-24 August 2018 ; and
- RPS: 27-31 August 2018, 3-7 September 2018, 8-12 and 31 October 2018, 1-2 November 2018 and 14, 17-18 and 23 October 2019.

Surveys performed by Cumberland Ecology were completed by two observers who conducted a 30 minute random meander within a stratification unit (habitat type), as per the Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities Working Draft (DEC 2004). A total of 22 random meanders were completed across the study area and recorded using a hand held GPS unit. Two observers walked approximately 5m apart for the duration of the 30 minute search and any threatened plants identified were recorded. The locations of the random meander transects performed are shown in **Appendix F**.

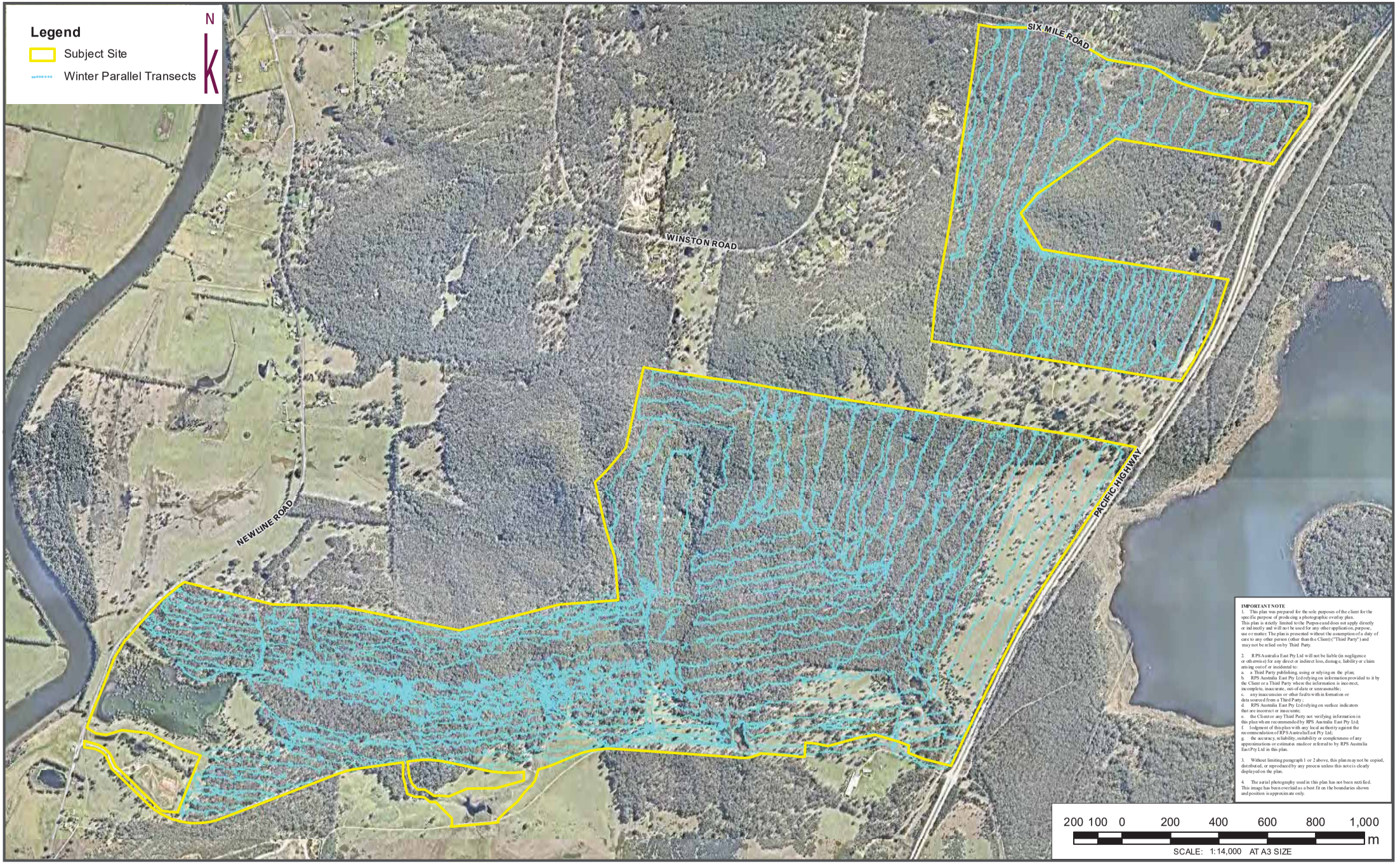
A systematic threatened flora survey was performed in winter 2018 (**Figure 4.4**), followed by targeted threatened flora surveys performed in the following spring (**Figure 4.5**) and summer (**Figure 4.6**) seasons using the parallel transect method (OEH 2016a). Threatened species requiring seasonally appropriate surveys include the following:

- *Corybas dowlingii* (Red Helmet Orchid);
- *Cymbidium canaliculatum* (Tiger Orchid);
- *Dendrobium melaleucaphilum* (Spider Orchid);
- *Diuris pedunculata* (Small Snake Orchid);
- *Diuris praecox* (Rough Doubletail);
- *Genoplesium baueri* (Bauer's Midge Orchid); and
- *Pterostylis chaetophora.*

The comprehensive systematic sampling design used in the winter 2018 survey (see **Figure 4.4**) covered the entirety of the subject site and was considered adequate for surveying *Grevillea parviflora* subsp. *parviflora* (which is not considered as likely to occur as it is not known to occur in Seaham Spotted Gum Ironbark), Red Helmet Orchid, Tiger Orchid, Spider Orchid, Small Snake Orchid and Rough Doubletail.

Stratification units were developed for the targeted surveys of ground orchids (i.e. *Pterostylis chaetophora*) in the October – November flowering period (surveys performed in 2018 and 2019). These stratification units were delineated from the literature [i.e. grassy forests with melaleuca midstorey as indicated by the habitat profile provided by the Threatened Species Profile Database (OEH 2019b), habitat description for this species as provided in the OEH CERs and habitat conditions observed at the nearby Ferrodale 'reference site' located approximately 1 km to the northeast of the subject site]. The stratified survey was performed within vegetation described as Seaham Spotted Gum Ironbark (MU 16).

Surveys performed in late November and early December (2019) to map preferred Koala feed trees (see **Section 4.2.1.2.5**) were used to simultaneously search for threatened flora known to flower at that time of year (e.g. *Cryptostylis hunteriana*), notwithstanding the nil likelihood of this species occurring within the subject site [i.e. *Cryptostylis hunteriana* is not likely to occur in Seaham Spotted Gum Ironbark Forest (Bell 2017)]



TITLE : FIGURE 4.4: SYSTEMATIC THREATENED FLORA SURVEY (WINTER 2018) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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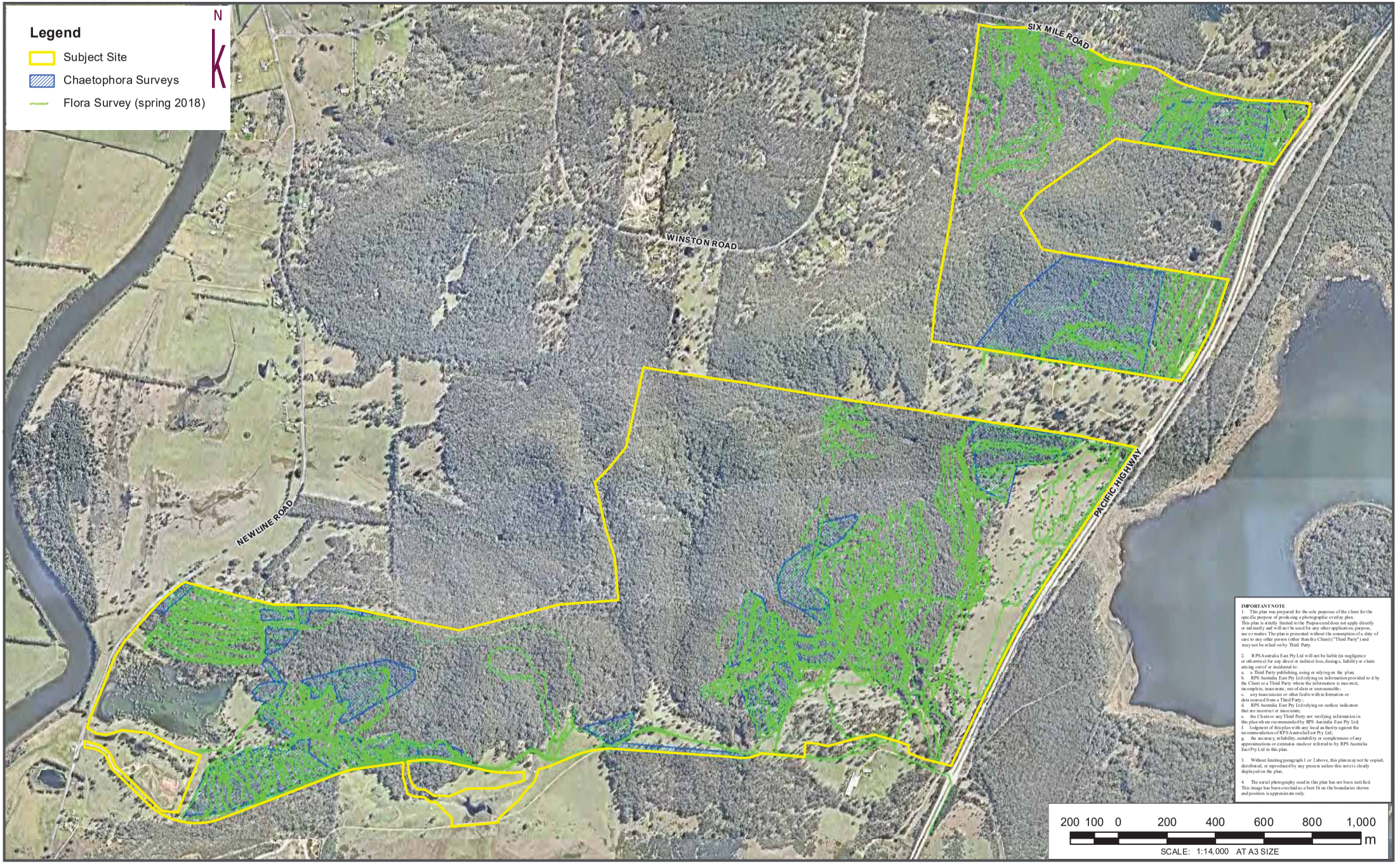

TITLE : FIGURE 4.5: TARGETED THREATENED FLORA SURVEY (SPRING 2018) WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.05 Targeted Th Flora Survey (spring 2018) within SS Map A A3 20191205.mxd

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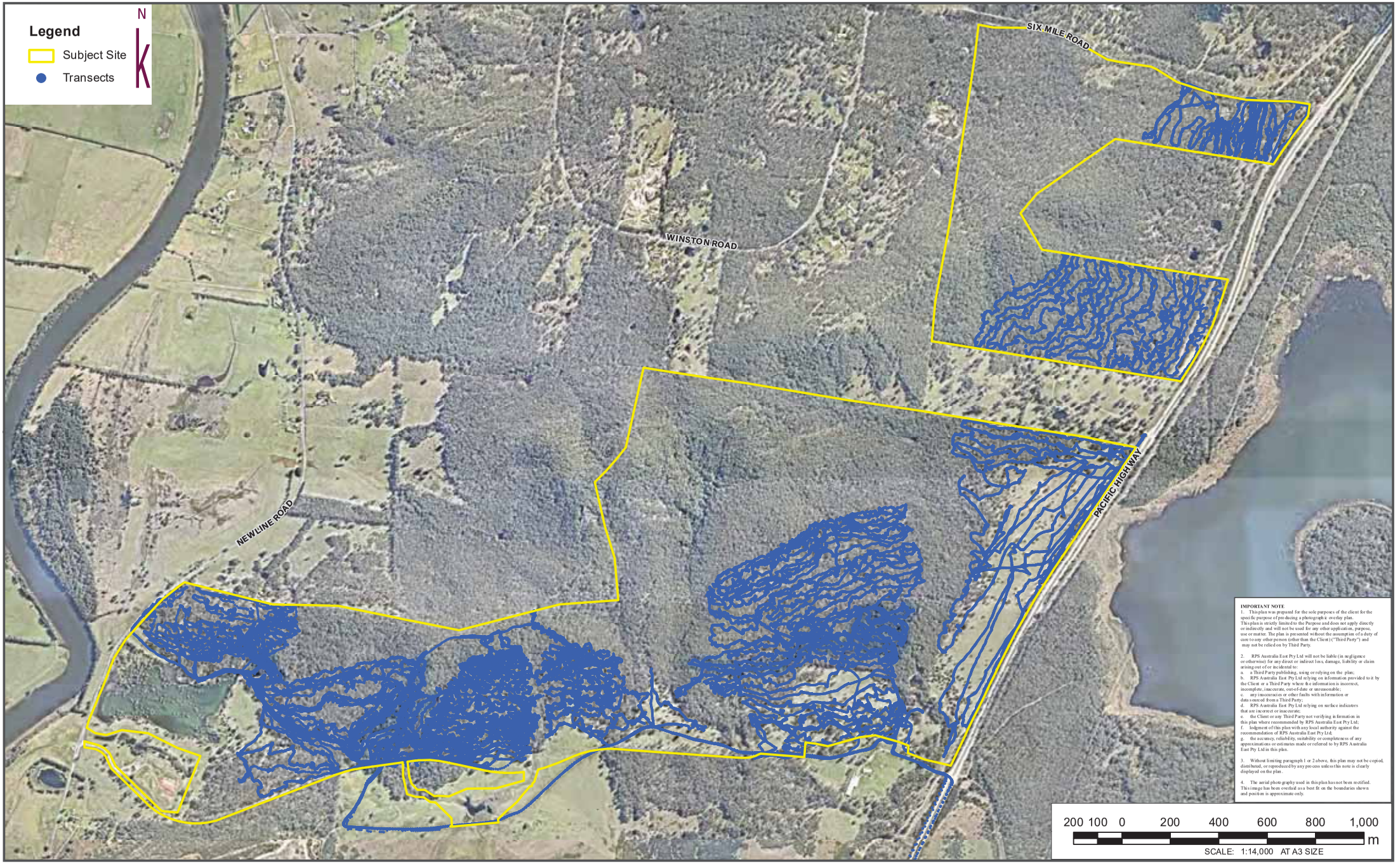

TITLE : FIGURE 4.6: TARGETED THREATENED FLORA SURVEY (SUMMER 2019) WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/02/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (james.hugo)

PATH: \\nfile1\Data\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.06 Targeted Th Flora Survey (summer 2019) within SS C A3 20200227.mxd

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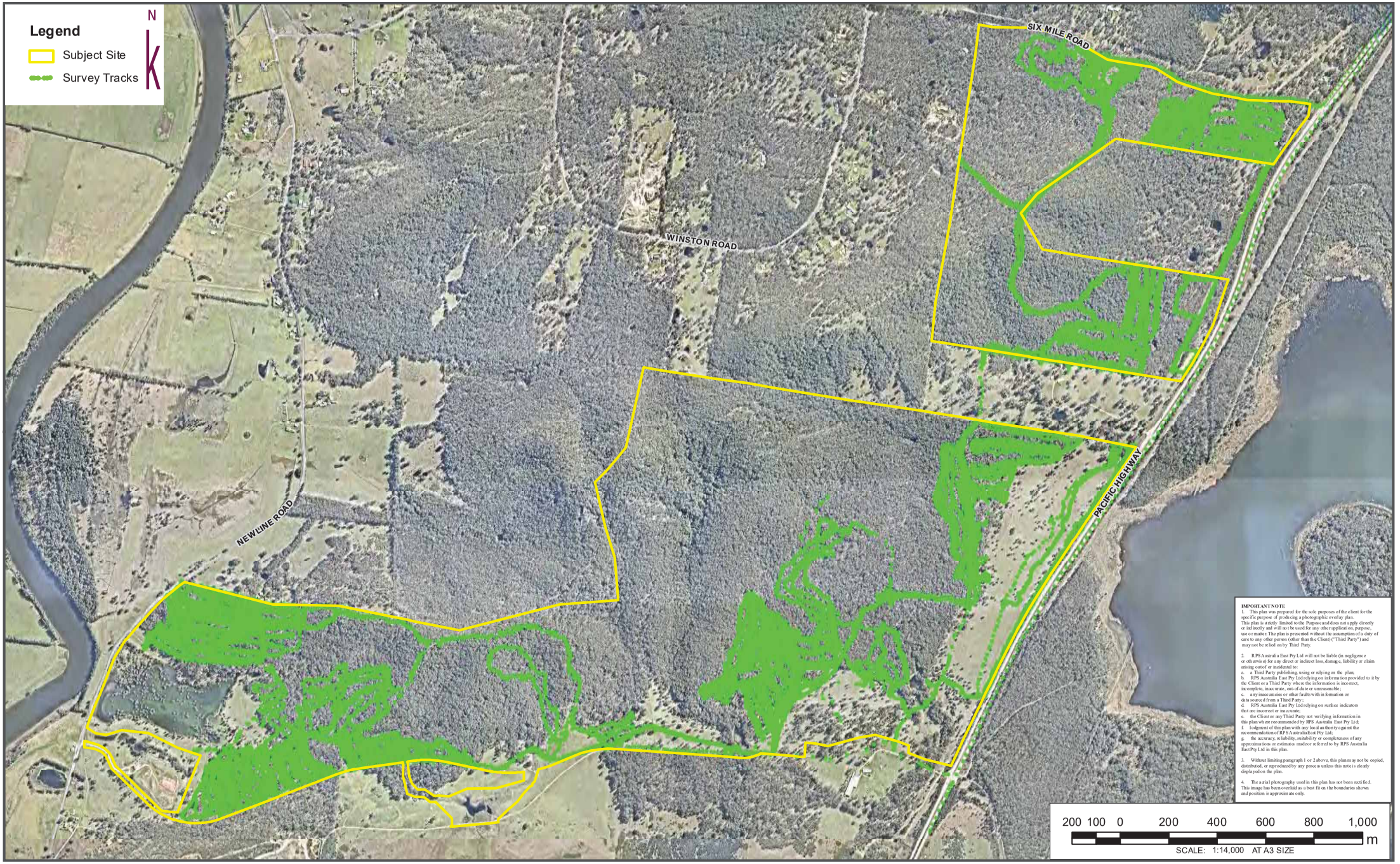

TITLE : FIGURE 4.7: TARGETED THREATENED FLORA SURVEY (SPRING 2019) WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.07 Targeted Th Flora Survey (spring 2019) within SS B A3 20191205.mxd

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4.2.1.4 Fauna Survey

4.2.1.4.1 Habitat assessment

The nature and extent of fauna habitats within the study area was systematically assessed during the winter 2018 parallel transect survey (**Figure 4.4**). Site assessments for threatened and native fauna included consideration of important indicators of habitat condition and complexity including the occurrence of microhabitats such as tree hollows, fallen logs, bushrock, caves and crevices, manmade structures, riparian areas, wetlands and water bodies. The structural complexity of vegetation, the age structure of the woodland and the nature and extent of human disturbance throughout the study area was also described. Structural features considered included the extent and nature of the understorey and ground stratum, extent of canopy and flowering characteristics of flora. Indirect indicators of fauna use of the site such as droppings, diggings, footprints, scratches, nests, burrow paths and runways were recorded.

4.2.1.4.2 Ground and arboreal mammal surveys

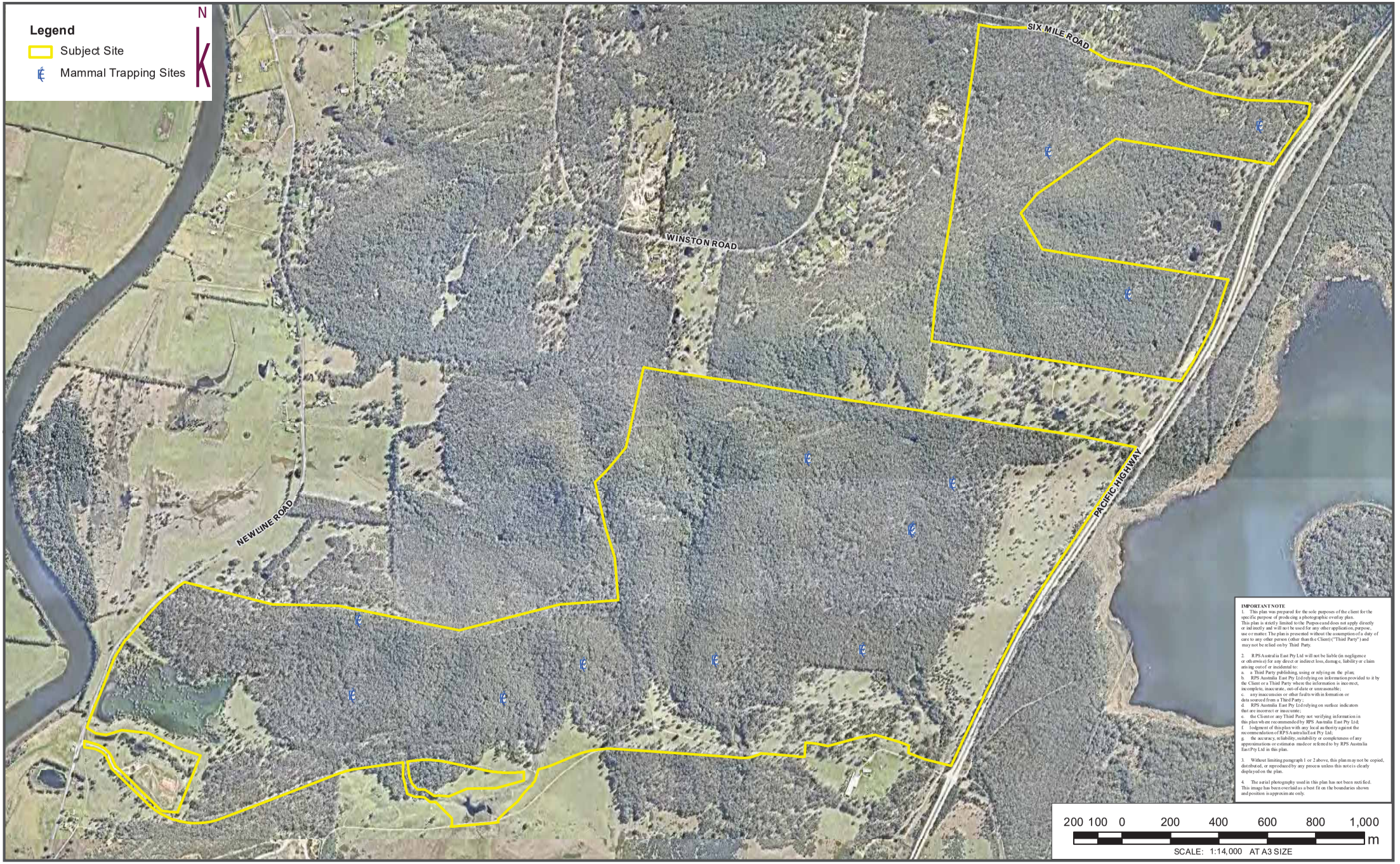
Cumberland Ecology

Trapping was used to detect arboreal and terrestrial fauna occurring within the study area, utilising a trap line of 10 arboreal Elliot B traps and 10 terrestrial hair tubes. Hair tubes were used instead of Elliot A traps. The arboreal and terrestrial traps were set approximately 10 m apart depending on available habitat. Arboreal traps were placed on platforms attached to habitat trees at a height of approximately two metres. Terrestrial hair tubes were placed in association with the arboreal traps, in areas with suitable habitat cover (under logs, shrubs and close to bush rock) and hammered into place with tent pegs.

In addition to the four trap lines, a total of five hair tube transects were set up over 15 nights in January 2017. Twenty hair tubes were set up at each transect, 10 arboreal and 10 terrestrial, spaced approximately 10 m apart. One additional hair tube line was also set up with only 10 arboreal hair tubes (Hair tube line H6), spaced approximately 10 m apart. Arboreal hair tubes were attached to suitable habitat trees at a height of approximately two metres. Terrestrial hair tubes were placed on the ground in areas providing some habitat cover, such as under logs, shrubs and rocks. All hair tubes were baited with a mixture of peanut butter, honey and rolled oats. The location of trapping surveys performed by Cumberland Ecology is provided in **Appendix F**.

RPS

Ground trap lines comprised 20 Elliott A and 10 Elliott B traps. Arboreal traps were co-located with the ground traplines and comprised at least six arboreal Elliot B traps. Ground traps were separated by 5 to 10 m with arboreal traps being separated by 10-20 m. The overall length of the trapline was approximately 100 m. Arboreal traps were placed on platforms attached to habitat trees at a height of approximately two to three metres. Honey water was allied daily to the trunks. Both arboreal and terrestrial traps were baited with a mixture of peanut butter, honey and rolled oats. Arboreal traps were checked each morning, within 2 hours of sunrise. Any fauna captured was identified and then released, and the bait replaced. The locations of the trap line transects are shown on **Figure 4.8**.



TITLE : FIGURE 4.8: MAMMAL TRAPPING LOCATIONS WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.08 Mannual Trap locations within SS_RPS B A3 20191205.mxd

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4.2.1.4.3 Infra-red cameras

Cumberland Ecology

Fourteen Infra-Red (IR) cameras were set up near likely foraging areas over 15 nights in January 2017. One camera was placed at each of the trap lines, four cameras were arboreal and the remaining six IR cameras were terrestrial and placed across the study area in areas of suitable habitat. The four IR cameras placed at the trap lines and six terrestrial IR cameras were placed on trees near suitable habitat and angled towards the ground, where bait (consisting of a mixture of peanut butter, honey and rolled oats) was buried to attract fauna species. The arboreal IR cameras were placed in suitable habitat trees, at a height of approximately two metres, and at a distance of at least one metre from a bait station. The bait station consisted of a hamster feeder attached to the tree at a height of approximately two metres and filled with a mixture of honey and water. IR camera trap locations installed by Cumberland Ecology is provided in **Appendix F**.

RPS

Six IR cameras were installed in multiple survey periods from October 2018 to March 2019. Cameras were placed facing a habitat feature of interest with baits placed within the centre of the cameras field of view. Oily tuna baits were applied in all circumstances. Most cameras were established facing the base of a Grey Gum tree to increase the chances of detecting Koala activity. IR camera trap locations installed by RPS are shown in **Figure 4.8**.

4.2.1.4.4 Koala Spot Assessment Technique (SAT) surveys

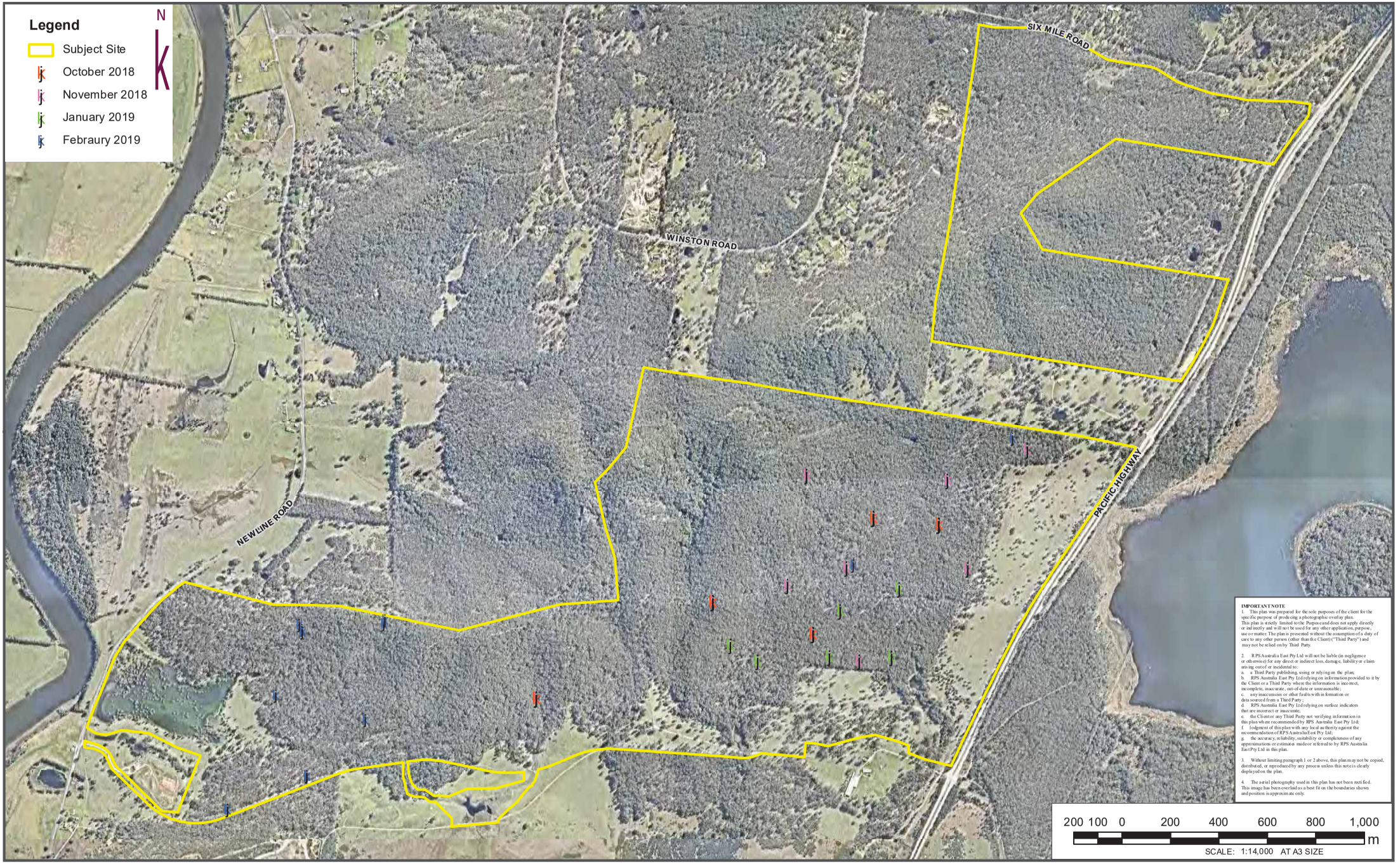
The Koala Spot Assessment Technique (SAT) methodology was carried out as outlined in Phillips and Callaghan (2011). A 500 m sampling grid was established over the study area with a total of 21 SAT sites surveyed (BioLink 2019a; **Appendix G**). Field assessments performed at each SAT survey site included:

- the selection and sampling of a central mature Koala feed tree (or another species if none present);
- Sampling of up to 29 of the trees nearest the central tree for a total of 30 trees;
- At each SAT survey site, a maximum of two person minutes was spent searching for faecal pellets (scats) within a one metre radius of the base of each selected tree. Searching ceased if a Koala faecal pellet was located before this time expired.
- Searching for faecal pellets involved an initial inspection of the ground surface followed by a robust disturbance (raking) of the leaf litter if necessary to search for faecal pellets.
- The species of each tree searched was recorded along with presence/absence of Koala faecal pellets. Notes were made on whether the scats were fresh or old and a photograph and/or sample was taken.

Area searches for the Koala were also undertaken at each of the SAT survey sites, irrespective of results of the faecal pellet searches. At each of the SAT survey sites, a five minute visual inspection of trees was conducted within a 25 m radius of the central tree. Any individual Koalas present during this inspection were recorded. The location of SAT surveys is provided in **Appendix F** and **Appendix G**.

4.2.1.4.5 Koala and Spotted-tailed Quoll Detection Dog Surveys and DNA Analysis (OWAD, 2019)

A systematic unbiased sampling design was applied and deemed appropriate for this site to allow rapid assessment across the site whilst enabling relatively homogenous geographic coverage of the site. The site was divided into 64 sampling cells each of 6.25ha, being 250m x 250m or equivalent surface area (see **Figure 4.10**).



TITLE : FIGURE 4.9: INFRA-RED CAMERA TRAP LOCATIONS WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.09 IR Camera Trap locations within SS RPS B A3 20191205.mxd

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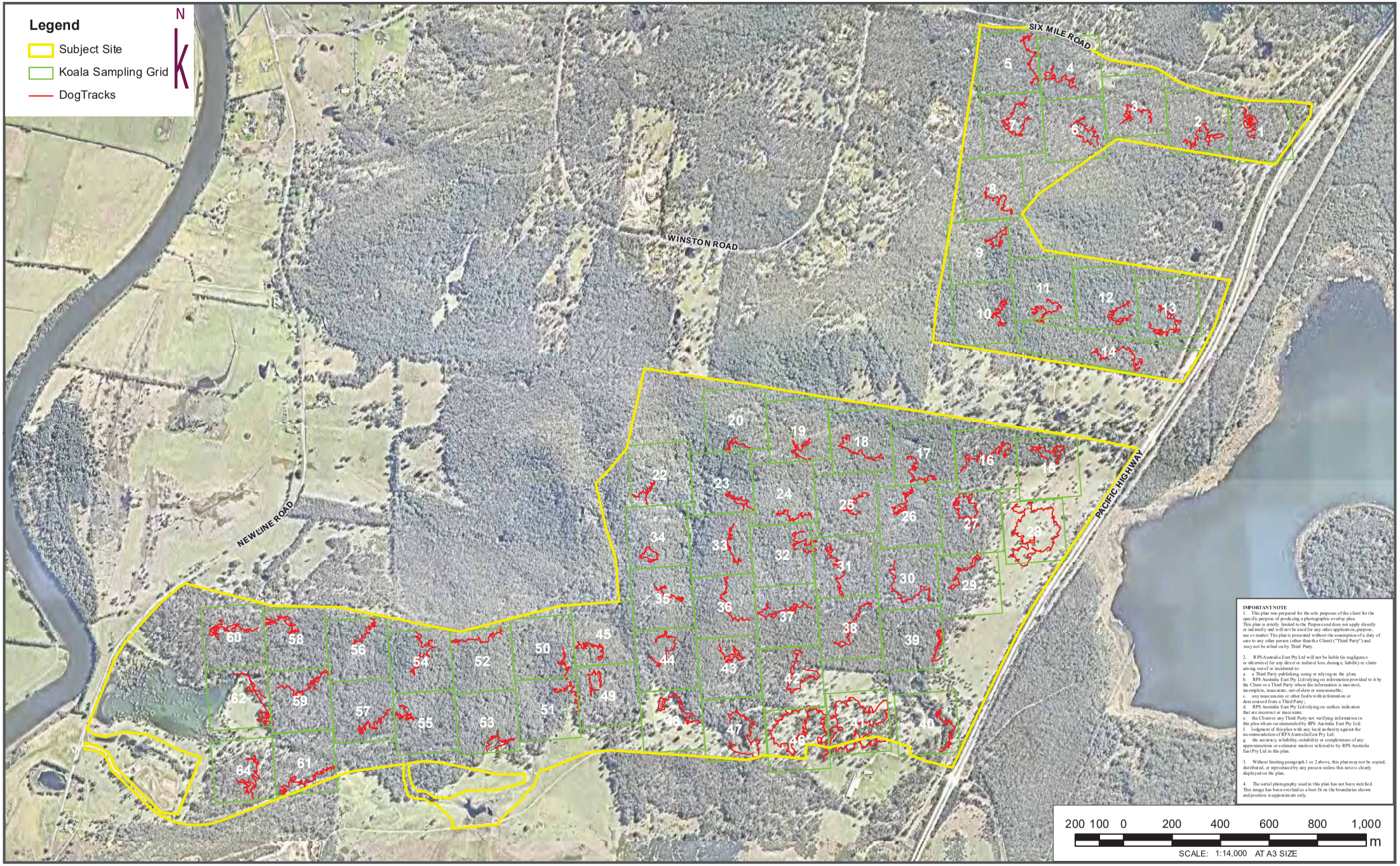

TITLE : FIGURE 4.10:KOALA AND SPOTTED-TAIL QUOLL DETECTION DOG SURVEYS WITHIN THE SUBJECT SITE (OWAD)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.10 Koala_Spotted-tail Quoll_Dog Surveys within SS (OWAD) B A3 20191205.mxd

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One search (by a dog and handler) was performed within each sampling cell. Each search was time-based, allowing five minutes of 'active search time' by the detection dog in each cell. A chronometer was started when the dog was prompted to search; was stopped if/when the dog indicated, allowing for the survey team to assess the scats and enter field data; and the chronometer was resumed when the handler prompted the dog to continue searching, until the five minute time limit was reached.

A second survey was performed at selected sites in the Port Stephens LGA in July 2019 to obtain faecal material for a genetic study. The genetic study was performed to examine for genetic clustering within the local area to inform the definition of local population. Sites investigated include a registered BioBank at Karuah (owned by Port Stephens Council), Boomerang Park, Soldiers Point (Stoney Creek Reserve), Mambo Wetlands and Grahamstown Dan west (Hunter Water Corporation).

Koala scats identified as having potential for DNA analysis were assessed in the field and, if deemed potentially viable for analysis, were collected by placement in a specialised collection kit. The scats were collected following the methods described by Wedrowicz *et al* (2013). Each collection kit was labelled with the following information:

- A unique sample code;
- Site identification and date collected;
- Name of entity collecting the sample (OWAD Environment); and
- Coordinates (UTM zone 56 format).

At completion of the field survey, the samples were carefully packed in a cardboard parcel with desiccant sachets, and posted to the laboratory via overnight postage. Samples were tested for DNA isolation and quality control. Those that passed this process were subject to genetic analysis including the following tests:

- Gender
- DNA profiling
- Pathogen detection

A detailed description of the methods and analysis applied is provided in OWAD (2019a) and OWAD (2019b) (**Appendix H**).

4.2.1.4.6 Nutritional analysis of eucalypt leaves

In consultation with Associate Professor Robert Clark, from the Australian National University Statistical Consulting Unit, ANU designed a survey approach to cover as much area as possible to account for within and between tree species variability. This was done to look at the quality of forage across the site and compare the transects and site as a whole to existing data on forage quality across all the koala feed trees. Sampling was stratified to include polygons with and without koala scat detected by dogs to investigate whether there was a relationship between forage quality and koala scat observations.

Nine 250m transects were established. Trees were sampled in clumps of four, with each clump spaced approximately 80m apart, resulting in a total of 16 trees per transect. Studies have shown that the genetics of a tree strongly influences the chemical composition of its leaves, and that eucalypt trees of the same species are less likely to be related to each other if they are at least 60 m apart (Andrew *et al.* 2007). Thus, distance between sampled clumps was an important consideration for the sampling design of our study. We only sampled eucalypt tree species that were from a list of koala food trees developed for a separate foliage quality project.

At the beginning of each transect, the tree closest to the initial GPS point with a DBH of at least 10 cm was chosen as the central tree in the first clump. That tree and its three nearest neighbours of any species that fit the same criteria were also sampled.

Each transect crossed two grid cells, as shown in **Figure 4.10**, that either both had koala scat observations from detection dogs or both did not have any scat detected. There were five “koala scats observed” transects and four “no scats observed” transects. Furthermore, transects were stratified so that four were outside the development zone, three were within it, and two were on the edge and crossed the development zone boundary. To ensure that all koala food tree species were sampled, and to maximize site-area coverage, we also spot sampled a further 11 clumps of 4 to 6 trees spaced across the site with a total of 201 trees sampled across 13 species (Marsh and Youngentob 2019; **Appendix I**).

The leaves obtained from the survey were stored in dry ice and sent to the laboratory to measure:

- Total nitrogen;
- Available nitrogen;
- Unsubstituted B-ring flavanones (UBFs); and
- formylated phloroglucinol compounds (FPCs).

A detailed description of the methods performed and sampling locations is provided in **Appendix I** (Marsh and Youngentob 2019).

4.2.1.4.7 Diurnal Bird Census

Cumberland Ecology

A total of 21 diurnal bird census surveys were undertaken during the January 2017 survey period. Surveys were undertaken at each SAT survey site by an ecologist for 30 minutes. Any bird species that were observed or heard calling were recorded and listed in the total species list for the study area. Locations of each bird census point is shown in **Appendix F**.

Biodiversity Conservation Monitoring

To target rare winter birds and record diversity and abundance of avian species across the site, four sample methods were used:

- 3 ha sample areas (stopping rule-based area searches);
- 400m^2 fixed area 20-minute surveys;
- Targeted searches of flowering trees; and
- Active meanders between sample sites.

The winter 2018 bird sampling locations are shown in **Appendix J**.

Due to the scale and complexity of this site a combination 3 ha stopping rule-based area (n=10) was surveyed every day. At the same locations and in conjunction with the above, 400 m^2 quadrats (n=10) were searched for 20 mins; all birds species were recorded and counted. All surveyor movements made between sample points were undertaken on foot, providing active searches between fixed locations across the site and providing opportunities to locate flowering trees.

Birds were surveyed across the study area for six days during the winter of 2018. An additional 4 days of spot sampling were undertaken (also in winter) to target flowering trees. These areas of flowering trees surveyed were sampled on every sample day (10 days). All surveys targeted periods of high bird activity, predominantly between the hours of 6 am - 9 am and 3pm - 6pm and only during suitable weather.

Surveys throughout this period were described as follows:

- 28/07/2018 Targeted searches and survey of flowering trees.
- 29/07/2018 Targeted searches and survey of flowering trees.
- 30/07/2018 Targeted searches and survey of flowering trees. Area, time and meander searches.
- 31/07/2018 Targeted searches and survey of flowering trees. Area, time and meander searches.

- 1/08/2018 Targeted searches and survey of flowering trees. Area, time and meander searches.
- 2/08/2018 Targeted searches and survey of flowering trees. Area, time and meander searches.
- 3/08/2018 Targeted searches and survey of flowering trees. Area, time and meander searches.
- 8/08/2018 Targeted searches and survey of flowering trees.
- 9/08/2018 Targeted searches and survey of flowering trees.
- 10/08/2018 Targeted searches and survey of flowering trees. Area, time and meander searches.

Estimating the area of search

Generally, for smaller patches (<50 ha) one moves freely throughout the patch in every sample period. In comparison, larger patches (>50 ha) can be broken into sub-sets and these sampled as independent (i.e. not overlap samples). In total, ten 3 ha sample areas were established using a mobile GIS application. The surveyor moved around freely looking and listening within the area until the stopping rule is triggered. During this time all species were recorded by ear and unknown species were keyed out on site with the use of a digital recorder.

Stopping rule

A stopping rule in which "surveying was stopped after a minimum of two new (or fewer species) were encountered after the first search of the area" was applied.

Fixed survey duration quadrants

In total 10 fixed area quadrats (400m^2 each) were erected and surveyed on five occasions over a two-week period for a 20 minute survey period at each site (n=10). Surveys were conducted between 0700 and 1000 hours or between 1700 and 1900 hours, windy or rainy days were avoided. Assumptions that needed to be meet included, all birds exactly in the quadrat were detected, that birds did not move before detection, distances are measured accurately, and individual birds are detected independently.

RPS

Bird surveys performed by RPS were generally consistent with the 'fixed survey duration quadrats' method outlined above (BIOCM 2018) with the exception of replication (i.e. three samples at each sample location). The surveys were performed in spring - summer 2018, as shown in **Figure 4.11**, to specifically target species such as the Regent Honeyeater in their breeding period. Timed bird surveys were also performed prior to the stag watching investigations performed in August 2019 (see **Section 4.2.1.4.9** for location details on this survey).

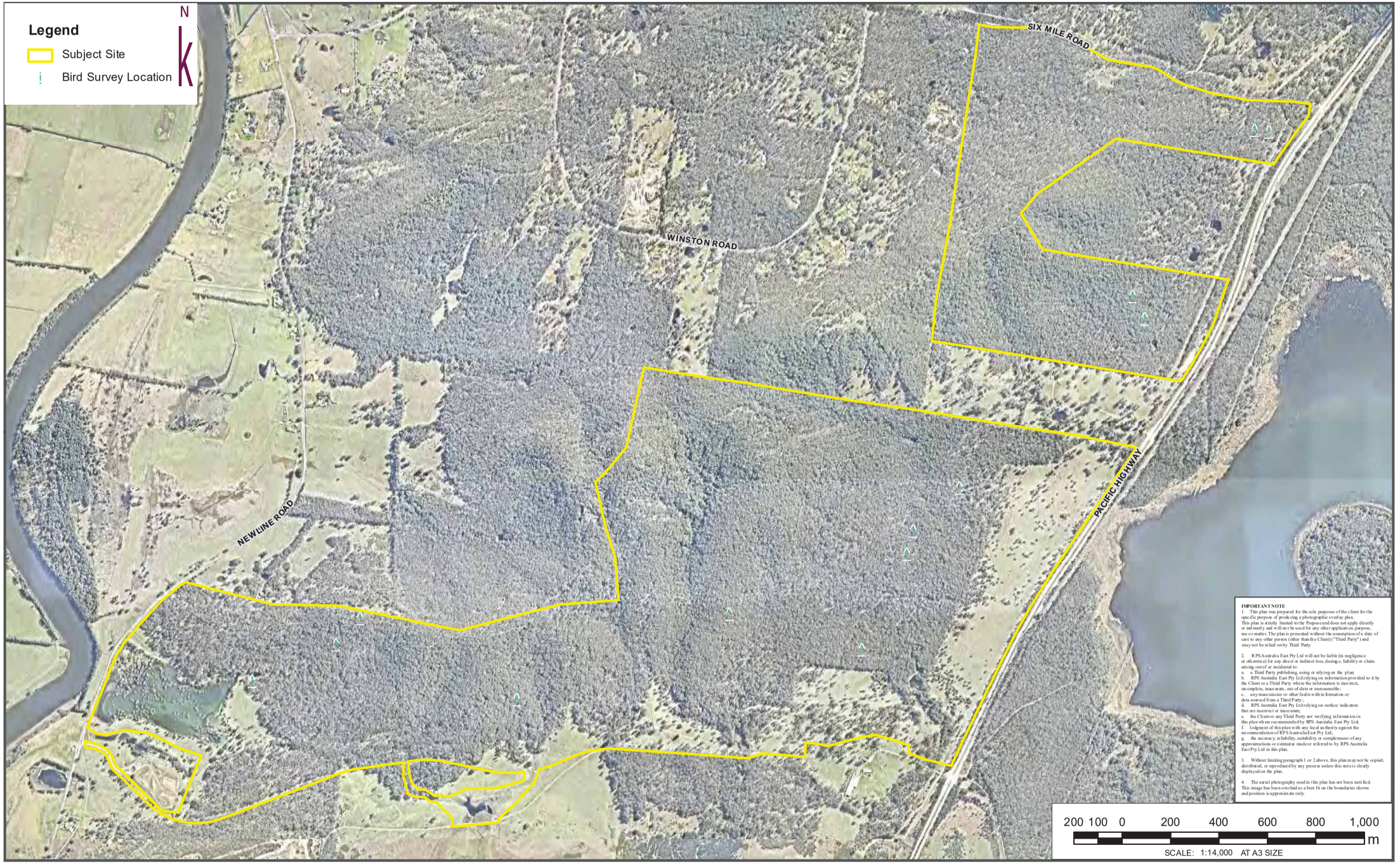
4.2.1.4.8 Microbat survey

Cumberland Ecology

One ANABAT detector and two SM2BAT Songmeters were set up for four nights, between the 9-13 January 2017. Each unit was left at each location for two nights. A further two SM2BAT Songmeters were set up for two nights of survey between the 23-25 January 2017. Units were placed in areas of suitable habitat. Each unit was recording for 12 hours, from dusk to dawn. Harp traps were also set up at each trap line in a suitable flyway. Each harp trap was left for two nights and checked each morning at dawn. The location of these surveys is provided in **Appendix F**.

RPS

Five Anabat II recorders were co-located with IR camera placements, as shown in **Figure 4.8**. Detectors were set to record microbat calls for 2 hrs after sunset for each deployed evening. Detectors were deployed for a minimum of 14 days at the specified locations. The RPS bat sampling locations are shown in **Figure 4.12**.



TITLE : FIGURE 4.11: BIRD CENSUS SURVEY LOCATIONS WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.11 Bird Census Survey Locations within SS (RPS) B A3 20191205.mxd

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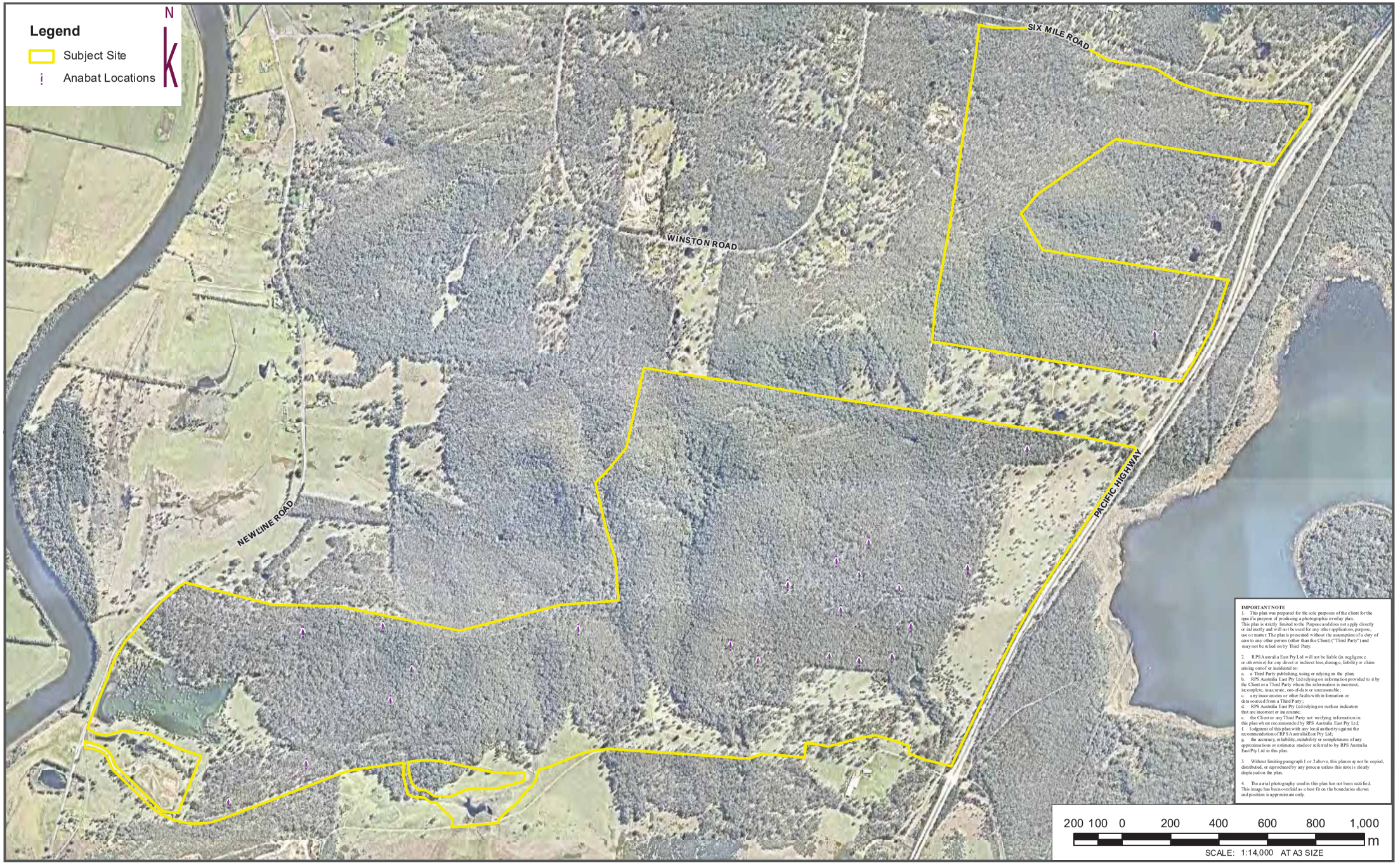

TITLE : FIGURE 4.12: BAT CENSUS SURVEY LOCATIONS WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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4.2.1.4.9 Nocturnal Surveys

Cumberland Ecology

Spotlighting surveys were undertaken over six nights in January 2017, with two ecologists using a high powered torch to search for evidence of nocturnal mammals. A spotlighting transect was completed at each of the trap lines by two ecologists for 30 minutes each. Random meanders were also undertaken throughout the remainder of the study area. Call playback was also undertaken during spotlighting surveys and targeted the following species:

- Powerful Owl;
- Barking Owl;
- Masked Owl;
- Sooty Owl;
- Bush-stone Curlew;
- Squirrel Glider;
- Yellow-bellied Glider;
- Spotted-tailed Quoll; and
- Koala.

The nocturnal sampling performed by Cumberland Ecology is shown in **Appendix F**.

RPS

Spotlighting surveys and call playback survey were performed to target the following species:

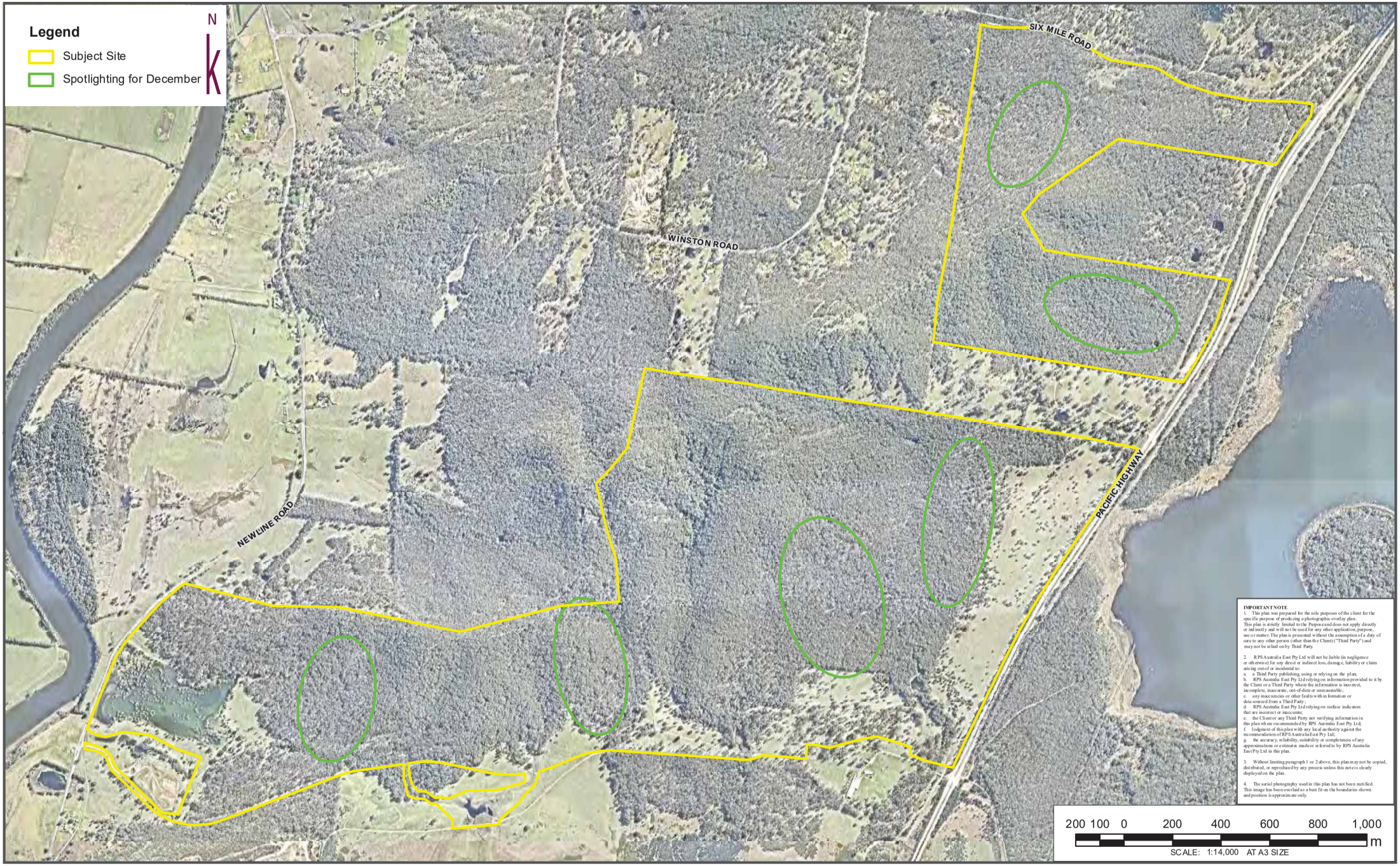
- Powerful Owl;
- Barking Owl;
- Masked Owl;
- Sooty Owl;
- Bush-stone Curlew;
- Squirrel Glider; and
- Koala.

The nocturnal sampling performed by RPS is shown in **Figure 4.13**.

In addition, targeted stag watching surveys were performed for large forest owls in August and September 2019 at selected hollow-bearing trees within the Proposal impact footprint. A tree survey was performed prior to the stag watching to identify trees with potential for owl roosting. Trees with the following characters were selected for this purpose:

- DBH > 80cm; and
- Hollows with openings >20cm.

The location of trees with hollows subject to stag watching is shown in **Figure 4.14**.



TITLE : FIGURE 4.13: NOCTURNAL SURVEY LOCATIONS WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.13 Nocturnal Survey Locations within SS (RPS) B A3 20191205.mxd

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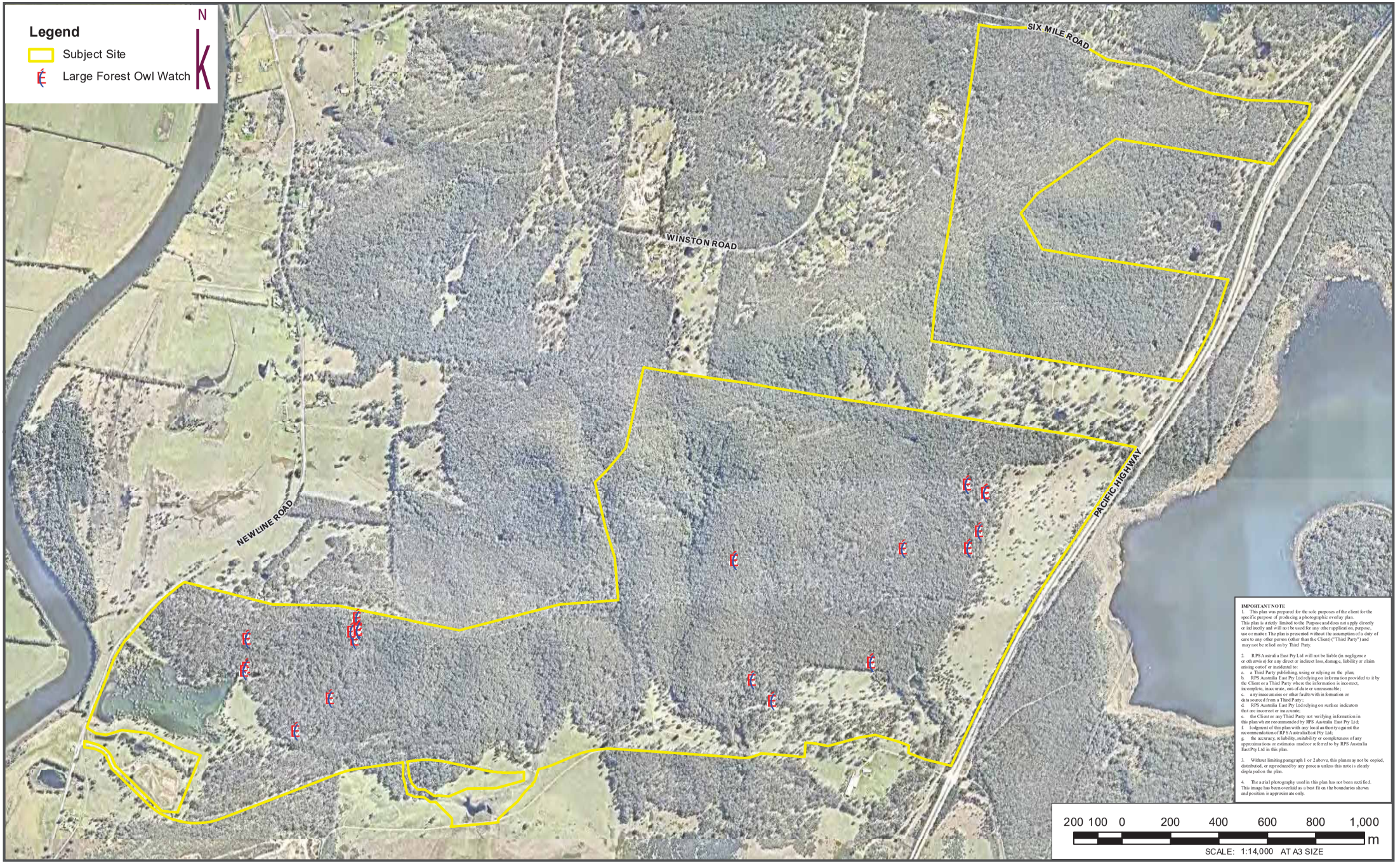

TITLE : FIGURE 4.14: STAG/HOLLOW-BEARING TREE WATCH FOR LARGE FOREST OWLS

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.14 Stag_Hollow-bearing Tree Watch for Large Forest Owls A3 20191205.mxd

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4.2.1.4.10 Amphibians

Cumberland Ecology

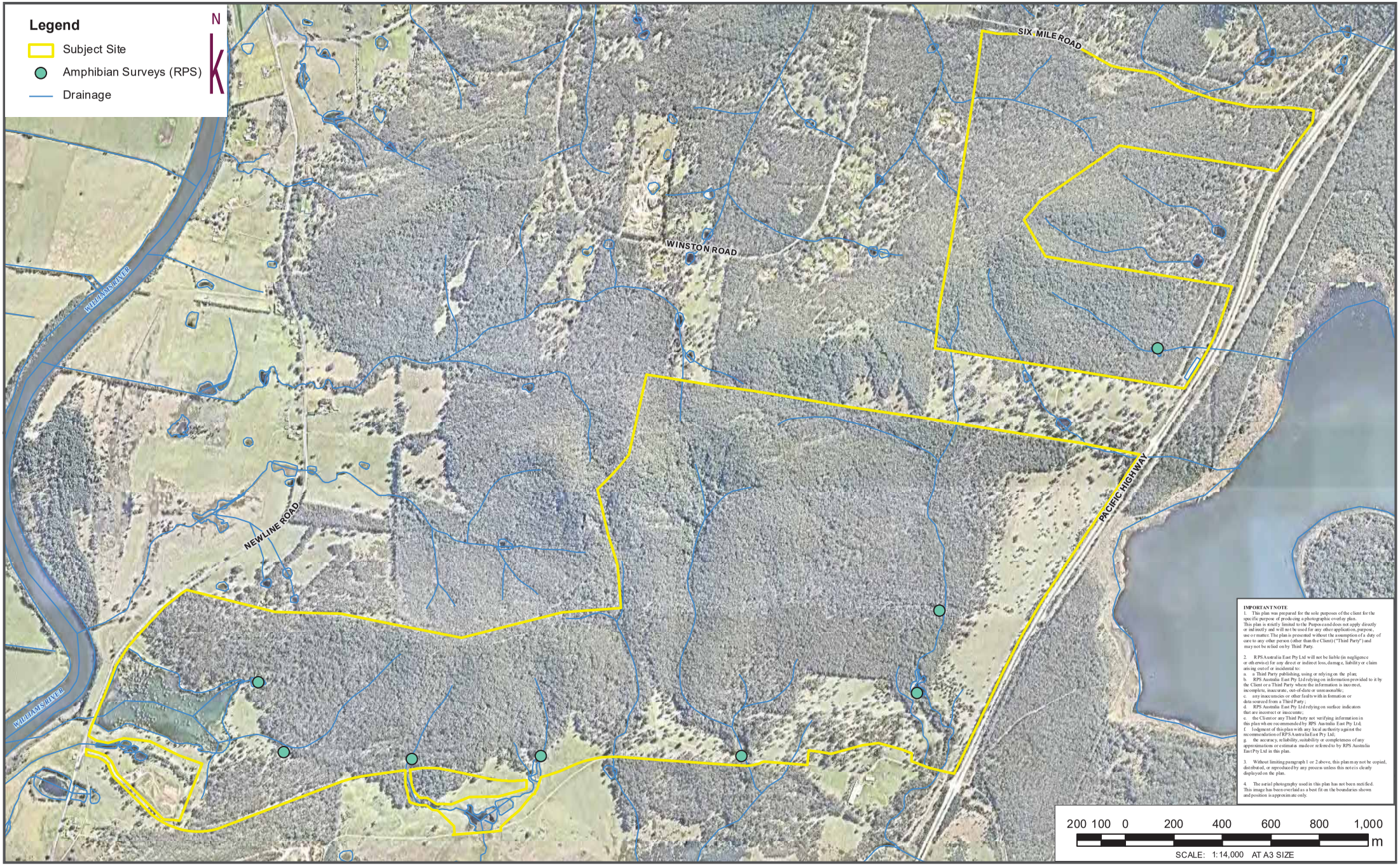
Spotlighting surveys were undertaken over four nights in January 2017 by two ecologists using a high powered torch to search for evidence of the Wallum Froglet and Green and Golden Bell Frog. Surveys were conducted for 30 minutes each at four wetland and dam locations, along the bank and in fringing vegetation. Call playback was undertaken for both species. The amphibian surveys performed by Cumberland Ecology is shown in **Appendix F**.

RPS

Call recognition surveys were conducted for 10-20 minutes each at various locations in the study area as shown in **Figure 4.15**. Surveys were performed after a significant rainfall even in November 2018 to increase the likelihood of detecting cryptic species such as the Green-thighed Frog and Green and Golden Bell Frog. Streamside surveys for stream obligate species were performed for the Giant Barred Frog (*Mixophyes iteratus*) and Southern Barred Frog (*Mixophyes balbus*).

4.2.1.4.11 Incidental observations

Any incidental fauna species that were observed, heard calling, or otherwise detected during the survey periods were recorded and listed in the total species list for the study area.



TITLE : FIGURE 4.15: AMPHIBIAN SURVEY LOCATIONS WITHIN THE SUBJECT SITE (RPS)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **9/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.15 Amphibian Survey Locations within SS (RPS) B A3 20191205.mxd

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4.2.2 Documenting Survey Effort

4.2.2.1 Flora Survey Effort

Flora survey effort as performed by Cumberland Ecology (2019) is summarised in **Appendix F**. Flora survey effort as performed by RPS is summarised in **Table 4.3**.

Table 4.3 Flora survey type, dates and effort (RPS)

Survey Type	Suggested minimum effort	Year	Date	Survey	Person hours	Effective Sample Area
Parallel transects for threatened flora	3x100m traverses per 51-250 hectares of stratification unit (DECC 2004) Seasonal tailored to species detection (e.g. orchids) Parallel transects with 5-10 m separation depending on conditions (OEH 2016a)	2018	27-31 August, 3-7 September, 17-20 September, 5 October, 8-12 October, 17 October, 24-25 October, 30-31 October, 1 and 7-9 November	> 50 transects/ stratification unit	560 person hours	~108.00 ha
		2019	14, 17-18, 23 October	> 50 transects/ stratification unit	64 person hours	~16.00 ha
RDPs	Random meander 30 minutes for each quadrat sampled within the same stratification unit as the quadrat (DECC 2004)	2018	27-31 August, 3-7 September, 17-20 September, 5 October	888 RDPs	260 person hours	27.90 ha
Tree canopy stem survey	Random meander 30 minutes for each quadrat sampled within the same stratification unit as the quadrat (DECC 2004)	2019	11-15 February	12 person days	88 person hours	23.50 ha
Flora/ BBAM/ BAM Plots	1 quadrat per stratification unit <2 hectares 2 quadrats per 2-50 ha of stratification unit 3 quadrats per 51-250 ha of stratification unit 5 quadrats per 251-500 ha of stratification unit 10 quadrats per 501-1000 ha of stratification unit, plus one additional quadrat for each extra 100 ha	2018	17, 24-25, 30-31 October, 1, 7-9 November	28 plots	52 person hours	2.80 ha
		2019	February, May 2019			
PKFT mapping	Complete coverage of impact area (PSC 2002)	2019	25-29 November and 2-6 December	49 person days	420 person hours	212 ha

Cumulatively, it is estimated that a combined total of about 250 ha of direct sampling has occurred within the subject site during the 2018/ 19 survey period representing a direct sample of over half the total native vegetation cover of this area (i.e. ~50% sampling effort). This sampling effort, performed over multiple seasons across two years has been spatially representative and this therefore regarded as spatially and temporally comprehensive.

4.2.2.2 Fauna Survey Effort

Fauna survey effort as performed by Cumberland Ecology (2019) are summarised in **Appendix F**. Fauna survey effort performed by RPS is summarised in **Table 4.4**.

Table 4.4 Fauna survey type, dates and effort

Survey Type	Suggested minimum effort	Year	Date	Time	Units	Total
General surveys and habitat assessment	One hour per stratification unit (amphibians) 30-minute search on two separate days targeting specific habitat per stratification unit (reptiles)	2018	27-31 August, 3-7 September, 17-20 September, 5 October	15 days	4 people	480 person hrs
	Area search (birds) Search habitat for owl pellets and likely hollows (large forest owls and mammals) Search for bat excreta at or near potential habitats (bats)	2019	19 and 21 August 2019	2 days	2 people	30 person hrs
Elliot A traps	100 trap nights over 3-4 consecutive nights (small mammals)	2018	8-12 October (4 sites), 15-19 October (4 sites), 29-31 October and 1-2 November (4 sites)	20 traps over 4 nights/ site	80 traps/ night	960 trap nights
Elliot B traps	24 trap nights over 3-4 consecutive nights (arboreal)	2018	8-12 October (4 sites), 15-19 October (4 sites), 29-31 October and 1-2 November (4 sites)	6 traps over 4 nights/ site	28 traps/ night	336 trap nights
	100 trap nights over 3-4 consecutive nights (terrestrial mammals)	2018	8-12 October (4 sites), 15-19 October (4 sites), 29-31 October and 1-2 November (4 sites)	5 traps over 4 nights/ site	20 traps/ night	240 trap nights
IR Cameras (wire cage substitute)	24 trap nights over 3-4 consecutive nights (wire cage)	2018-2019	25 October – 19 November 2018; 21 December 2018 – 22 February 2019	5 cameras/ night	88 nights	440 trap nights
SAT surveys	SAT per 12.25 ha habitat area	2018 2019	19-26 February (BioLink) 18-19 October (RPS) 3-15 September (BioLink)	30 mins/site	2 people/ 50 sites	50 person hrs
Detection Dog	N/A (timed 5 minutes for 64 X 6.25 ha sites)	2018	18-23 November	5 mins	64 sites	5.3 dog hrs
Diurnal Bird Census	A one-hour census at dawn or dusk, for each identified wetland (birds)	2018	15-19, 29-31 October, 1-2 November	20 mins/site	36 sites	24 person hrs
	A half-hour census at dusk (birds) (stag watching locations)	2019	19, 21, 26-28 August; 11-12 September	30 mins/ site	25 sites	12.5 person hrs
	Area search (birds) repeated on 10 separate days for rare winter birds (BioCM 2018)	2018	28-31 July; 1-3 August; 8-10 August	20 mins/ site	10 sites	33.3 person hrs

Survey Type	Suggested minimum effort	Year	Date	Time	Units	Total
Nocturnal Surveys (Reptiles, amphibians, owls and mammals)	30-minute search on two separate nights targeting specific habitat (reptiles) 30 minutes on two separate nights per stratification unit (amphibians) At least one playback on each of two separate nights (amphibians) Two hours per 200m of water body edge (amphibians) Call playback for large forest owls (4 consecutive nights) 2 x 1 hour and 1km up to 200 hectares of stratification unit, walking at approximately 1km per hour on 2 separate nights (e.g. arboreal mammals and flying foxes)	2018	5 October and 10-14 December	4hrs/ night	3 people/ 4 sites	45 person hrs
Stag Watching	Observing potential roost hollows for 30mins prior to sunset and 60mins following sunset.	2019	19, 21, 26-28 August; 11-12 September	1.5 hrs/ site	25 sites	38 person hrs
Echolocation Recordings (Anabat)	Two sound activated recording devices utilised for the entire night (a minimum of four hours), starting at dusk for two nights	2018-2019	25 October – 19 November 2018; 21 December 2018 – 22 February 2019	5 cameras/ night	88 nights	440 trap nights
Incidental observations	Collection of predator scats for hair analysis 30 minutes searching each relevant habitat, including trees for scratch marks	2018-2019	throughout survey periods			

4.2.2.3 Weather Conditions

Weather conditions during flora and fauna surveys were generally appropriate for detection of a variety of flora and fauna. A summary of weather conditions in the wider locality of the study area during the flora and fauna survey periods is provided in **Table 4.5**.

Table 4.5 Weather Conditions During Surveys

Date	Temperature Min (°C)	Temperature Max (°C)	Rainfall (mm)
27/08/2018	9.9	19.8	13.8
28/08/2018	7.4	21.4	2.6
29/08/2018	3.6	23.5	0.0
30/08/2018	3.2	18.7	0.0
31/08/2018	6.6	20.7	0.0
03/09/2018	8.8	16.6	0.2
04/09/2018	10.7	17.5	25
05/09/2018	10.3	18.7	6.8
06/09/2018	7.7	23.1	1.6
07/09/2018	14.3	19.1	7.2
17/09/2018	6.2	18.2	0.0
18/09/2018	5.2	24.8	0.0
19/09/2018	11.1	29.6	0.0
20/09/2018	9.8	16.2	12
03/10/2018	8.8	23.1	0.0
05/10/2018	10.3	20.9	28.0
06/10/2018	7.7	16.7	37.8
07/10/2018	14.3	18.2	3.0
08/10/2018	13.3	22.8	5.2
09/10/2018	10.6	24.3	0.2
10/10/2018	13.5	20.7	0.0
11/10/2018	13.0	17.6	25.0
12/10/2018	12.4	19.6	2.8
15/10/2018	12.3	22.4	3.6
16/10/2018	16.3	24.8	0.2
17/10/2018	18.3	25.3	4.4
18/10/2018	18.7	27.1	2.6
19/10/2018	16.3	28.9	0.8
23/10/2018	13.2	29.4	0.0
24/10/2018	16.9	21.8	0.0
25/10/2018	15.7	22.1	0.0
29/10/2018	11.8	21.5	0.2
30/10/2018	10.8	28.8	0.0
31/10/2018	17.9	25.2	0.0
01/11/2018	19.0	20.7	0.0
02/11/2018	20.8	24.2	0.0
07/11/2018	20.9	27.3	0.0
08/11/2018	14.9	20.3	18.8
09/11/2018	14.4	21.7	0.0

Date	Temperature Min (°C)	Temperature Max (°C)	Rainfall (mm)
19/11/2018	13.4	28.9	0.0
20/11/2018	12.8	31.2	0.0
21/11/2018	19.9	19.4	0.0
22/11/2018	18.2	23.4	0.0
23/11/2018	16.6	29.4	0.0
10/12/2018	15.9	27.3	0.0
11/12/2018	19.8	23.3	4.2
12/12/2018	18.9	24.6	1.4
13/12/2018	19.9	32.0	0.4
14/12/2018	20.0	27.1	13.4
14/02/2019	17.5	32.7	0.0
12/02/2019	16.5	39.4	0.0
13/02/2019	20.8	26.2	0.0
14/02/2019	20.4	25.9	0.0
15/02/2019	13.1	27.4	0.0
19/08/2019	11.1	18.8	0.0
20/08/2019	6.4	20.8	0.0
26/08/2019	11.4	19.4	0.2
27/08/2019	7.2	19.9	0.0
28/08/2019	8.5	19.7	0.0
11/09/2019	8.7	18.9	0.0
12/09/2019	5.3	27.4	0.0
14/10/2019	7.7	24.1	0.0
17/10/2019	15.0	32.8	0.4
18/10/2019	11.1	22.4	0.0
23/10/2019	11.9	28.7	0.0
25/11/2019	12.1	32.0	0.0
26/11/2019	15.7	37.5	0.0
27/11/2019	11.2	22.7	0.0
28/11/2019	19.8	29.2	0.0
29/11/2019	19.8	29.7	0.0
02/12/2019	15.1	24.6	0.0
03/12/2019	11.3	30.3	0.0
04/12/2019	11.5	33.4	0.0
05/12/2019	12.2	35.3	0.0
06/12/2019	17.6	34.5	0.0
09/12/2019	19.8	29.1	0.0
10/11/2019	17.3	41.9	0.0
11/11/2019	18.1	24.2	0.0

Weather station data was obtained from the two different active stations (Bureau of Meteorology 2019):

- Station 61078 - Williamtown RAAF base for daily maximum and minimum temperatures; and
- Station 61031 - Raymond Terrace (Kinross) for daily rainfall data.

4.2.2.4 Survey Personnel

RPS survey personnel are provided in **Table 4.6**.

Table 4.6 RPS Survey Personnel

Survey Personnel	Role	Contact Details
Mark Aitkens	Principal Ecologist	(02) 4940 4200
Joe May	Ecologist	(02) 4940 4200
Janene Devereux	Senior Ecologist	(02) 4940 4200
Kieran Marshall	Ecologist	(02) 4940 4200
Shelomi Doyle	Ecologist	(02) 4940 4200
Shawn Ryan	Ecologist	(02) 4940 4200
Daniel Watts	Ecologist	(02) 4940 4200
Sam Des Forges	Ecologist	(02) 4940 4200
Alan Midgely	Ecologist	(02) 4940 4200
Hayden Beck	Senior Ecologist	(02) 4940 4200
Rhys Corrigan	Ecologist	(02) 4940 4200
Giorginna Xu	Ecologist	(02) 4940 4200
Dan Creevey	Ecologist	(02) 4940 4200
Zach Cotter	Ecologist	(02) 4940 4200
Tom Stephens	Ecologist	(02) 4940 4200
Lachlan Jones	Ecologist	(02) 4940 4200
Joe Gibbs	Ecologist	(02) 4940 4200
Duncan Scott-Lawson	Ecologist	(02) 4940 4200

Spring parallel transects targeting *Pterostylis chaetophora* and BAM plots (2018) were performed by Simon Danielsen Principal Botanist at Astrebla Ecological Services in association with RPS staff listed in **Table 4.6**.

Microbat calls recorded on the bat echolocation devices were analysed by Greg Ford from Balance! Environmental and the scat and hair tube samples collected were analysed by Georgeanna Story from Scats About (Cumberland Ecology 2019).

4.2.2.5 Limitations

The flora and fauna of the study area have been subject to a series of surveys over at least 15 years (since 2003). Consequently, the ecology of the study area and subject site and indeed the flora and fauna of the locality is well known. A combination of this and recent surveys over multiple seasons across the entirety of the subject site has been used to minimise the uncertainty of this assessment.

4.2.2.5.1 Survey Effort

Cumulatively, it is estimated that a combined total of about 250 ha of direct sampling has occurred within the subject site during the 2018/ 19 survey period representing a direct sample of over half the total native vegetation cover of this area (i.e. ~50% sampling effort). This sampling effort, performed over multiple seasons across two years, is spatially and temporally representative and this therefore regarded as sufficiently comprehensive for minimising uncertainty.

4.2.2.5.2 Flora

The weather conditions at the time of the flora surveys were generally favourable for plant growth and production of features required for identification of most species. Shrubs, grasses, herbs and creepers were readily identifiable in most instances. It is expected that not all flora species present would have been recorded during surveys. Despite this, it is considered that sufficient information has been collected to

assess issues including conservation significance of the flora, condition and viability of vegetation and likely impact on native vegetation.

4.2.2.5.3 Fauna

Targeted fauna surveys performed by Cumberland Ecology for the preparation of this SIS were undertaken in mid-summer (January 2017) which is the optimal season for surveying the majority of fauna species. However, temperatures during the survey period were quite high on several days (>35°C) and may have limited some bird and mammal activity during this time. Weather related limitations were addressed by performing fauna surveys in October 2018 – February 2019 and August – September 2019 during cooler more suitable conditions to supplement the Cumberland Ecology dataset. Opportunistic surveys performed as part of the parallel track survey for threatened flora were substantial and included additional survey timing of August 2018, February 2019 and October – December 2019.

4.3 Survey Results

DGR 4.3 Survey Results

DGR 4.3.1 Subject species survey results

DGR 4.3.2 General species survey results

4.3.1 Subject Species Survey Results

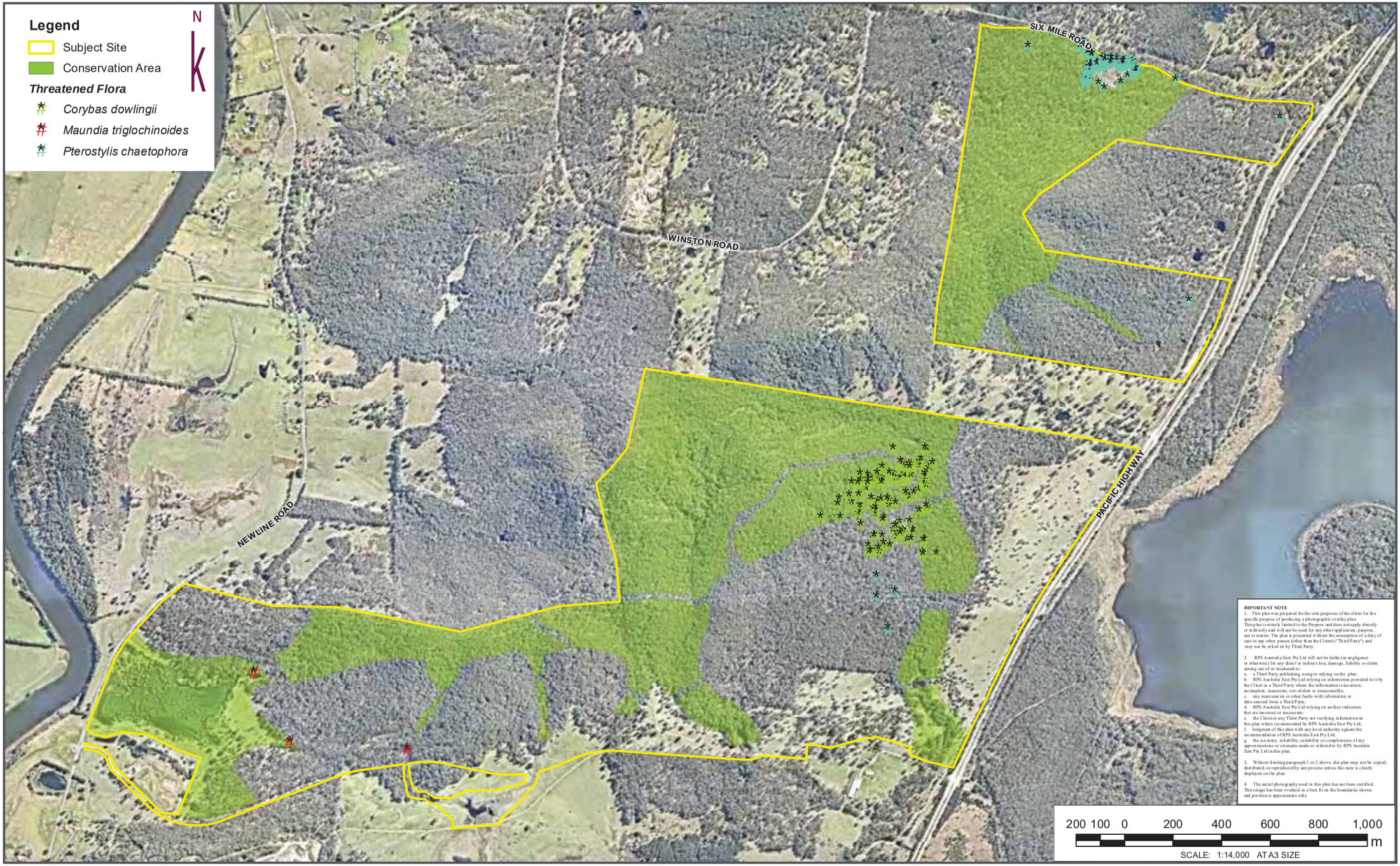
4.3.1.1 Threatened Flora

Three threatened flora species are known to occur within the subject site as outlined in **Table 4.7**, which also provides estimates of the number of individuals from direct counts and habitat area mapping using a 30 m buffer from recorded individuals.

Table 4.7 Threatened Flora within the Subject Site

Species	TSC Act	Proposal impact footprint		Conservation Area	
		Count	Habitat Area (ha)	Count	Habitat Area (ha)
Maundia triglochinoides	Vulnerable	50	0.08	42	0.15
Pterostylis chaetophora	Vulnerable	20	1.41	468	4.36
Corybas dowlingii	Endangered	118	4.66	1,467	8.62

The location of threatened flora recorded within the subject site is shown in **Figure 4.16**. It is considered that the survey methods and effort expended are comprehensive and have provided an accurate appraisal of the occurrence of threatened flora within the subject site.



TITLE : FIGURE 4.16: THREATENED FLORA SPECIES RECORDED WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.16 Th Flora species recorded within SS D A3 20200721.mxd

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4.3.1.2 Threatened Fauna

Threatened fauna species recorded within the subject site as listed below:

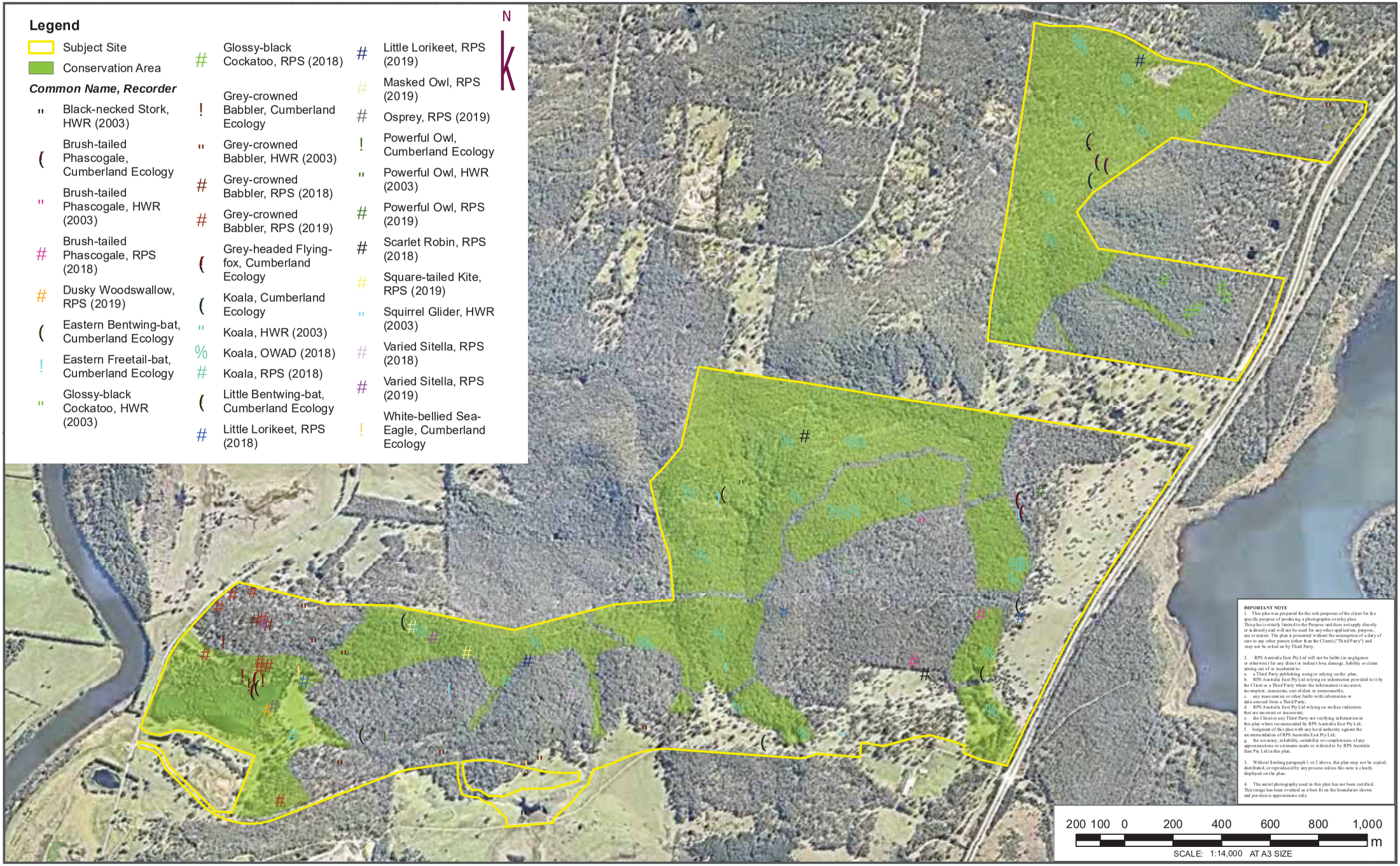
- Glossy-black Cockatoo;
- Brown Treecreeper;
- Varied Sittella;
- Little Lorikeet;
- White-bellied Sea Eagle;
- Grey-crowned Babbler;
- Powerful Owl;
- Koala;
- Brush-tailed Phascogale;
- Grey-headed Flying Fox;
- Eastern Bentwing-bat;
- Little Bentwing-bat; and
- Eastern Freetail-bat.

Locations of threatened fauna recorded within the subject site are shown in **Figure 4.17**, as supplemented by the distribution of Koala records by detection method in **Figure 4.18**.

4.3.1.3 Threatened Ecological Communities

Vegetation forming part of the following listed threatened ecological communities occur within the subject site and are shown in **Figure 4.19**:

- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions;
- Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions EEC (preliminary listing);
- Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions VEC;
- Swamp Oak Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions; and
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC.



TITLE : FIGURE 4.17: THREATENED FAUNA OF THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.17 Th Fauna species recorded within SS C A3 20200721.mxd

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TITLE : FIGURE 4.18: KOALA RECORDS BY DETECTION TYPE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.18 Koala Records by Detection Type D A3 20200721.mxd

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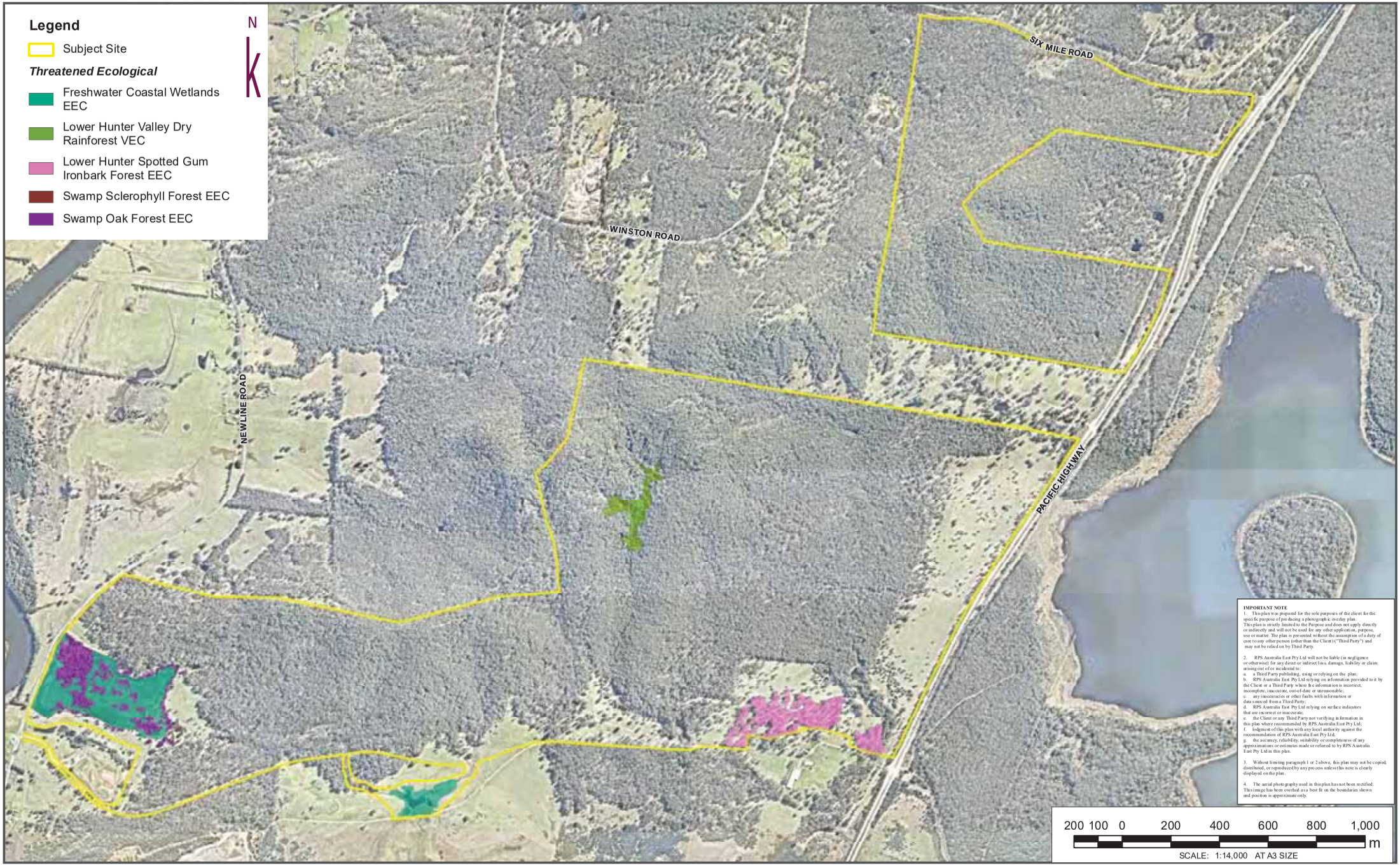

TITLE : FIGURE 4.19: THREATENED ECOLOGICAL COMMUNITIES MAPPED WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/02/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (james.hugo)

PATH: \\ntlfile1\Data\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.19 Th Eco Com mapped within SS C A3 20200227.mxd

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4.3.2 General Species Survey Results

4.3.2.1 Vegetation Communities

Revised vegetation mapping was performed following the completion of flora surveys within the subject site. The revised vegetation map, as shown in **Figure 4.19**, is the product of results obtained from a PRIMER analysis of formal plot data (i.e. nMDS plots shown in **Figure 4.20** for Cumberland Ecology and RPS datasets) and renewed interpretation of recent high resolution aerial photography and satellite imagery. A summary of the revised vegetation mapping for PCTs within the subject site is provided in **Table 4.8**.

Table 4.8 PCTs of the subject site including extent

PCT	TEC	PCT Name	Condition	Subject Site (ha)
783	Yes [13]	Coastal freshwater swamps of the Sydney Basin Bioregion	Medium	11.37[14]
1230	Yes [15]	Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	Poor	0.15
1525	Yes [16]	Sandpaper Fig - Whalebone Tree warm temperate rainforest	High	2.42
1584	No	White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	High	149.45
1590	No	Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	High	262.46
1590	No	Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	Medium	2.15
1590	No	Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	Poor	5.89
1600	Pre [17]	Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	Medium	6.21
1728	Yes [18]	Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast	Medium	5.49
TOTAL				**445.59**

Figure 4.21(a) shows the relationship between the non-native vegetation types Exotic Grassland (low relief) and Exotic Grassland (high relief), which are excluded from **Table 4.8**, and the mapped PCTs shown in **Figure 4.19**. This exotic vegetation represents treeless lands reflective of historical land clearing events and agricultural practices (e.g. livestock grazing). However, the nMDS plot indicates some difference between these two exotic grassland classes, with differences likely to be attributed to soil type (i.e. Ten Mile and Wallalong versus Hexham soil landscapes) and influence from proximal PCTs [i.e. Exotic Grassland (low relief) is adjacent to PCT 1728 and Exotic Grassland (high relief) is adjacent to PCT 1600 and 1590]. Grasses and herbs comprising many exotic species characterise this land cover and, for this reason, these vegetation groups have not been assigned a native PCT.

[13] *Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* EEC

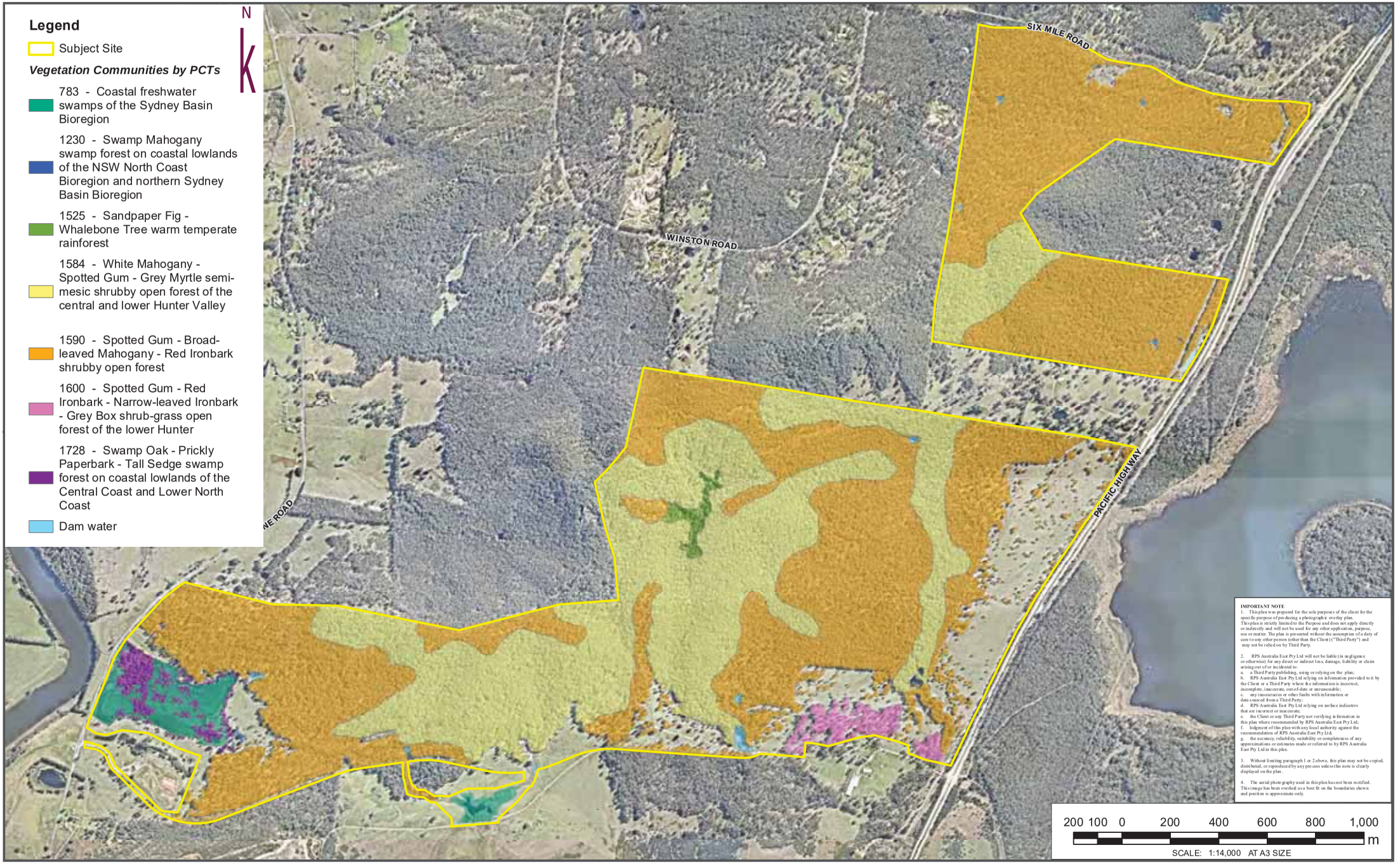
[14] Maximum potential extent and does not consider temporal variation observed in wetland wet and dry Phases

[15] *Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* EEC

[16] *Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions* VEC

[17] Preliminary determination for *Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin and North Coast Bioregions* EEC

[18] *Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions* EEC



TITLE : FIGURE 4.20: PCTS MAPPED WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/02/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (james.hugo)

PATH: \\nfile1\Data\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.20 PCTs mapped within SS B A3 20200227.mxd

CLIENT: **PM NO 1 PTY LIMITED**

JOB REF: **PR130430**

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MAKING COMPLEX EASY

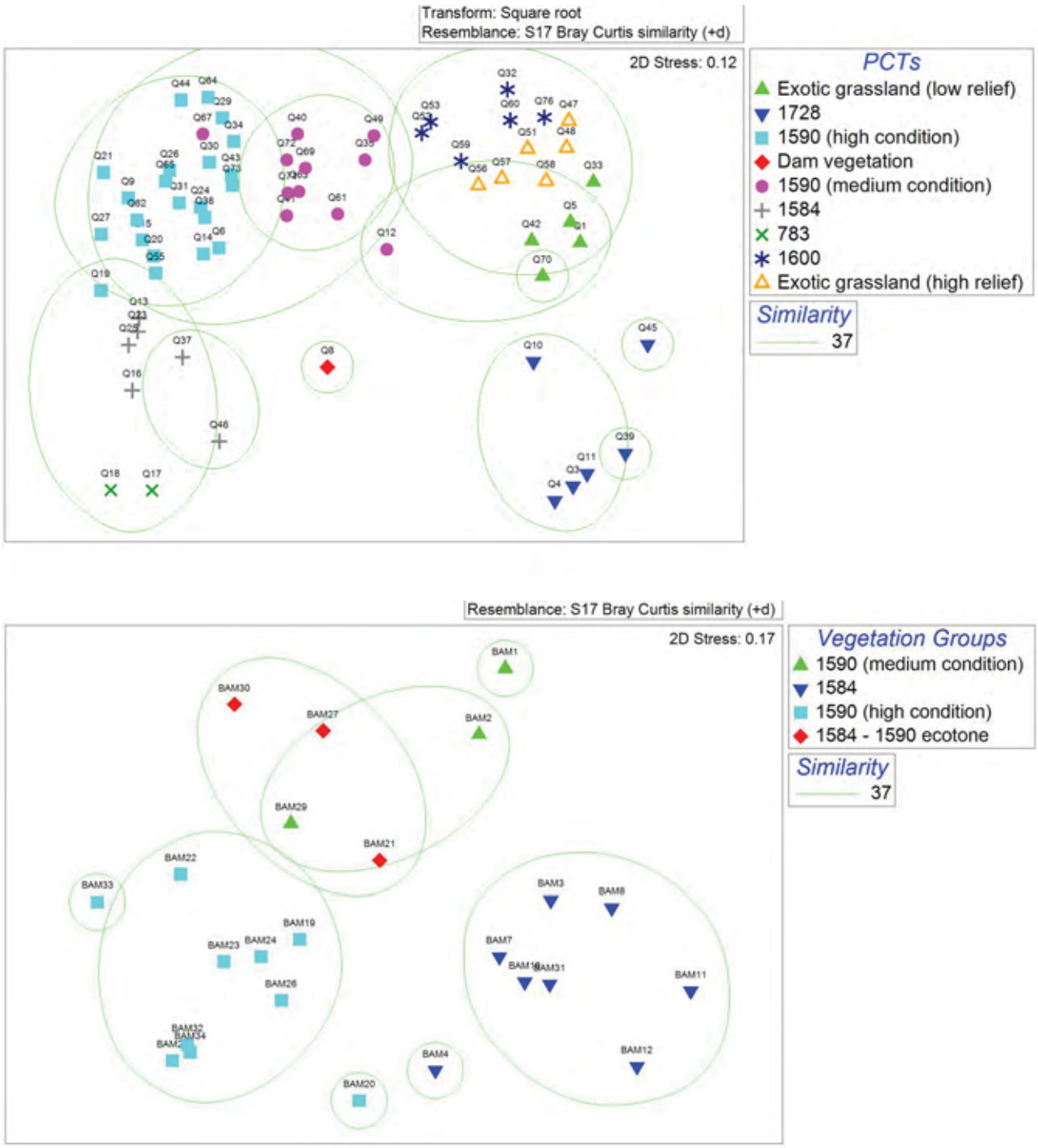


Figure 4.21 nMDS plot of Cumberland Ecology (a) and RPS (b) flora plot data obtained from the subject site

PCT classifications represented in **Table 4.7** and **Figure 4.18a** is supported by an analysis of similarity (ANOSIM) of between groups species composition, which revealed a significant Global R of 0.837 ($p < 0.001$) and significant R values ($p < 0.05$) for all pair-wise comparisons with the exception of those identified in bold in **Table 4.9**. Notable pair-wise comparisons worthy of discussion include 'PCT 1584 – PCT 783' and 'PCT 1590 (medium condition) – PCT 1590 (high condition).

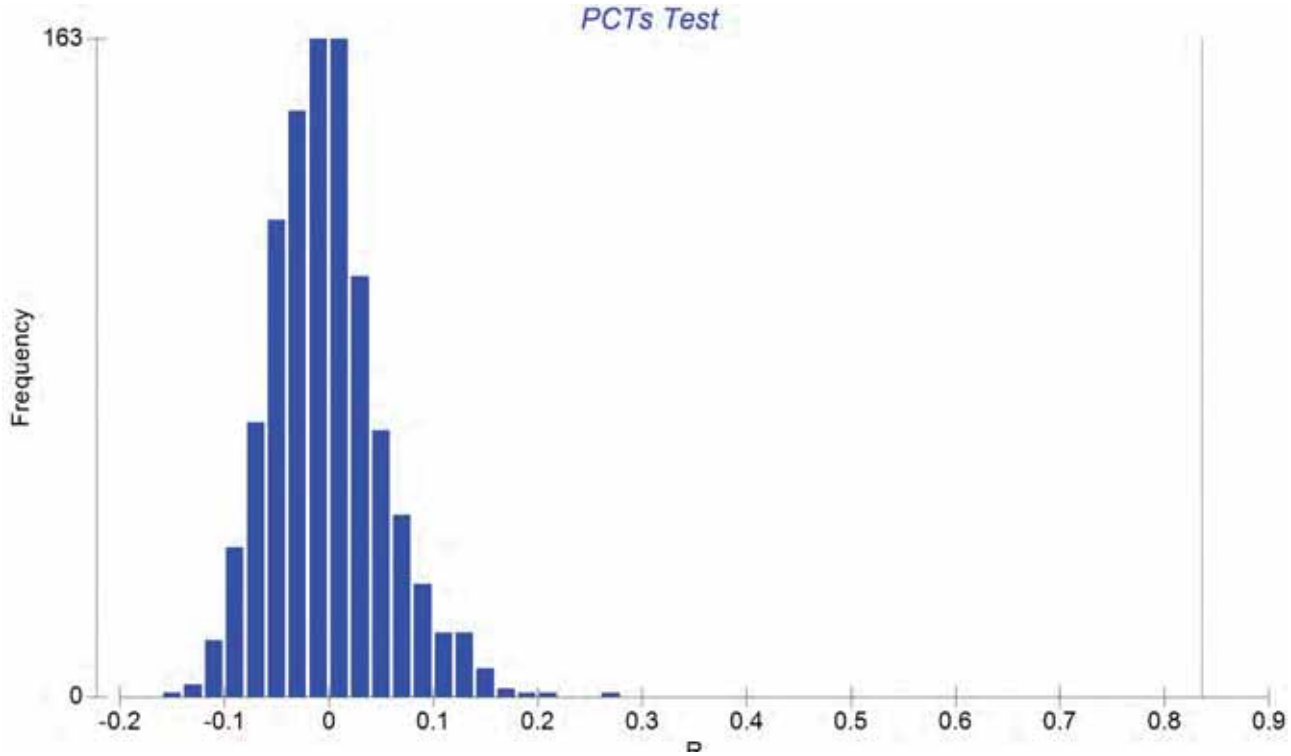
Table 4.9 ANOSIM Pair-wise comparisons between PCT classifications

Group Pair	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
PCT 1728					
783	1	3.6	28	28	1
1584	1	0.2	462	462	1
1590 (high condition)	1	0.1	376740	999	0
1590 (medium condition)	0.983	0.1	12376	999	0
1600	0.961	0.2	462	462	1
PCT 1590 (high condition)					
783	0.99	0.4	276	276	1
1584	0.612	0.1	376740	999	0
1590 (medium condition)	0.491	0.1	193536720	999	0
1600	0.991	0.1	376740	999	0
PCT 1590 (medium condition)					
783	1	1.3	78	78	1
1584	0.968	0.1	12376	999	0
1600	0.702	0.1	12376	999	0
PCT 1600					
783	1	3.6	28	28	1
1584	1	0.2	462	462	1
PCT 1584					
783	**0.417**	**7.1**	**28**	**28**	**2**
Exotic grassland (low relief)					
1728	0.731	0.4	462	462	2
1590 (high condition)	1	0.1	80730	999	0
1590 (medium condition)	0.906	0.1	4368	999	0
1584	1	0.2	462	462	1
783	1	4.8	21	21	1
1600	0.696	0.2	462	462	1
Exotic grassland (high relief)					
1728	0.956	0.2	462	462	1
Exotic grassland (low relief)	0.597	0.2	462	462	1
1584	1	0.2	462	462	1
783	1	3.6	28	28	1
1600	0.839	0.2	462	462	1
1590 (medium condition)	0.886	0.1	12376	999	0
1590 (high condition)	1	0.1	376740	999	0
Dam vegetation					
783	**1**	**33.3**	**3**	**3**	**1**
1584	**0.644**	**14.3**	**7**	**7**	**1**
1590 (medium condition)	**0.907**	**8.3**	**12**	**12**	**1**
1590 (high condition)	0.966	4.3	23	23	1
1728	**0.867**	**14.3**	**7**	**7**	**1**
1600	**1**	**14.3**	**7**	**7**	**1**
Exotic grassland/ (low relief)	**1**	**16.7**	**6**	**6**	**1**

Group Pair	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Exotic grassland (high relief)	**1**	**14.3**	**7**	**7**	**1**

PCTs pairwise tests
Distance (0 to inf)

	Exotic grassland (low relief)	1728	1590 (high condition)	Dam vegetation	1590 (medium condition)	1584	783	1600
Exotic grassland (low relief)								
1728	0.73067							
1590 (high condition)	1	1						
Dam vegetation	1	0.86667	0.96576					
1590 (medium condition)	0.90601	0.98268	0.49136	0.90744				
1584	1	1	0.6116	0.64444	0.96753			
783	1	1	0.9902	1	1	0.41667		
1600	0.696	0.96111	0.99051	1	0.70216	1	1	
Exotic grassland (high relief)	0.59733	0.95556	0.99951	1	0.88615	1	1	0.83889



As shown in **Figure 4.20(a)**, plots included in the PCT 1600 classification are similar to those of both 'exotic grassland' classes; a relationship reflective of historical land clearing and livestock grazing induced change in groundcover floristics. PCT 1600 was mapped as a native vegetation type due to the tree canopy cover and moderately native groundcover stratum, despite the impacts of agricultural practices to the understorey. As earlier mentioned, the effects of livestock grazing are apparent in PCT 1600 and include the simplification of understory vegetation structure, increased grassiness and exotic flora diversity. Subtle changes in native grass species composition were also noted such as the absence of palatable grasses in livestock grazed areas [e.g. Kangaroo Grass (*Themeda triandra*)].

The pair-wise comparison between PCT 1590 (high condition) and PCT 1590 (medium condition) shows relatively weak difference (R statistic = 0.491) while remaining significant ($p < 0.001$), indicating similarity at the PCT level but sufficient difference to warrant sub-structured classification (i.e. differences in condition). A sub-structured classification is supported by the 37% similarity contours in **Figure 4.20(a)**, which encompasses both PCT 1590 condition classes as a whole and individually.

The indicator for reduced condition in PCT 1590 (medium) is its midway position in the nMDS plot (**Figure 4.18(a)**) between PCT 1590 (high), where there is limited to no livestock grazing, and the heavily grazed PCT 1600/ 'Exotic grassland' vegetation units. This midway position of PCT 1590 (medium) is likely to reflect the effect of livestock grazing as observed and in common with PCT 1600. The effects of livestock grazing include the simplification of vegetation structure, decline in palatable groundcover species such as Kangaroo Grass (*Themeda triandra*), increase in less palatable species such as Barbed Wire Grass (*Cymbopogon refractus*) and increased exotic species richness and abundance.

The pair-wise comparison between PCTs 1584 and 783 returned a non-significant difference (i.e. $p > 0.05$), indicating relatively poor resolution between these two PCT classifications (i.e. similarity exists between these two vegetation classes and suggests aggregation into one PCT). PCT 783, which is characterised by a small patch restricted to a riparian corridor and is engulfed by PCT 1584, is heavily influenced by this surrounding vegetation and therefore likely to share similarity with it. It is considered that the combination of naturally occurring edge effects (i.e. ecotones) and the small patch size of PCT 783 explain the similarities between these two vegetation groups.

PCT 1728 comprises Swamp Oak (*Casuarina glauca*) above a groundcover stratum comprising a mix of native species commonly found in forested wetlands and exotic species occurring in the proximal treeless grazed lands. This is evident in the nMDS plot where plots classed as Exotic Grassland (low relief) are the closest to those assigned to PCT 1728 (**Figure 4.18a**).

The analysis of RPS flora plots, as shown in the corresponding nMDS plot (**Figure 4.20(b)**), had the purpose of improving boundary mapping between PCTs 1584 and 1590 through plot placement in areas with previously poor sampling effort. This analysis confirmed differences observed in the Cumberland Ecology plot dataset. It also confirmed the presence of broad ecotones PCTs 1584 and 1590 within the subject site. Improved vegetation boundary mapping was achieved through this analysis, particularly in areas subject to site preparation works.

Vegetation descriptions provided are based on the SIMPER output obtained from the Bray-Curtis resemblance analysis performed for the Cumberland Ecology (2019) dataset. Species that were important contributors to dissimilarity of PCTs were identified using the similarity percentages routine (SIMPER; Clarke 1993) with the output provided in **Table 4.10**. Species shaded grey are *a priori* identified important contributor species (Beck *et al*. 2017).

Table 4.10 SIMPER output for PCTs of the subject site

PCT and Species Composition	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
1728 Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast					
Average similarity: 38.51					
Trees					
Casuarina glauca	1.76	3.59	1.12	9.33	57.3
Shrubs					
Melaleuca styphelioides	1.18	1.64	0.68	4.25	74.7
Herbs					
Juncus usitatus	1.76	4.31	2.25	11.18	27.17
*Senecio madagascariensis**	1.47	4.09	7.36	10.61	37.78
Ludwigia peploides subsp. montevidensis	1.59	3.19	1.18	8.28	65.58
*Atriplex prostrata**	1.03	1.63	0.73	4.22	78.92
*Aster subulatus**	0.86	1.28	0.78	3.31	82.24
Ranunculus inundatus	0.76	0.78	0.48	2.03	84.27
*Eichhornia crassipes**	0.83	0.75	0.45	1.95	86.21
*Plantago lanceolata**	0.76	0.69	0.48	1.8	88.01

PCT and Species Composition	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Enydra woollsii	0.64	0.67	0.47	1.75	89.75
Carex appressa	0.57	0.5	0.48	1.29	91.04
Grasses					
Cynodon dactylon	2.32	6.16	4.73	15.99	15.99
Paspalum distichum	1.78	3.92	1.28	10.18	47.97
*Paspalum dilatatum**	1.15	1.88	0.78	4.87	70.45
Exotic Grassland (low relief)					
Average similarity: 39.73					
Trees					
Nil					
Shrubs					
Nil					
Herbs					
*Senecio madagascariensis**	1.59	3.33	4.02	8.38	39.48
*Verbena bonariensis**	1.33	2.87	3.59	7.22	46.7
Juncus usitatus	1.26	2.09	1.07	5.26	51.96
*Plantago lanceolata**	1.26	2.09	1.07	5.26	57.22
*Hypochaeris radicata**	1.31	2.05	1.07	5.17	62.39
*Gamochaeta purpurea**	1.13	1.96	1.11	4.93	67.32
Pratia purpurascens	1.03	1.42	1.06	3.57	70.89
*Sida rhombifolia**	0.85	1.13	0.61	2.83	77.01
*Cerastium glomeratum**	0.85	0.8	0.62	2.01	79.03
*Romulea rosea**	0.85	0.8	0.62	2.01	81.04
*Conyza sumatrensis**	0.77	0.65	0.59	1.64	82.68
Fimbristylis dichotoma	0.75	0.53	0.32	1.34	85.53
Centella asiatica	0.57	0.34	0.32	0.85	88.68
*Cirsium vulgare**	0.57	0.3	0.32	0.75	89.43
Dichondra repens	0.57	0.3	0.32	0.75	90.17
Grasses					
*Axonopus fissifolius**	2.04	4.41	4.04	11.09	11.09
*Paspalum dilatatum**	2.03	4.25	3.58	10.69	21.78
Cynodon dactylon	1.93	3.7	2.49	9.32	31.1
*Sporobolus africanus**	1.08	1.31	0.59	3.29	74.18
Dichelachne micrantha	0.68	0.6	0.62	1.51	84.19
Eragrostis brownii	0.69	0.53	0.32	1.34	86.87
*Setaria parviflora**	0.57	0.38	0.32	0.97	87.83
Exotic Grassland (high relief)					
Average similarity: 58.30					
Trees					
Nil					
Shrubs					
Nil					
Herbs					

PCT and Species Composition	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
*Hypochaeris radicata**	1.41	3.4	9.63	5.84	27.72
*Senecio madagascariensis**	1.41	3.4	9.63	5.84	33.55
*Cyperus sesquiflorus**	1.41	3.4	9.63	5.84	39.39
Fimbristylis dichotoma	1.41	3.4	9.63	5.84	45.23
Hypericum gramineum	1.41	3.4	9.63	5.84	51.06
Centella asiatica	1.18	2.17	1.35	3.71	72.29
*Plantago lanceolata**	1.18	2.17	1.35	3.71	76
Euchiton involucratus	0.97	1.73	1.29	2.96	78.97
Pratia purpurascens	0.94	1.37	0.78	2.36	81.32
*Medicago polymorpha**	0.94	1.37	0.78	2.35	83.68
*Verbena officinalis**	0.94	1.36	0.78	2.34	86.02
*Juncus cognatus **	0.74	0.89	0.79	1.52	89.67
*Romulea rosea**	0.71	0.72	0.48	1.23	90.9
Grasses					
*Axonopus fissifolius**	2.08	4.86	8.05	8.33	8.33
*Andropogon virginicus**	1.82	4.22	8.05	7.23	15.56
*Paspalum dilatatum**	1.63	3.68	11.85	6.32	21.88
Cynodon dactylon	1.41	3.4	9.63	5.84	56.9
Eragrostis brownii	1.41	3.4	9.63	5.84	62.74
Sporobolus creber	1.41	3.4	9.63	5.84	68.57
*Poa annua**	0.94	1.25	0.79	2.14	88.15

1600 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter					
Average similarity: 53.15					
Trees					
Nil					
Shrubs					
Nil					
Herbs					
*Hypochaeris radicata**	1.41	2.43	7.67	4.58	20.36
Glycine tabacina	1.59	2.43	7.67	4.58	24.94
*Plantago lanceolata**	1.41	2.43	7.67	4.58	29.52
Hypericum gramineum	1.35	2.19	4.99	4.13	42.8
*Verbena officinalis**	1.18	1.61	1.33	3.03	48.86
Carex inversa	1.18	1.53	1.35	2.87	54.67
Carex longebrachiata	1.04	1.23	1.33	2.31	56.98
*Romulea rosea**	0.94	1.06	0.78	1.99	58.97
*Verbena rigida **	0.94	1.04	0.78	1.96	60.93
*Herbertia lahue **	1	1.03	0.78	1.93	62.86
*Senecio madagascariensis**	0.94	0.98	0.78	1.85	64.71
Fimbristylis dichotoma	0.94	0.98	0.78	1.85	66.56
*Taraxacum officinale**	0.94	0.97	0.78	1.83	70.24
Asperula conferta	0.94	0.94	0.78	1.78	72.01
Centella asiatica	0.94	0.92	0.78	1.73	73.74
Glycine microphylla	1.12	0.89	0.78	1.68	75.42

PCT and Species Composition	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
*Aster subulatus**	0.87	0.88	0.75	1.66	77.08
Dichondra repens	0.94	0.86	0.79	1.62	78.7
*Hypochaeris microcephala **	0.87	0.85	0.75	1.6	81.93
*Medicago polymorpha**	0.87	0.79	0.75	1.49	84.98
Ranunculus lappaceus	0.8	0.79	0.76	1.49	86.47
Plantago gaudichaudii	0.87	0.78	0.77	1.47	87.94
Oxalis perennans	0.8	0.65	0.77	1.23	90.63
Grasses					
*Paspalum dilatatum**	1.78	2.98	7.67	5.61	5.61
*Axonopus fissifolius**	1.8	2.87	3.59	5.4	11.01
Cymbopogon refractus	1.62	2.53	7.94	4.77	15.78
Cynodon dactylon	1.41	2.43	7.67	4.58	34.1
Sporobolus creber	1.47	2.43	7.67	4.58	38.68
Bothriochloa decipiens	1.18	1.61	1.33	3.03	45.83
Poa sieberiana	1.28	1.56	1.34	2.94	51.8
Eragrostis brownii	0.94	0.98	0.78	1.85	68.41
Bothriochloa macra	0.94	0.86	0.79	1.62	80.33
Aristida ramosa	0.87	0.83	0.77	1.56	83.49
*Andropogon virginicus**	0.87	0.78	0.77	1.47	89.41

1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (medium)					
Average similarity: 43.50					
Trees					
Corymbia maculata	1.06	0.87	0.94	2	57.23
Eucalyptus tereticornis	0.75	0.39	0.58	0.89	81.12
Eucalyptus siderophloia	0.65	0.29	0.44	0.66	86.63
Shrubs					
*Lantana camara**	1.21	0.94	0.97	2.17	51.04
Breynia oblongifolia	0.64	0.51	0.77	1.18	71.27
Notelaea longifolia	0.55	0.38	0.6	0.87	81.99
Leucopogon juniperinus	0.62	0.37	0.6	0.84	83.7
Acacia ulicifolia	0.49	0.25	0.46	0.57	87.76
Herbs					
Geitonoplesium cymosum	1.17	1.31	1.98	3.01	13.26
Dichondra repens	1.21	1.28	1.34	2.95	16.21
*Hypochaeris radicata**	1.21	1.27	1.34	2.92	19.13
Brunoniella australis	1.16	1.25	1.34	2.88	22.01
Lomandra filiformis	1.21	1.24	1.34	2.84	27.74
*Plantago lanceolata**	1.21	1.23	1.34	2.82	30.55
Glycine microphylla	1.16	1.22	1.34	2.81	33.36
Pratia purpurascens	1.16	1.22	1.34	2.81	36.18
Cheilanthes sieberi	1.06	0.99	1	2.27	46.7
Opercularia diphylla	1.03	0.94	1	2.17	48.87
*Senecio madagascariensis**	1.06	0.94	1	2.16	53.2
Oxalis perennans	0.98	0.84	0.98	1.93	59.16

PCT and Species Composition	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Lomandra multiflora	0.92	0.79	0.98	1.82	60.98
Lagenophora stipitata	0.86	0.64	0.75	1.48	65.93
Eustrephus latifolius	0.86	0.64	0.75	1.47	67.4
Glycine tabacina	0.77	0.53	0.6	1.23	70.09
Parsonsia straminea	0.67	0.5	0.77	1.15	73.6
Carex inversa	0.77	0.5	0.6	1.15	74.75
Centella asiatica	0.77	0.5	0.6	1.14	75.89
Juncus usitatus	0.74	0.5	0.77	1.14	77.03
Vernonia cinerea	0.73	0.48	0.6	1.1	78.12
Fimbristylis dichotoma	0.76	0.46	0.59	1.05	80.23
Tricoryne elatior	0.58	0.38	0.6	0.87	82.86
Murdannia graminea	0.64	0.35	0.46	0.81	84.52
Arthropodium sp. B	0.64	0.33	0.46	0.76	85.28
Glycine clandestina	0.45	0.25	0.46	0.57	87.2
*Conyza sumatrensis**	0.45	0.22	0.47	0.5	89.28
*Lysimachia arvensis**	0.51	0.2	0.35	0.45	89.73
Grasses					
Microlaena stipoides	1.91	2.39	6.24	5.5	5.5
Cymbopogon refractus	1.64	2.06	5.83	4.74	10.24
Echinopogon caespitosus	1.14	1.25	1.92	2.88	24.9
*Axonopus fissifolius**	1.23	1.22	1.34	2.81	38.98
*Paspalum dilatatum**	1.17	1.2	1.33	2.76	41.74
Eragrostis brownii	1.17	1.17	1.29	2.69	44.43
Eragrostis leptostachya	1.04	0.88	0.99	2.03	55.23
Aristida vagans	1.02	0.78	0.77	1.79	62.77
Entolasia marginata	0.96	0.73	0.77	1.69	64.45
Oplismenus aemulus	0.89	0.64	0.77	1.46	68.86
Paspalidium distans	0.77	0.51	0.6	1.18	72.44
Entolasia stricta	0.73	0.46	0.59	1.06	79.18
Aristida ramosa	0.61	0.3	0.46	0.7	85.98
Poa sieberiana	0.65	0.22	0.34	0.52	88.28
Cynodon dactylon	0.61	0.22	0.34	0.51	88.79
Echinopogon ovatus	0.51	0.2	0.35	0.45	90.18
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (high)					
Average similarity: 43.26					
Trees					
Corymbia maculata	1.83	2.04	1.95	4.71	4.71
Eucalyptus acmenoides	1.32	1.05	0.85	2.42	56.51
Eucalyptus siderophloia	1.04	0.71	0.75	1.64	66.8
Eucalyptus fibrosa	0.89	0.53	0.58	1.24	73.9
Eucalyptus globoidea	0.88	0.48	0.52	1.11	75.01
Eucalyptus tereticornis	0.6	0.2	0.34	0.47	90.04
Shrubs					
Leucopogon juniperinus	1.46	1.39	1.46	3.21	26.52

PCT and Species Composition	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Notelaea longifolia	1.28	1.28	1.88	2.97	32.56
Breynia oblongifolia	1.15	1.17	1.6	2.7	46.6
*Lantana camara**	1.27	1.02	1.07	2.36	58.88
Acacia ulicifolia	0.67	0.45	0.71	1.04	76.05
Daviesia ulicifolia	0.66	0.37	0.54	0.85	80.69
Herbs					
Dichondra repens	1.61	1.86	2.7	4.3	9
Brunoniella australis	1.47	1.63	1.99	3.78	12.78
Eustrephus latifolius	1.31	1.44	1.65	3.34	23.31
Lomandra multiflora	1.27	1.33	1.58	3.07	29.59
Pratia purpurascens	1.25	1.26	1.35	2.91	35.48
Opercularia diphylla	1.17	1.25	1.36	2.9	38.37
Geitonoplesium cymosum	1.19	1.19	1.34	2.74	43.9
Cheilanthes sieberi	1.17	1.06	1.15	2.45	54.09
Vernonia cinerea	1.08	1.01	1.15	2.34	61.22
Desmodium rhytidophyllum	0.88	0.7	0.88	1.62	68.42
Lomandra filiformis	0.99	0.65	0.69	1.51	69.93
Glycine clandestina	0.8	0.6	0.78	1.39	71.32
Oxalis perennans	0.76	0.58	0.78	1.35	72.67
Lepidosperma laterale	0.7	0.41	0.55	0.95	78.94
Glycine microphylla	0.62	0.35	0.49	0.82	82.35
Desmodium varians	0.63	0.35	0.55	0.82	83.17
Glycine tabacina	0.63	0.32	0.48	0.74	83.9
Hardenbergia violacea	0.59	0.31	0.48	0.72	84.62
Pandorea pandorana	0.62	0.3	0.48	0.7	85.32
Dianella caerulea var. caerulea	0.57	0.3	0.48	0.68	86.7
Clematicissus opaca	0.56	0.26	0.42	0.6	87.94
Billardiera scandens	0.52	0.25	0.42	0.57	88.5
Goodenia heterophylla subsp. eglandulosa	0.6	0.24	0.37	0.56	89.06
Hibbertia obtusifolia	0.57	0.22	0.36	0.5	89.57
Grasses					
Cymbopogon refractus	1.5	1.59	1.91	3.68	16.46
Microlaena stipoides	1.54	1.52	1.3	3.51	19.97
Entolasia stricta	1.32	1.2	1.13	2.78	41.15
Aristida vagans	1.26	1.11	1	2.55	49.15
Imperata cylindrica	1.34	1.08	0.88	2.49	51.65
Echinopogon caespitosus	1.11	0.87	0.88	2.02	63.24
Oplismenus aemulus	1.1	0.83	0.87	1.93	65.16
Entolasia marginata	0.74	0.42	0.54	0.97	77.02
Paspalidium distans	0.68	0.42	0.54	0.96	77.98
Poa labillardierei	0.84	0.39	0.42	0.91	79.84
Themeda triandra	0.79	0.36	0.43	0.84	81.53
Eragrostis brownii	0.63	0.3	0.42	0.69	86.01
Panicum effusum	0.65	0.28	0.41	0.64	87.33

PCT and Species Composition	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
1584 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley					
Average similarity: 45.31					
Trees					
Corymbia maculata	2.14	2.63	7.27	5.81	5.81
Eucalyptus acmenoides	1.61	1.47	1.18	3.24	48.63
Eucalyptus siderophloia	1.25	1.04	1.2	2.3	65.1
Shrubs					
Pittosporum multiflorum	1.94	2.36	6.52	5.21	11.02
*Lantana camara**	2.03	2.21	2.76	4.88	15.9
Notelaea longifolia	1.69	1.91	4.42	4.22	20.12
Breynia oblongifolia	1.38	1.37	1.35	3.03	51.66
Melaleuca styphelioides	1.49	1.25	1.12	2.77	60.2
Denhamia silvestris	1.27	1.18	1.27	2.6	62.8
Morinda jasminoides	1	0.76	0.79	1.69	70.74
Glochidion ferdinandi	1.15	0.71	0.75	1.58	73.96
Clerodendrum tomentosum	0.99	0.57	0.76	1.26	82.34
Myrsine variabilis	0.74	0.32	0.47	0.71	90.35
Herbs					
Eustrephus latifolius	1.38	1.6	5.27	3.53	31.68
Pandorea pandorana	1.33	1.57	7.34	3.46	38.62
Dichondra repens	1.52	1.53	1.33	3.39	42.01
Geitonoplesium cymosum	1.34	1.33	1.35	2.94	54.61
Brunoniella australis	1.1	0.84	0.79	1.85	69.06
Cayratia clematidea	1.03	0.74	0.74	1.64	72.38
Commelina cyanea	1.03	0.71	0.74	1.56	75.52
Parsonsia straminea	0.98	0.68	0.76	1.51	77.03
Cissus antarctica	0.93	0.66	0.78	1.45	78.47
Pratia purpurascens	0.96	0.6	0.75	1.33	79.8
Stephania japonica	0.8	0.58	0.78	1.28	81.08
Plectranthus parviflorus	0.8	0.57	0.78	1.26	83.6
Tylophora barbata	0.86	0.42	0.48	0.94	84.53
Doodia aspera	0.86	0.4	0.48	0.89	85.43
Clematis aristata	0.86	0.4	0.48	0.87	86.3
*Isolepis levynsiana**	0.86	0.39	0.48	0.85	87.15
Carex longebrachiata	0.76	0.38	0.48	0.83	87.98
Pellaea falcata	0.81	0.37	0.48	0.83	89.64
Grasses					
Entolasia marginata	1.65	1.91	4.57	4.21	24.33
Oplismenus imbecillis	1.76	1.73	1.3	3.81	28.15
Microlaena stipoides	1.6	1.58	1.32	3.49	35.16
Imperata cylindrica	1.56	1.53	1.33	3.39	45.39
Entolasia stricta	1.44	1.28	1.23	2.83	57.43
Oplismenus aemulus	1.33	0.95	0.78	2.1	67.2
Poa affinis	0.84	0.38	0.48	0.83	88.81

PCT and Species Composition	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
1525 Sandpaper Fig - Whalebone Tree warm temperate rainforest					
Average similarity: 64.54					
Trees					
Eucalyptus acmenoides	2.24	3.6	n/a	5.58	17.26
Streblus brunonianus	1.87	2.79	n/a	4.32	61.92
Shrubs					
Backhousia myrtifolia	2.45	3.94	n/a	6.11	6.11
Pittosporum multiflorum	2.34	3.6	n/a	5.58	22.84
*Lantana camara**	2.24	3.6	n/a	5.58	34
Ceratopetalum apetalum	2.12	3.22	n/a	4.99	38.98
Notelaea longifolia	2.12	3.22	n/a	4.99	43.97
Morinda jasminoides	2	3.22	n/a	4.99	48.96
Breynia oblongifolia	1.73	2.79	n/a	4.32	66.24
Duboisia myoporoides	1.98	2.79	n/a	4.32	74.88
Denhamia silvestris	1.83	2.28	n/a	3.53	78.41
Herbs					
Doodia aspera	2.34	3.6	n/a	5.58	11.69
Pandorea pandorana	1.87	2.79	n/a	4.32	53.28
Geitonoplesium cymosum	1.73	2.79	n/a	4.32	57.6
Pellaea falcata	1.98	2.79	n/a	4.32	70.56
Polymeria calycina	1.57	2.28	n/a	3.53	81.94
Glycine tabacina	1.41	2.28	n/a	3.53	85.46
Pellaea paradoxa	1.71	2.28	n/a	3.53	88.99
Cissus antarctica	1.57	2.28	n/a	3.53	92.52
Grasses					
Oplismenus imbecillis	2.34	3.6	n/a	5.58	28.42

PCT 1584 White Mahogany – Spotted Gum – Grey Myrtle semi-mesic shrubby open forest of the central and lower hunter valley

This PCT occurs throughout the elevated, south/ east facing slopes of the subject site and generally aligns with the Ten Mile Road (variant) soil landscape (see **Figure 2.2**). The canopy is dominated by *Corymbia maculata* (Spotted Gum) and *Eucalyptus acmenoides* (White Mahogany), with other species present including *Alphitonia excelsa*, *Syncarpia glomulifera*, and *Ceratopetalum apetalum*. The understorey is comprised predominately of a diverse array of mesic species. *Backhousia myrtifolia* (Grey Myrtle) is common in the small tree layer, and in some areas in the canopy. Other small trees include juveniles of the canopy species and *Glochidion ferdinandi* (Cheese Tree), *Melaleuca styphelioides* (Prickly-leaved Tea Tree), *Ficus coronata* (Sandpaper Fig), and *Hymenosporum flavum* (Native Frangipani).

The shrub layer is diverse, relatively dense in many areas, and includes species such as *Hibiscus heterophyllus* subsp. *heterophyllus*, *Pittosporum multiflorum* (Orange Thorn), *Croton verreauxii* (Green Native Cascarilla), *Scolopia braunii* (Flintwood) and *Streblus brunonianus* (Whalebone Tree).

The ground layer is dominated by ferns, grasses, and a diverse number of climbers. Ferns include *Doodia aspera* (Prickly Rasp Fern), *Pellaea falcata* (Sickle Fern), and *Adiantum aethiopicum* (Maidenhair Fern). Grasses include *Oplismenus aemulus* (Basket Grass), *Oplismenus imbecillis* (Creeping Beard Grass), *Poa affinis*, *Microlaena stipoides*, and *Entolasia marginata*. Climbers include *Parsonsia straminea* (Common

Silkpod), *Morinda jasminoides* (Sweet Morinda), *Tylophora barbata* (Bearded Tylophora), and *Cissus antarctica* (Kangaroo Vine).

Graminoids such as *Carex longebrachiata*, *Commelina cyanea* (Scurvy Weed), *Gymnostachys anceps*, *Lomandra longifolia* (Spiny Mat-rush), and *Cyperus tenellus* are also present in the ground layer, along with forbs such as *Stellaria flaccida* and *Pseuderanthemum variabile* (Pastel Flower).

Examples of this community are shown in **Plate 4.1**, **Plate 4.2** and **Plate 4.3**.

Plate 4.1 PCT 1584 in the western gully of the subject site

Plate 4.2 PCT 1584 in the eastern gully of the subject site

Plate 4.3 PCT 1584 within the southern part of the subject site

PCT 1590 Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (nominate)

This community is the dominant community across the study area and is highly variable in terms of floristics and structure. The canopy species vary across the study area with spatial distribution, topography, and aspect, although *Corymbia maculata* (Spotted Gum) is a core component of the canopy in all areas. A typical form of this variable vegetation is shown in **Plate 4.4**. A 'Hinterland' variant is also recognised (Bell 2013) and is described separately.

Plate 4.4 PCT 1590 in the northern part of the subject site

Other common species in the community include *Eucalyptus globoidea* (White Stringybark) and *Eucalyptus acmenoides* (White Mahogany). *Eucalyptus siderophloia* (Northern Grey Ironbark) is the most common

ironbark in the community, while *Eucalyptus fibrosa* (Red Ironbark) is present, generally in the lower lying areas of the community, and *Eucalyptus crebra* (Narrow-leaved Ironbark) has a scattered distribution in the community. *Eucalyptus punctata* (Grey Gum) is also common through most of the community, with the exception of lower lying areas in the east of the southern property where it tends to be replaced by *Eucalyptus propinqua* (Small-fruited Grey Gum). *Eucalyptus tereticornis* (Forest Red Gum) is a common component of the canopy in the western areas. *Eucalyptus moluccana* exhibits scattered occurrences throughout the subject site and does not occur as a canopy dominant.

The sub-canopy is generally comprised of younger individuals of the canopy species present in particular areas, with the only non-eucalypt species recorded in the layer being *Allocasuarina torulosa*, *Clerodendrum tomentosum*, and *Melaleuca nodosa* (Prickly-leaved Paperbark).

Common species recorded in the shrub layer include *Leucopogon juniperinus* (Prickly-beard Heath), *Notelaea longifolia*, *Daviesia ulicifolia* (Bitter-gorse Pea), and juvenile *Pittosporum undulatum* (Sweet Pittosporum). Other species recorded in the layer less frequently include *Polyscias sambucifolia* (Elderberry Panax), *Breynia oblongifolia* (Coffee Bush), *Acacia implexa* (Hickory), *Pultenaea paleacea* (Chaffy Bush Pea) and *Hibbertia aspera* (Rough-Guinea Flower). The exotic species *Lantana camara* is common in many areas of the community and dominant in the shrub layer in small localised areas.

The ground layer throughout the community is frequently dominated by native grasses with common species including *Imperata cylindrica* (Blady Grass), *Aristida vagans*, *Themeda triandra* (Kangaroo Grass), *Microlaena stipoides* and *Cymbopogon refractus* (Barbwire Grass). A number of other species such as *Oplismenus aemulus* (Basket Grass), *Panicum effusum* (Hairy Panic), and *Entolasia stricta* occur less frequently and have scattered distributions across the study area. Other graminoids recorded include *Lomandra filiformis* subsp. *filiformis*, *Dianella caerulea* var. *producta*, *Tricoryne elatior* (Yellow Autumn-lily), and *Lepidosperma laterale*.

Forbs are present throughout the layer with species such as *Brunoniella australis*, *Vernonia australis*, *Goodenia heterophylla*, and *Opercularia diphylla* frequently recorded. Other species include *Hybanthus stellarioides* and *Lagenophora stipitata*. Native climbers are common with species recorded including *Desmodium rhytidophyllum*, *Hardenbergia violacea* (False Sarsparilla), and *Clematicissus opaca* (Pepper Vine).

Exotic species are present sporadically in the ground layer of the community, though are more common in the medium and poor condition areas of this community. Species recorded include the grasses *Paspalum dilatatum* and *Axonopus fissifolius** (Carpet Grass), and forbs *Plantago lanceolata* and *Sida rhombifolia* (Paddy's Lucerne).

South facing slopes in the west of the southern property of the study area are dominated by a canopy of *Eucalyptus tereticornis* (Forest Red Gum), which occurs with *Eucalyptus globoidea* (White Stringybark), with the small tree layer comprised of younger trees of these species. This localised variation appears to be driven by shallow soils on massive bedrock. An example of this community is shown in **Plate 4.5**.

The shrub layer in these areas is dominated by the exotic species *Lantana camara*, although the native *Leucopogon juniperinus* is common. Other native species in the shrub layer include *Breynia oblongifolia*, *Hibbertia diffusa* (Wedge Guinea Flower), *Notelaea longifolia*, and *Backhousia myrtifolia*.

The ground layer is grassy and dominated by *Poa labillardierei*, *Microlaena stipoides*, and *Cymbopogon refractus*, with other natives species such as *Echinopogon ovatus* (Forest Hedgehog Grass), *Bothriochloa macra* (Redleg Grass), *Eragrostis leptostachya* (Paddock Lovegrass), and *Dichelachne micrantha* (Shorthair Plume Grass) occurring less frequently. Native forbs present include *Hybanthus stellarioides*, *Wahlenbergia stricta*, *Pratia purpurascens* and *Pseudognaphalium luteoalbum* (Jersey Cudweed). Native twiners such as *Geitonoplesium cymosum*, *Glycine microphylla*, and *Desmodium varians* are common. Monocotyledonous herbs present include *Wurmbea dioica* (Early Nancy), *Juncus planifolius*, and *Lomandra multiflora* subsp. *multiflora*.

Plate 4.5 PCT 1590 dominated by Forest Redgum and White Stringybark

Exotic species are present, though not dominant in the ground layer, and include *Pavonia hastata** (Pink Pavonia), *Axonopus fissifolius**, *Verbena rigida**, and *Senecio madagascariensis**.

Lower lying, flatter terrain supports further variation. In these areas the canopy is dominated by *Corymbia maculata* (Spotted Gum) and the ironbarks *Eucalyptus siderophloia* and *Eucalyptus fibrosa* (Red Ironbark). The shrub layer ranges from dense to sparse, tending to be dominated by *Melaleuca nodosa* (Prickly-leaved Paperbark), particularly in the occurrence on the northern property. Examples of this variation within the study area are shown in **Plate 4.6** and **Plate 4.7**.

Plate 4.6 PCT 1590 with sparse shrub layer

Other shrub species present include *Leucopogon juniperinus*, *Bursaria spinosa* (Blackthorn), *Acacia falcata* (Sickle Wattle), *Acacia ulicifolia* (Prickly Moses) and *Daviesia ulicifolia*. The exotic shrub *Lantana camara** also occurs in the community though has a scattered distribution.

Plate 4.7 PCT 1590 with a dense, tall shrub layer of *Melaleuca nodosa*

The ground layer is grassy with dominant species including *Themeda triandra*, *Cymbopogon refractus*, *Microlaena stipoides*, *Imperata cylindrica*, and *Aristida vagans*. Other species present include *Entolasia marginata* (Bordered Panic), *Digitaria diffusa*, and *Panicum simile* (Two-colour Panic). A diverse array of other monocotyledonous herbs are present in the community with species including *Dichopogon fimbriatus* (Nodding Chocolate Lily), *Lomandra multiflora* subsp. *multiflora* (Many-flowered Mat-rush), *Lepidosperma laterale*, and *Tricoryne elatior* (Yellow-Autumn Lily). The fern *Cheilanthes sieberi* (Poison Rock Fern) is common in the ground layer, and a number of twiners are present including *Desmodium gunnii* and *Desmodium varians*. Native forbs such as *Opercularia diphylla*, *Dichondra repens* (Kidney Weed), *Plantago gaudichaudii* and *Lagenophora stipitata* (Blue Bottle-daisy) are also common.

Exotic weeds occur uncommonly. Species recorded include *Senecio madagascariensis** (Fireweed), *Richardia brasiliensis** (White Eye) and *Axonopus fissifolius**.

Further localised rocky north facing slope in the southwest of the study area is dry sclerophyll forest with some dry rainforest elements. The canopy consists of *Eucalyptus crebra* (Narrow-leaved Ironbark), *Corymbia maculata* (Spotted Gum), and *Alphitonia excelsa* (Red Ash). The small tree layer consists of younger individuals of the canopy species as well as *Pittosporum undulatum* (Sweet Pittosporum). An example of this variation is shown in **Plate 4.8**.

Plate 4.8 PCT 1590 on north facing slopes in the southwest of the subject site

The shrub layer is relatively sparse, with the exception of the exotic species *Lantana camara** which dominates the layer. Other shrub species present include *Cupaniopsis anacardioides* (Tuckeroo), *Denhamia silvestris* (Narrow-leaved Orangebark), *Breynia oblongifolia* (Coffee Bush), and *Acacia ulicifolia*.

The ground layer is dominated by the native grass *Microlaena stipoides*, with other abundantly occurring grasses including *Poa labillardierei*, *Themeda triandra*, and *Cymbopogon refractus*. Other graminoids such as *Lomandra multiflora* subsp. *multiflora*, *Carex inversa*, and *Lomandra filiformis* subsp. *filiformis* are common in the layer along with forbs such as *Dichondra repens*, *Pratia purpurascens* (Whiteroot), *Brunoniella australis*, and *Daucus glochidiatus* (Native Carrot). Climbers such as *Rubus parvifolius* (Native Raspberry), *Geitonoplesium cymosum* (Scrambling Lily), *Jasminum volubile* (Stiff Jasmine) and *Glycine microphylla* (Small-leaf Glycine) are also present.

PCT 1590 Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (Hinterland variant)

This variant of PCT 1590, as described by Bell (2013) occurs on a flat hilltop and a lower lying area in the north-east of the southern property, and a low lying area in the south of the northern property. *Angophora costata* (Smooth-barked Apple) and *Eucalyptus acmenoides* (White Mahogany) are consistent canopy species in all areas of the community. A number of other canopy species including *Eucalyptus umbra* (Bastard Mahogany), *Eucalyptus fibrosa* (Red Ironbark), and *Corymbia gummifera* (Red Bloodwood) have scattered distributions within the PCT, while *Eucalyptus pilularis* (Blackbutt) occurs generally in the lower lying areas. The small tree layer of the community consists of younger individuals of the canopy species along with patchy occurrences of *Allocasuarina torulosa* (Forest Oak). Examples of this PCT are shown in **Plates 4.11** and **4.12** below.

The shrub layer is relatively sparse, and in a regrowth state in some areas due to clearing of the understorey. Species recorded include the natives *Pittosporum revolutum* (Rough-fruited Pittosporum), *Hibbertia aspera* (Rough Guinea Flower), *Acrotriche divaricata*, *Notelaea longifolia* (Large Mock-olive), and *Persoonia linearis* (Narrow-leaved Geebung). The exotic species *Lantana camara* is present in the shrub layer in some areas, though is not abundant.

The ground layer is dominated by native grasses such as *Entolasia stricta* (Wiry Panic), *Microlaena stipoides*, *Themeda triandra* (Kangaroo Grass), *Imperata cylindrica* (Blady Grass), and *Aristida vagans* (Threeawn Grass). Grasses that occur less frequently include *Digitaria parviflora* (Finger Grass) and

Cymbopogon refractus (Barbwire Grass). Other graminoids such as *Lomandra filiformis* subsp. *filiformis*, *Carex longebrachiata*, and *Ptilothrix deusta* are relatively common in the layer.

Plate 4.9 *Angophora costata* variant of PCT 1590 (north)

Plate 4.10 *Angophora costata* variant of PCT 1590 (south)

A number of native forbs such as *Pratia purpurascens* (Whiteroot), *Vernonia cinerea, Brunoniella australis* (Blue Trumpet), and *Gonocarpus tetragynus* are also present in the ground layer. Exotic weed species are uncommon in the layer with a scattered distribution. Species present include the grasses *Paspalum dilatatum** and *Axonopus fissifolius** (Carpet Grass), and the forbs *Plantago lanceolata**, *Senecio madagascariensis** (Fireweed), and *Conyza sumatrensis** (Tall Fleabane).

PCT 1600 Spotted Gum – Red Ironbark – Narrow-leaved Ironbark – Grey Box shrub-grass open forest of the lower hunter

This vegetation is highly localised in a single patch in the south-east of the subject site where it occurs on soils formed on a localised basalt extrusion; a soil feature not observed elsewhere within the subject site. This part of the subject site comprises complex geology where Carboniferous and Permian geology meet at a regional fault line feature known as the Hunter Mooki Thrust. Floristics of this patch are highly disturbed from past land clearing and livestock grazing and may, in combination with the basalt soil influence, represent a highly localised and undescribed variant of PCT 1590.

The dominant canopy species in the community is *Corymbia maculata* (Spotted Gum), with *Eucalyptus crebra* (Narrow-leaved Ironbark), *Eucalyptus moluccana* (Grey Box), and *Eucalyptus tereticornis* (Forest Red Gum) also present in the layer. A small tree layer is present comprised of younger trees of the canopy species. However, the canopy has been impacted by historical clearing for agriculture and the ground layer in the majority of the area is dominated by exotic grasses and native groundcovers generally tolerant of grazing pressure. An example of this community is shown in **Plate 4.9** with a highly disturbed version shown in **Plate 4.10** (exotic groundcover).

Plate 4.11 PCT 1600 within intact ground layer

The shrub layer within the community is absent, due to grazing, with the only shrub species recorded being young *Leucopogon juniperinus* (Prickly Beard-heath) and *Breynia oblongifolia* (Coffee Bush) individuals. The ground layer is dominated by native grasses in the more intact areas, with common species including *Poa sieberiana*, *Cymbopogon refractus* (Barbwire Grass), *Aristida vagans* (Threeawn Grass), *Themeda triandra* (Kangaroo Grass), and *Microlaena stipoides*. The graminoid *Lomandra filiformis* subsp. *filiformis* is also common in the layer, along with *Carex longebrachiata*. Native forbs recorded include *Brunoniella australis*, *Eremophila debilis* (Winter Apple), *Vernonia cinerea*, and twiners such as *Desmodium varians* (Slender Tick-trefoil), *Desmodium brachypodum* (Large Tick-trefoil), and *Glycine tabacina* are also present.

Dominant exotic grasses in the lower-lying degraded areas of the community include *Axonopus fissifolius** and *Paspalum dilatatum*. Exotic forbs such as *Plantago lanceolata*, *Hypochaeris radicata* (Catsear), and *Verbena rigida* (Veined Verbena) are also common in the degraded areas and scattered throughout the more intact areas.

Plate 4.12 PCT 1600 with exotic dominated ground layer

PCT 1728 Swamp Oak – Prickly Paperbark – Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast

This community occurs within the study area within a large ephemeral wetland in the west. The community consists predominately of a scattered canopy of *Casuarina glauca* (Swamp Oak) and *Melaleuca styphelioides* (Prickly-leaved Tea Tree). The scattered nature of the canopy is likely due to both historic clearing for grazing of the fringing areas of the wetland (**Plate 4.13**), and by deep waters during the wetter months of the year generally inhibiting the occurrence of canopy species in the central areas of the wetland. Patches of the community in the central areas of the wetland occur on raised areas of soil, and occur as small islands when the wetland is fully flooded (see **Plate 4.14**).

Plate 4.13 PCT 1728 on the eastern fringes of the large western wetland

Plate 4.14 Central areas of the ephemeral wetland in dry conditions

Species present in the lower layer include native species such as *Ludwigia peploides* subsp. *montevidensis* (Water Primrose), *Utricularia gibba* (Floating Bladderwort), *Alternanthera denticulata* (Lesser Joyweed), *Persicaria decipiens* (Slender Knotweed), and the grass *Paspalum distichum* (Water Couch). Several individuals of the threatened aquatic herb *Maundia triglochinoides* were recorded in a single small dam to the east of the larger wetland located in the western parts of the study area.

Areas mapped as this community in the centre of the large western wetland lack vegetative cover in drier periods when the soil surface consists of expanses of cracked mud. Due to the depth of water in wet periods vegetation in these areas is likely to consist free floating species such as *Azolla* spp. and *Spirodela* spp.

The ground layer in the community is degraded in many areas and dominated by exotic species such as the forb *Alternanthera philoxeroides**, the tall sedge *Juncus acuta**, and the grass *Cynodon dactylon*. Despite the dominant occurrences of exotic species in many areas, native species are common throughout. Species present include sedges such as *Carex appressa* and *Juncus usitatus*, forbs such as *Centella asiatica* (Indian Pennywort), *Enydra woollsii*, and *Ludwigia peploides* subsp. *montevidensis*, and the grasses *Paspalum distichum* and *Microlaena stipoides* (Weeping Grass).

The climber *Parsonsia straminea* (Common Silkpod) is present growing up individuals of the canopy species, some of which also support the mistletoe *Amyema congener* subsp. *congener*. The fern *Blechnum indicum* (Swamp Fern) was recorded at one location close to the northern shoreline of the wetland.

4.3.2.2 Flora

A total of 377 native species and 98 exotic species were recorded within the subject site. Cumberland Ecology (2019) (**Appendix F**) and **Appendix M** lists the flora species recorded during these investigations.

4.3.2.2.1 Native Species

Distributional variation in individual flora can be the result of many factors such as terrain (e.g. aspect and slope), soils (e.g. type moisture content and depth), disturbance (i.e. natural and anthropogenic) and transitions between these variables. While PCT mapping provides a generalisation of flora distributions (i.e. map units comprising relatively homogenous floristic composition), it should be noted that the distribution of individual species does vary across the landscape.

Tree species mapping is likely to have a substantial influence in the mapping of threatened species habitat polygons where such species are reliant on associated habitat resources. For example, the use of tree species in habitat mapping for specialist folivores such as the Koala is likely to result in a more accurate depiction of habitat than broad habitat surrogates (e.g. PCTs). In such circumstances, the mapping of species habitat using key habitat features is encouraged (PSC 2002; OEH 2014; OEH 2017; OEH 2018) and has been applied in this assessment where appropriate.

4.3.2.2.2 Exotic Species

Extensive occurrences of exotic flora were mapped for the following species within the subject site:

- Lantana (*Lantana camara**) [Weed of National Significance (WoNS)];
- African Olive (*Olea europaea* subsp. *cuspidata**); and
- Blackberry (*Rubus fruticosus* species aggregate*) (WoNS).

Projected foliage cover is mapped for each of these species is in **Figures 4.22**, **4.23** and **4.24**. The percent foliage cover for Lantana and African Olive is significant in parts of the study area. The influence these dense weed occurrences on native PCTs can include:

- Reduced native plant species richness;
- Reduced native plant percent cover; and
- Altered vegetation structure.

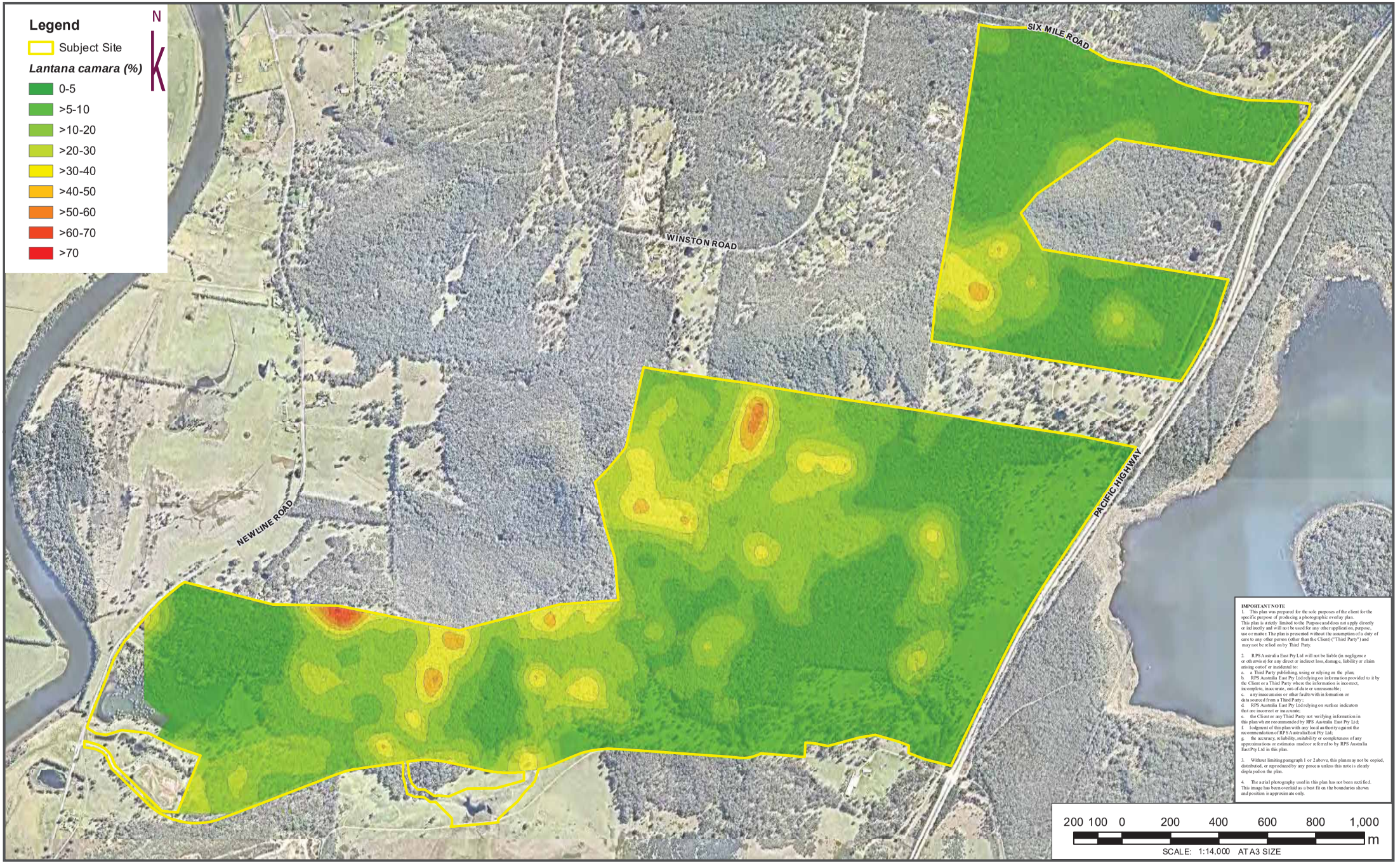
The denser patches of these weed species are likely to have both a negative and positive influence on flora and fauna habitat. State of QLD (2009) estimates that 142 native species may be benefited by Lantana at the expense of negative impacts on 1,480 native species. The impacts on native vegetation and fauna by Lantana (and other woody weed species of similar growth form and invasiveness) can be generally characterised as follow:

“Lantana thickets can provide a substitute habitat for a range of animals, including bandicoots, whipbirds, quail, wrens, birdwing butterflies and brush turkeys, where it has replaced the natural understorey vegetation. However, due to the structural and nutritional simplification caused by lantana invasion, these habitats cannot support the range of animals found in most environmental systems. In addition, lantana provides a refuge for feral animals such as cats, pigs, rabbits, foxes and wild dogs, which compound the negative impacts on native plant and animal populations” (State of QLD 2009).

Other notable weed species occurrences are mapped in **Figure 4.25** and include the following species:

- Fireweed (*Senecio madagascariensis**) [19] (WoNS);
- Alligator Weed (*Alternanthera philoxeroides**) (WoNS)
- Carpet Grass (*Axonopus fissifolia**)[12];
- Spear Thistle (*Cirsium vulgare**)[12];
- Whiskey Grass (*Andropogon virginicus**)[12];
- Water Hyacinth (*Eichhornia crassipes**) (WoNS);
- Wild Tobacco (*Solanum mauritianum**);
- Asparagus Fern (*Asparagus aethiopicus**) (WoNS);
- Large-leaved Privet (*Ligustrum lucidum**);

[19] not mapped, as species is common in exotic grasslands of the subject site



TITLE : FIGURE 4.22: LANTANA PERCENT FOLIAGE COVER WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.22 Lantana Percent Foliage Cover within SS BA3 20191206.mxd

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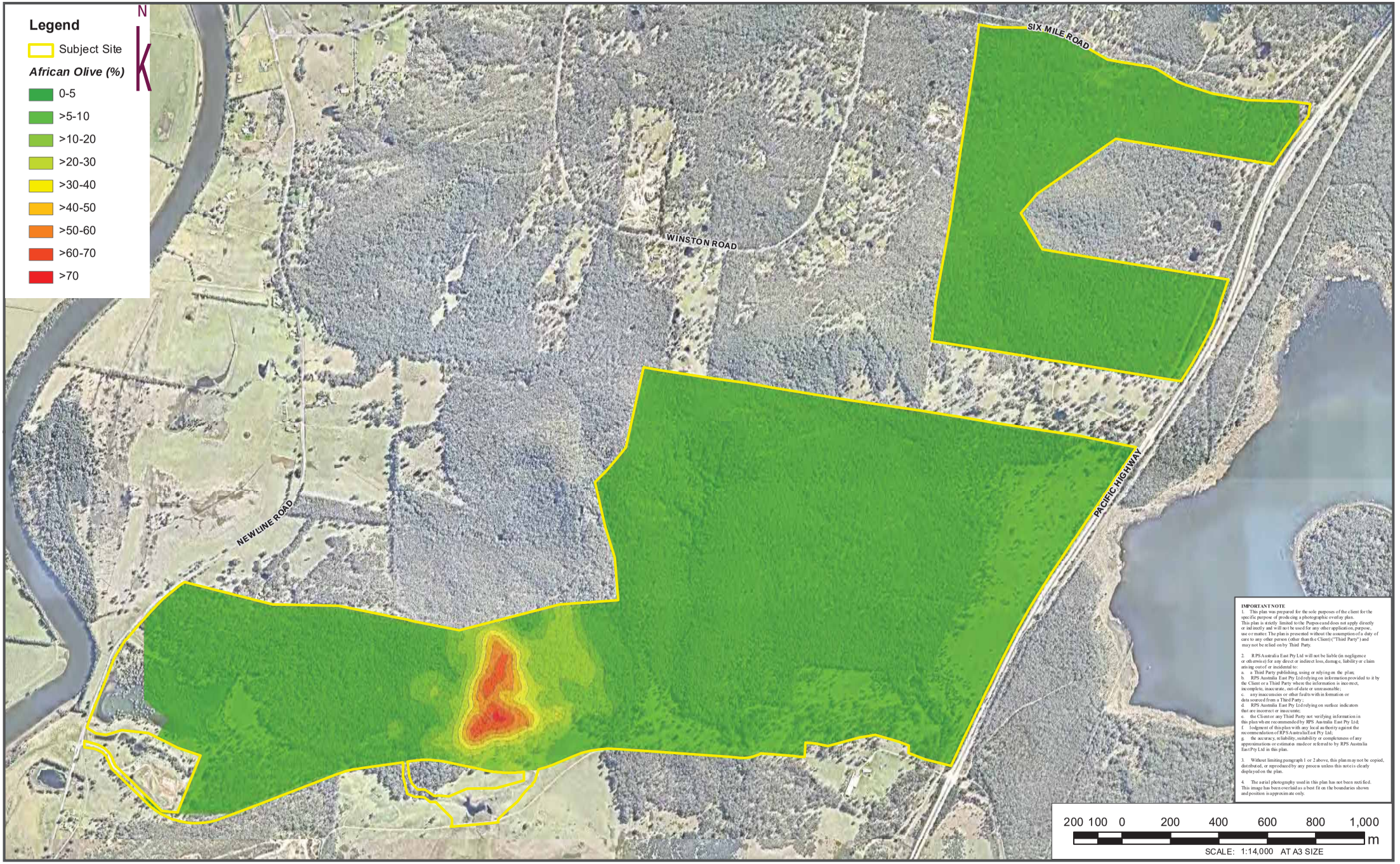

TITLE : FIGURE 4.23: AFRICAN OLIVE PERCENT FOLIAGE COVER WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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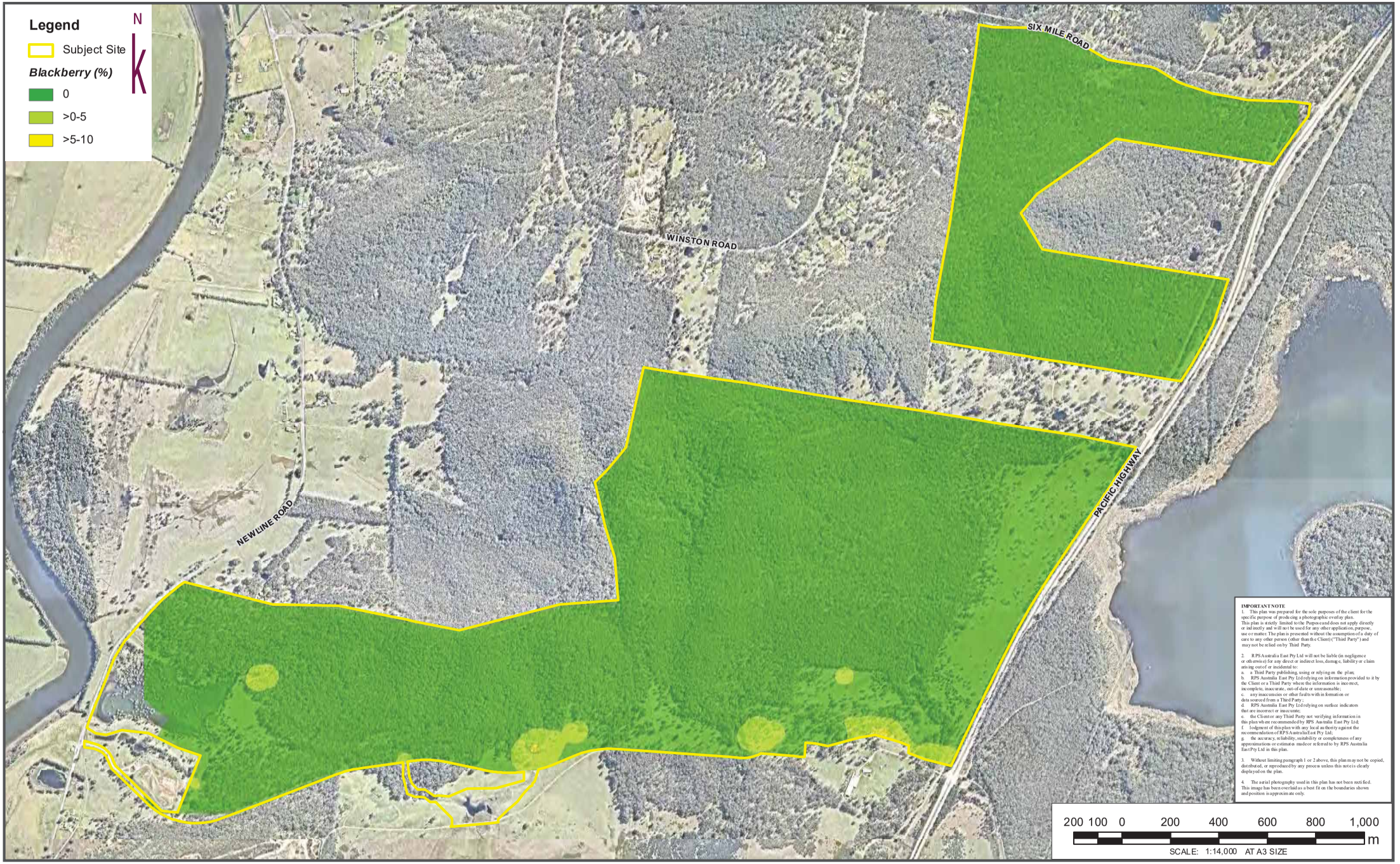

TITLE : FIGURE 4.24: BLACKBERRY PERCENT FOLIAGE COVER WITHIN SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.24 Blackberry Percent Foliage Cover within SS B A3 20191206.mxd

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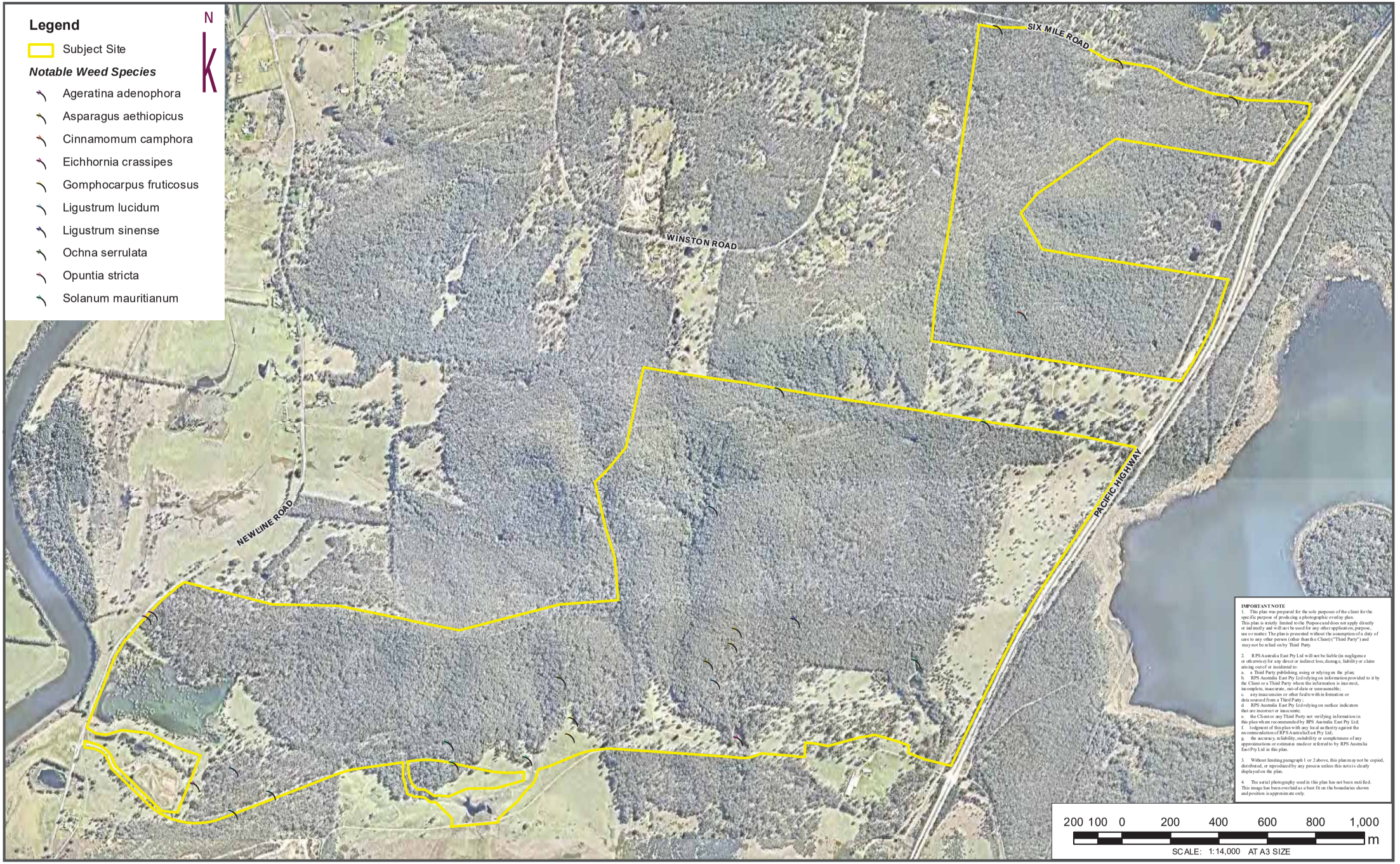

TITLE : FIGURE 4.25: NOTABLE WEEDS WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.25 Notable Weeds within SS B A3 20191206.mxd

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- Small-leaved Privet (*Ligustrum sinense**);
- Crofton Weed (*Ageratina adenophora**);
- Cotton Bush (*Gomphocarpus fruticosus**);
- Camphor Laurel (*Cinnamomum camphora**);
- Mickey Mouse Plant (*Ochna serrulata**); and
- Prickly Pear (*Opuntia stricta**) (WoNS).

4.3.2.3 Habitat

4.3.2.3.1 Overview

Fauna of the study area can be broadly characterised by those occupying habitats broadly described as dry sclerophyll and mesic forests on various geomorphic surfaces (e.g. soils, aspect, slope) dissected by 1st to 3rd order streams and some floodplain environs. The catchment mostly comprises ephemeral 1st and 2nd order streams on moderately steep grades that exhibit short duration flows following effective rainfall events. These flows ultimately drain into wetlands located on the coastal floodplain in the south and west. Few instances of naturally prolonged water accumulations occur within these drainages outside the floodplain environment.

In some drainages, these flows are intercepted by constructed online water detention structures built for the purposes of watering livestock. Also, there are scattered turkey nest dams throughout the subject site acting as additional offline watering points.

The hydrogeomorphology of a third order stream in the east of the study area is characterised by small semi-permanent pools interconnected by dry elongated clayey riffle zones with no gravel substrate. Flows in this stream are rainfall dependant and are generally stagnant outside rainfall events.

Rocky ground is commonly seen on elevated lands, which on mid to lower slopes breaks to clayey soils. Forest maturity, which is broadly defined by the size classes of canopy species, varies across the subject site in response to past and present land use practices. A heterogenous distribution of fallen logs and hollow-bearing trees was observed; these representing habitat features with positive influence on bird, mammal and reptile species diversity.

The following sections provide greater details on the character and distribution of fauna habitat throughout the subject site.

4.3.2.3.2 Forest maturity

Old-growth forest is ecologically mature forest where the effects of disturbances are now negligible (DEC 2004). At Kings Hill, and after excluding landcovers described as forested wetland and wetland, the native vegetation cover of the subject site comprises a mix of open forest (i.e. 30-50%) to forest (i.e. 51-70%) structure. This vegetation has also been variously influenced by historical disturbances and exotic flora and fauna as outlined above.

The variation in forest maturity across the study area reflects historical/ current disturbances and, for this reason, there is no presence of ‘old growth forest’. However, noted effects of disturbance vary spatially; thus engendering variation in forest maturity. For example, the central forested parts of the subject site exhibit a young forest typified by a relatively dense even aged stand of Spotted Gum with isolated occurrences of other tree species such as Grey Box, Broad-leaved Ironbark, Northern Grey Ironbark, Grey Gum and Small-fruited Grey Gum. Further, there are few hollow-bearing trees and fallen logs occurring within this this part of the study area; thus simplifying the associated habitat value. Conversely, the steeper less accessible parts of the site appear to have a diverse array of tree species with greater age variation as exhibited by trees with a large diameter at breast height (dbh), presence of hollows and fallen logs.

Forest maturity was modelled within the KHD owned part of the study area using the following parameters:

- Trees with >80cm dbh (i.e. strong positive indicator of a mature forest);
- Trees with 50-79cm dbh (i.e. positive indicator of a mature forest);
- Trees with <5 cm and 5-9 cm dbh (i.e. indicating regeneration and lower maturity); and
- Moderately dense to dense Lantana cover (i.e. negative indicator as Lantana indicates disturbance and/ or unnaturally inhibits regeneration of canopy species).

The modelled extent of forest maturity is shown in **Figure 4.26** and is based on quantitative data obtained from RDPs for this area.

4.3.2.3.3 Hollows and Fallen Logs

Habitat such as hollow-bearing trees, fallen log length and tree species is heterogeneously distributed throughout the study area for reasons related to environmental factors (e.g. soils, slope, aspect), influence of feral fauna and exotic flora and disturbance history (e.g. logging and clearing). Two key habitat features important in the distribution of fauna, including threatened species, are listed below:

- Fallen logs (> 10cm diameter); and
- Hollow-bearing trees.

The modelled distribution of these habitat features is shown in **Figure 4.27** for fallen logs and **Figure 4.28** for hollow-bearing trees and provides an indication of habitat complexity. The occurrence of significant hollow-bearing trees is also included in **Figure 4.28**. Threatened species benefited by the presence (and abundance) of these habitat features includes the Brush-tailed Phascogale, Squirrel Glider, large forest owls and Brown Treecreeper.

4.3.2.3.4 Tree Canopy

The tree canopy composition and its value for folivores and nectivores varies across the study area and accordingly has an influence on habitat suitability for species reliant on these resources such as the Koala, Grey-headed Flying Fox, Little Lorikeet, Regent Honeyeater and Swift Parrot.

Regional scale Koala Habitat suitability modelling (Law et al 2017) (250 m resolution), as shown in **Figure 4.29**, shows three suitability classes within the study area (i.e. 0.4-0.5, 0.5-0.6 and 0.6-0.7) with the maximum locally occurring suitability class (i.e. 0.8-0.9 or 'very high'), occurring to the south at Tomago. Possible movement pathways that take into consideration habitat value and possible barriers is also illustrated on **Figure 4.29**, indicating the subject site is at the southern extremity of an unbounded habitat patch that extends into large patches of native vegetation to the north including Wallaroo and Karuah NPs.

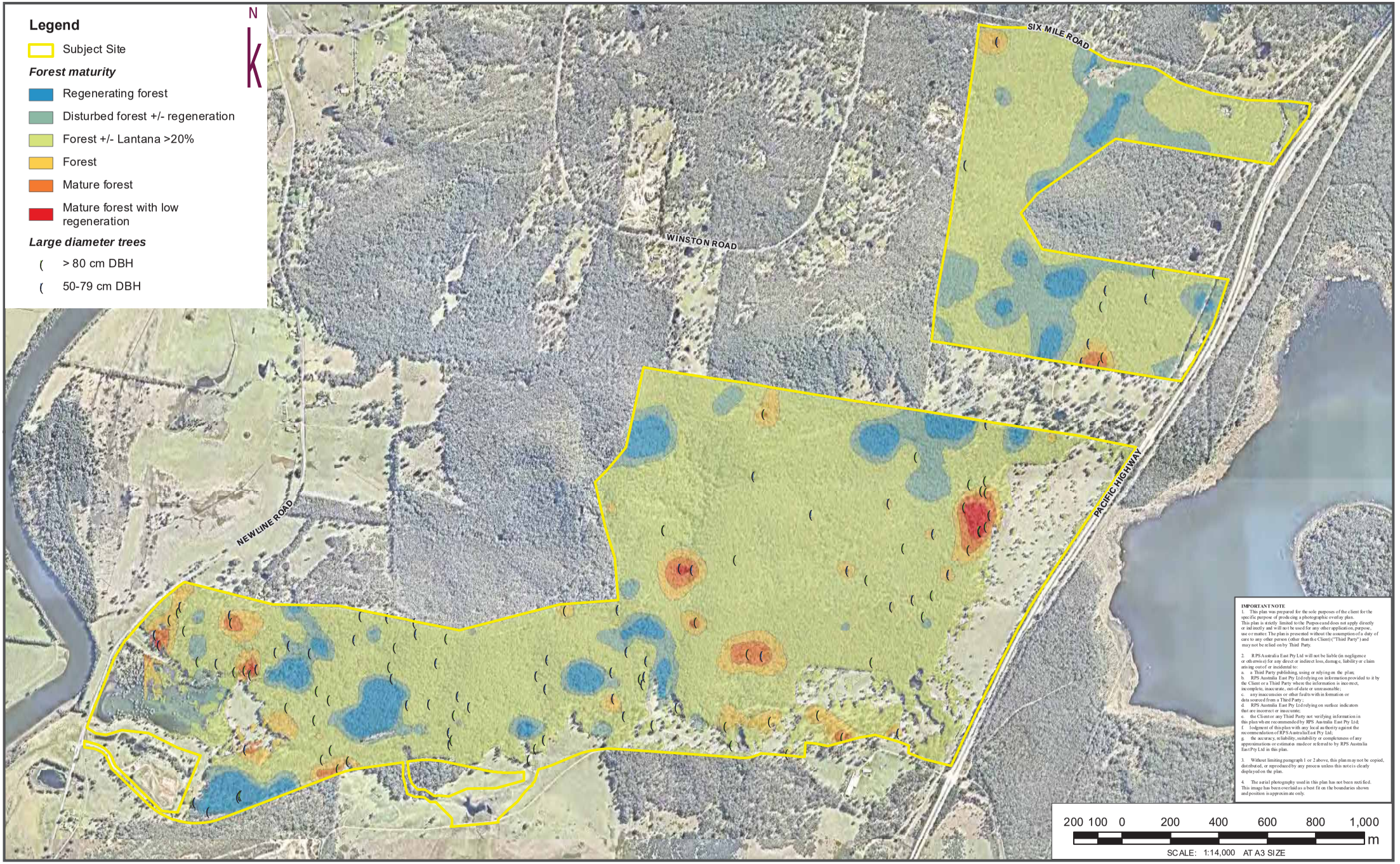
The Koala shows preference for specific feed tree species (OEH 2018; PSC 2002), with the distribution of preferred feed tree species often reflective of preferred habitat (primary and secondary). Primary feed tree species listed for Port Stephens are listed below:

- Paramatta Redgum (*Eucalyptus parramattensis* subsp. *decadens*);
- Forest Redgum; and
- Swamp Mahogany (*Eucalyptus robusta*).

To qualify as a Primary feed tree, the above listed species need to one of the following criteria (BioLink 2019a, BioLink 2019b; **Appendix G**):

- Occurs on alluvial or high fertility soils with a 100mm DBH or greater; or
- Occurs on low fertility soils with a 300mm or greater DBH.

In the case of the subject, the only Primary feed tree species present is Swamp Mahogany as isolated individuals surrounding wetland 803.



TITLE : FIGURE 4.26: FOREST MATURITY WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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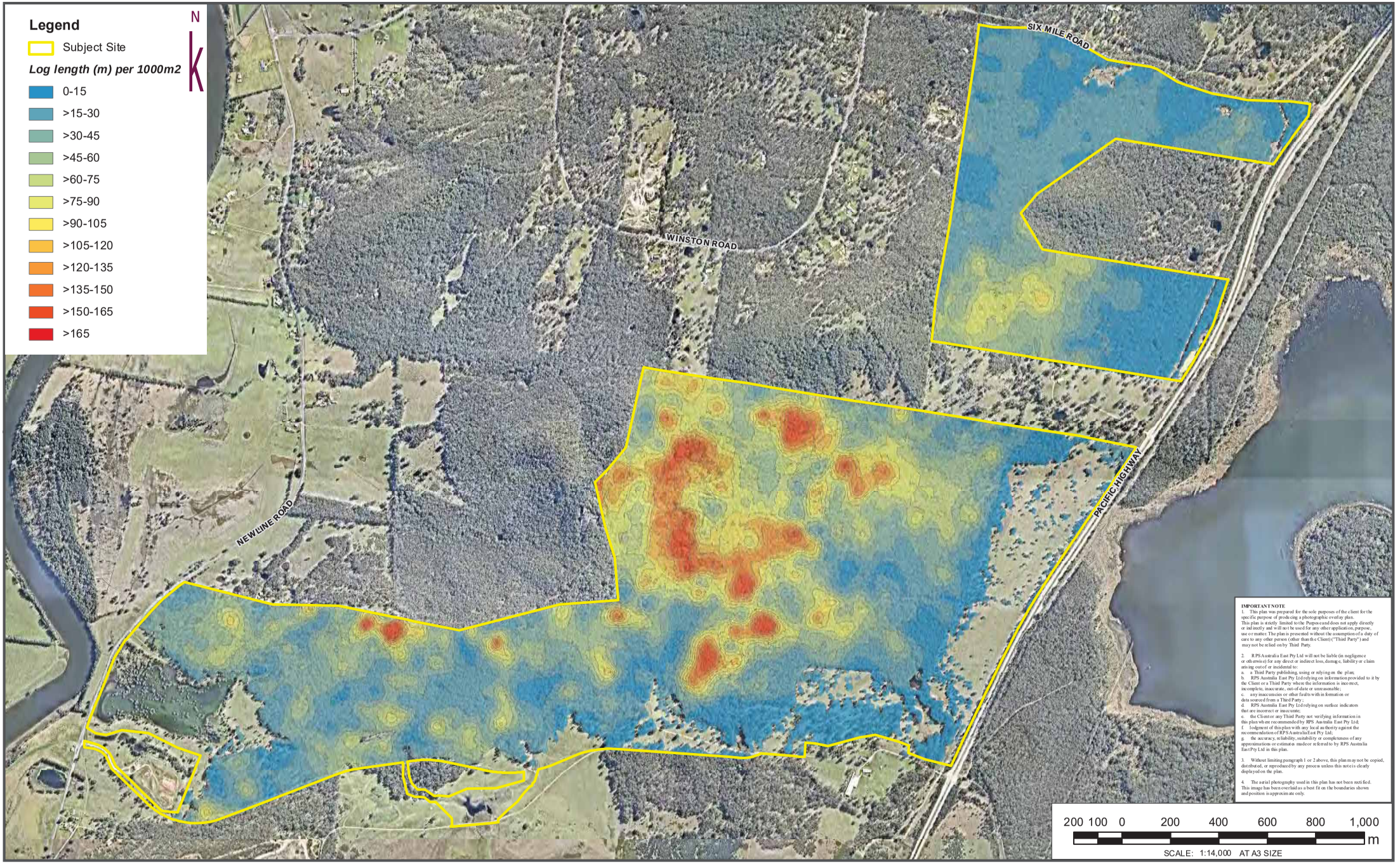

TITLE : FIGURE 4.27: DISTRIBUTION OF FALLEN LOGS WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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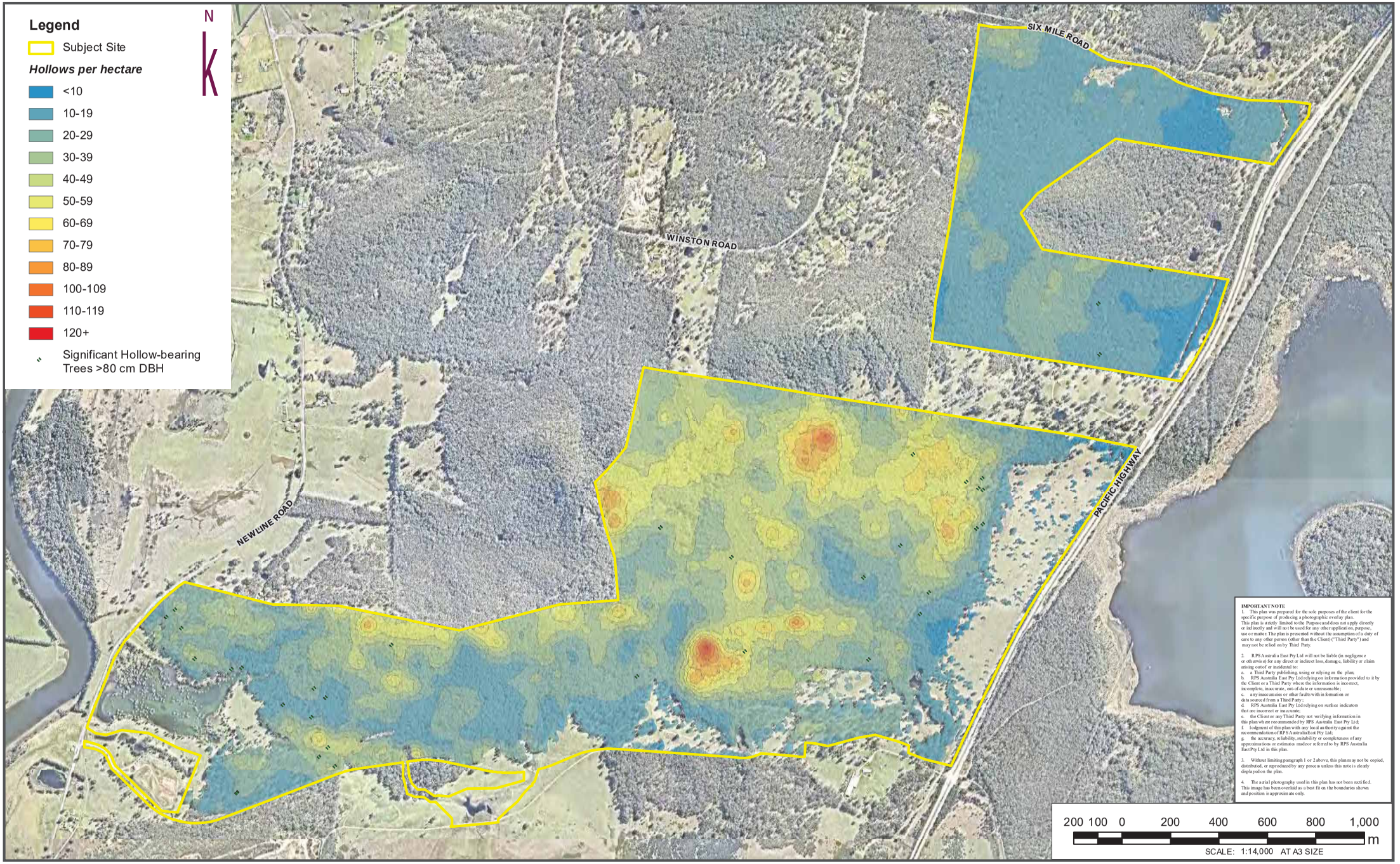

TITLE : FIGURE 4.28: DISTRIBUTION OF HOLLOW-BEARING TREES WITHIN SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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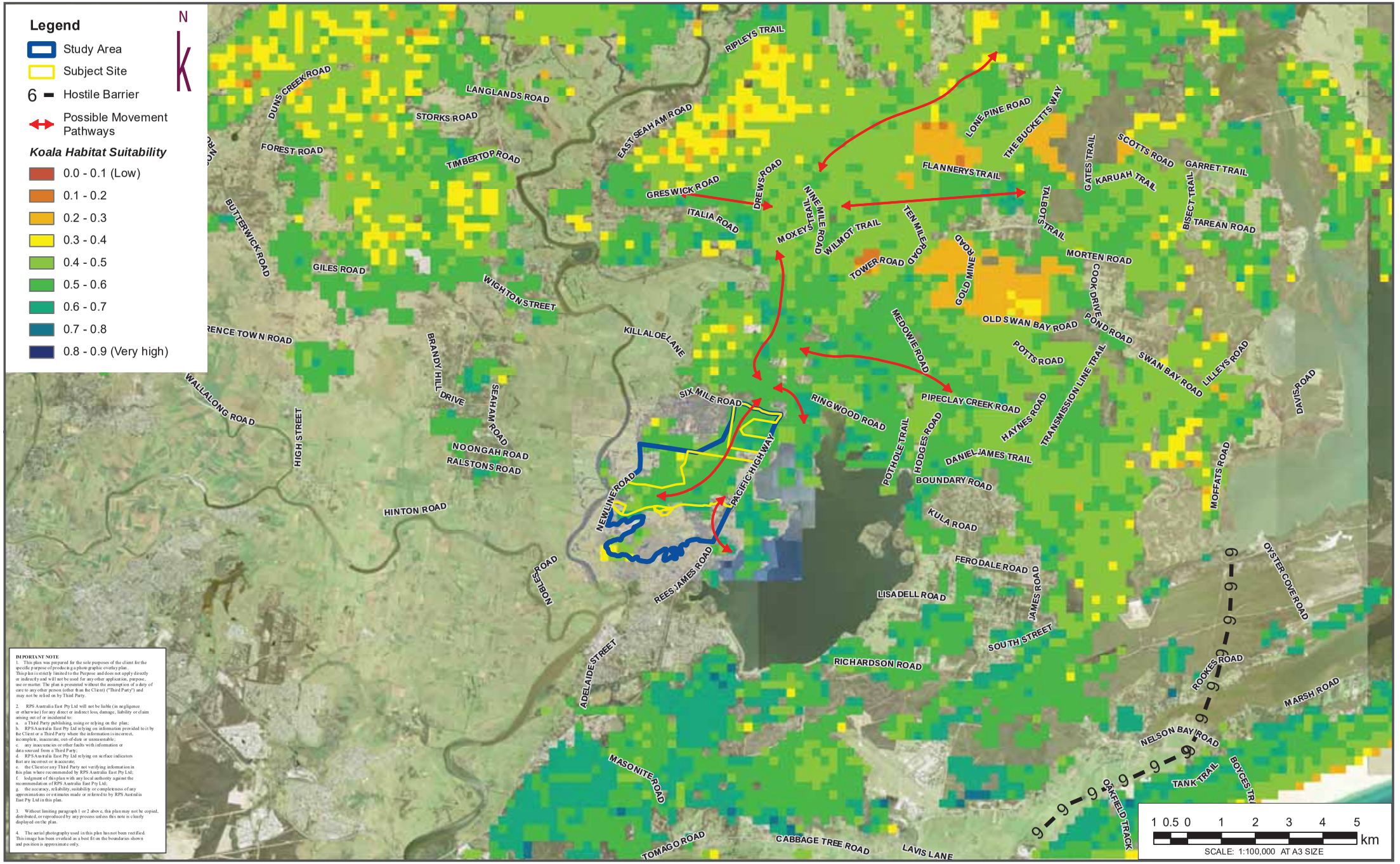

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TITLE : FIGURE 4.29: MODELLED KOALA HABITAT SUITABILITY WITHIN THE LOCALITY (LAW ET AL)

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/02/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (james.hugo)

PATH: \\nt\file1\Data\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.29 Modelled Koala Habitat Suitability within the Study Area (Law et al 2017) C A3

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PSC (2002) and EcoLogical (2013) indicate that secondary feed tree species may include the species listed below, although nutritional value for the Koala would need to be tested to confirm its status:

- Tallowwood;
- Grey Gum;
- Small-fruited Grey Gum;
- Grey Box;
- Narrow-leaved Ironbark;
- Broad-leaved Ironbark;
- Northern Ironbark;
- White Stringybark;
- White Mahogany;
- Broad-leaved White Mahogany; and
- Spotted Gum*.

Eby and Law (2008) identify the following tree species that occur within the study area as important nectar sources for the Grey-headed Flying Fox:

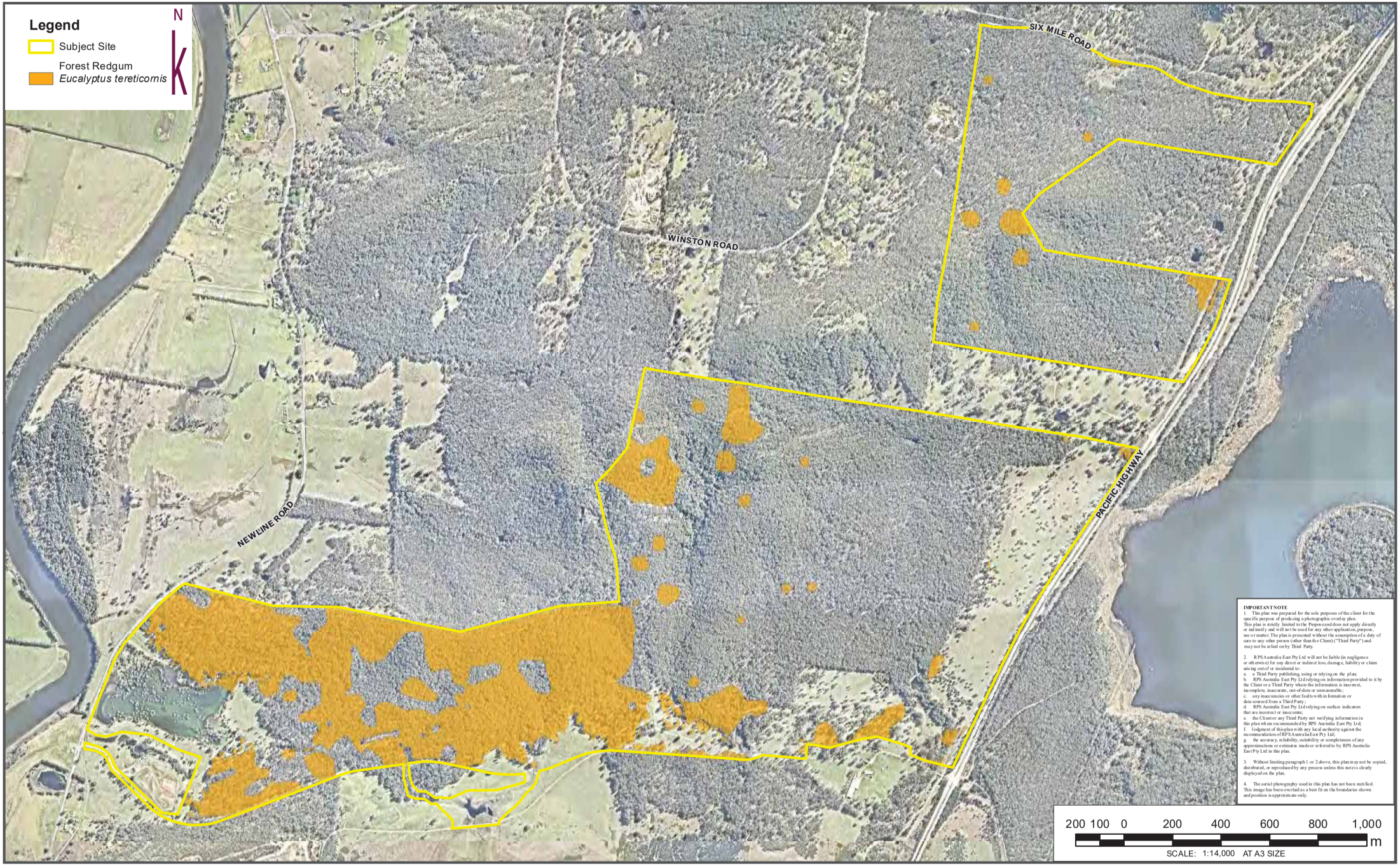
- Spotted Gum (winter bottleneck);
- Red Bloodwood (summer lactation);
- Grey Box (summer lactation);
- Blackbutt (summer lactation and winter bottleneck);
- Northern Grey Ironbark (summer lactation); and
- Forest Redgum (spring-summer lactation).

Individual distribution maps for these tree species is shown in **Figures 4.30** to **4.44**.

Eby and Law (2008) also note the importance of Spotted Gum, Red Bloodwood, Grey Box , Blackbutt, Northern Grey Ironbark and Forest Redgum for:

- Nectar dependent birds [i.e. Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Anthochaera phrygia*) in winter]; and
- Apex predators [i.e. Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*), Spotted-tail Quoll (*Dasyurus maculatus*)].

The relationship between tree canopy species and apex predators relates to the abundance of prey species such as Brush-tailed Possum (*Trichosurus vulpecula*); a species reliant on Eucalypt foliage with relatively high digestible nitrogen (e.g. eucalypt subgenus: *Symphyomyrtus*). Field surveys show high abundances of Brush-tailed Possum throughout the study area; this consistent with the high abundance of Symphyomyrts.



TITLE : FIGURE 4.30: MODELLED DISTRIBUTION OF FOREST REDGUM (EUCALYPTUS TERETICORNIS) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

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TITLE : FIGURE 4.31: MAPPED LOCATION OF SWAMP MAHOGANY (*EUCALYPTUS ROBUSTA*) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/02/2020**

PURPOSE: **ECOLOGY**

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PATH: \\nfile1\Data\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.31 Mapped location of Swamp Mahogany (Eucalyptus robusta) within SS B A3

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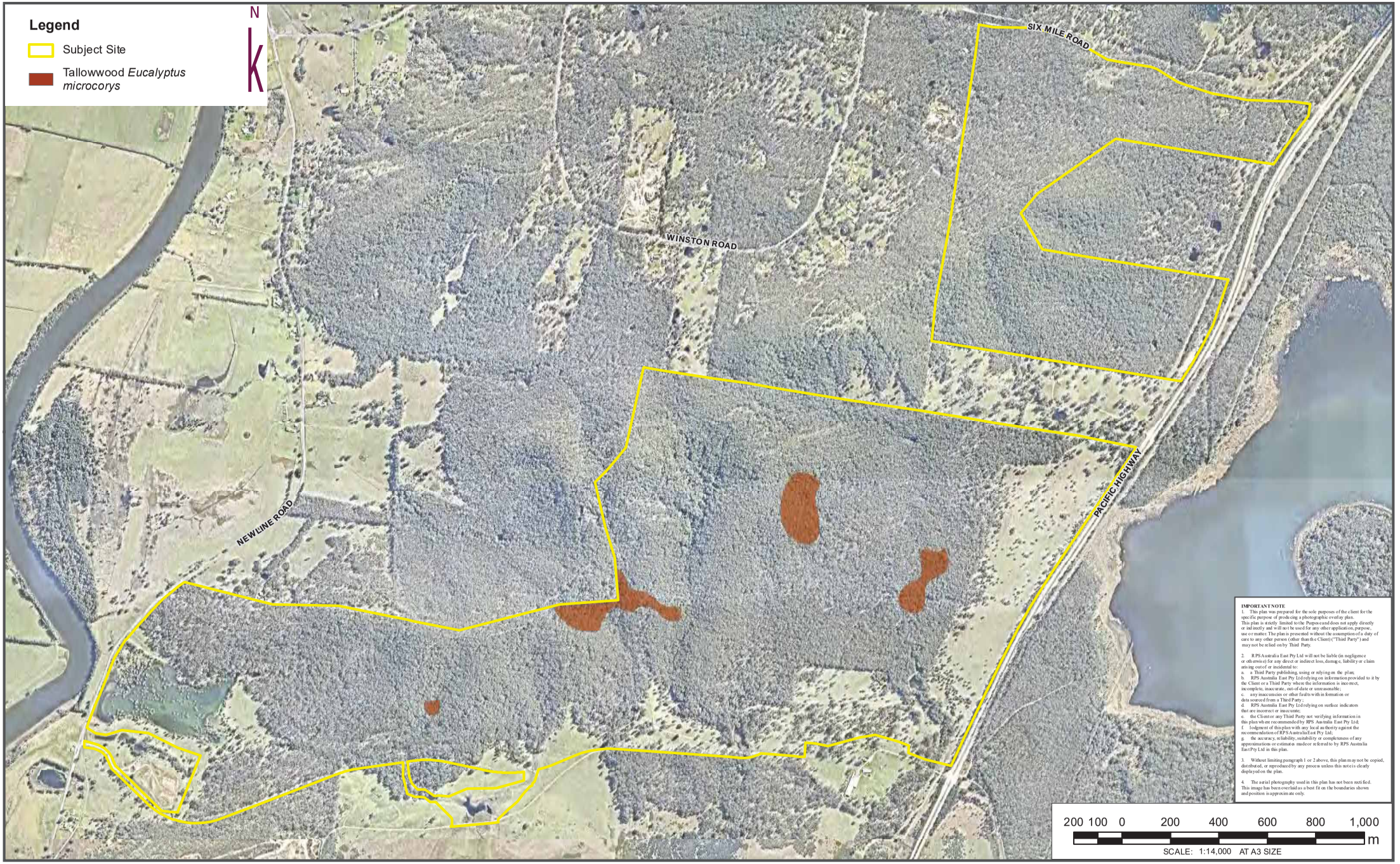

TITLE : FIGURE 4.32: MODELLED DISTRIBUTION OF TALLOWWOOD (EUCALYPTUS MICROCORYS) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.32 Modelled distribution of Tallowwood (Eucalyptus microcorys) within SS B A3

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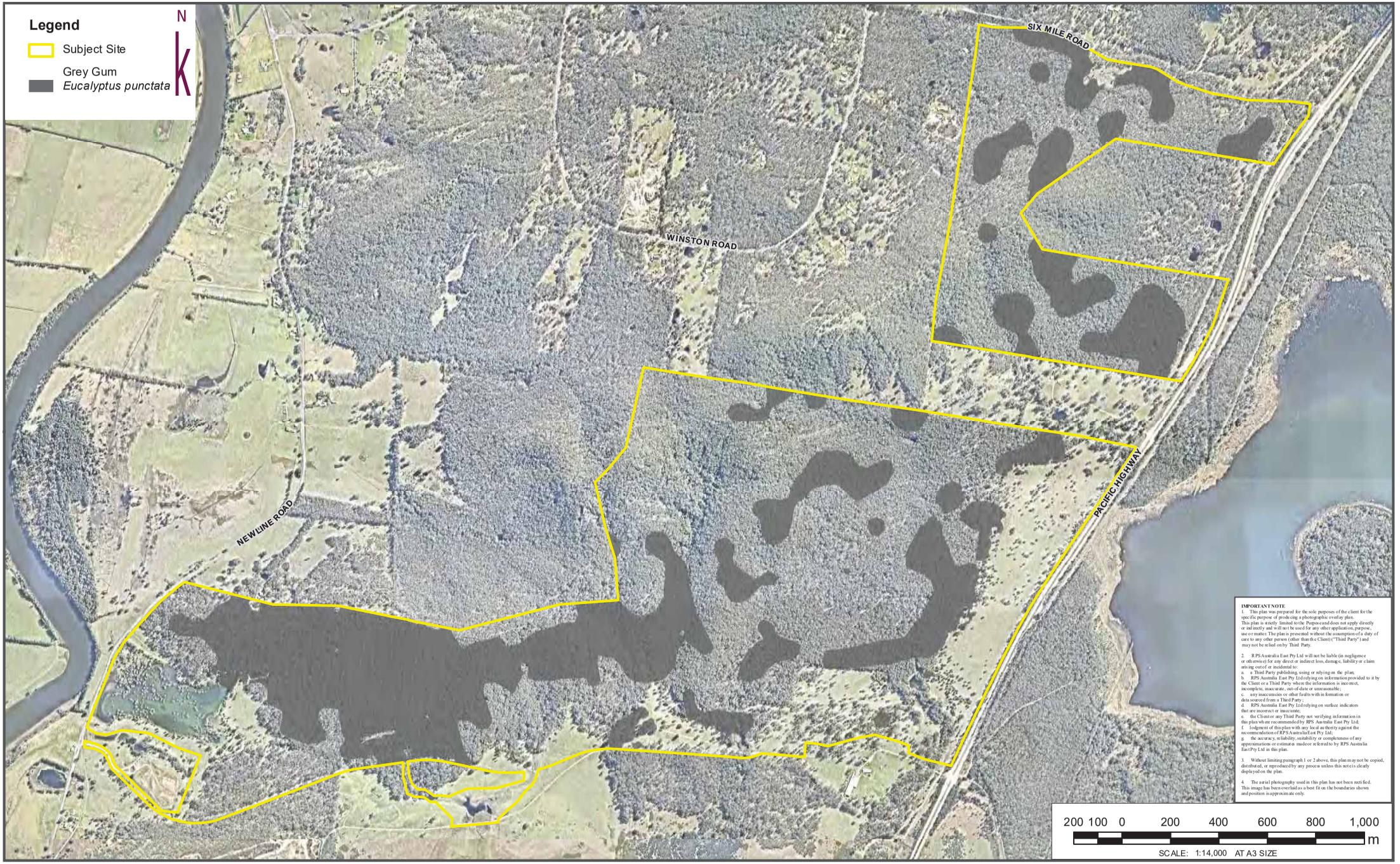

TITLE : FIGURE 4.33: MODELLED DISTRIBUTION OF GREY GUM (EUCALYPTUS PUNCTATA) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.33 Modelled distribution of Grey Gum (Eucalyptus punctata) within SS B A3

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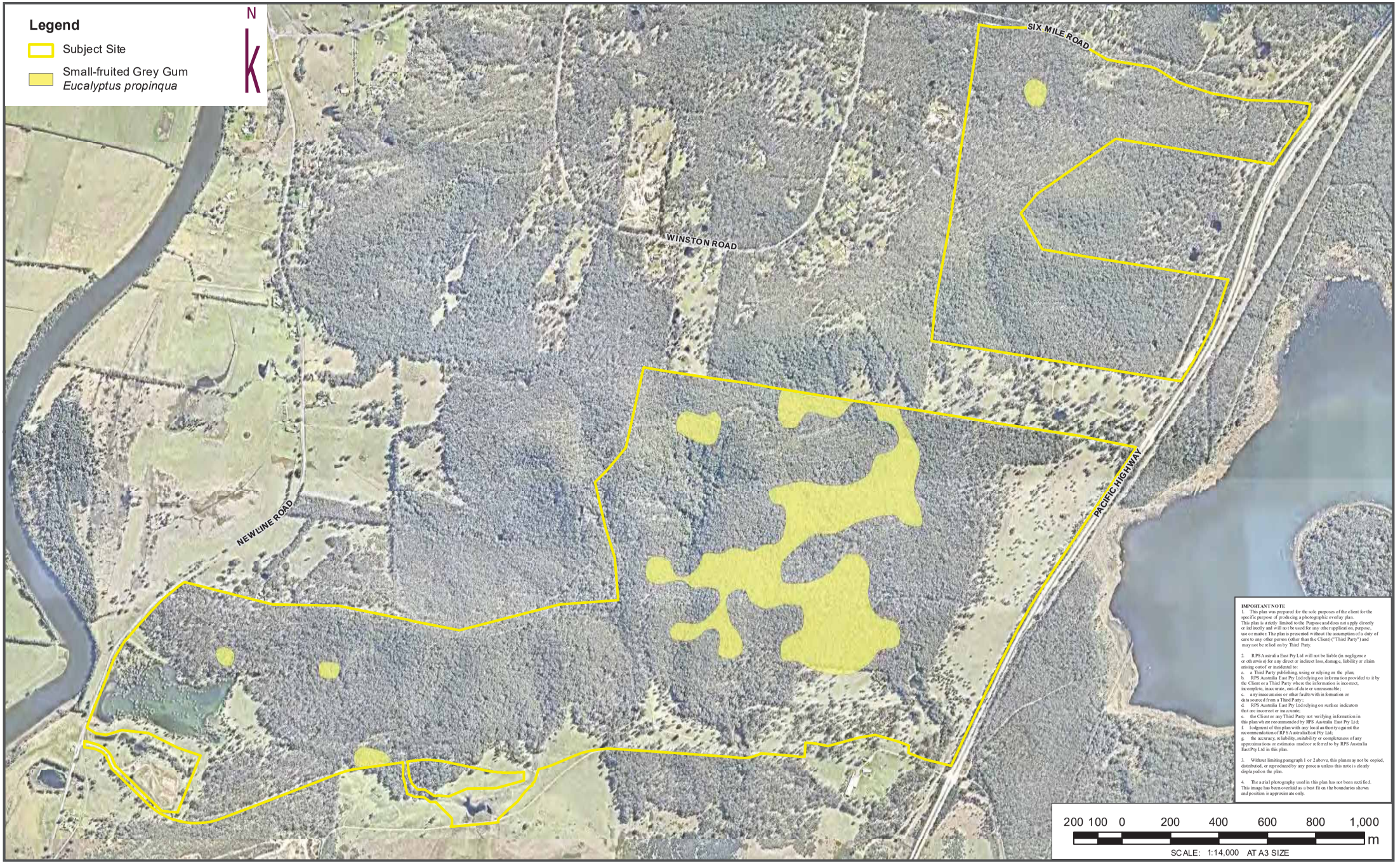

TITLE : FIGURE 4.34: MODELLED DISTRIBUTION OF SMALL-FRUITED GREY GUM (EUCALYPTUS PROPINQUA) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.34 Modelled distribution of Small-fruited Grey Gum (Eucalyptus propinqua) within SSB

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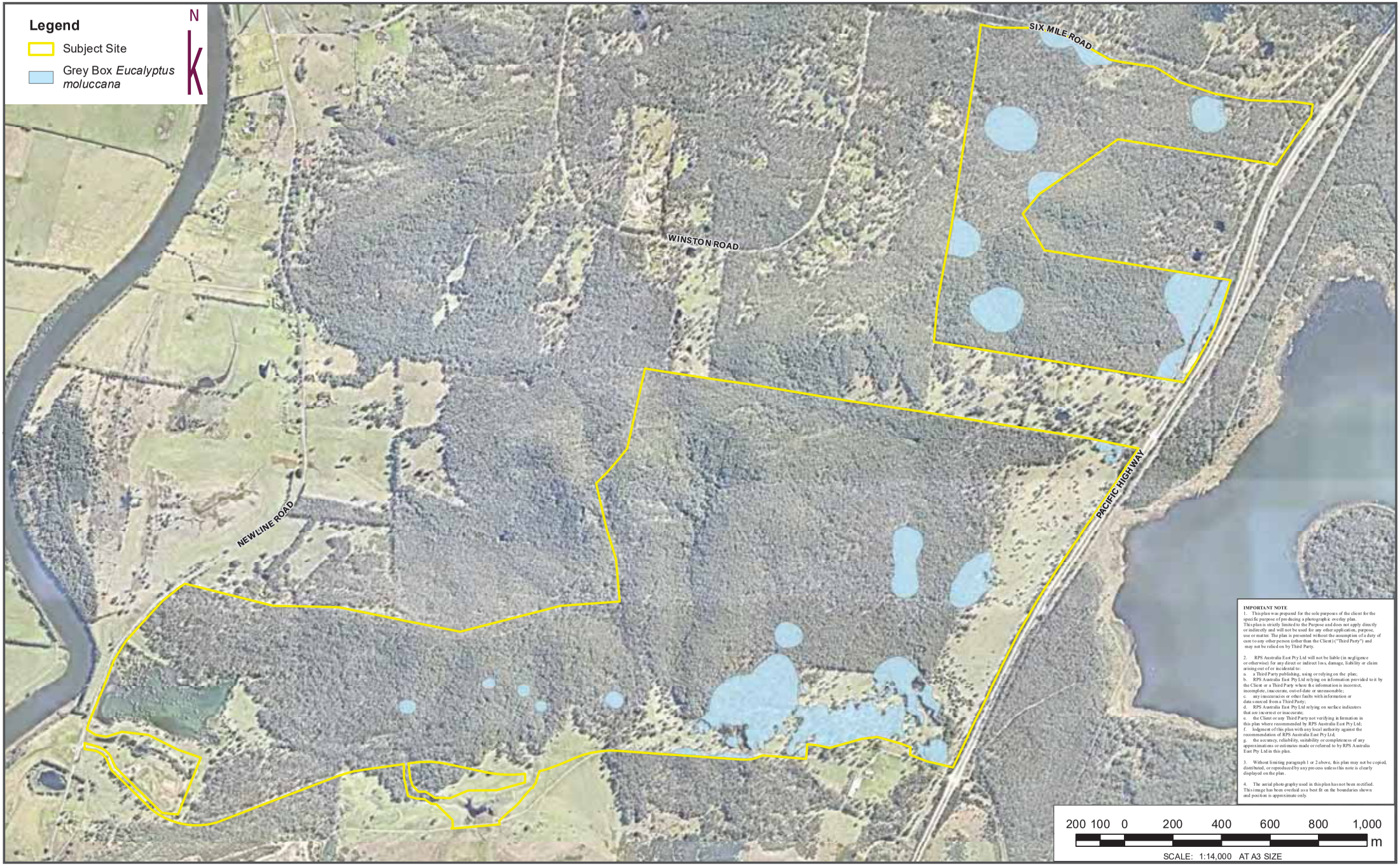

TITLE : FIGURE 4.35: MODELLED DISTRIBUTION OF GREY BOX (EUCALYPTUS MOLUCCANA) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/02/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (james.hugo)

PATH: \\nt\file1\Data\JOBS\130\k130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.35 Modelled distribution of Grey Box (Eucalyptus moluccana) within SS C A3

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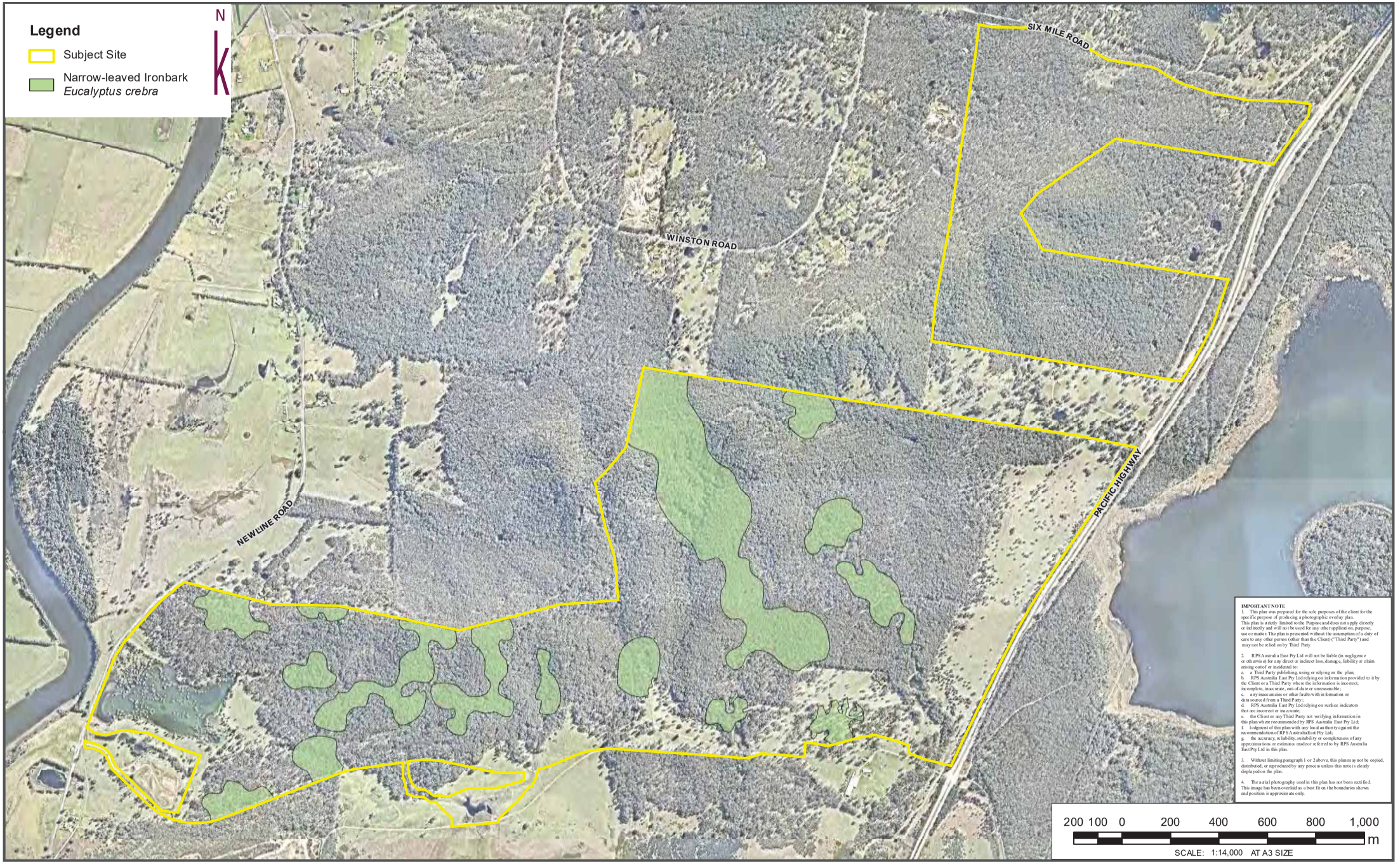

TITLE : FIGURE 4.36: MODELLED DISTRIBUTION OF NARROW-LEAVED IRONBARK (EUCALYPTUS CREBRA) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.36 Modelled distribution of Narrow-leaved Ironbark (Eucalyptus credbra) within SS B

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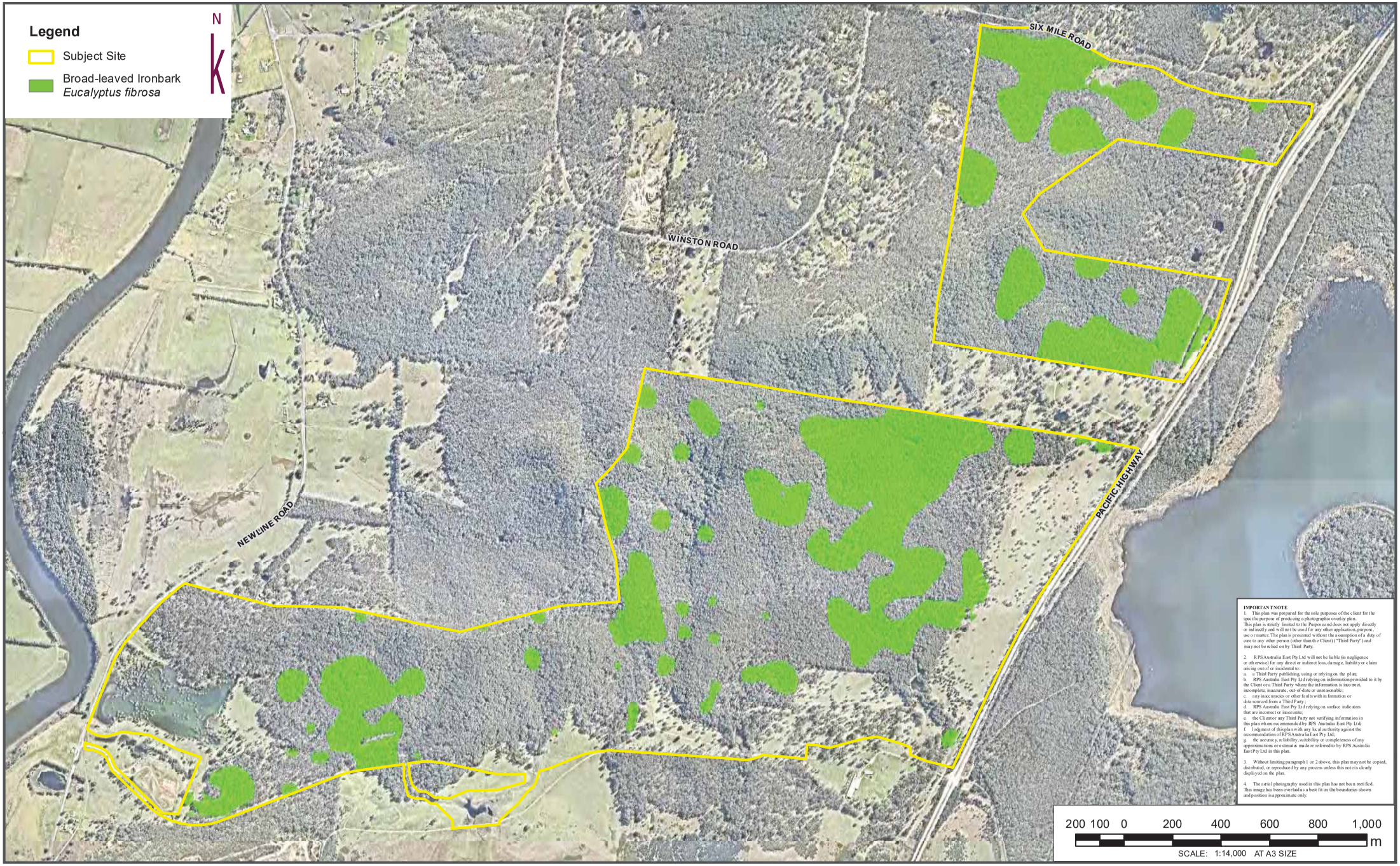

TITLE : FIGURE 4.37: MODELLED DISTRIBUTION OF BROAD-LEAVED IRONBARK (EUCALYPTUS FIBROSA) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.37 Modelled distribution of Broad-leaved Ironbark (Eucalyptus fibrosa) within SS B A3

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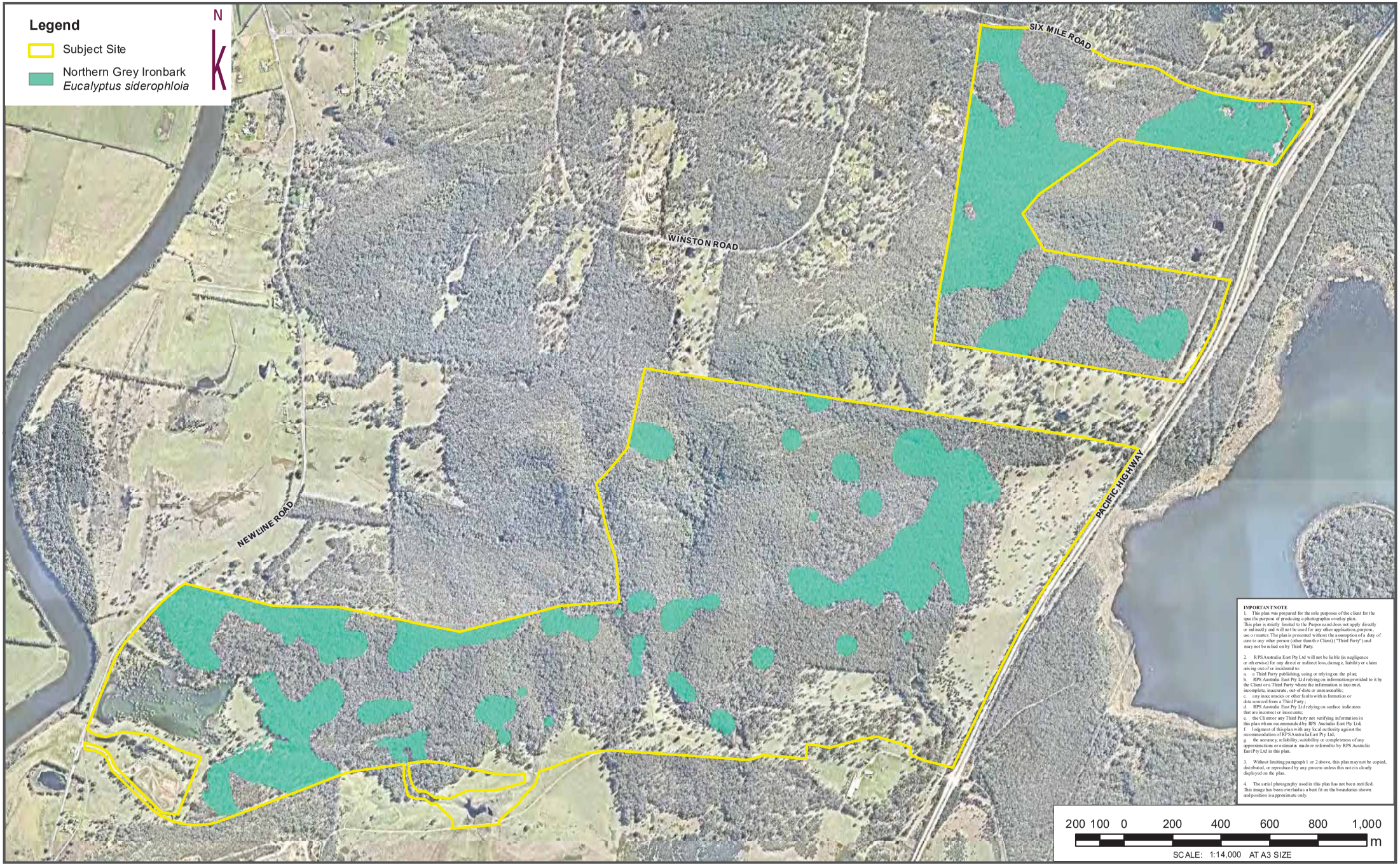

TITLE : FIGURE 4.38: MODELLED DISTRIBUTION OF NORTHERN GREY IRONBARK (EUCALYPTUS SIDEROPHLOIA) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.38 Modelled distribution of Northern Grey Ironbark (Eucalyptus siderophloia) within SS

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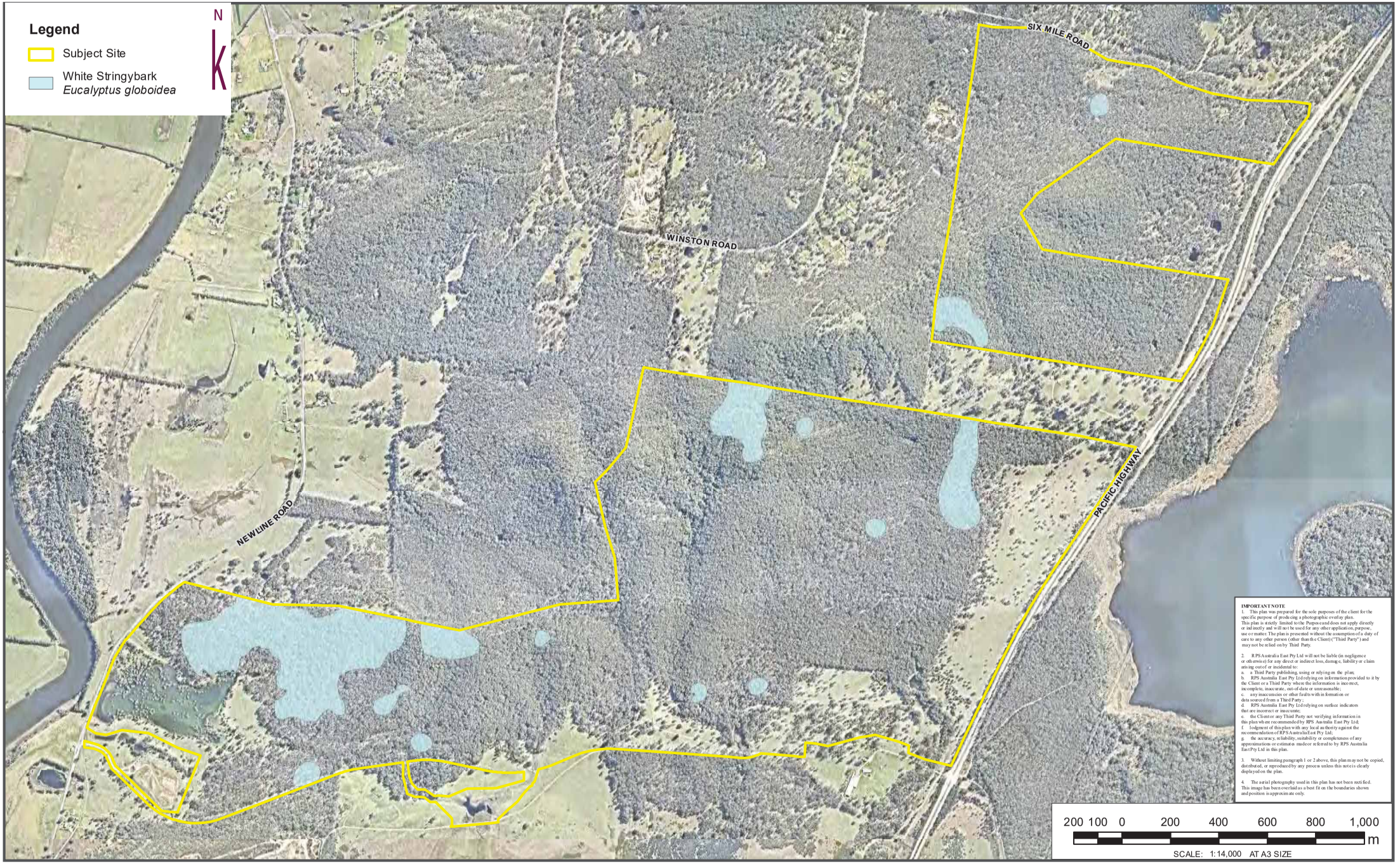

TITLE : FIGURE 4.39: MODELLED DISTRIBUTION OF WHITE STRINGYBARK (EUCALYPTUS GLOBOIDEA) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.39 Modelled distribution of White Stringybark (Eucalyptus globoidea) within SS B A3

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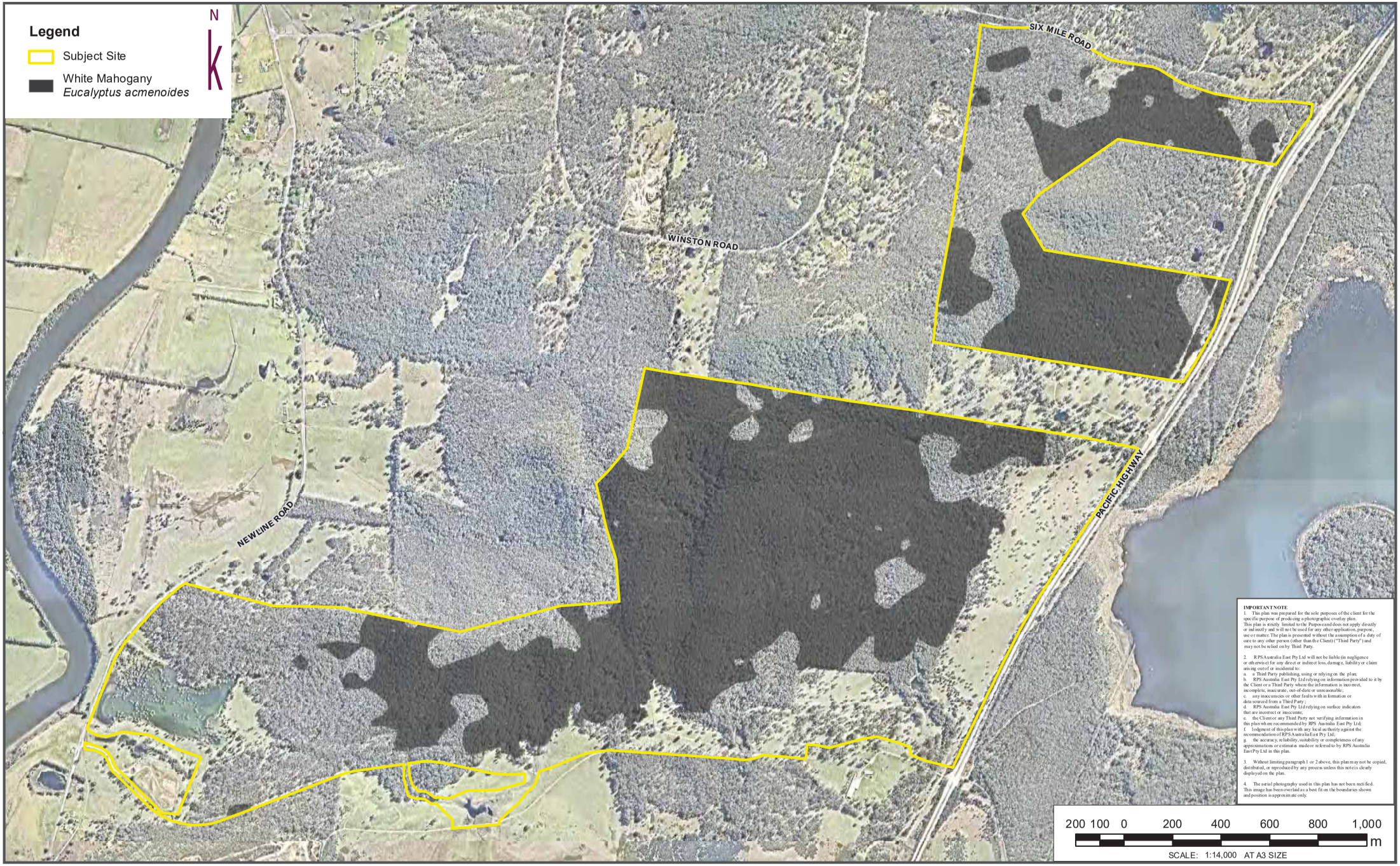

TITLE : FIGURE 4.40: MODELLED DISTRIBUTION OF WHITE MAHOGANY (*EUCALYPTUS ACMENOIDES*) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.40 Modelled distribution of White Mahogany (Eucalyptus acmenoides) within SS B A3

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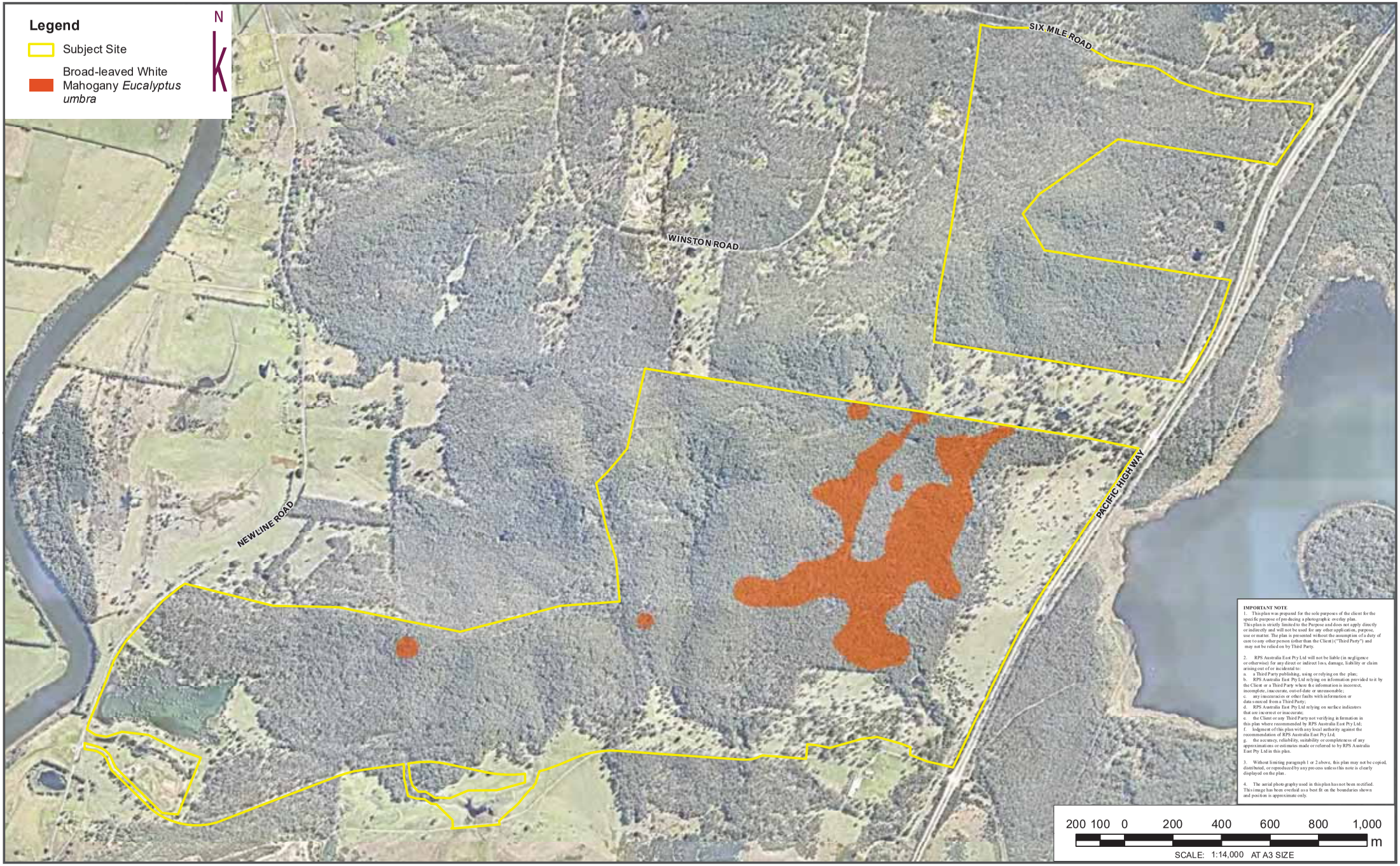

TITLE : FIGURE 4.41: MODELLED DISRTIBUTION OF BROAD-LEAVED WHITE MAHOGANY (*EUCALYPTUS UMBRA*) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/02/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (james.hugo)

PATH: \\nt\file1\Data\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.41 Modelled distribution of Broad-leaved White Mahogany (Eucalyptus umbra)

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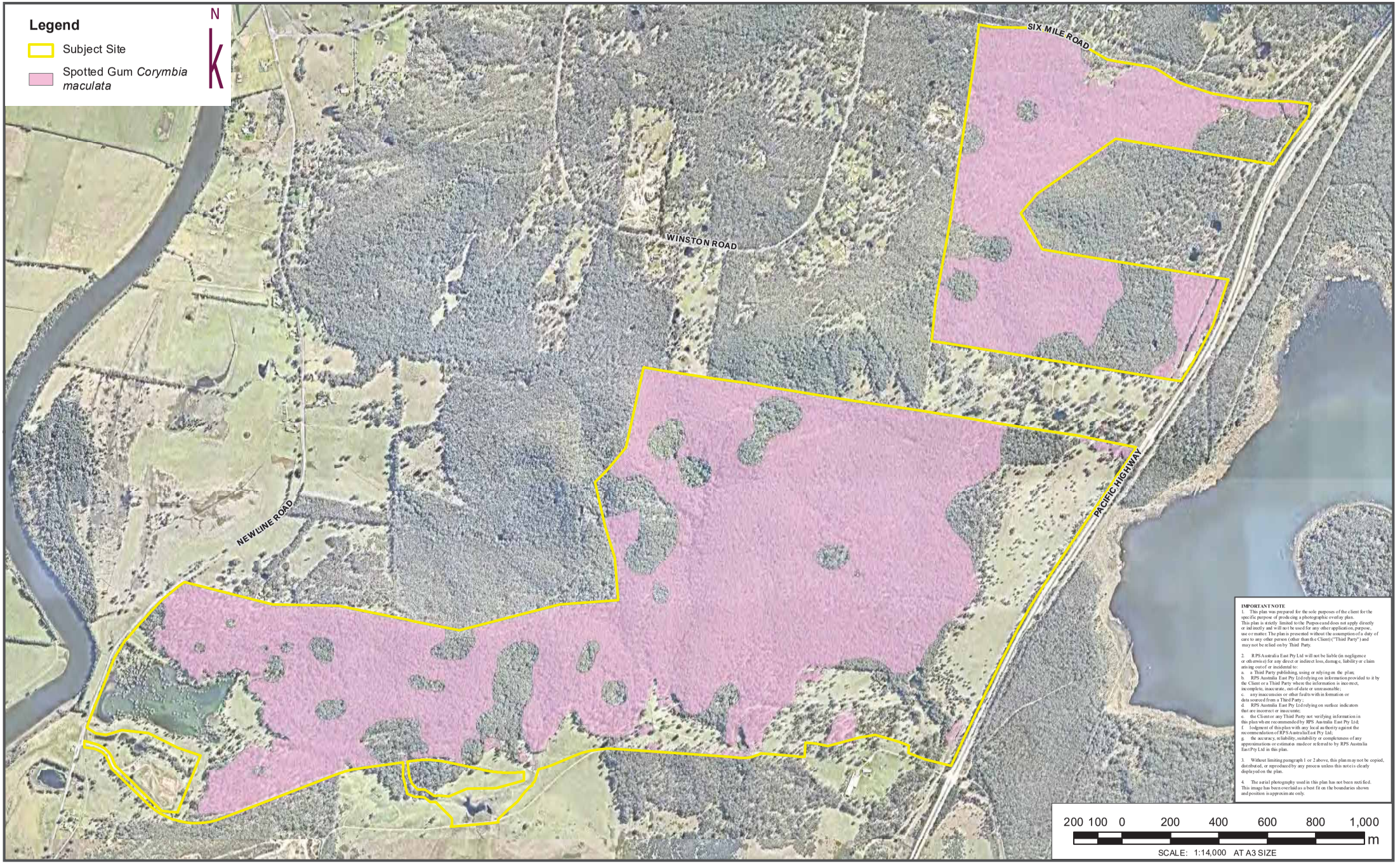

TITLE : FIGURE 4.42: MODELLED DISTRIBUTION OF SPOTTED GUM (*CORYMBIA MACULATA*) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.42 Modelled distribution of Spotted Gum (Corymbia maculata) within SSB A3

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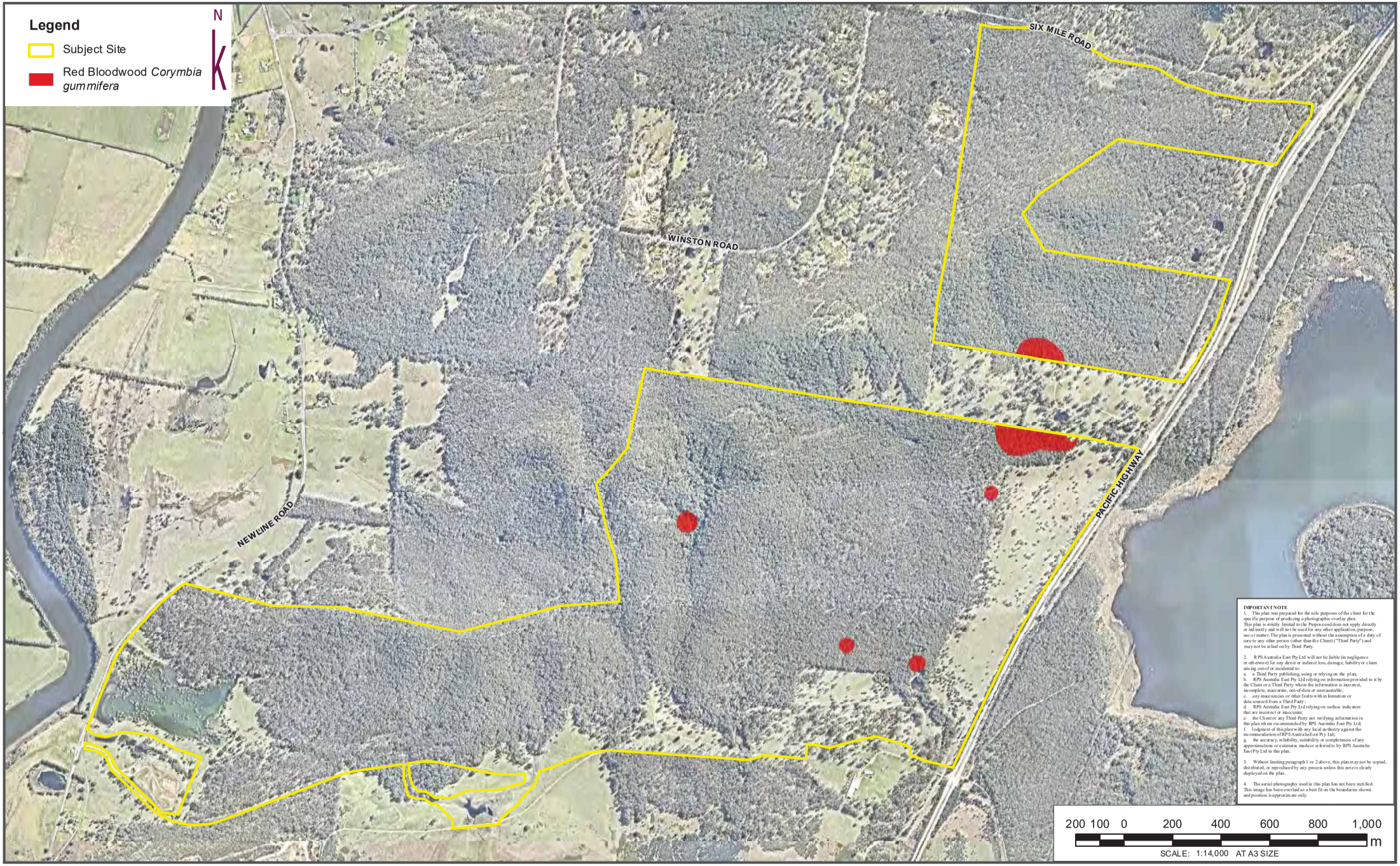

TITLE : FIGURE 4.43: MODELLED DISTRIBUTION OF RED BLOODWOOD (*CORYMBIA GUMMIFERA*) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.43 Modelled distribution of Red Bloodwood (Corymbia gummifera) within SS B A3

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TITLE : FIGURE 4.44: MODELLED DISTRIBUTION OF BLACKBUTT (*EUCALYPTUS PILULARIS*) WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/02/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (james.hugo)

PATH: \\nt\file1\Data\JOBS\130\k130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.44 Modelled distribution of Blackbutt (Eucalyptus pilularis) within SS C A3

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4.3.2.4 Fauna

The list of fauna species recorded is provided in **Appendices N** to **Q**. A general description of the survey results is provided in the following sections.

4.3.2.4.1 Amphibians

Amphibian diversity observed within the study area is generally consistent with the waterway conditions described above. Most amphibian activity was recorded within or nearby the online detention structures/ turkey nest dams. Non-burrowing ground dwelling species such as the Eastern Common Froglet (*Crinia signifera*), Tyler's Toadlet (*Uperoleia tyleri*), Striped Marsh Frog (*Limnodynastes peroni*) and Spotted Marsh Frog (*Limnodynastes tasmaniensis*) were commonly observed in these circumstances.

Conversely, burrowing species such as the Ornate Burrowing Frog (*Opisthodon ornatus*) were not observed owing to the hard clay soils and lack of soft sandier substrates that would otherwise promote the occurrence of such species. Similarly, it is considered that habitat for the critically endangered Mahony's Toadlet (*Uperoleia mahonyi*) is absent from the study area; a species reliant on moist sandy soils in areas of low relief throughout the Port Stephens area (e.g. Tomago sand beds).

Bibron's Toadlet (*Pseudophryne bibroni*) was commonly heard calling from the flanks of moist drainages, with relatively increased abundances notable for this species in the drier parts of the study area where other frog species were less abundant. This species was also observed in open grasslands where small ephemeral pools were noted in the east.

Treefrog species were commonly observed with notable aggregations associated with the online water detention structures in the west of the study area. Species observed included Verreaux's Tree Frog (*Litoria verreauxi*), Peron's Tree Frog (*Litoria peroni*), Broad-palmed Frog (*Litoria latopalmata*), Eastern Dwarf Tree Frog (*Litoria fallax*), Bleating Tree Frog (*Litoria dentata*) and Tyler's Tree Frog (*Litoria tyleri*). Spotlighting and call recognition surveys failed to detect any occurrence of the common Green Treefrog (*Litoria caerulea*) or the endangered Green and Golden Bell Frog (*Litoria aurea*). The latter species has not been previously observed within the study area despite the presence of broad habitat suitability in wetlands to the south and west.

The amphibian surveys were performed immediately followed a significant regional rainfall event that would have increased the likelihood of detecting the Green-thighed Frog (*Litoria brevipalmata*). This species was not observed within the study area despite being observed elsewhere at a Mandalong Valley reference site in the previous night. The habitat for this species is considered to be absent from the study area (e.g. offline ephemeral pools on elevated benches in forested wetlands, forest and rainforest).

The third order stream in the east of the study area was also surveyed with no indications of 'stream dwelling species' being present. The geomorphology and hydrology of this stream is characterised by semi-permanent pools interconnected by dry elongated clayey riffle zones with no gravel substrate and rainfall dependant flows. Water is generally stagnant outside rainfall events. These habitat conditions are not suitable for species such as Southern Barred Frog (*Mixophyes balbus*) and Giant Barred Frog (*Mixophyes iteratus*). Observed frog activity was generally low in this drainage and mainly denoted by Bibron's Toadlet and Eastern Common Froglet.

4.3.2.4.2 Mammals

Surveys indicate the subject site comprise a large population of Brush-tailed Possum (*Trichosurus vulpecula*), some with an appetite for flowering ground orchids (*Dipodium vaerigatum*) as shown in **Plate 4.15**.

Plate 4.15 Brush-tailed Possum (*Trichosurus vulpecula*) eating a ground orchid

The Brush-tailed Phascogale (*Phascogale tapoatafa*) was also infrequently observed within the subject site as shown in **Plate 4.16**. This species occupies variably sized home ranges (small to large) depending on available resources for foraging and breeding and is very cryptic and difficult to detect with conventional means (i.e. is known to escape Elliott traps following capture).

Plate 4.16 Brush-tailed Phascogale (*Phascogale tapoatafa*) using ground habitat for movement

Survey results indicate that the mature parts of the forest comprise more ground mammal species such as Brown Antechinus (*Antichinus stuartii*), Bush Rat (*Rattus fuscipes*) and Long-nosed Bandicoot (*Perameles*

nasuta) with the latter species not observed outside areas with complex vegetation and habitat structure (i.e. vegetation with dense understorey comprising high levels of fallen logs). More generally, camera and Elliott trapping indicated a broad trend of low ground fauna occupancy in the less mature parts of the forest; an expected finding as habitat structure is important for breeding, foraging and predator evasion.

Macropods within the open treeless parts of the site are mostly Eastern Grey Kangaroo (*Macropus gigantea*). Red-necked Wallaby (*Macropus rufogriseus*) is an occasional visitor of these environment as it is more commonly observed within the forested parts of the study area. Eastern Grey Kangaroo is uncommon within the forests and generally only occurs in the grassier open vegetation near forest margins. Frequent observations of the Dingo (*Canis dingo*) were recorded as shown in **Plate 4.17**.

Plate 4.17 Dingo (*Canis dingo*)

4.3.2.4.3 Reptiles

The most commonly observed species was the Lace Monitor (*Varanus varius*), a habitat generalist not reliant on the conditions described above, with occasional observations of Red-bellied Black Snake (*Pseudechis porphyriacus*).

4.3.2.4.4 Exotic Species

Fauna surveys of the study area indicate a low abundance of feral mammals such as European red fox (*Vulpes Vulpes*), European rabbit (*Oryctolagus cuniculus*) and feral cat (*Felis catus*). The study area is home to a population of Fallow Deer (*Dama dama*) as shown in **Plate 4.16**. The distribution of this species is mostly in the central to northern parts of the study area where terrain and groundcover vegetation is more suitable for grazing.

Plate 4.18 Fallow Deer (*Dama dama*)

4.4 Subject Species Habitat Mapping

DGR 4.4 Subject species habitat mapping

4.4.1 Introduction

Fauna habitat on the study area generally consists of open forest or woodland communities dominated by Spotted Gum and Ironbark vegetation with some cleared grassland areas in the lower lying areas. These areas provide potential habitat for microchiropteran bats, birds and mammals. There is some rock outcropping and boulders on the upper slopes, suitable for reptiles and potential roost sites for microchiropteran bats. Several minor drainage lines and wetland/farm dams are present in the southern section of the study area, providing habitat for amphibians.

Detailed habitat mapping has been carried out for subject species that are known to occur within the subject site or are likely to occur and have not been observed due to factors such as those outlined in **Section 4.1.1** (i.e. false absences and imperfect detection). These species include:

Threatened Flora

- *Corybas dowlingii* (Red Helmet Orchid);
- *Maundia triglochinoides* (Small Water-ribbons); and
- *Pterostylis chaetophora*.

Threatened Fauna

- Glossy-black Cockatoo (known);
- Brown Treecreeper (known);
- Varied Sittella (known);
- Little Lorikeet (known);
- White-bellied Sea Eagle (known);

- Square-tailed Kite (known, flying over wetland 804 and vegetation adjacent to wetland 803);
- Osprey (known, flying over wetland 803);
- Magpie Goose (moderate likelihood – not detected);
- Australian Bittern (moderate likelihood – not detected);
- Black Bittern (moderate likelihood – not detected);
- Dusky Woodswallow (known);
- Black-necked Stork (known from older records, unconfirmed in recent surveys);
- Grey-crowned Babbler (known);
- Powerful Owl (known);
- Masked Owl (known);
- Regent Honeyeater (moderate likelihood – not detected);
- Swift Parrot (moderate likelihood – not detected);
- Scarlet Robin (known);
- Squirrel Glider (known from older records, unconfirmed in recent surveys);
- Koala (known);
- Brush-tailed Phascogale (known);
- Spotted-tailed Quoll (moderate likelihood – not detected);
- Grey-headed Flying Fox (known);
- Cave roosting microchiropteran bat species:
  - Eastern Bentwing-bat (known);
  - Little Bentwing-bat (known);
- Hollow roosting microchiropteran bat species:
  - Yellow-bellied Sheath-tail Bat (moderate likelihood – not detected);
  - Eastern False Pipistrelle (known);
  - Greater Broad-nosed Bat (known);
  - Eastern Freetail-bat (known); and
  - Southern Myotis (moderate likelihood – not detected);
- Wetland frog species:
  - Green and Golden Bell Frog (moderate likelihood – not detected);
  - Wallum Froglet (moderate likelihood – not detected).

Habitat areas for each of these species within the subject site is described in **Sections 4.4.2** to **4.4.30**. Subject species identified in **Section 3.1** that have not had any habitat mapping provided include those that have been adequately surveyed for and are unlikely to occur within the subject site.

4.4.2 Red Helmet Orchid

The habitat of *Corybas dowlingii* is described in the NSW Scientific Committee (2007) final determination as "typically grows in gullies in tall open forest on well-drained gravelly soil at elevations of 10-200m". It forms clonal colonies, an aspect of its ecology that has allowed for the successful translocation of this species at Bulahdelah in response to an impact from the construction of the Pacific Highway bypass at that location.

A review of the taxonomic and conservation status of *C. dowlingii* (Wagner et al 2020; **Appendix K**) has revealed this orchid is not a species rather a stable hybrid between *C. barbare* and *C. aconitiflorus*. The genetic structure analysis showed varying levels of genetic admixture for several *C. aconitiflorus*, *C. barbarae*, and *C. dowlingii* samples, thus further corroborating the presence of hybridisation and introgression within the species complex. The taxonomic status of *C. dowlingii* D.L.Jones has been revised to *C.* × *dowlingii* D.L.Jones *stat. nov*. to reflect its hybrid origin. The conservation status of *C.* × *dowlingii* was reviewed and it was concluded that the conservation status of *C.* × *dowlingii* is of least concern and it is recommend this be reflected in the Australian legislation at state and federal level (Wagner et al 2020).

The final determination (NSW Scientific Committee 2007) identifies three populations of *C. dowlingii*. The Bulahdelah population of *C. dowlingii* includes approximately 3,400 plants, while the Port Stephens populations include approximately 15,000 plants. The size of the Freemans Waterhole population is unknown. In relation to the latter, a recent study for 1,000 ha of native vegetation near Freemans Waterhole in the Awaba – Eraring locality resulted in the detection of an estimated 325,000 individuals of *C. dowlingii* at 2,132 locations (i.e. mean ~152 plants/ location) (RPS 2019). This is in addition to numerous finds of this species in the Mandalong valley (RPS 2014).

While not noted to occur in the conservation reserve network (NSW Scientific Committee 2007), *C. dowlingii* occurs within Columbey National Park (Bell 2009) with a portion of the above-mentioned Awaba – Eraring population occurring within the Lake Macquarie City Council administered BioBank site. Wagner et al (2020) also note the occurrence of *C.* × *dowlingii* in Lake Innes Nature Reserve.

Desktop searches failed to identify the occurrence of *Corybas dowlingii* within the locality; however, they were identified within the study area during winter targeted surveys in 2018. This species is known to flower from June to August, with peak flowering determined by weather and rainfall.

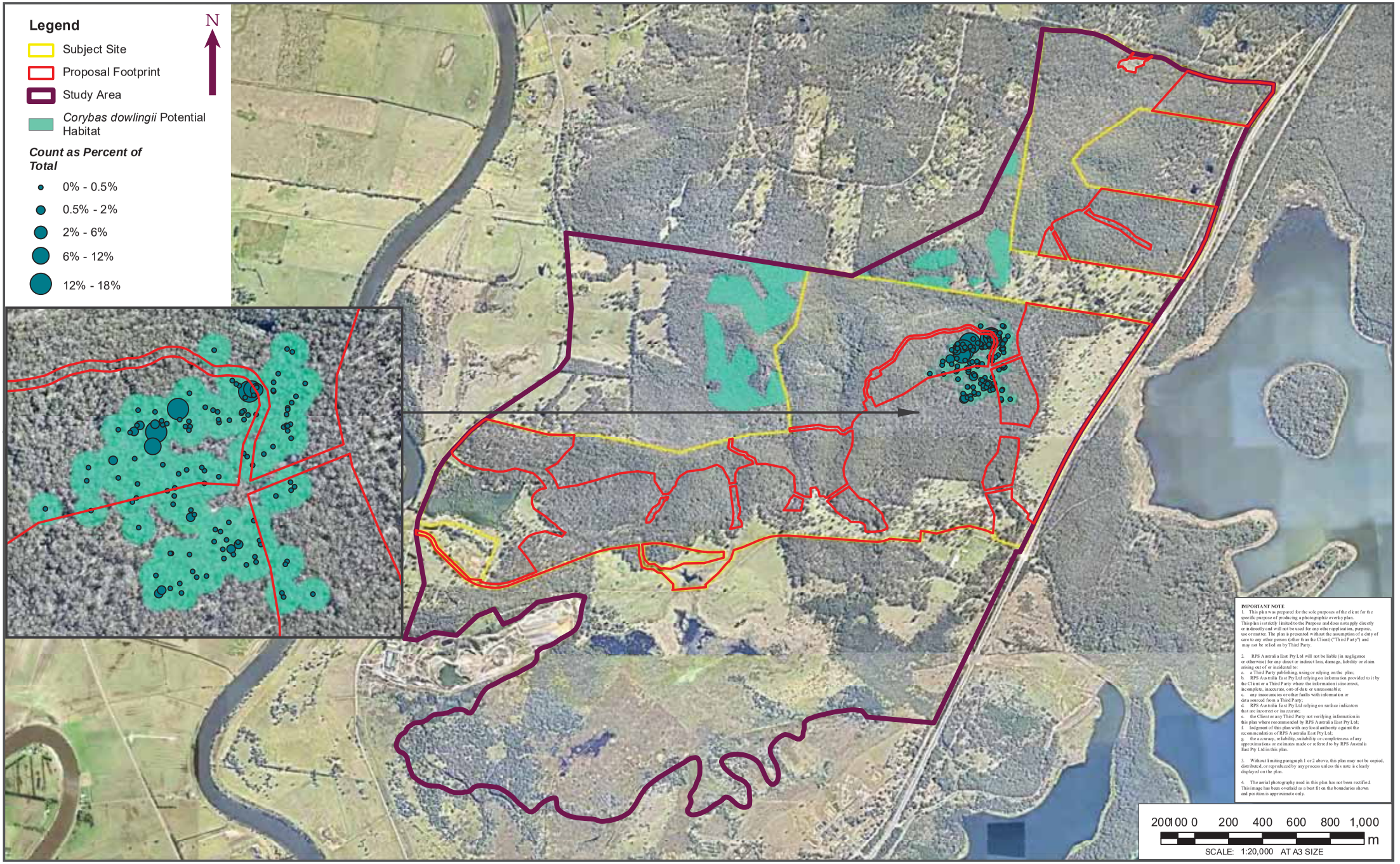
The targeted survey performed for *Corybas dowlingii* was in accordance with OEH (2016a) and, as such, the results of this survey provide an accurate estimate of this species occurrence and distribution within the site. The habitat area occupied by *Corybas dowlingii* is mapped in **Figure 4.45**.

4.4.3 Small Water-ribbons

Small Water-ribbons (*Maundia triglochinoides*) is a monotypic genus, which is restricted in distribution to coastal New South Wales and southern Queensland. Harden (1993) describes it as a wetland species that "grows in swamps or shallow freshwater in heavy clay; north from southern Sydney". BCD (2019b) note the ecology and habitat of *Maundia triglochinoides* as follows:

- Grows in swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients and is associated with wetland species (e.g. *Triglochin procerum*);
- Flowering occurs during warmer months (November-January);
- Probably wind pollinated;
- Diaspore is the seed and root tubers, which are probably dispersed by water; and
- Spreads vegetatively, with tufts of leaves arising along rhizome. Populations expand following flood events and contract to more permanent wetlands in times of low rainfall

The targeted survey performed for Small Water-ribbons was in accordance with OEH (2016a) and, as such, the results of this survey provide an accurate estimate of this species occurrence and distribution within the site. The habitat area occupied by Small Water-ribbons is mapped in **Figure 4.46**.



TITLE : FIGURE 4.45: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE RED HELMET ORCHID WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.45 Potential habitat and recorded locations of the Red Helmet Orchid within SA D A3

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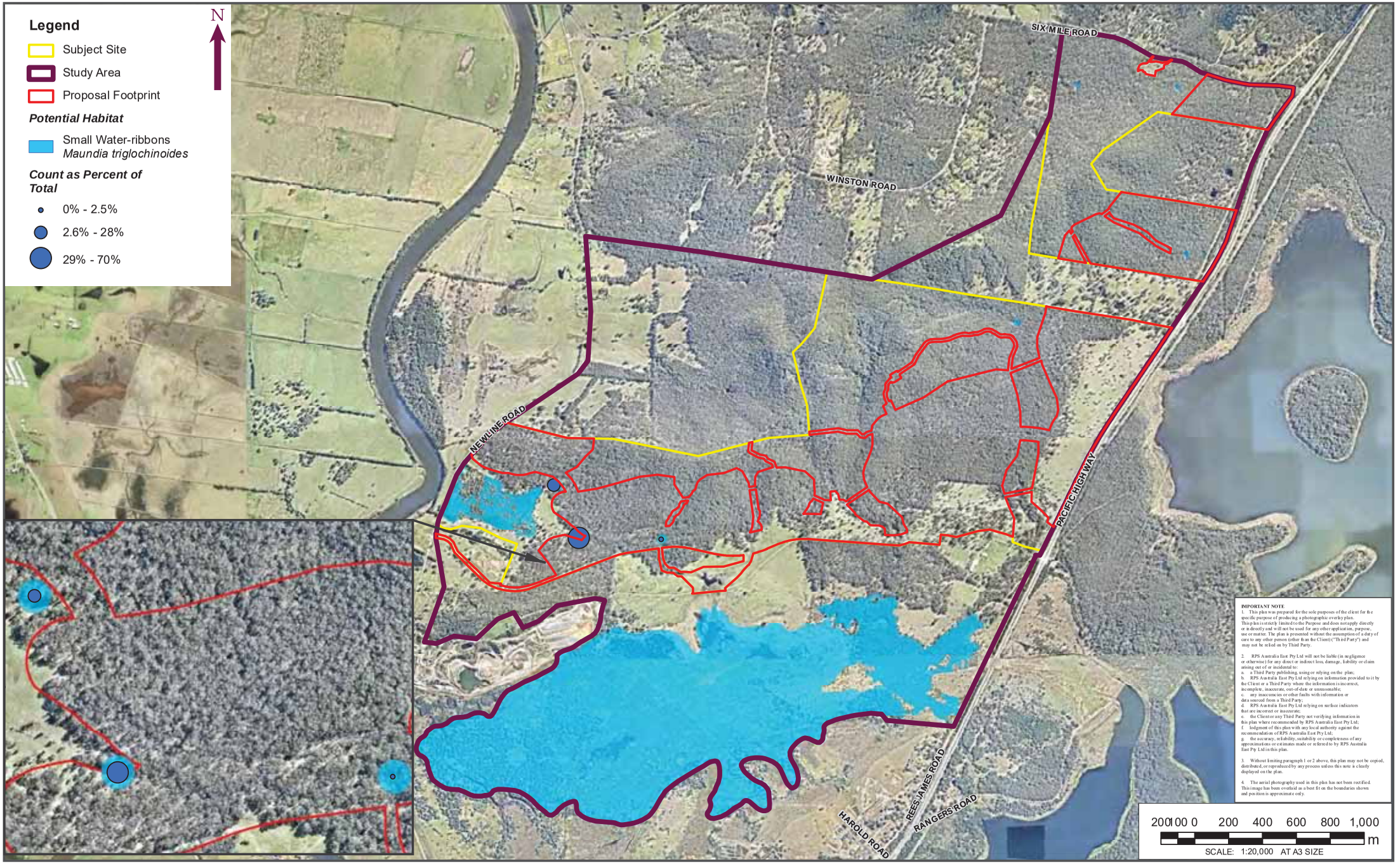

TITLE : FIGURE 4.46: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE SMALL WATER-RIBBONS WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.46 Potential habitat and recorded locations of the Small Water-ribbons within SA C A3

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4.4.4 Taree Rustyhood Orchid

Pterostylis chaetophora M.A.Clem. & D.L.Jones (*Oligocahetochilus chaetophrus* (M.A.Clem. & D.L.Jones) Szlach.) has been recorded at four locations within the subject site and multiple locations in the study area (i.e. Conservation Area). These locations fall within the species extent of occurrence, where habitat occupancy is restricted to dry sclerophyll forest with a coastal/ sub-coastal distribution from Sydney to Gympie in Queensland (NSW Scientific Committee 2014).

Locally, the species is known to occur within the western parts of the Grahamstown Dam catchment where 'hundreds of plants' are known from a 100 m^2 area (NSW Scientific Committee 2014). This species exhibits a widespread distribution in Columbey National Park where 370 individuals have been recently detected within 63 sub-populations (Bell 2019). Other nearby occurrences include two locations peripheral to Wallaroo State Forest (Mark Aitkens and Shawn Ryan pers obs 2019); although of individual plants numbers for this state forest and adjoining Wallaroo National Park were not recorded or unknown.

This species is part of the '*Saving our Species'* program where it is managed at six sites known as Purfleet (Mid-Coast LGA), Columbey National Park (Dungog LGA), Bundabah (Mid-Coast LGA), Rainbow Flat (Mid-Coast LGA), Grahamstown Dam (Port Stephens LGA) and Black Creek (Cessnock LGA) (BCD 2019). Annual monitoring is performed at four of these sites (Bell 2019).

The NSW Scientific Committee (2014) describes the preferred habitat of *Pterostylis chaetophora* as "seasonally moist, dry sclerophyll forest with a grass and shrub understorey". Supplementary observations from habitat occupied as observed in the annual *Saving our Species* monitoring program (Bell 2019) provide a more regionally specific characterisation of habitat viz.:

- Columbey National Park: "open forest of *Eucalyptus moluccana*, *Eucalyptus fibrosa*, *Eucalyptus umbra*, *Corymbia maculosa* and dense *Melaleuca nodosa* thickets" [EPS (2018) in Bell (2019)];
- Bundabah: "dense *Melaleuca nodosa* regrowth following a past clearing event" with widely scattered *Corymbia maculata* and *Eucalyptus fibrosa*;
- Grahamstown Dam: "open area amongst tea tree forest in clay loam";
- Black Creek: vegetation generally described as dominated by *Eucalyptus crebra* and *Corymbia maculata* on higher slopes and rises, with lower slopes and gullies dominated by *Eucalyptus tereticornis*, *Angophora floribunda* and *Eucalyptus crebra*.

Combined, these observations indicate a preference for Spotted Gum Ironbark forests; a finding generally consistent with observations from within the study area. However, factors controlling habitat occupancy also appear dependent on a suite of specific micro habitat conditions.

Pterostylis chaetophora belongs to group within the subtribe Pterostylidinae commonly referred to as Rustyhoods or Rufa Greenhoods (Jones 2006). In 2001 a Polish botanist created the genus *Oligochaetochilus* Szlach. Into which all species in this group have since been transferred. All subsequent detailed molecular and morphological analyses of Pterostylidinea has supported the recognition of *Oligochaetochilus* as a very strongly supported, morphologically distinct and easily recognised monophyletic group (Jones and Clements 2002; Webb et al., unpublished). Currently *Oligochaetochilus* comprises 62 described species (APNI) distributed across southern and eastern Australia from Shark Bay, Western Australia to Blenco Falls inland from Cardwell in north Queensland (Atlas of Living Australia). Species in the genus are adapted to semi-arid to arid habitat throughout these areas and are amongst the most arid loving and drought tolerant orchids in Australia. Key adaptations of this group include:

- A subterranean root tuber storage organ that is replaced annually [even if the plant does not appear above ground in severe conditions]
- Associated and dependence on a mycorrhizal fungus (*Ceratobasidium sp. aff. cornigerum*) that annually invades the underground stem collar cells, just below the rosette, and from which the orchid derives much of its nutrients.

- Leaves forming a rosette appressed to ground protecting area of mycorrhizal activity in early part of season then, drying at the commencement of growth of the inflorescence or at anthesis.
- Dull reddish-green or brown coloured flowers inconspicuous to many herbivores.
- Multiple flowers per raceme for increased likelihood of pollination
- Specific Mycetophilideae Fly pollinators attracted by psueodpheromone emitted by flower and insectiform labellum that mimics female fly.
- High seed production ~ 3,500-4,000 seeds per each fertilised flower from each pollination event;
- Flower height (i.e. elevated position to aid in seed dispersal potential);
- Dark seeds with sclerophied seed coat to resistant to desiccation during the following dispersal during the hotter drier months of the year.

The germination and establishment of seedlings and continued survival of *Pterostylis chaetophora* plants is solely dependent on its relationship with the symbiotic fungus *Ceratobasidium sp. aff. cornigerum* (Dr Mark Clements pers. coms. 2019); this being consistent with findings from earlier mycorrhizal – *Pterostylis* studies (Warcup 1981) and numerous subsequent studies on the subject [e.g. Rasmusen (1995)]. Without this fungus, *Pterostylis chaetophora* is unable to germinate and establish new plants and continue to grow and reproduce in the wild.

Nourishment gained from this fungus is through specialised cells located in the stem collar situated in the underground stem apex and below the leaf bases. Flowering is predetermined each year dependant on the size of the tubers in mature plants. Typical each year adult plants grow to maturity to facilitate sexual reproduction whilst concurrently gaining sufficient nutrients for healthy seed production and asexual reproduction through tuber replacement. In drought years, *Pterostylis chaetophora* may limit reproduction to tuber replacement only (Dr Mark Clements pers. coms. 2019).

The fungus on which the orchid depends occurs in a matrix in bushland where it preferentially inhabits the more exposed partially bare areas of depauperate soils where there is typically less competition from other fungi and many plant species. In these micro-habitats there is sufficient cellulose material such as the dead roots of grasses or herbs for the fungus to grow and produce metabolites such as sugars. It is these nutrients that the orchids exploit through parasitising of the fungal hyphae that invade the orchid stem collar cells (Dr Mark Clements pers. comm. 2019). In addition to the importance of bare ground, observations of occupied habitat at Kings Hill and more broadly in the local area (i.e. Grahamstown West, Wallaroo State Forest and Columbey National Park) have provided insight into the identification of micro habitat conditions important to the occurrence of this fungus. These include:

- Presence of tufted perennial C4 native grasses; a ground stratum structure where inter-tussock spaces appear to support the perennial presence of bare earth. Kangaroo Grass (*Themeda triandra*) was always observed in association with *Pterostylis chaetophora*. Other similar species observed include Barbed-wire Grass (*Cymbopogon refractus*). Further, it is hypothesised that these perennial C4 grasses provide a reliable source of cellulose material, particularly in the cooler moister months where growth by the symbiont fungus is most likely.
- Absence or low abundance of C3 native grasses. Typically, these grasses tend to dominate the ground surface during the winter – spring period at a time coincident with orchid emergence and reliance on the symbiont fungus. It is possible that structural crowding by these grasses and limited cellulose supply at this time of year (i.e. production of live green material) may potentially minimise fungus incidence and/ or growth at a crucial stage of the orchid's lifecycle (i.e. preparation for flowering in spring).
- Absence of exotic grasses. It is hypothesised that the symbiont fungus is poorly associated with exotic grass species.
- Thin and incomplete leaf litter layer that maintains the occurrence of bare earth patches. Excessive leaf litter accumulations extinguish the localised perennial presence of bare ground thereby limiting successful soil inoculation by the symbiont fungus.

- A species rich mix of tree species with open forest structure and canopy gaps was routinely observed in association with *Pterostylis chaetophora* incidence. Species include Grey Box (*Eucalyptus moluccana*), Ironbarks [mostly Broad-leaved Ironbark (*Eucalyptus fibrosa*)], Forest Redgum (*Eucalyptus tereticornis*) and Spotted Gum (*Corymbia maculata*). Interestingly, the latter species was never dominant. Forests dominated by Spotted Gum are often characterised by relatively deep litter layer development due to the quantum of bark and leaf shedding often associated with this species (i.e. reduced potential for bare earth patches to develop and persist).
- The proximal incidence of *Melaleuca nodosa*. The presence of this species, which is likely linked to imperfectly drained soils, could represent favourable soil conditions for *Pterostylis chaetophora* locally retaining elevated soil moisture levels after sufficient autumn – winter rainfall events. This habitat preference may be important in the perennial survival of orchid tubers and also serve to activate flowering events (OEH 2019b).

A disturbance history of some kind was also noted at all occupied sites indicating a possible positive relationship with this factor. Disturbances noted in occupied habitat are varied and include formed and infrequently managed electricity and road easements, wheel rutting in association with localised hard setting soils, quarrying and soil mounding. This is contrary to the NSW Scientific Committee (2014), which identifies disturbance such as road works, rubbish dumping and uncontrolled vehicle access as a threat to this species, occurrences within the study area, Grahamstown Dam, Wallaroo State Forest and Columbey National Park all indicate a with disturbance.

It is possible that surface disturbances, exposing subsurface, depauperate soil layers may locally provide conditions suitable for the fungus *Ceratobasidium sp. aff. cornigerum* (i.e. extent and/ or presence of bare earths). While it is accepted that some disturbance types are detrimental (e.g. physical covering and/ or excavation of tubers), disturbances promoting the presence and/ or extent of suitable microhabitat conditions, such as removal of thick vegetation and soil surface exposure, may locally amplify orchid numbers.

Time since disturbance may also be an important factor in determining occurrence. All areas occupied by *Pterostylis chaetophora* sites appear to coincide with relatively stable landforms where the effects of prior disturbance and associated erosion activity is greatly reduced. Evidence of landform stability was evident by the relatively high abundance of crypotgams (e.g. moss gardens), crust formation on bare earths (i.e. limited evidence of active erosion), high rock cover (i.e. provides abiotic rain splash protection thereby reducing the incidence of erosion) and presence of longer lived vascular plants that respond to disturbance through seed (e.g. Fabaceae: *Daviesia ulicifolia* and *Pultenaea villosa*) and root suckering (e.g. *Melaleuca nodosa*).

Surveys of likely habitat within study area (i.e. PCT 1590 with suitable soil and plant species occurrences) and in Columbey National Park (Bell 2019) indicate a naturally low density within undisturbed habitat [e.g. 2.8 orchids per hectare in Bell (2019)]. In light of the broader observations outlined, this further supports positive role of disturbance in the species lifecycle (i.e. disturbance being a pulse event favouring the occurrence of synchronous close proximity flowering to maximise the likelihood of seed set, production and propagule establishment). Naturally operating disturbances may include bioturbation by ground mammals (e.g. diggings by Bandicoots and Short-beaked Echidna), tree fall involving root ball exposure and fine scale mosaiced fire patterns.

The initial habitat model used to inform the 2018 targeted survey for *Pterostylis chaetophora* was broadly defined as 'dry sclerophyll forest (i.e. PCT 1590) comprising patches of *Melaleuca* sp.', with the extent of this survey determined by PCT mapping (see **Figure 4.20**) and modelled Melaleuca occurrence. The stratified survey was performed using parallel transects generally in accordance with OEH (2016a). A second targeted survey performed in the 2019 flowering period (i.e. early to mid October) focused on the residual areas of PCT 1590 that were not inspected in 2018 (i.e. areas were *Melaleuca* sp. was generally absent).

With the exception of the abandoned quarry, vegetation sampled in the 2019 targeted survey comprised less suitable habitat with its exclusion for the 2018 survey justified. Lower habitats conditions were notably attributed to a greatly reduced amount of bare earth patches (i.e. the symbiotic fungus *Ceratobasidium sp. aff. cornigerum* is less likely to occur), where ground conditions were characterised by higher abundances of

C3 grasses and/ or leaf litter cover (and depth). Kangaroo Grass was generally absent and tree canopy was often dominated by Spotted Gum to produce a denser canopy structure.

Conversely, surveys around the historically disturbed quarry in the north of the study area were within favourable habitat conditions. These surveys yielded the greatest number of plants (~ 460 specimens) and appear to confirm the positive relationship between disturbance and *Pterostylis chaetophora* abundance. The results of this targeted survey are provided in **Figure 4.47**.

4.4.5 Glossy-black Cockatoo

The Glossy Black Cockatoo can be found in open eucalypt forest with hollow-bearing trees and a mid-storey of Casuarina and Allocasuarina species (Sheoak). The eucalypt woodland provides hollows within which they nest and Sheoak provides a food source as they feed almost exclusively on them.

The total number of mature individuals is estimated to be around 12 000 (Garnett & Crowley 200), with about 70% of those individuals occurring within NSW. the subject site contains suitable habitat for Glossy-black Cockatoos where patches of *Allocasuarina littoralis* and *Allocasuarina torulosa* occur, as well as containing eucalypt woodland and being located within their known range.

Evidence of activity has been recorded in the study area following observations of chewed *Allocasuarina* orts. These observations coincided with the occurrence of a single stand of Allocasuarina. Potential habitat within the study area and recorded locations for this species (i.e. chewed orts) is mapped in **Figure 4.48**.

4.4.6 Brown Treecreeper

Endemic to eastern Australia, occurring in eucalypt woodlands of inland plains and slopes of the Great Dividing Range and less commonly found on coastal plains and ranges. It mainly inhabits woodlands that are dominated by stringybarks or rough-barks eucalypts. They are usually found in woodlands with an open grassy understorey and are also found in forests bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses. It is not usually found in forests with a dense shrub layer.

Brown treecreepers are sedentary and as such are considered to be resident in much of their range, being present all year in many sites. Hollows are an important habitat features as they are essential to nesting and fallen logs and leaf litter are utilised for foraging in addition to trees. Ants make up approximately 80% of their diets, with other invertebrates such as moths, termites, cockroaches, beetles, flies and insect larvae also comprising part of their diet. This species has been infrequently observed within the study area. Potential habitat within the study area and recorded location for this species is mapped in **Figure 4.49**.

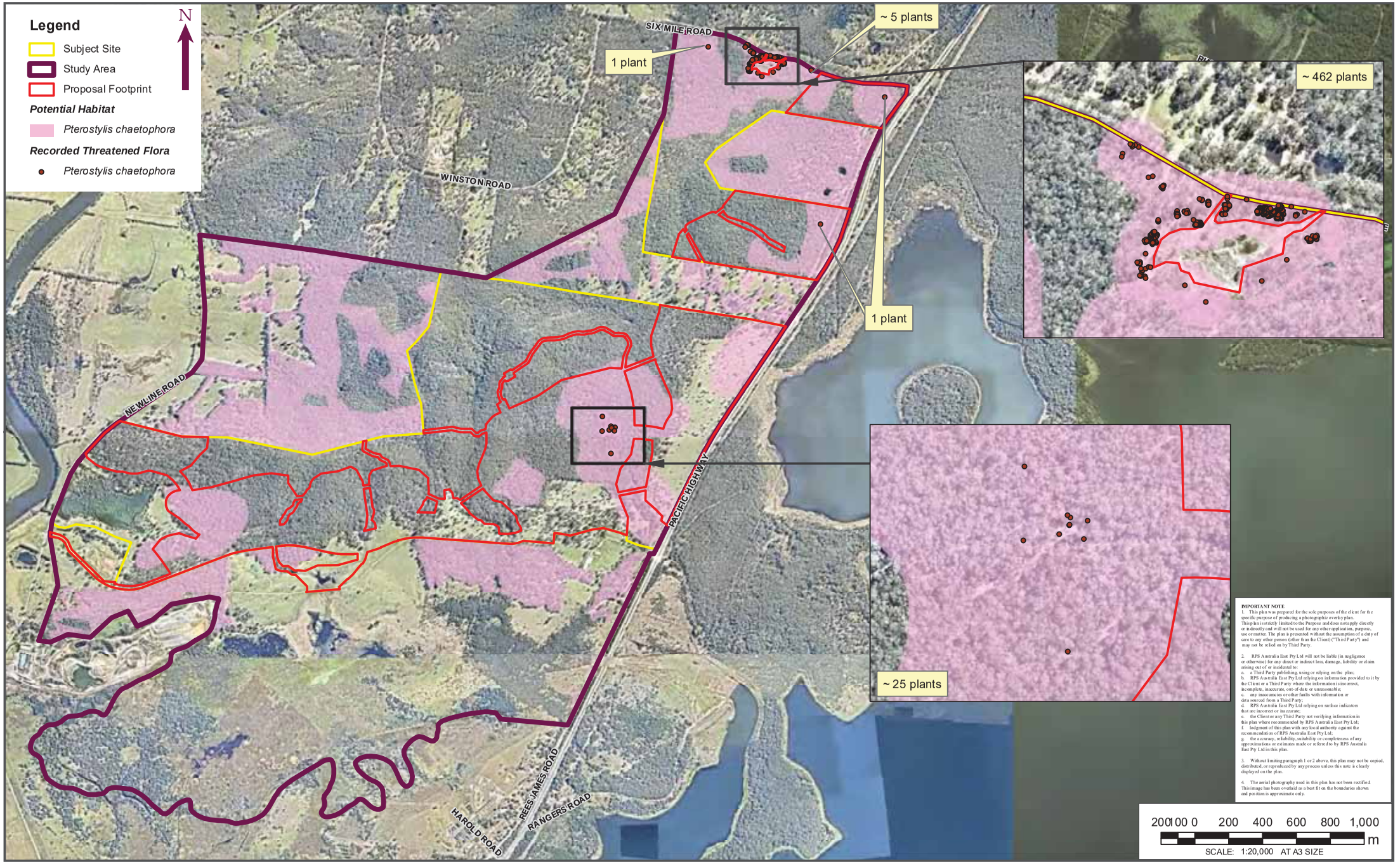
4.4.7 Varied Sittella

Varied Sittellas are found throughout the Australian mainland in forested areas. They are a sedentary and are known to have almost contiguous distribution. They inhabit eucalyptus forests and woodland and prefer rough-barked eucalypt species.

Varied Sittellas require crevices in rough bark, dead branches, twigs in a tree canopy and other features that enable them to feed on a variety of arthropods. They build a cup-shaped nest of cobwebs and plant fibres high in a tree canopy and often reuse that same location for successive years. This species was observed once within the study area. Potential habitat within the study area and the recorded location for this species is mapped in **Figure 4.50**.

4.4.8 Little Lorikeet

Little Lorikeets were identified flying through the site on a number of occasions. They are gregarious, travelling and feeding in small flocks and often feeding together with other lorikeet species such as the Musk Lorikeet. They forage primarily in the canopy of eucalypt forests and woodlands with a particular focus on riparian habitats due to the higher soil fertility and thus greater productivity of nectar. Whilst eucalypts are their main food source, they will also forage in mistletoe, Angophoras and occasionally Melaleuca.



TITLE : FIGURE 4.47: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE PTEROSTYLIS CHAETOPHORA WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.47 Potential habitat and recorded locations of the Pterostylis chaetophora SA D A3

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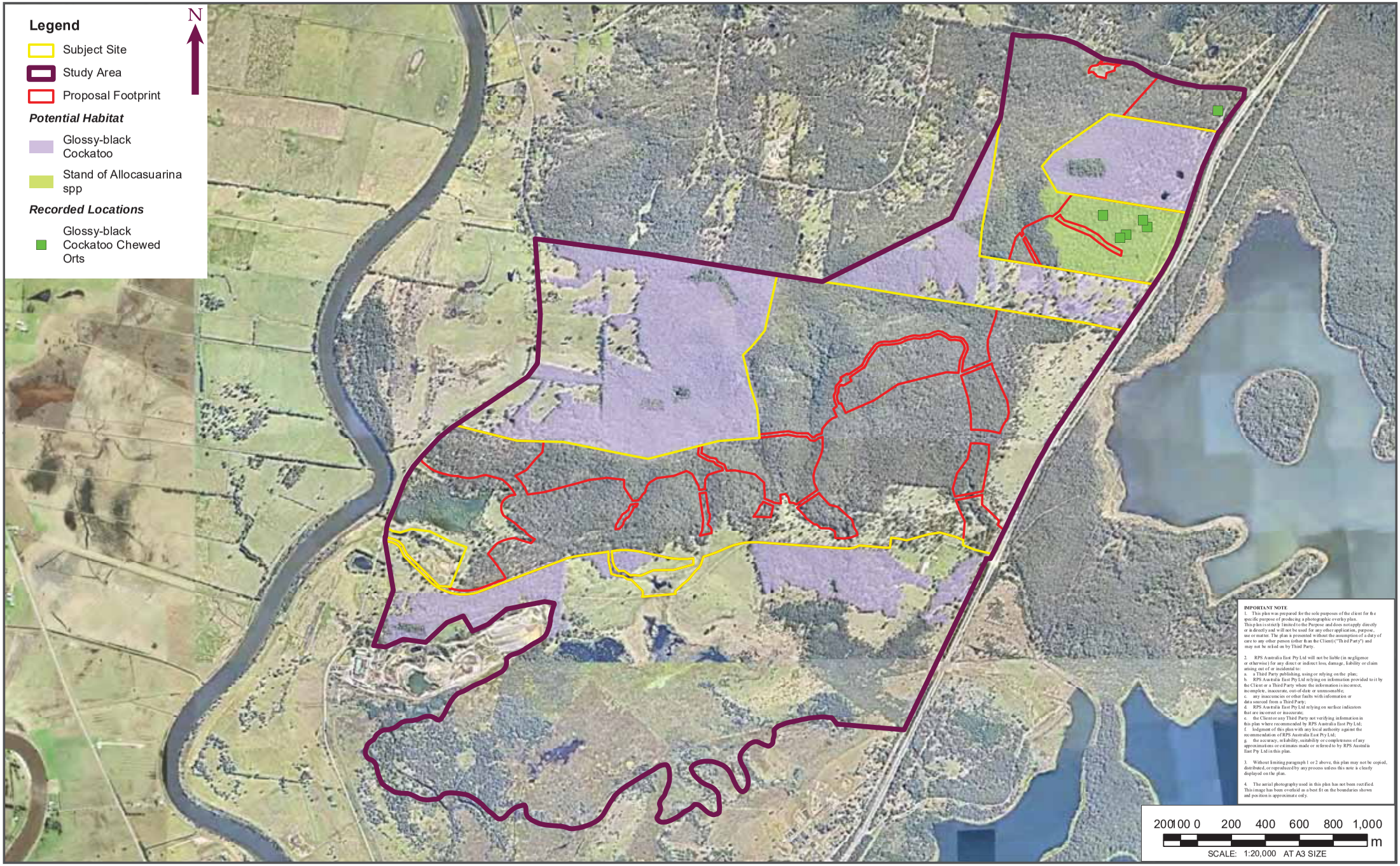

TITLE : FIGURE 4.48: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE GLOSSY-BLACK COCKATOO WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.48 Potential habitat and recorded locations of the Glossy-black Cockatoo within SA D A3

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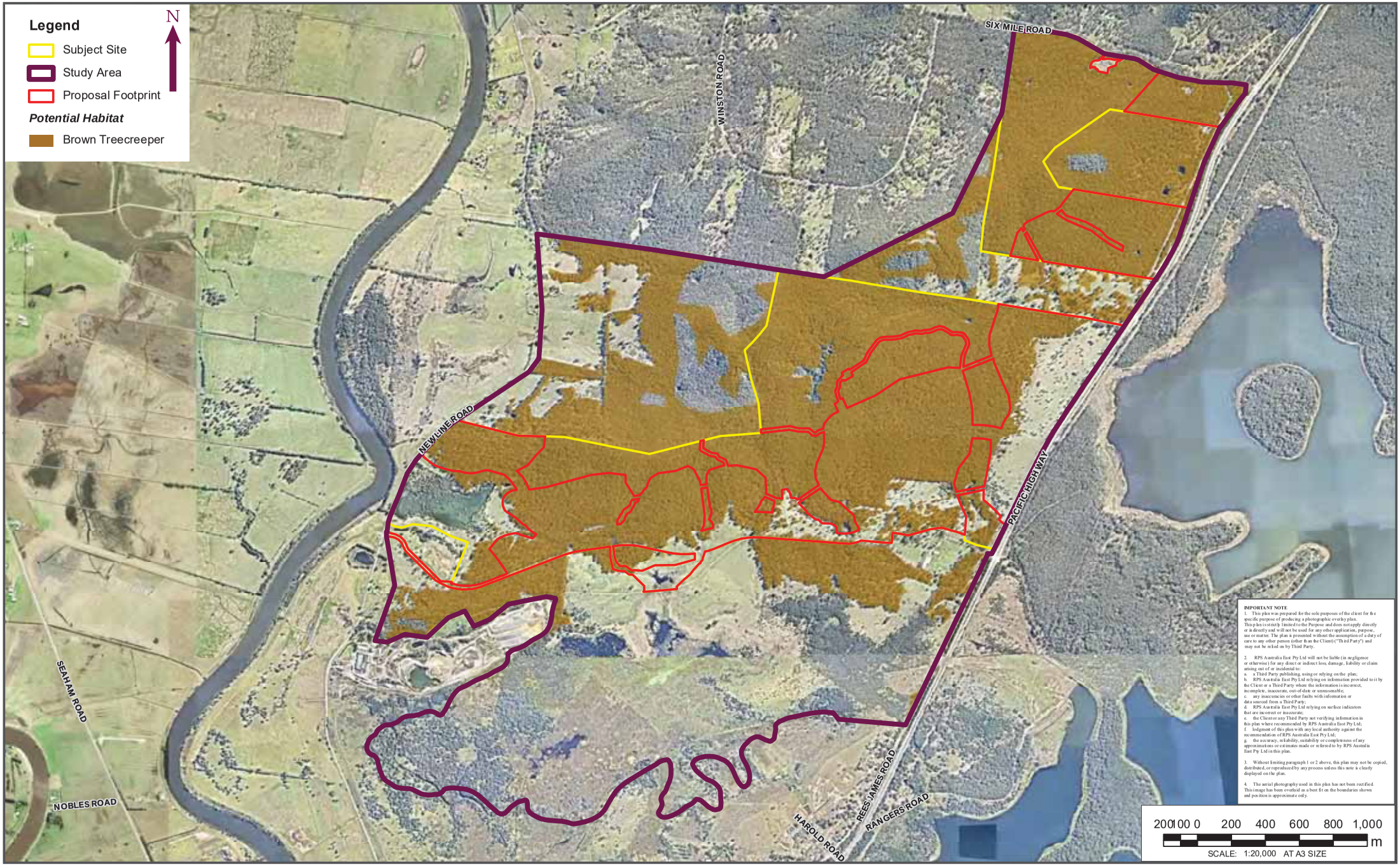

TITLE : FIGURE 4.49: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE BROWN TREECREEPER WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.49 Potential habitat and recorded locations of the Brown Treecreeper within SA C A3

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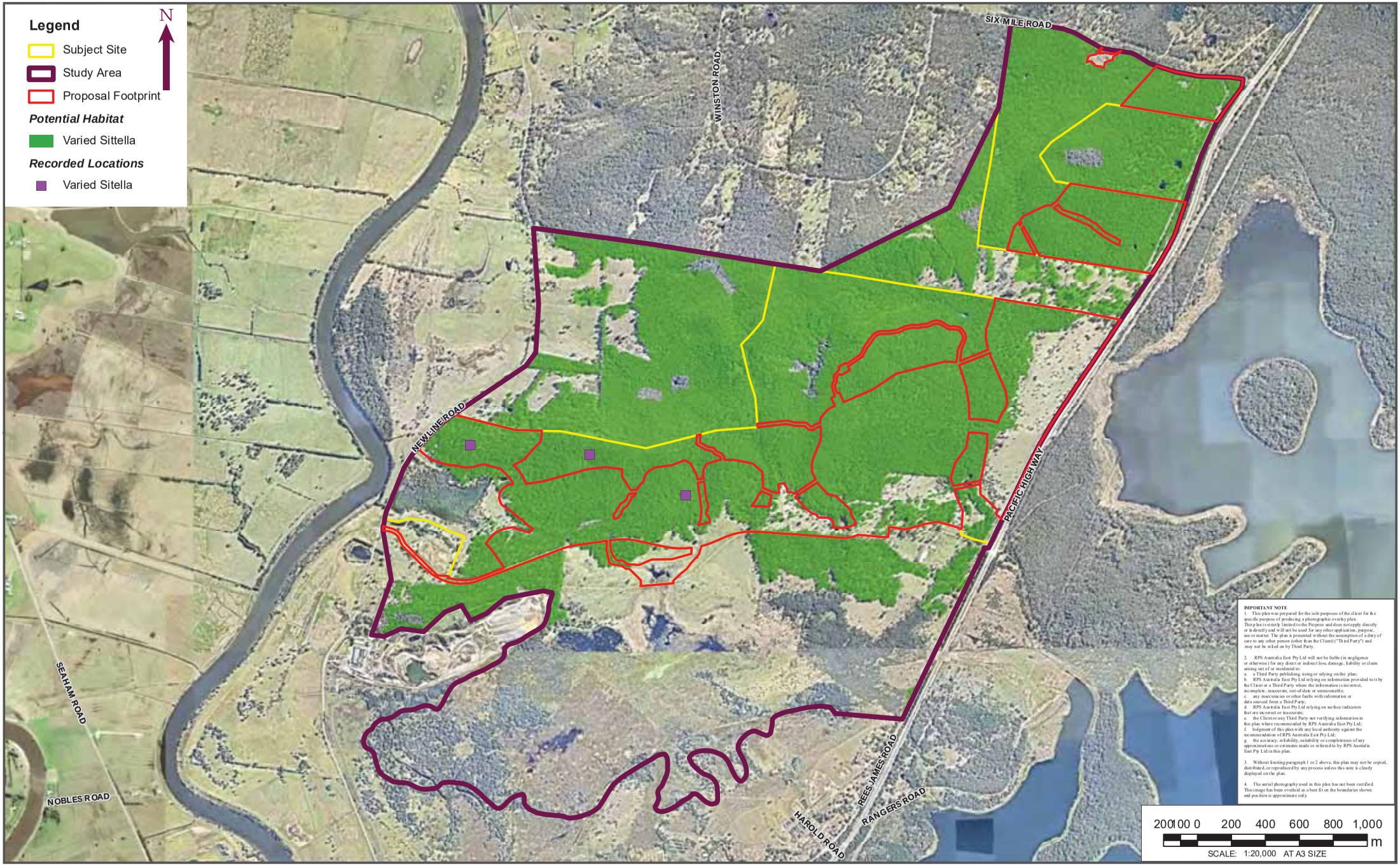

TITLE : FIGURE 4.50: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE VARIED SITTELLA WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.50 Potential habitat and recorded locations of the Varied Sittella within SA C A3 20200719.mxd

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As with feeding, roosting generally occurs in the canopy of eucalypt forests and woodlands, though usually a long distance from the foraging site. Nesting is usually carried out in close proximity to feeding sites in the hollows of smooth-barked eucalypts. Potential habitat within the study area and recorded locations for this species are mapped in **Figure 4.51**.

4.4.9 White-bellied Sea-Eagle

The White-bellied Sea Eagle is found in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands (DoE 2020a). It occupies habitat characterised by the presence of large areas of open water (larger rivers, swamps, lakes, the sea) and have been recorded in (or flying over) a variety of terrestrial habitats (DoE 2020a). This species has been recorded at or in the vicinity of freshwater swamps, lakes, reservoirs, billabongs, saltmarsh and sewage ponds. Within the locality, there are 71 recorded locations of the White-bellied Sea Eagle, scattered throughout and predominantly in association with Grahamstown Dam in the east and along larger riparian areas and wetlands.

A large wetland exists in the south-west of the study area, which reduces in size in the drier months. During high rainfall events, this wetland becomes a large waterbody providing a larger expanse of foraging habitat for the White-bellied Sea Eagle. A pair of White-bellied Sea Eagle's has been repeatedly recorded in the study area as well as a White-bellied Sea Eagle nest in close proximity to the large wetland in the west. A second nest was also recorded in the study area. Potential habitat and the recorded locations of the White-bellied Sea Eagle within the study area is shown in **Figure 4.52** with the polygon is based on the TAS DPIPWE (2011) buffer prescription for protecting nest sites (i.e. 250 m).

4.4.10 Square-tailed Kite

The Square-tailed Kite is found along coastal and subcoastal areas from south-western to northern Australia, Queensland, NSW and Victoria. In NSW, scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems. It is a summer breeding migrant to the south-east, including the NSW south coast, arriving in September and leaving by March (OEH 2019b).

This species prefers open forests and woodlands on fertile soils with abundant passerines (especially honeyeaters) and will range into open habitats however does not utilise treeless areas (Marchant and Higgins 1993). Specifically in NSW, the Square-tailed Kite prefers ridge and gully forests, dominated by *E.longifolia*, *E. maculata* or *E.elata* and *E.smithii* and *Angophora* and *Callitris* species. This species searches for prey from the air and is specialised to hunt among trees and in open forest and woodland. Most prey is taken from the canopy and shrubs and Square-tailed Kites rarely forage on the ground (Marchant and Higgins 1993). Appears to occupy large hunting ranges of more than 100km^2.

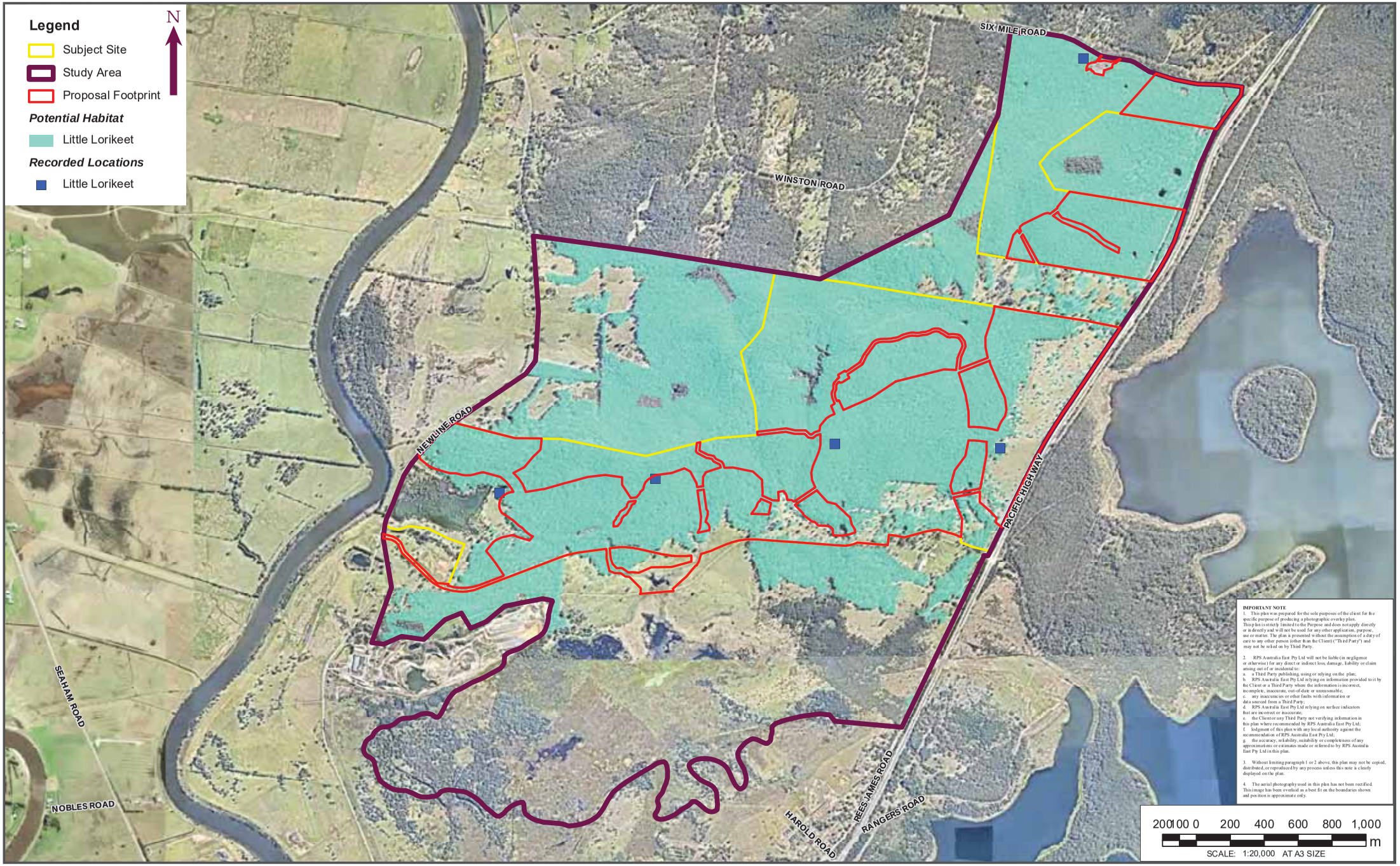
Breeding is from July to February, with nest sites nests in mature living trees often near water and with surrounding forests/woodlands (Marchant and Higgins 1993).

Potential habitat and the recorded locations of the Square-tailed Kite within the study area is shown in **Figure 4.53**.

4.4.11 Osprey

Osprey are found in littoral habitats, terrestrial wetlands and coastal lands of tropical and temperate Australia and including some offshore islands. They exhibit a preference for coastal cliffs and elevated islands in some parts of their range (Boekel 1976; Domm 1977), but may also occur on low sandy, muddy or rocky shores and over coral cays (Marchant & Higgins 1993). They may occur over atypical habitats such as heath, woodland or forest when travelling to and from foraging sites (Czechura 1985; Hembrow 1988; Pruett-Jones & O'Donnell 2004; Roberts & Ingram 1976). Being predominately coastal, this species utilises a variety of marine and littoral habitats and requires extensive sheets of clean, open water, fresh, brackinsh or saline for

fishing (Marchant and Higgins 1993). Eastern Osprey predominantly feed on medium sized, live fish (especially mullet where available) (Birdlife Australia 2019).



TITLE : FIGURE 4.51: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE LITTLE LORIKEET WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.51 Potential habitat and recorded locations of the Little Lorikeet within SA B A3

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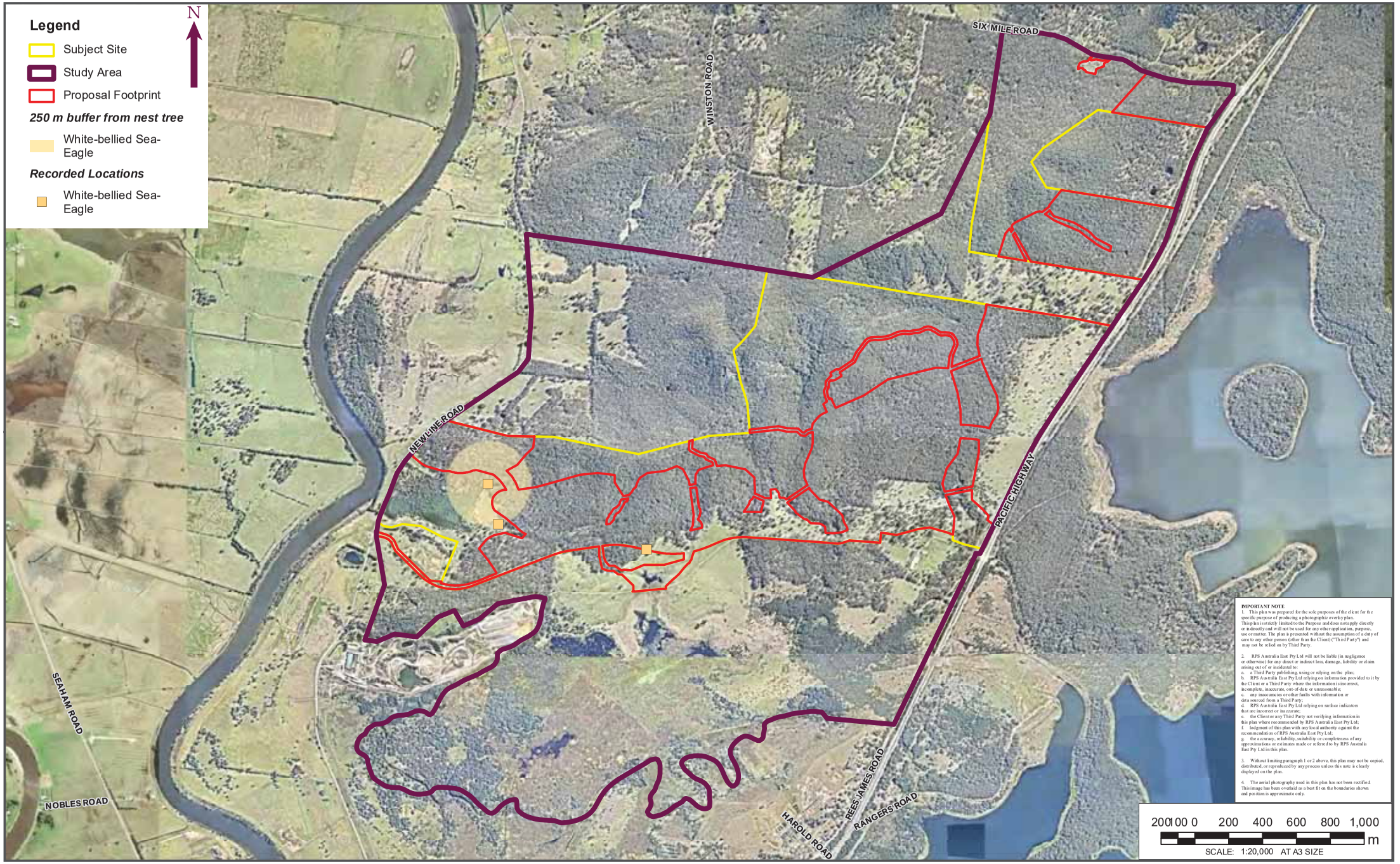

TITLE : FIGURE 4.52: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE WHITE-BELLIED SEA-EAGLE WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.52 Potential habitat and recorded locations of the White-bellied Sea Eagle within SA D A3

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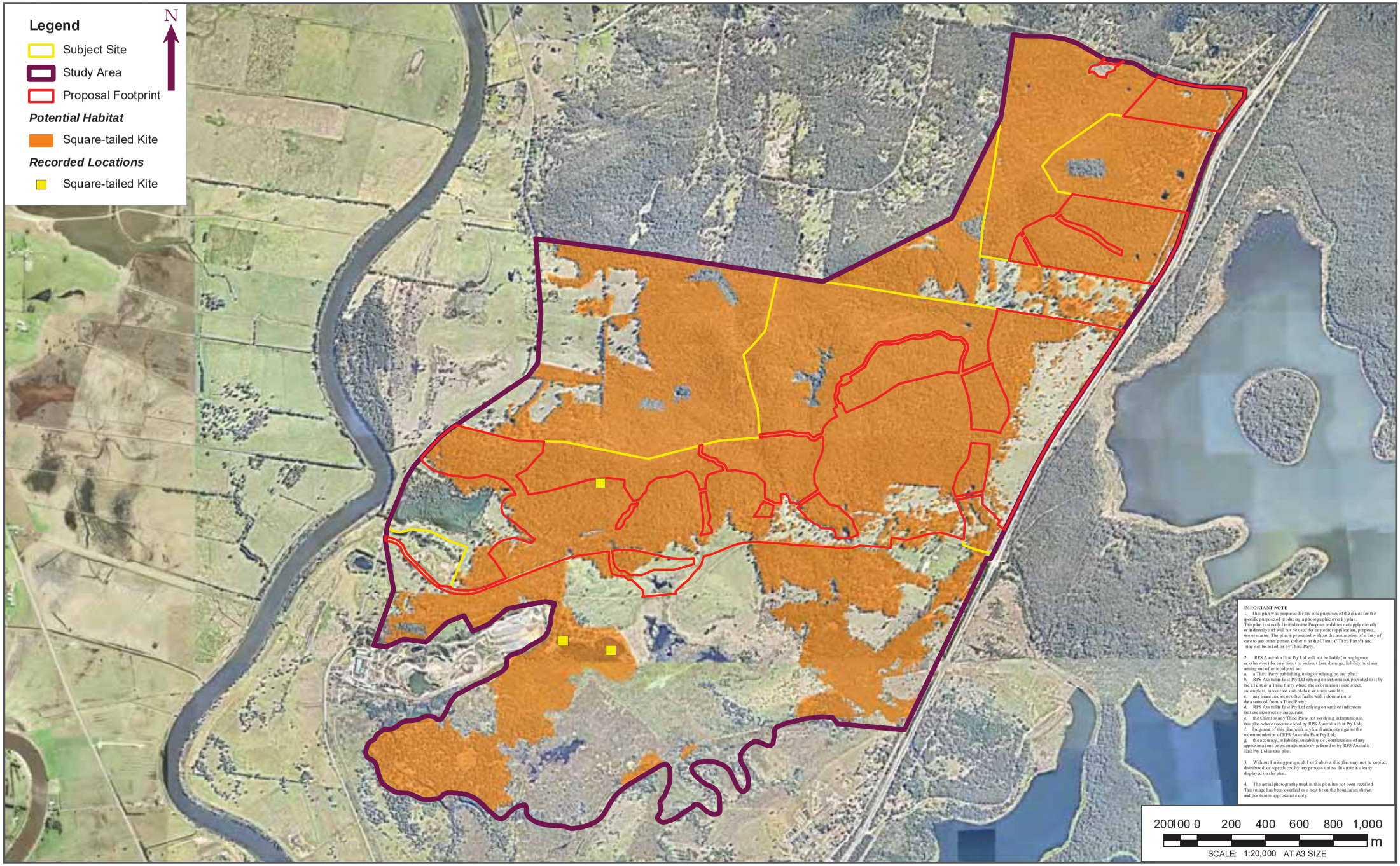

TITLE : FIGURE 4.53: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE SQUARE-TAILED KITE WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.53 Potential habitat and recorded locations of the Square-tailed Kite within SA D A3

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Eastern Osprey breed from July to September in NSW, where nesting occurs mainly on the coasts and islands near large water bodies or oceans (Marchant and Higgins 1993). Potential habitat and the recorded locations of the Osprey within the study area is shown in **Figure 4.54**.

4.4.12 Magpie Goose

Magpie Geese are known within the hunter region, east of Cessnock, NSW (OEH 2019b). They are found within terrestrial wetlands (usually less than 1m deep) in monsoonal regions and can gather in flocks of up to thousands. They use different habitats throughout the year to meet the needs for breeding, feeding and roosting. This species' activities are centred, however. on wetlands and the floodplains of rivers (Marchant and Higgins 1990).

This species can breed in summer or winter rainfall regimes, requiring erect vegetation for nest construction and support over deeper water in secluded places, usually close to wetlands (Birdlife Australia 2019b). There is a preference for nests to be located near large areas of aquatic grasses for feeding young (Marchant and Higgins 1990). There is a local preference for water ribbon (*Triglochin procera*) (Marchant and Higgins 1990).

The Magpie Goose is a specialised feeder with wild rice, *Oryza*, Paspalum, Panicum and spike-rush, *Eleocharis*, forming the bulk of its diet (Birdlife Australia 2019b). Potential habitat and the recorded locations of the Magpie Goose within the study area is shown in **Figure 4.55**.

4.4.13 Australasian Bittern

The Australasian Bittern favours wetlands and occasionally estuarine habitats with tall dense vegetation where they can forage in still shallow water up to 0.3m in depth, often at the edges of pools or waterways (Marchant and Higgins 1990). Australasian Bitterns favour permanent fresh-waters, dominated by sedges, rushes, reeds or cutting grass (*Phragmites, Cyperus, Eleocharis, Juncus, Typha, Baumea, Bolboschoenus* etc) (Marchant and Higgins 1990). This species generally hides during the day and feeds mainly at night (OEH 2019b) on medium sized aquatic animals such as eels, frogs and freshwater crayfish (Marchant and Higgins 1990).

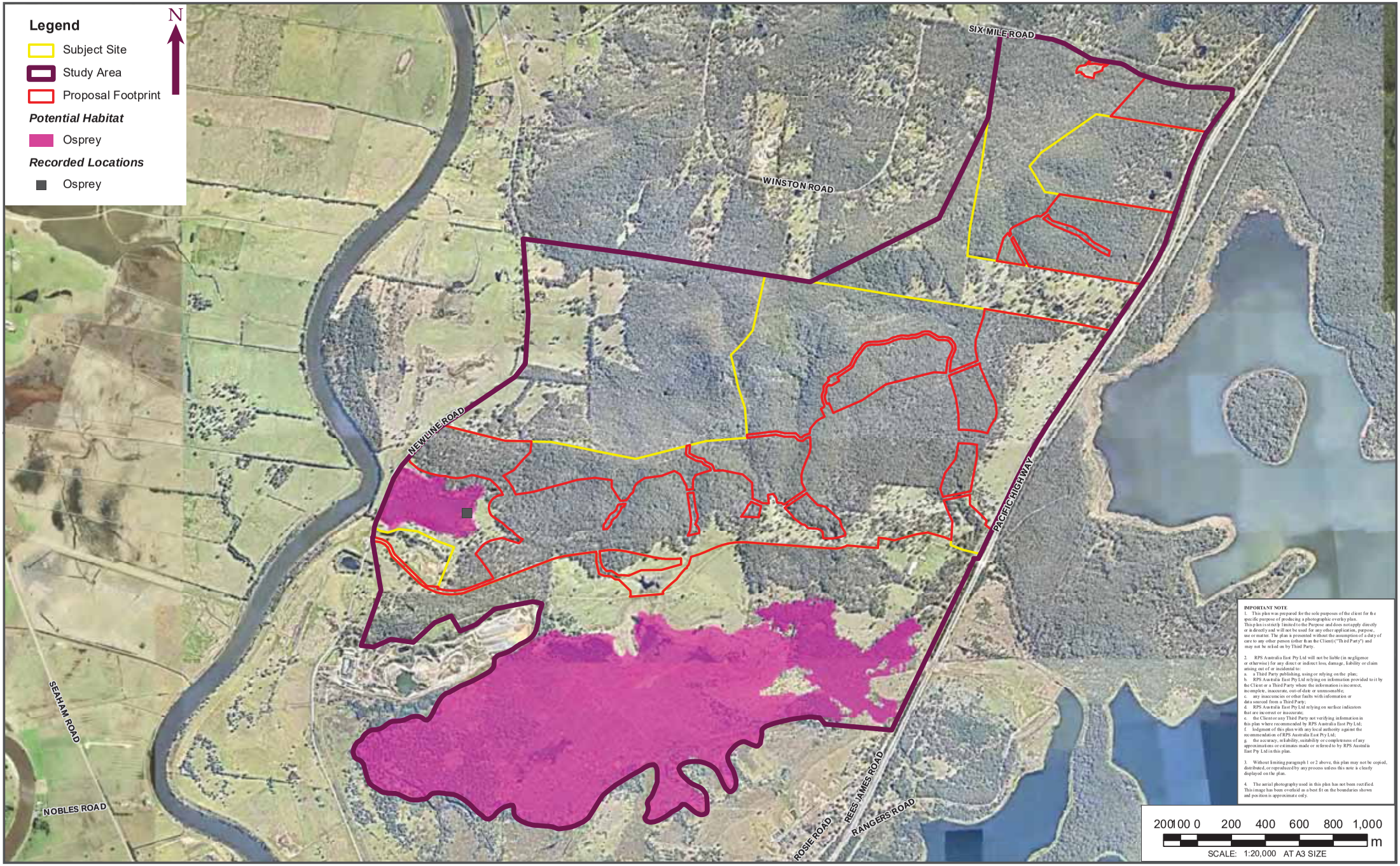
The Australasian Bittern appears to be capable of moving between habitats as suitability changes. It can occur in high densities in temporary or infrequently filled wetlands during exceptionally wet years and will also use ephemeral wetlands when moving from areas that are drying out (Garnett, 1992).

The Australasian Bittern breeds from October to February in single solitary pairs. Sometimes, however, several nests may be placed in close proximity to each other. Breeding occurs in deep, densely vegetated freshwater swamps and pools, building nests in deep cover over shallow water (Marchant and Higgins 1990). Potential habitat of the Australasian Bittern within the study area is shown in **Figure 4.56**.

4.4.14 Black Bittern

Black Bittern are found scattered along the east coast of NSW, rarely recorded south of Sydney (OEH 2019b). This species inhabits terrestrial wetlands, estuarine areas and littoral habitats (Marchant and Higgins 1990). During the day, roosts in trees or on the ground amongst dense reeds (OEH 2019b). Foraging occurs at the edge of running or still waters, usually in permanent wetlands fringed by dense vegetation (Marchant and Higgins 1990). Vegetation around wetland habitats may only form a narrow fringe and this species is also recorded within rank grassland, shrubland, woodland, sclerophyll forests, rainforests, and mangroves (Marchant and Higgins 1990).

Breeding occurs within densely vegetated wetlands in secluded places where nests are built in leafy trees overhanging water (Marchant and Higgins 1990). Potential habitat of the Black Bittern within the study area is shown in **Figure 4.57**.



TITLE : FIGURE 4.54: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE OSPREY WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.54 Potential habitat and recorded locations of the Osprey within SA C A3 20200719.mxd

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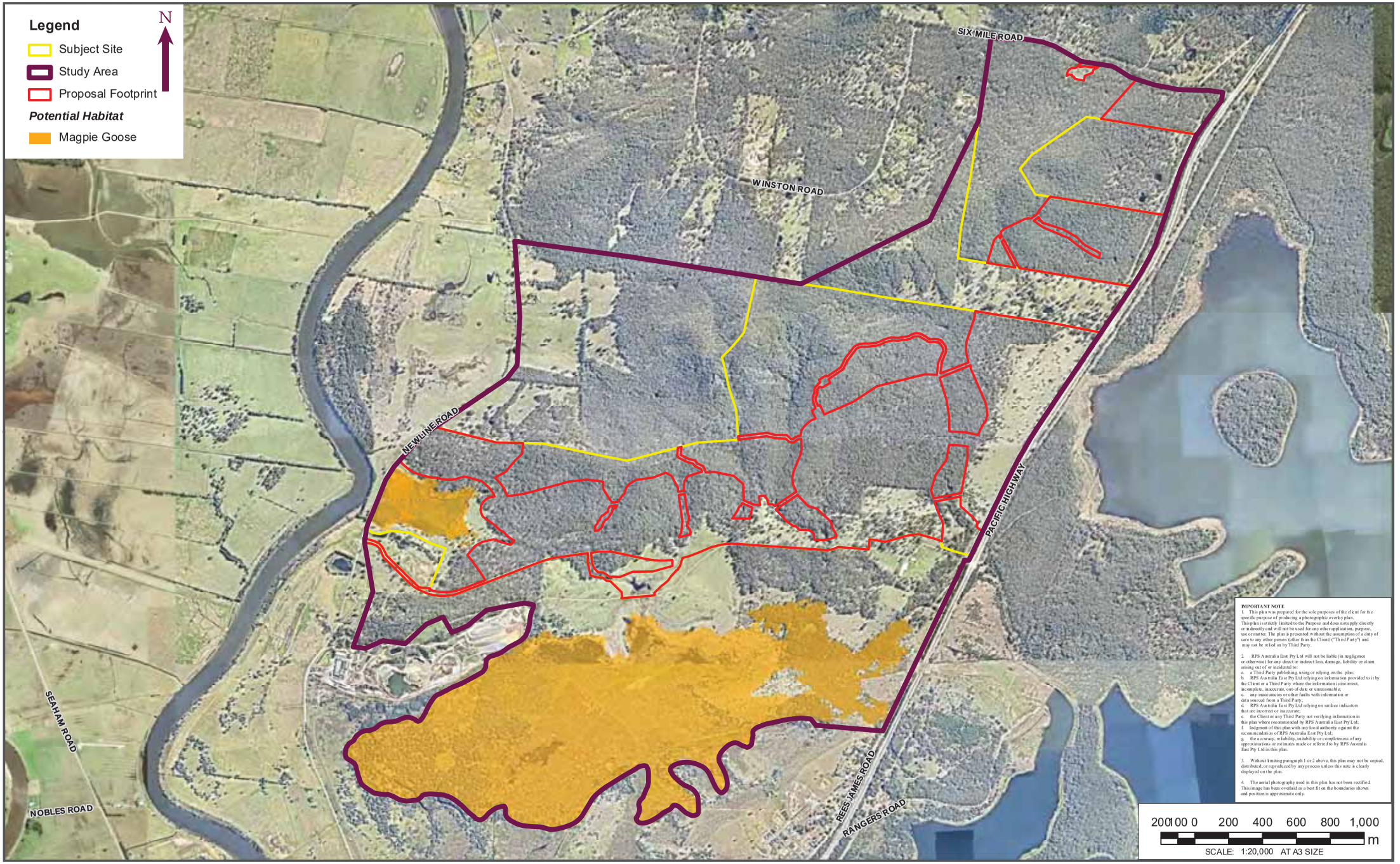

TITLE : FIGURE 4.55: POTENTIAL HABITAT OF THE MAGPIE GOOSE WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.55 Potential habitat of the Magpie Goose within the SA C A3 20200719.mxd

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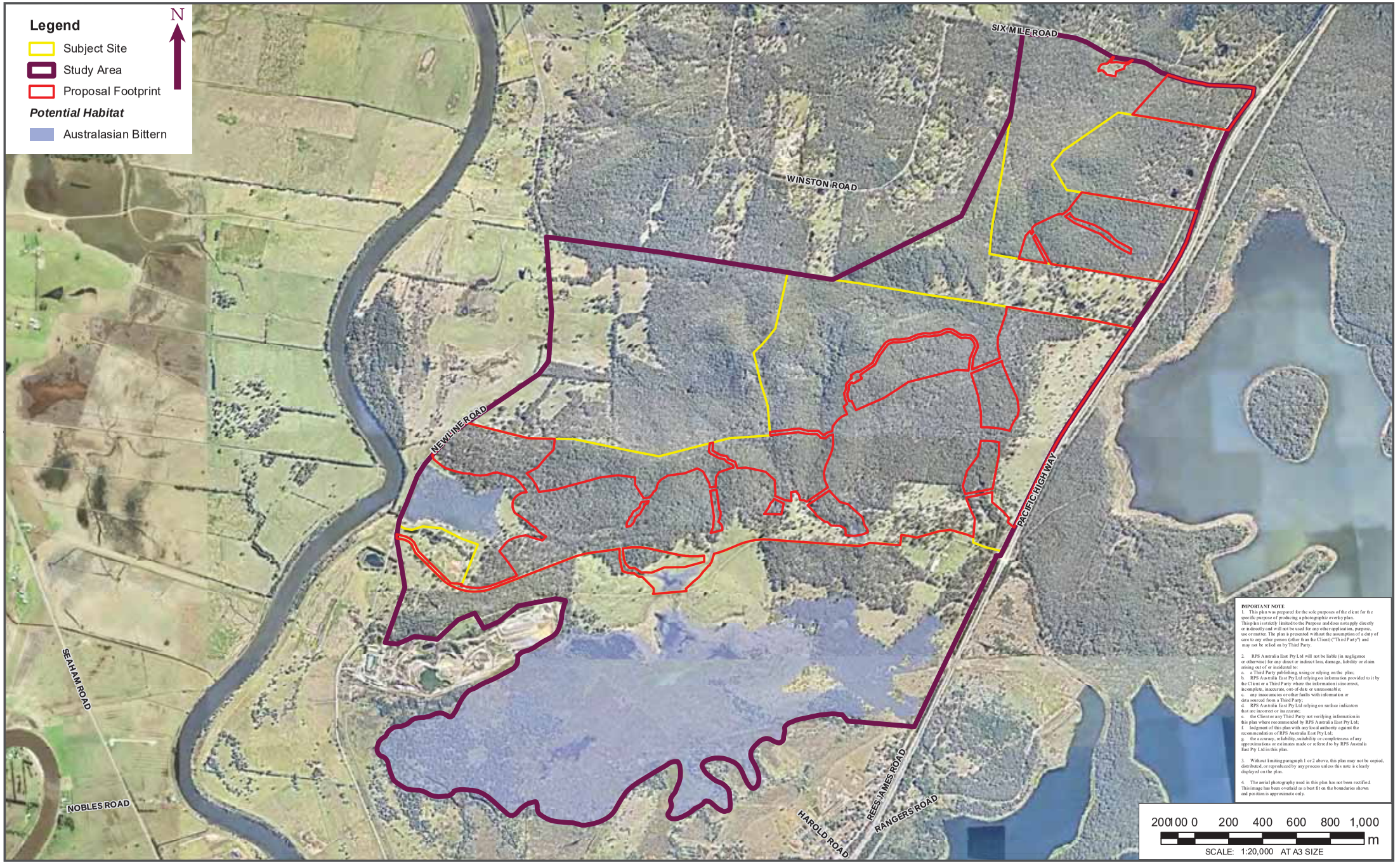

TITLE : FIGURE 4.56: POTENTIAL HABITAT OF THE AUSTRALASIAN BITTERN WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.56 Potential habitat of the Australasian Bittern within the SA D A3 20200719.mxd

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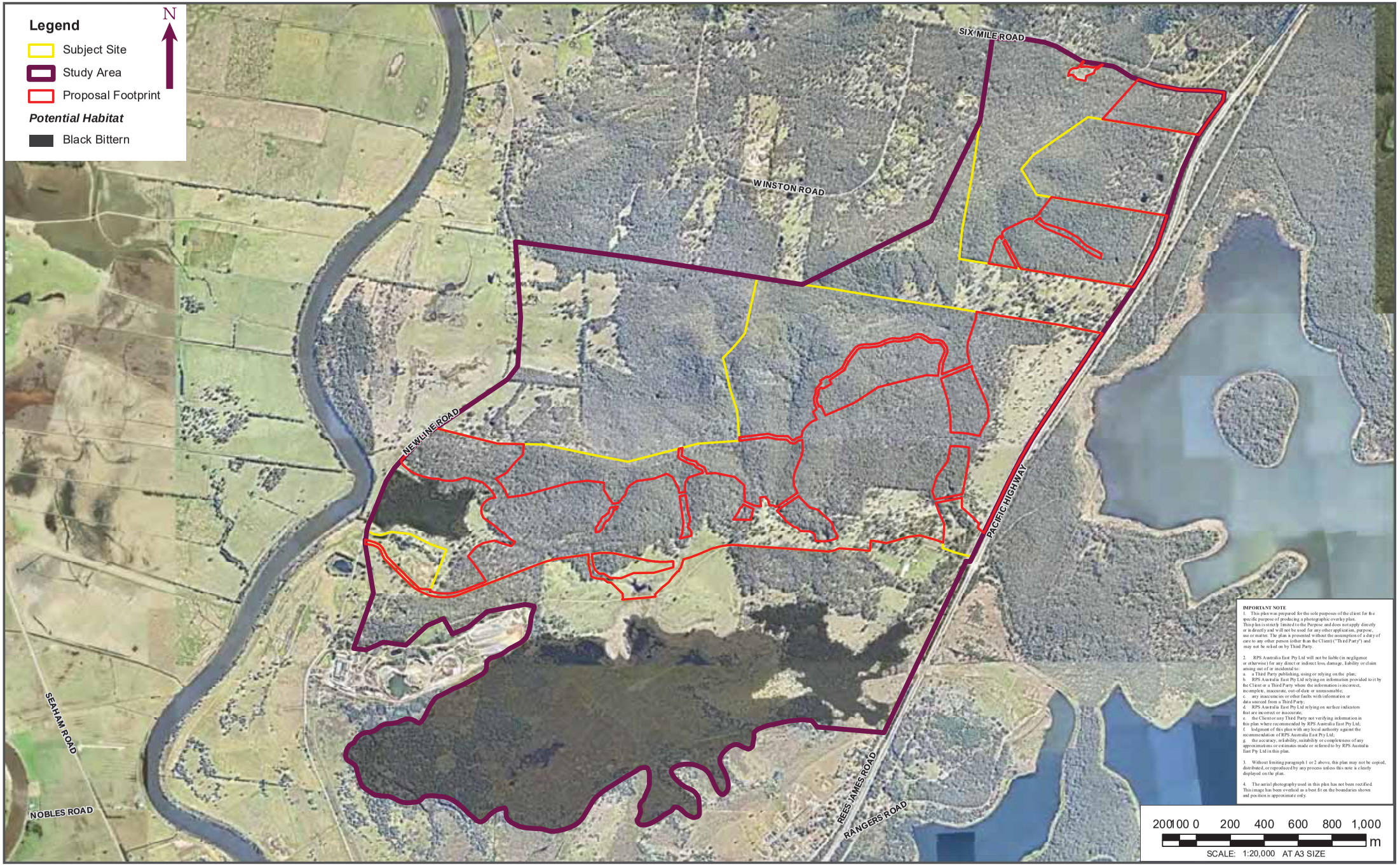

TITLE : FIGURE 4.57: POTENTIAL HABITAT OF THE BLACK BITTERN WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **19/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.57 Potential habitat of the Black Bittern within the S A D A3 20200719.mxd

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4.4.15 Dusky Woodswallow

Within NSW, Dusky Woodswallows are widespread from the coasts to western slope of the Great Divide. Depending on location and local climatic conditions (primarily temperature and rainfall), the species can be resident year round or migratory. In NSW, after breeding, birds migrate to the north of the state and to southeastern Queensland (OEH 2019b).

Dusky Woodswallows generally inhabit dry, open sclerophyll forests and woodlands which are usually dominated by eucalypts, including mallee associations and often found at edges or in clearings of forests and woodlands. This species is also recorded in shrublands and heathland and various modified habitats, including regenerating forests (and very occasionally in moist forests). (Marchant and Higgins 2006). This species also prefers a sparse understorey of eucalyptus saplings and acacias and other shrubs as well as ground cover of grasses, sedges and fallen woody debris (OEH 2019b).

Breeding generally occurs between August and January (Marchant and Higgins 2006). Nest sites vary greatly, but generally occur in shrubs or low trees, living or dead, horizontal or upright forks in branches, spouts, hollow stumps or logs, behind loose bark or in a hollow in the top of a wooden fence post. Nest sites may be exposed or well concealed by foliage (OEH 2019b). Potential habitat and the recorded locations of the Dusky Woodswallow within the study area is shown in **Figure 4.58**.

4.4.16 Black-necked Stork

The Black-necked Stork is considered widespread in coastal and subcoastal northern and eastern Australia, as far south as central NSW (although vagrants may occur further south or inland, well away from breeding areas). In NSW, the species becomes increasingly uncommon south of the Clarence Valley, and rarely occurs south of Sydney. Since 1995, breeding has been recorded regularly near Bulahdelah, 80 km north of Newcastle and is generally considered Australia's southernmost breeding pair (Clancy & Ford 2013). Breeding has also been recorded at Tomago in 2017 and has also been suspected within Hexham Swamp in 2014-2016 (Lindsey 2019)

This species inhabits tropical and warm-temperate terrestrial wetlands, estuarine and littoral habitats and occasionally grassland and wooded areas (Marchant and Higgins 1990). Foraging occurs in fresh or saline waters up to 0.5m deep, preferring extensive sheets of shallow freshwater over grassland or sedgeland; shallow swamps with short emergent vegetation and abundant aquatic flora and permanent billabongs and pools on floodplains (Marchant and Higgins 1990). Less common in intertidal waters, littoral and estuarine mudflats or areas of fringing mangroves (Marchant and Higgins 1990).

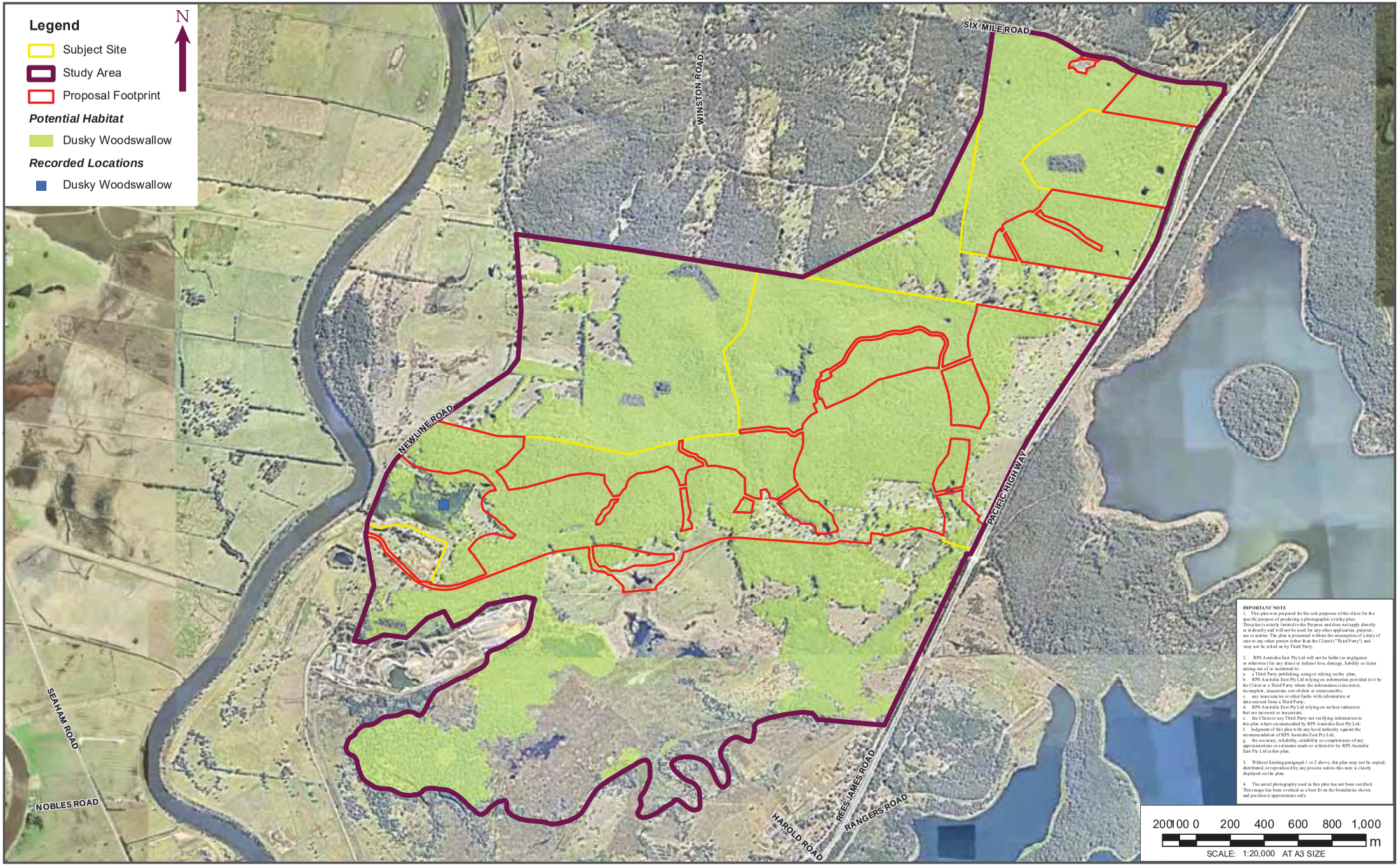
Black-necked Storks build large nests high in tall trees close to water that usually provide clear observation of the surroundings and are at low elevation (reflecting the floodplain habitat) (OEH 2019b). In NSW, breeding activity occurs May – January. Recorded nesting in Tomago NSW in 2017 involved a nest built in a Narrow-leaved Paperbark (*Melaleuca linariifolia*) approximately three metres tall, growing in wetland dominated by Common Reed (*Phragmites australis*). The tree had multiple trunks and the crown was broad and flattened at the top (Lindsey 2019). Potential habitat and the recorded locations of the Dusky Woodswallow within the study area is shown in **Figure 4.59**.

4.4.17 Grey-crowned Babbler

The Grey-crowned Babbler can be found in open Box-Gum Woodlands on the slopes, Box-Cypress pine and open Box Woodlands on alluvial plains and in woodlands on fertile soils in coastal regions (OEH 2019b). Woodlands typically have regenerating trees, tall shrubs and an intact ground cover of grass and forbs (NSW Scientific Committee, 2011c). Nests for this species are dome-shaped and built from sticks and are usually located in shrubs or saplings, and may also be built on the outermost leaves of low branches of larger eucalypts (OEH 2019b).

Foraging forays are commonly seen on the ground where it turns leaf litter, bark and small stones to uncover prey and also low shrubs and trees in feeding flocks of 2-15 birds. Feeding flocks maintain a tight association

and rarely separated by more than 30 m at any one time for social and predator evasion reasons (Higgins and Peter 2002).



TITLE : FIGURE 4.58: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE DUSKY WOODSWALLOW WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.58 Potential habitat and recorded locations of the Dusky Woodswallow within SA D A3

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Groups typically comprise 4-12 birds with declining populations often identified by small groups of 1-3 birds and linked to fragmentation (i.e. >300m separation between habitat patches), predation and habitat simplification (i.e. burning for fuel reduction, tree dieback, removal of fallen timber/ logs, cattle grazing and invasion of pasture grasses/ exotic plants). Groups live in permanent territories, often adjoining others, which are aggressively defended throughout the year. Home ranges or territories vary in area (e.g. 1.5 to 50 ha) with territory size dependant on resource availability and quality and not necessarily the number of birds. Offspring often stay with the breeding pair for up to two years, with dispersal occurring into neighbouring unoccupied habitat thereafter and form new breeding groups once sexually mature (i.e. 2-4 years) (Higgins and Peter 2002).

There are 13 recorded locations of the Grey-crowned Babbler within the locality. Recent surveys of the study area recorded two Grey-crowned Babblers and one nest. Habitat for this species is not widespread throughout the Conservation Area and is restricted and generally concentrated to the vegetated margins of wetland 803 where a complex of young trees and understory structure is apparent; a localised circumstance consistent with habitat occupancy by a second flock of this species in the periphery of wetland 804 to the south west (Mark Aitkens pers obs 2019). Preferred habitat and the recorded locations for this species are shown in **Figure 4.60**.

4.4.18 Powerful Owl

This species inhabits a range of vegetation types from woodland and open sclerophyll forest to tall open wet forest and rainforest (OEH 2019b). It typically utilises large areas of connected woodland or forest habitat but can also occur in fragmented habitats as well.

The Powerful Owl breeds and hunts in open or closed sclerophyll forest or woodlands and may also hunt in open habitats (OEH 2019b). As a hunter of arboreal prey, the Powerful Owl feeds predominantly on Common Ringtail Possums, Common Brush-tailed Possums, Greater Gliders and Sugar Gliders (Bain et al., 2014). Large eucalypts that are at least 150 years old, with hollows at least 0.5m deep are the primary nesting habitat for this species (OEH 2019b). Smaller trees with hollows and a shrub layer within which prey species reside are also habitat components for the Powerful Owl (OEH 2019b).

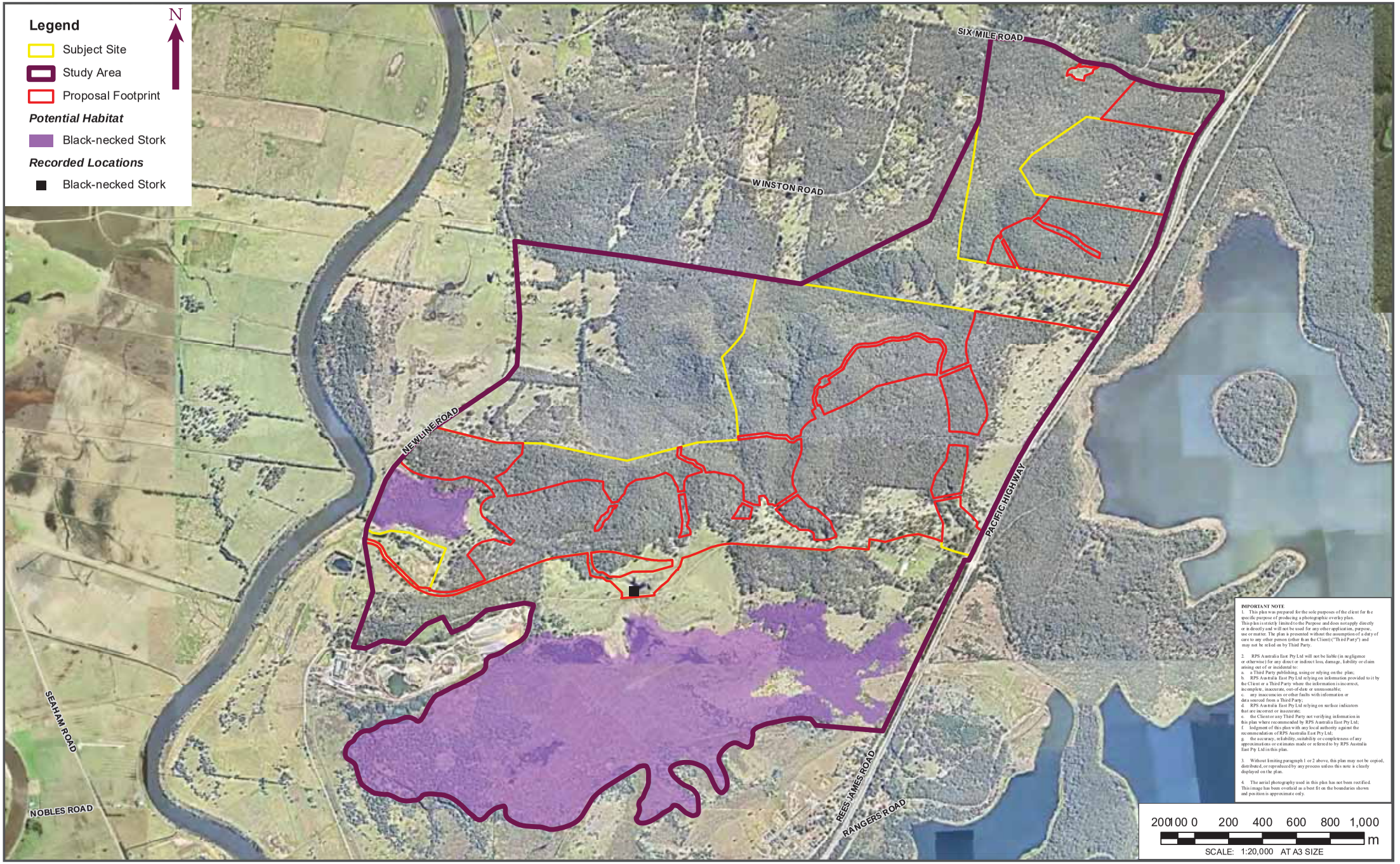
One Powerful Owl was recorded foraging within the study area during recent surveys. Suitable foraging habitat exists within the study area, with limited potential breeding habitat restricted to trees with larger hollows in association with dense understorey vegetation for cover that exist within PCT 1590, though there was no evidence of hollow occupation within these trees. Potential habitat and recorded locations for the Powerful Owl are shown in **Figure 4.61**. The mapped area (polygon) has considered the LMCC (2014) buffer prescription for protecting riparian corridors for movement (100 m width) relative to where the owl was recorded on site.

4.4.19 Masked Owl

The Masked Owl (*Tyto novaehollandiae*) is a large forest owl that occupies dry eucalypt forests and woodlands from sea level to 1100 m. Pairs have a large home-range of 500 to 1000 hectares and is not a species exhibiting seasonal variation in its distribution. It roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting with a preference for vertical hollows in large trees.

Masked Owls feed mainly on small mammals, such as rodents, rabbits and bandicoots. Other prey animals include possums, reptiles, birds and insects, with hunting taking place in the early hours of night. The birds sit on low perches listening for prey which, once detected, is taken from the ground or from the tree branches.

A Masked Owl was heard calling in the western part of the Conservation Area during stag watching in that location. This survey identified no utilisation of the hollows identified as potentially by this species within the impact area. Potential habitat of the Masked Owl and recorded location is shown in **Figure 4.62**.



TITLE : FIGURE 4.59: POTENTIAL HABITAT AND RECERDED LOCATIONS OF THE BLACK-NECKED STORK WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.59 Potential habitat and recorded locations of the Black-necked Stork within the SA C A3

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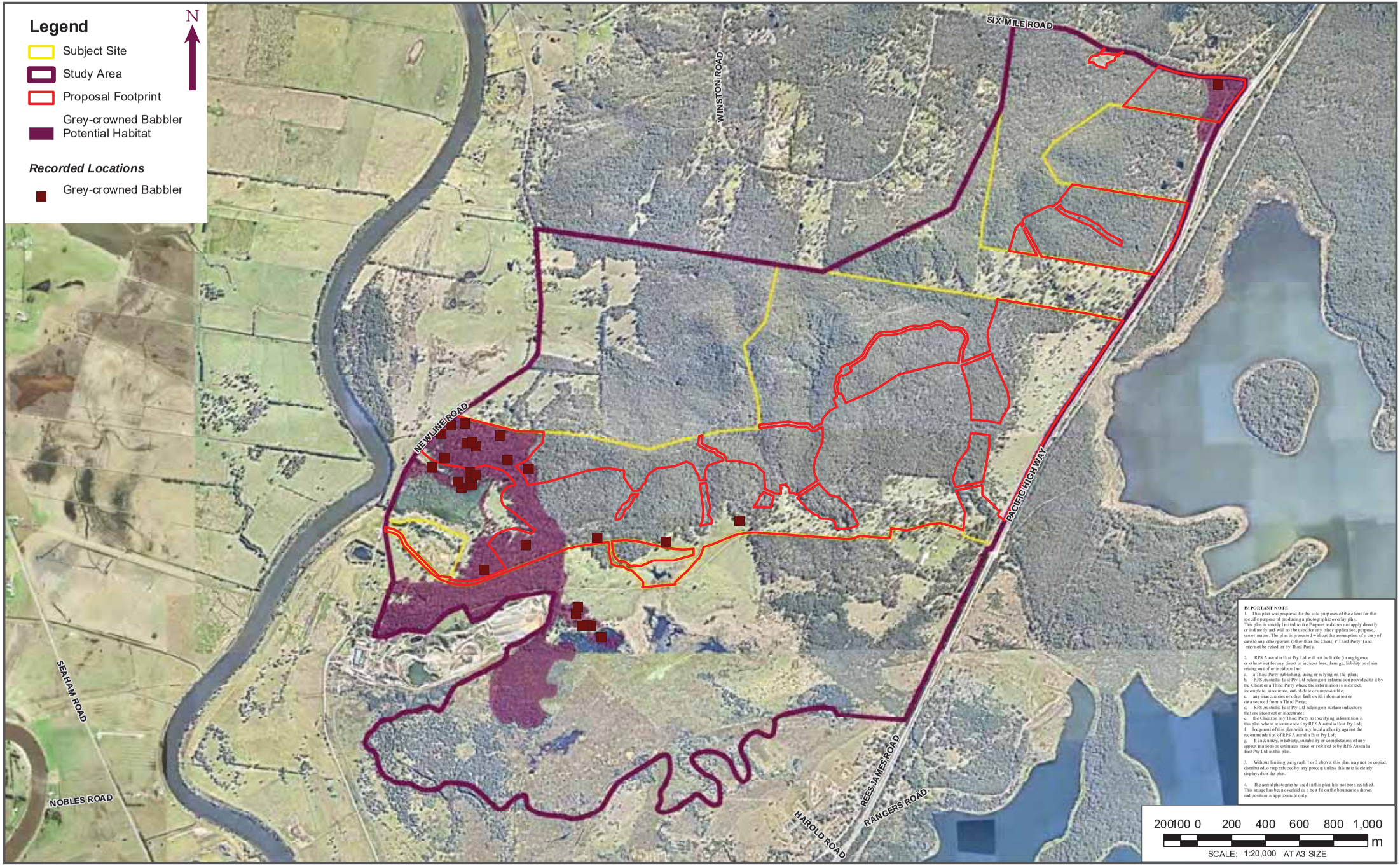

TITLE : FIGURE 4.60: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE GREY-CROWNED BABBLER WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.60 Potential habitat and recorded locations of the Grey-crowned Babbler within SA D A3

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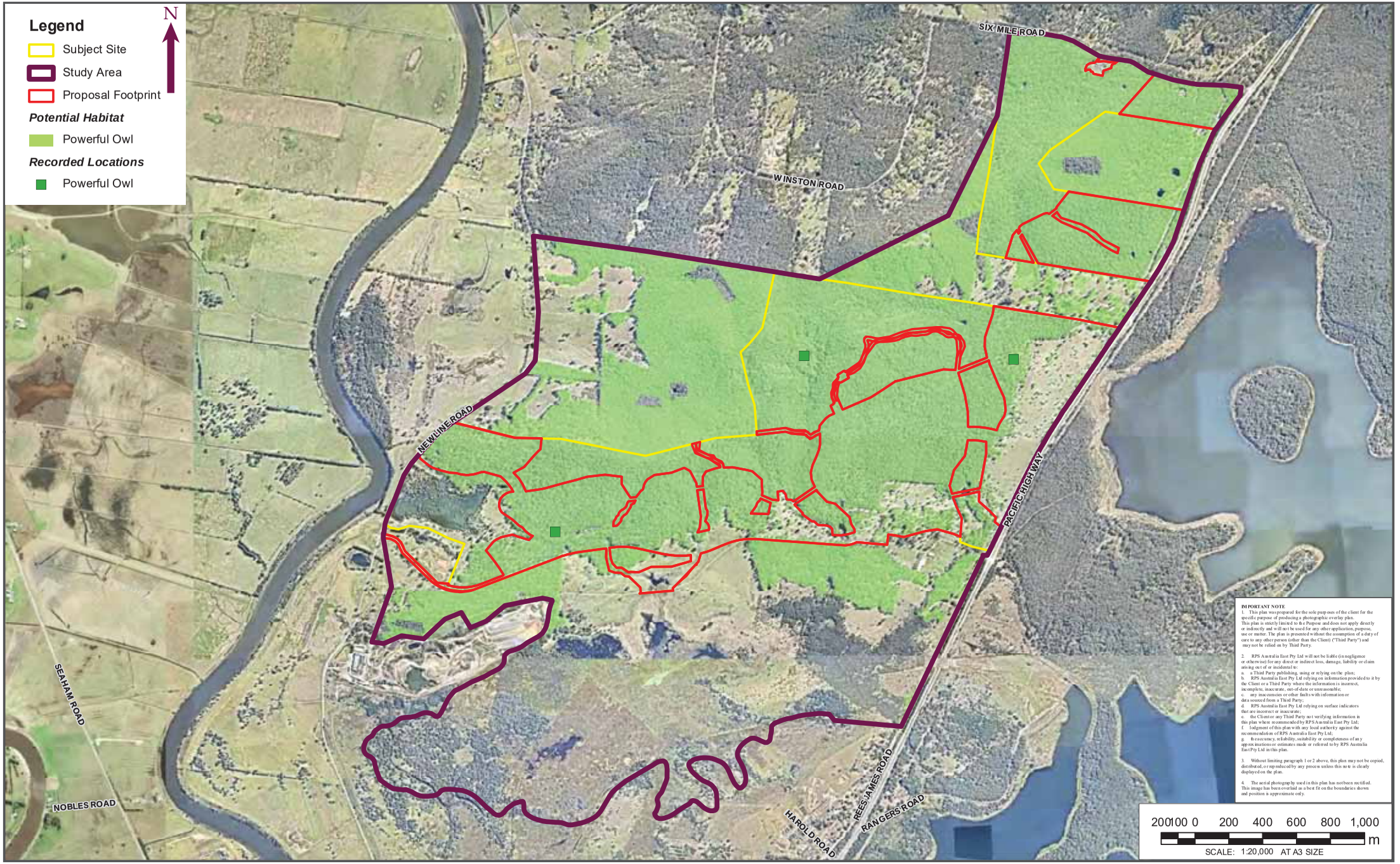

TITLE : FIGURE 4.61: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE POWERFUL OWL WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.61 Potential habitat and recorded locations of the Powerful Owl within SAC A3 20200720.mxd

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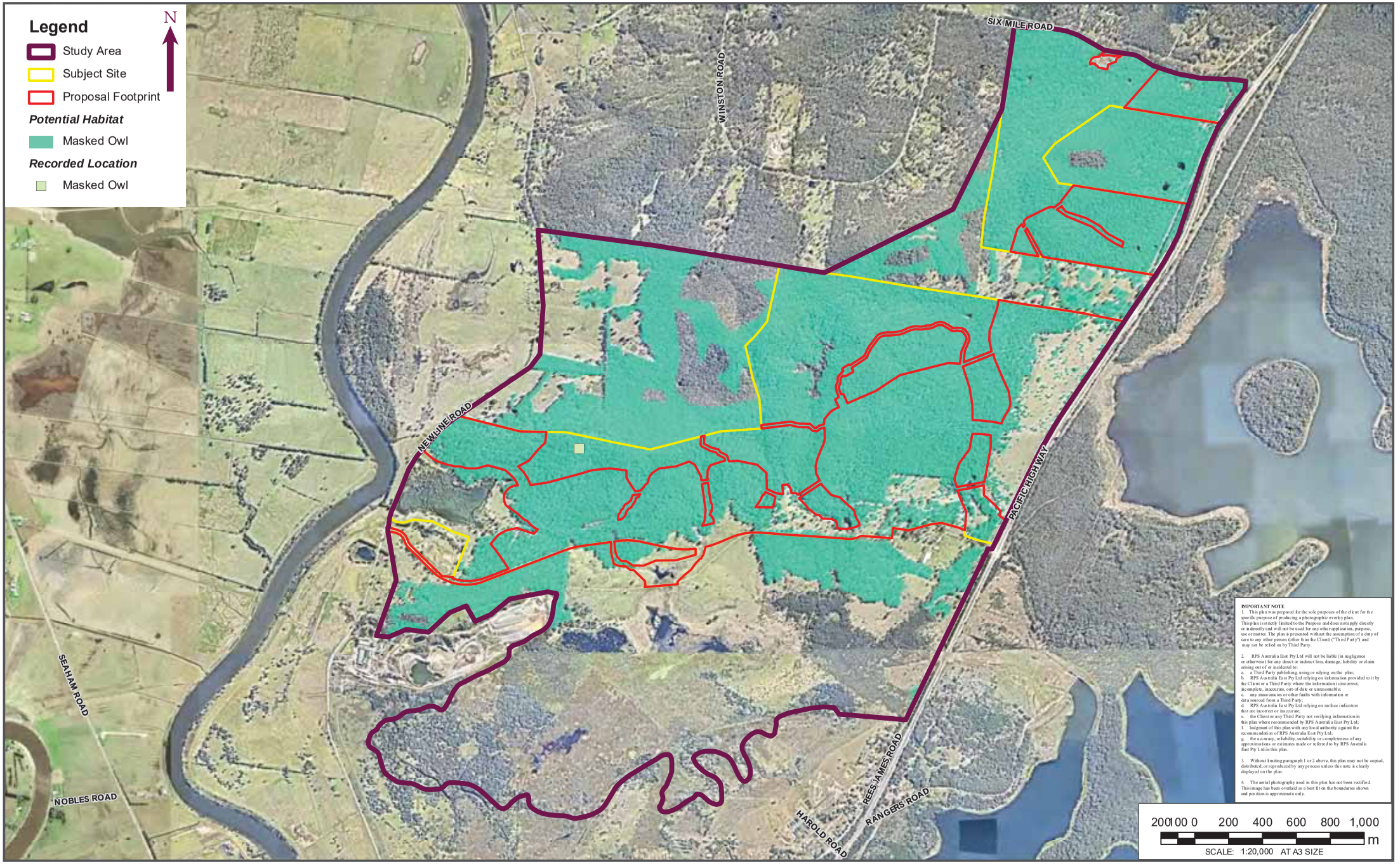

TITLE : FIGURE 4.62:POTENTIAL HABITAT OF THE MASKED OWL WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.62 Potential habitat of the Masked Owl within SA C A3 20200720.mxd

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4.4.20 Regent Honeyeater

The Regent Honeyeater inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers of mature trees, high canopy cover and abundance of mistletoes (OEH 2019b).

The Regent Honeyeater is a generalist forager, although it feeds mainly on the nectar from a relatively small number of eucalypts that produce high volumes of nectar. Key eucalypt species include Mugga Ironbark, Yellow Box, White Box and Swamp Mahogany. Other tree species may be regionally important. For example the Lower Hunter Spotted Gum forests near Cessnock have recently been demonstrated to support regular breeding events. Flowering of associated species such as Thin-leaved Stringybark (*Eucalyptus eugenioides*) and other Stringybark species, and Broad-leaved Ironbark (*E. fibrosa*) can also contribute important nectar flows at times. Nectar and fruit from the mistletoes *Amyema miquelii*, *A. pendula* and *A. cambagei* are also utilised. When nectar is scarce lerp and honeydew can comprise a large proportion of the diet. Insects make up about 15% of the total diet and are important components of the diet of nestlings (OEH 2019b).

Non-breeding flocks are seen foraging in flowering coastal Swamp Mahogany and Spotted Gum forests, particularly on the central coast and occasionally on the upper north coast. Recent observations of this behaviour were reported at the Hunter Botanic Gardens in early August 2018 where the species was observed occupying Blackbutt (*Eucalyptus pilularis*) forest adjacent swamp sclerophyll forests comprising species such as Swamp Mahogany (Mark Aitkens pers obs).

Potential non-breeding habitat within the study area is signified by winter flowering species notably the Spotted Gum. Breeding habitat is signified by vegetation with nectar supply during October – December, which may be provided by canopy species such as *Eucalyptus fibrosa* and *Eucalyptus tereticornis*. Potential habitat within the study area is shown in **Figure 4.63**.

4.4.21 Swift Parrot

The Swift Parrot is a winter migrant to the south-east mainland with occurrence on the mainland reported between February and October. On the mainland they occur in areas where eucalypts are flowering profusely or where there is abundant lerp (from sap-sucking bugs) infestations. Favoured local feed trees include winter flowering species such as Swamp Mahogany, Spotted Gum, Red Bloodwood and Forest Red Gum. Commonly used lerp infested trees include Grey Box and Blackbutt.

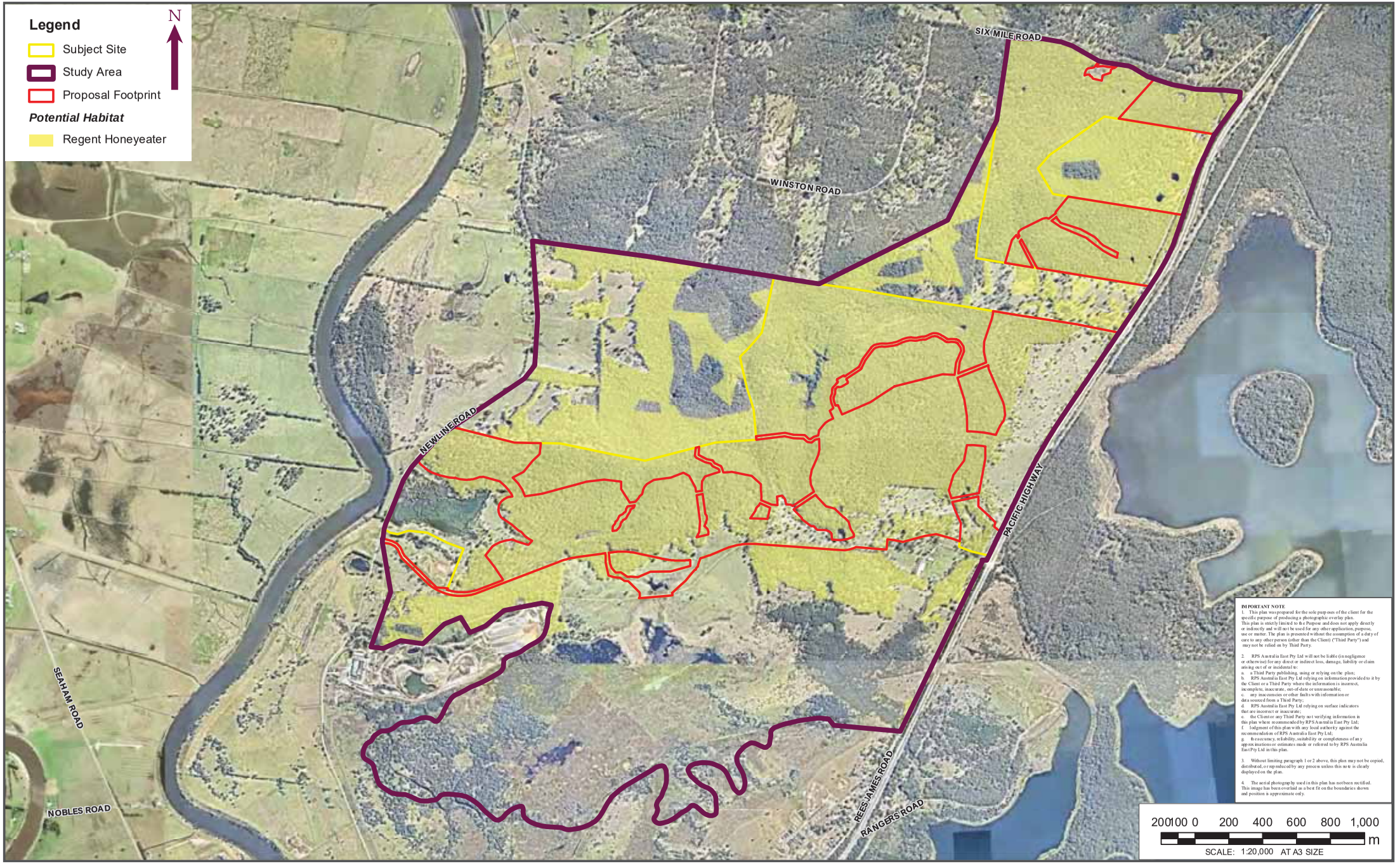
Following winter they return to Tasmania where they breed from September to January, nesting in old trees with hollows and feeding in forests dominated by Tasmanian Blue Gum (*Eucalyptus globulus*).

Potential foraging habitat is signified by vegetation with nectar supply during April-August. Within the study area, this may be provided by canopy species such as Spotted Gum and Forest Redgum. Potential habitat within subject site, as defined the by the presence of these species, is shown in **Figure 4.64.**

4.4.22 Scarlet Robin

The Scarlet Robin lives in open forests and woodlands in Australia, while it prefers rainforest habitats on Norfolk Island. During winter, it will visit more open habitats such as grasslands and will be seen in farmland and urban parks and gardens at this time.

This species was observed once within the study area. Potential habitat within the study area and the recorded location for this species is mapped in **Figure 4.65**.



TITLE : FIGURE 4.63: POTENTIAL HABITAT OF THE REGENT HONEYEATER WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

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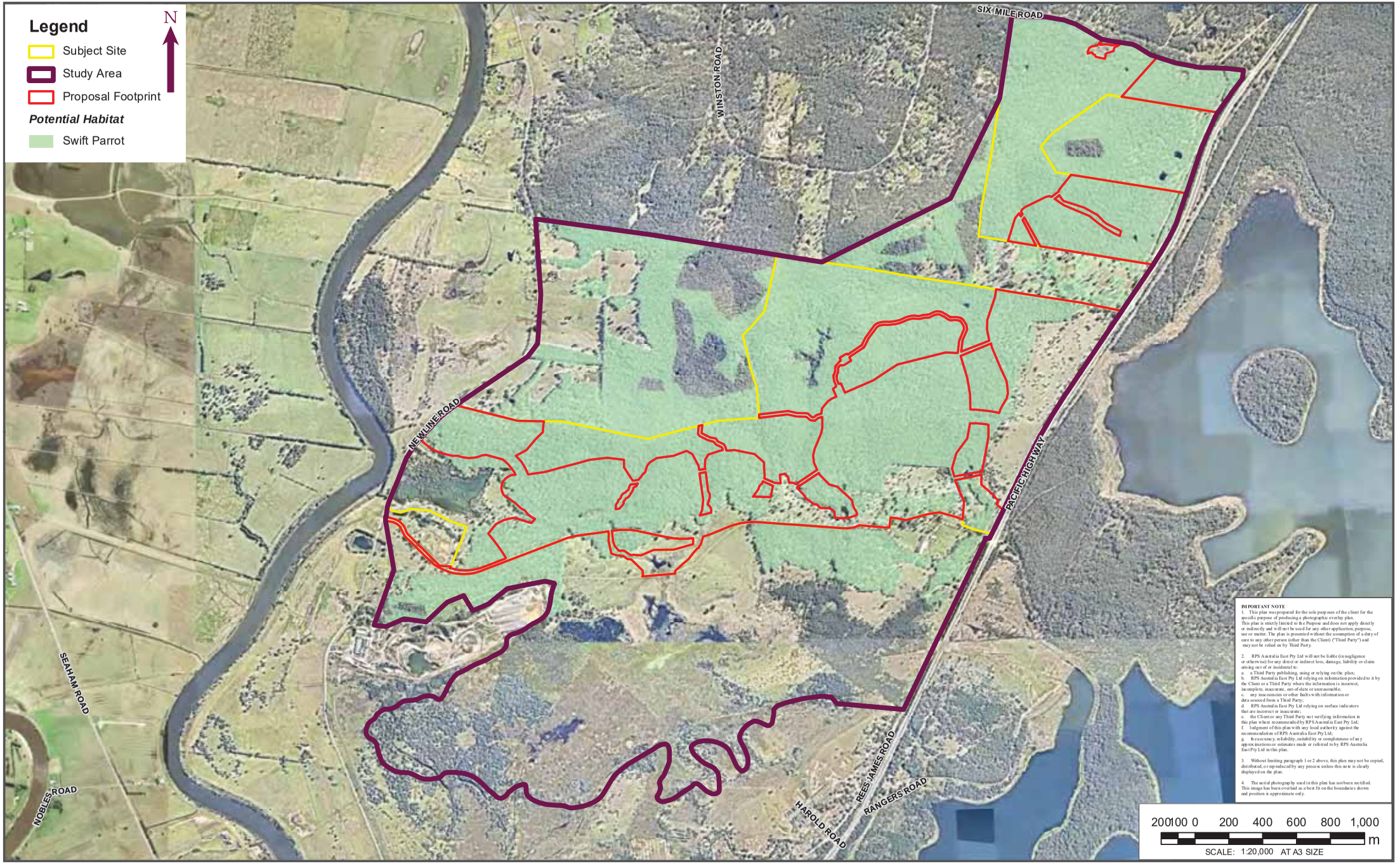

TITLE : FIGURE 4.64: POTENTIAL HABITAT OF THE SWIFT PARROT WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.64 Potential habitat of the Swift Parrot within SA C A3 20200720.mxd

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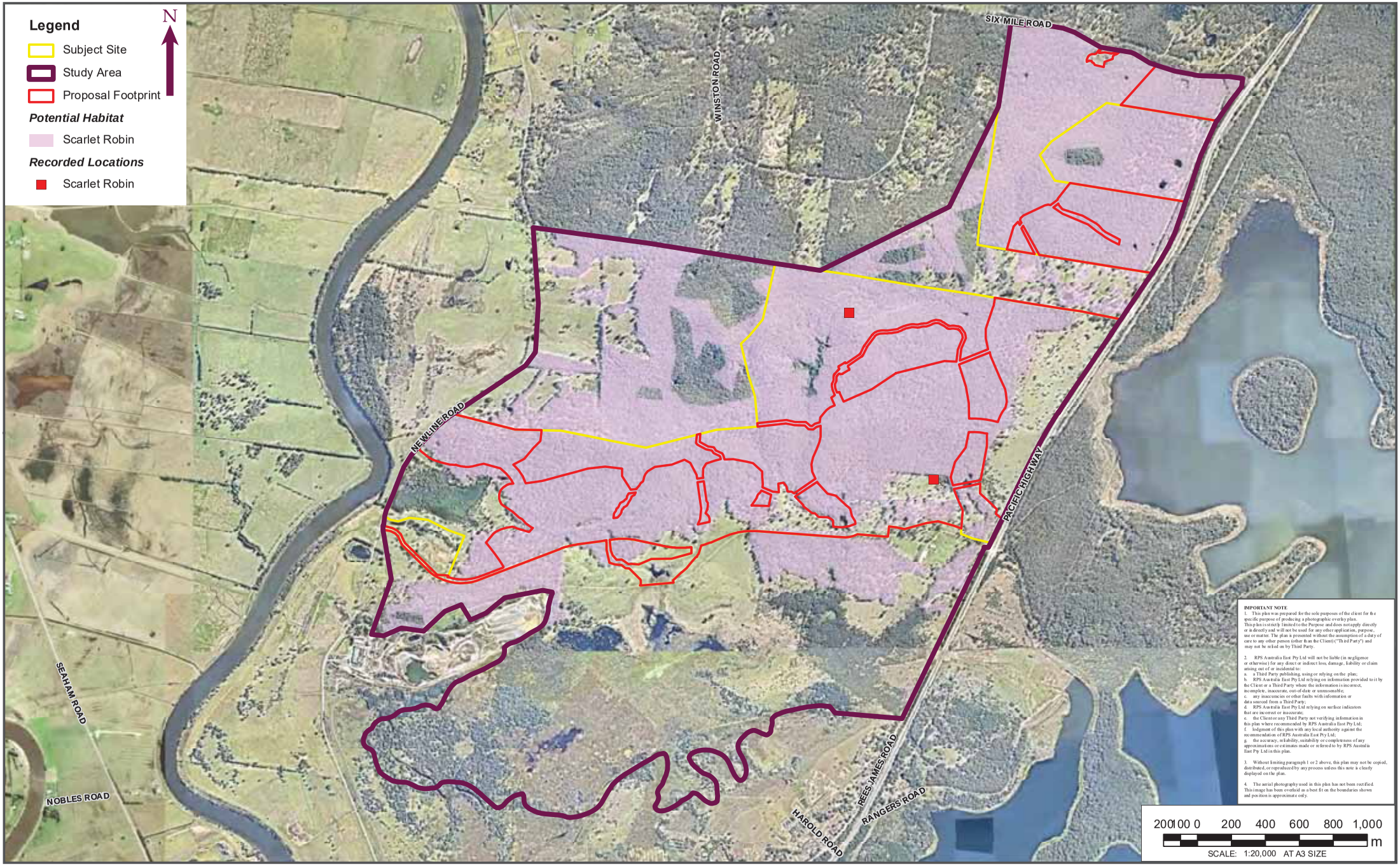

TITLE : FIGURE 4.65: POTENTIAL HABITAT OF THE SCARLET ROBIN WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.65 Potential habitat of the Scarlet Robin within SA C A3 20200720.mxd

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4.4.23 Squirrel Glider

Squirrel gliders are sparsely distributed in eastern Australia, from northern Queensland to western Victoria (OEH 2019b). Populations of this species are highly localised and dependent on availability of suitable foraging habitat with tree hollows. Colonies require multiple den trees within their home ranges (LMCC 2015).

Gliders nest in tree hollows and live in family groups, with reproduction peaking in late Autumn and Winter. (LMCC 2015). High population density is only achievable in habitats with abundant hollow bearing trees (>4 habitat trees/ha) and abundant food trees (Smith and Murray 2003; van der Ree 2000; Sharpe & Goldingay 2010). Dead trees (stags) are an important habitat component and are used when available (Rowston 1998; Ball, Goldingay & Wake 2011; Beyer, Goldingay & Sharpe 2008).

This species prefers a range of dry and moist sclerophyll forest, swamp forest, and woodland vegetation communities dominated by winter flowering eucalypts or flowering banksias, (Quin et al. 2004; Sharpe 2004; Sharpe & Goldingay 2010, HWR 2004), or summer flowering eucalypts with an understorey of acacia species that provide edible gum exudates in winter (eg *A. irrorata*, *A. parramattensis*, and *A. longifolia*) (Smith and Murray, 2003).

Squirrel gliders eat nectar from flowers, pollen and sugary plant and insect exudates (LMCC 2015). In addition to pollen and nectar, arthropods are an important food source (Sharpe & Goldingay 1998; Dobson, Goldingay & Sharpe 2005; Ball et al. 2009).

The occurrence of this species was not confirmed within the study area during recent surveys, however suitable habitat is present in all the Eucalypt forest within the study area. Potential habitat within the study area and the historical recorded location for this species (HWR 2004) is mapped in **Figure 4.66**.

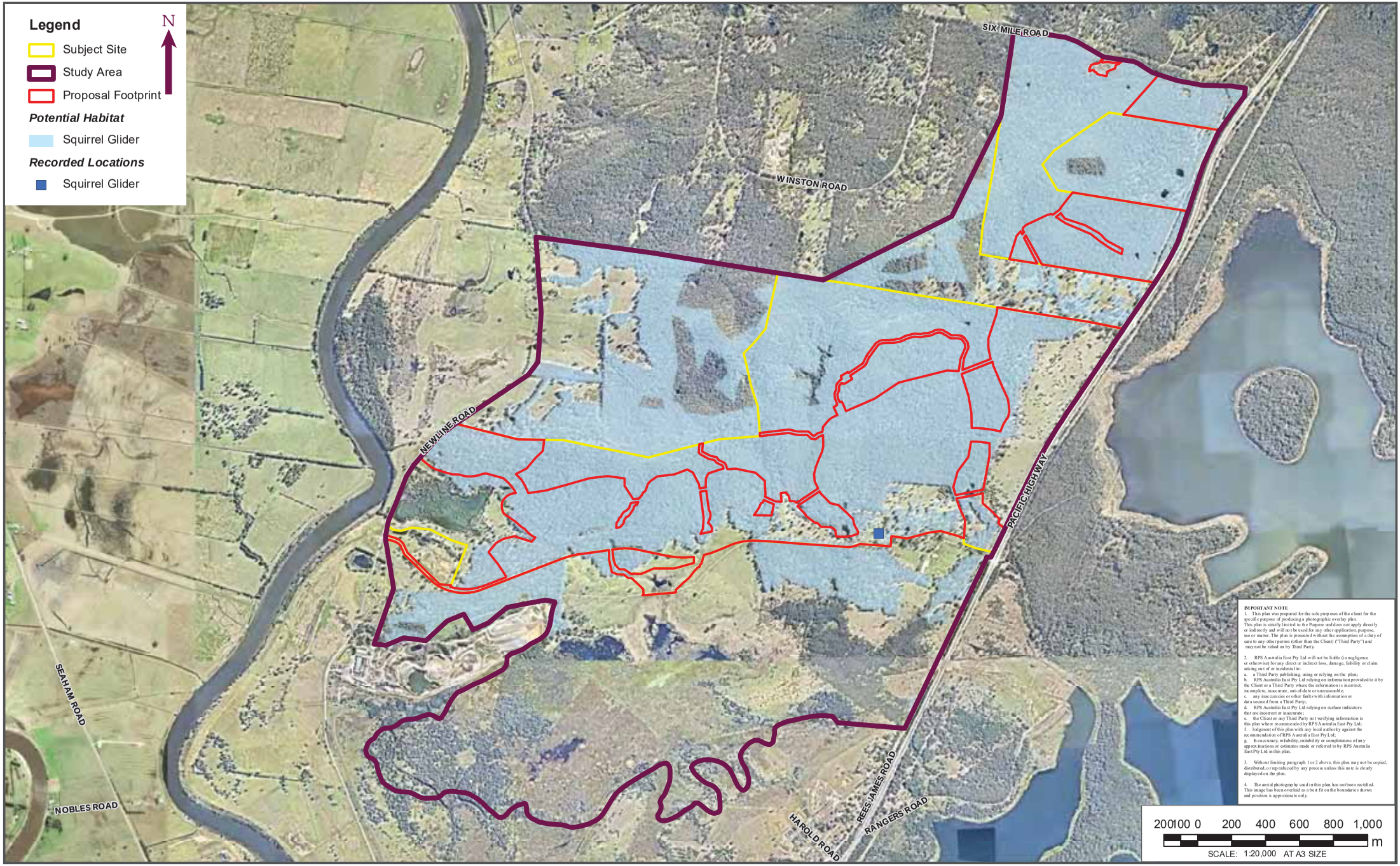
4.4.24 Koala

Koalas inhabit open eucalypt forest and woodland and feed on approximately 70 species of eucalypt and 30 species of non-eucalypt trees within NSW; however, local occurrences are more likely dependent on a small number of preferred feed tree species. In Port Stephens LGA the Koala is known to prefer three primary feed tree species (i.e. Forest Redgum, Swamp Mahogany and Earps Gum), a variety of secondary and supplementary tree species and is estimated to have a population numbering 800 individuals (NSW Threatened Species Scientific Committee 2018).

4.4.24.1 Preferred Koala Feed Trees

Preferred Koala feed trees (PKFTs) of the Port Stephens LGA are discussed in **Section 4.3.2.3** and were used as the basis for considering the extent of Koala habitat within the study area. Measures for total and digestible nitrogen and plant secondary metabolites (PSMs) were obtained for these tree species (Marsh and Youngentob 2019; **Appendix I**) to verify their status as PKFTs within the study area.

Eucalypt trees sampled at Kings Hill contained a range of total and digestible nitrogen concentrations (**Figure 4.67**). Digestible nitrogen concentrations were lower than total nitrogen in most species due to the binding of protein by tannins or PSMs in the leaves. Thus, digestible nitrogen concentrations better reflect the portion of nitrogen that is actually available to the animal. Most *E. tereticornis, E. moluccana, E. propinqua* and *E. punctata* trees contained relatively high concentrations of digestible nitrogen (**Figure 4.67b**). Most *E. globoidea* and *E. microcorys* also tended to have good (i.e. ≥ 1% DM) foliar concentrations of digestible nitrogen. *Eucalyptus acmenoides*, *E. umbra, E. crebra, E. fibrosa*, and *E. siderophloia* were poorer in digestible nitrogen (**Figure 4.67b**). These results accord well with the ranking of Koala feed tree importance stated by PSC (2002) and OEH (2018), with some noteworthy site specific findings (e.g. relatively high value of digestible nitrogen in *E. punctata* and *E. globoidea* and variability in *E. tereticornis*).



TITLE : FIGURE 4.66: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE SQUIRREL GLINDER WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.66 Potential habitat and recorded locations of the Squirrel Glinder within SA C A3

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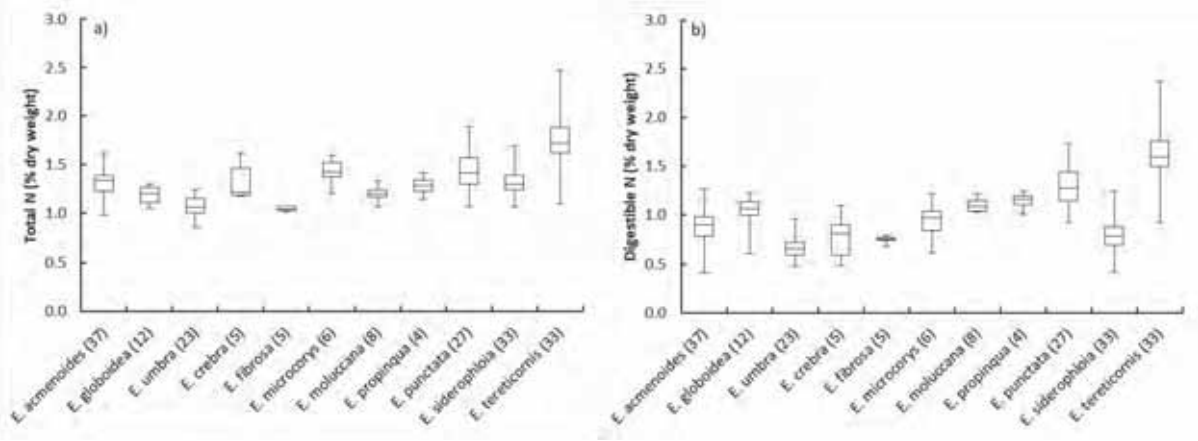


Figure 4.67 Range in Total and Digestible Nitrogen for 11 Eucalypt Species at Kings Hill

The range in a) total, and b) digestible nitrogen (N) concentrations for eucalypt species sampled at Kings Hill. Boxes show the first quartile, median and third quartile for each eucalypt species, and whiskers show the maximum and minimum concentrations. The number of samples collected is shown in brackets after the species name.

Different transects within the Kings Hill site also varied in total and digestible nitrogen concentrations (**Figure 4.68**). For example, more than 75% of the trees sampled in transect 8 had concentrations of available nitrogen higher than 1% dry weight, whereas more than 75% of the trees in transect 3 were below this concentration (**Figure 4.68b**). Much of this variation appeared to be driven by the species composition at each location.

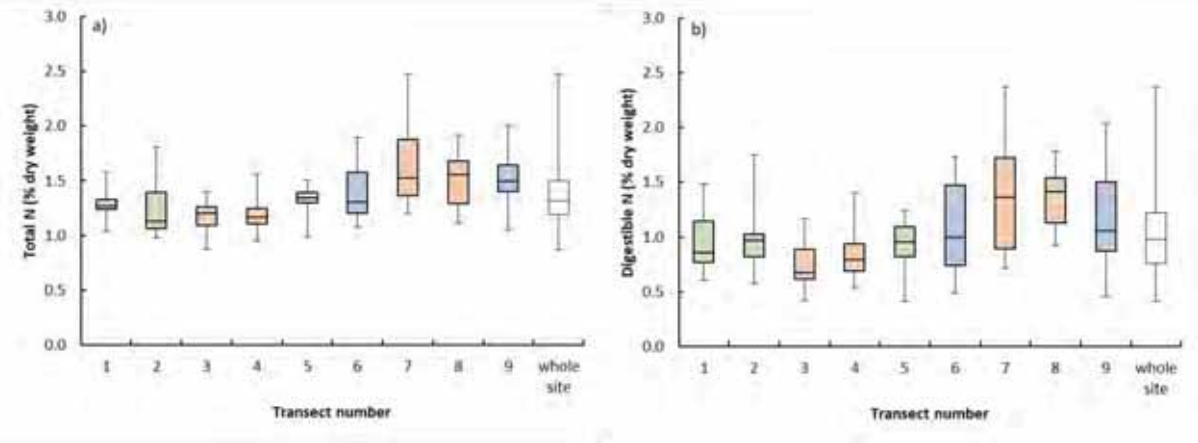


Figure 4.68 Range in Total and Digestible Nitrogen for each Transect Sampled at Kings Hill

The range in a) total, and b) digestible nitrogen (N) concentrations for eucalypt trees at each transect sampled at Kings Hill (16 trees per transect). Boxes show the first quartile, median and third quartile for each transect, and whiskers show the maximum and minimum concentrations. Transects coloured green are outside the development zone, blue are on the edge and orange are within.

4.4.24.2 Preferred Koala Feed Trees and Plant Secondary Metabolites

Foliar tannin or PSMs, which act as herbivore deterrents, varies within and between species at Kings Hill. PSMs are expressed in Symphyomyrts as FPCs and Monocalypts as UBFs. **Figure 4.69** provides the results for tree species sampled at Kings Hill.

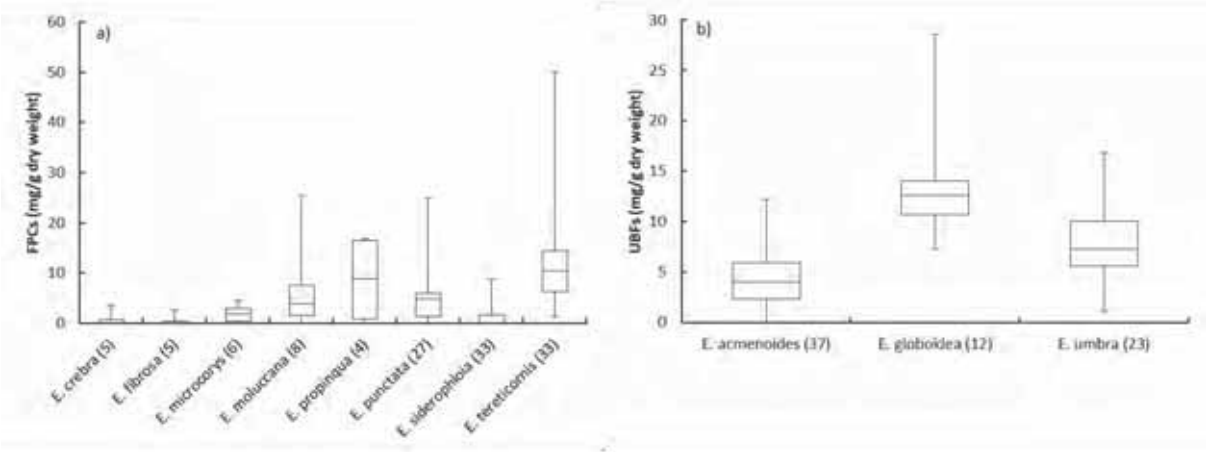


Figure 4.69 Range in PSMs for Symphyomyrts (FPCs) and Monocalypts (UBFs) at Kings Hill

The range of a) concentrations of FPCs in Symphyomyrtus species, and b) concentrations of UBFs in Monocalyptus species sampled at Kings Hill. Boxes show the first quartile, median and third quartile for each species, and whiskers show the maximum and minimum concentrations. The number of samples collected is shown in brackets after the species name.

Relatively low FPC concentrations were measured for *Eucalyptus crebra, E. fibrosa* and *E. siderophloia* (**Figure 4.69**). However, koalas may not be able to meet their protein requirements if they were to only eat these species due to the low digestible nitrogen concentrations in most trees of those species (i.e. <1% digestible nitrogen as shown in **Figure 4.67**).

Eucalyptus microcorys has moderate foliar concentrations of digestible nitrogen (i.e. ~1%) and low FPCs, thus increasing its overall browse quality (i.e. koalas can access the digestible nitrogen without having to contend with high levels of FPCs). For similar reasons, *E. punctata*, *E. propinqua* and *E. moluccana* are also likely to be important food species at Kings Hill, with *E. punctata* being of relatively high value. Although 25% of the *E. tereticornis* trees sampled at Kings Hill contained FPCs at concentrations higher than 15 mg/g dry weight, the very high concentrations of digestible nitrogen in this species are likely to make it an excellent source of food for koalas, particularly given that koalas can select individual trees with lower FPC concentrations.

More than half of the *E. acmenoides*, more than three quarters of the *E. umbra*, and all of the *E. globoidea* trees sampled at Kings Hill contained concentrations of UBFs that could be expected to reduce the amount of foliage that koalas can eat from those trees (i.e. UBFs deter herbivory at levels <3-6 mg/g) as shown in **Figure 4.69b**. Together with the low digestible nitrogen concentrations in many *E. acmenoides* and *E. umbra* in particular, koalas at Kings Hill may eat some of these trees in small amounts, but they are not likely to be a major dietary component.

This empirical investigation of PKFTs listed in Section **4.3.2.3** were locally validated with trees having the highest nutritional value, in order of importance, listed as follows:

- Forest Redgum;
- Grey Gum;
- Small-fruited Grey Gum;
- Grey Box; and
- Tallowwood.

All other species are classed as supplementary trees as they exhibit a combination of digestible nitrogen/ PSMs that are suboptimal for the Koala. However, these trees may have other importance.

4.4.24.3 Tree Forage Quality within subject site

The foliar chemistry data of each eucalypt species sampled at the Kings Hill site, as outlined in the preceding sections, was modelled (i.e. Kriging; ArcGIS) using RDP and tree nearest neighbour datasets in combination with the nutritional data to describe spatial variation in resource quality at a resolution relevant to the Koala (Moore et al 2010). The result of this modelling for digestible nitrogen is provided in **Figure 4.70**. SPMs were also mapped in the same manner to show the distribution of herbivore deterrents (**Figure 4.71** for FPCs and **Figure 4.72** for UBFs). These models were generated from measured nutritional data resampled at the plot level (**Figure 4.3**; n=187) to statistically estimate forage quality in unsampled areas; a methodological approach broadly consistent with Moore et al (2010) and a study investigating the contribution of one species, *E. sieberi*, to the forage quality of plots with variable tree species composition (Au et al. 2019; Au 2018). The results show a heterogenous pattern of digestible nitrogen and herbivore deterrent across the subject site.

4.4.24.4 Preferred Koala Feed Trees at Kings Hill

BioLink (2017) identified the following Preferred Koala Habitat (PKH) within the study area:

- Secondary Class A (in the west);
- Secondary Class C/B; and
- Secondary (other 2C).

BioLink (2017) note the following in relation to PKH mapping within the PSC LGA for the dominant vegetation type mapped within the study area (i.e. PCT 1590):

"Seaham Spotted Gum - Ironbark Forest contain one or more PKFTs and so warrants recognition as PKH. However, field data indicates that constituent PKFTs are a sub-dominant feature of the tallest-stratum, hence implying the need to downgrade both PCTs from Secondary (Class B) – which requires dominance by one or more Secondary PKFTs, to the lower and more marginally aligned Secondary (Class C/B)" (BioLink 2017).

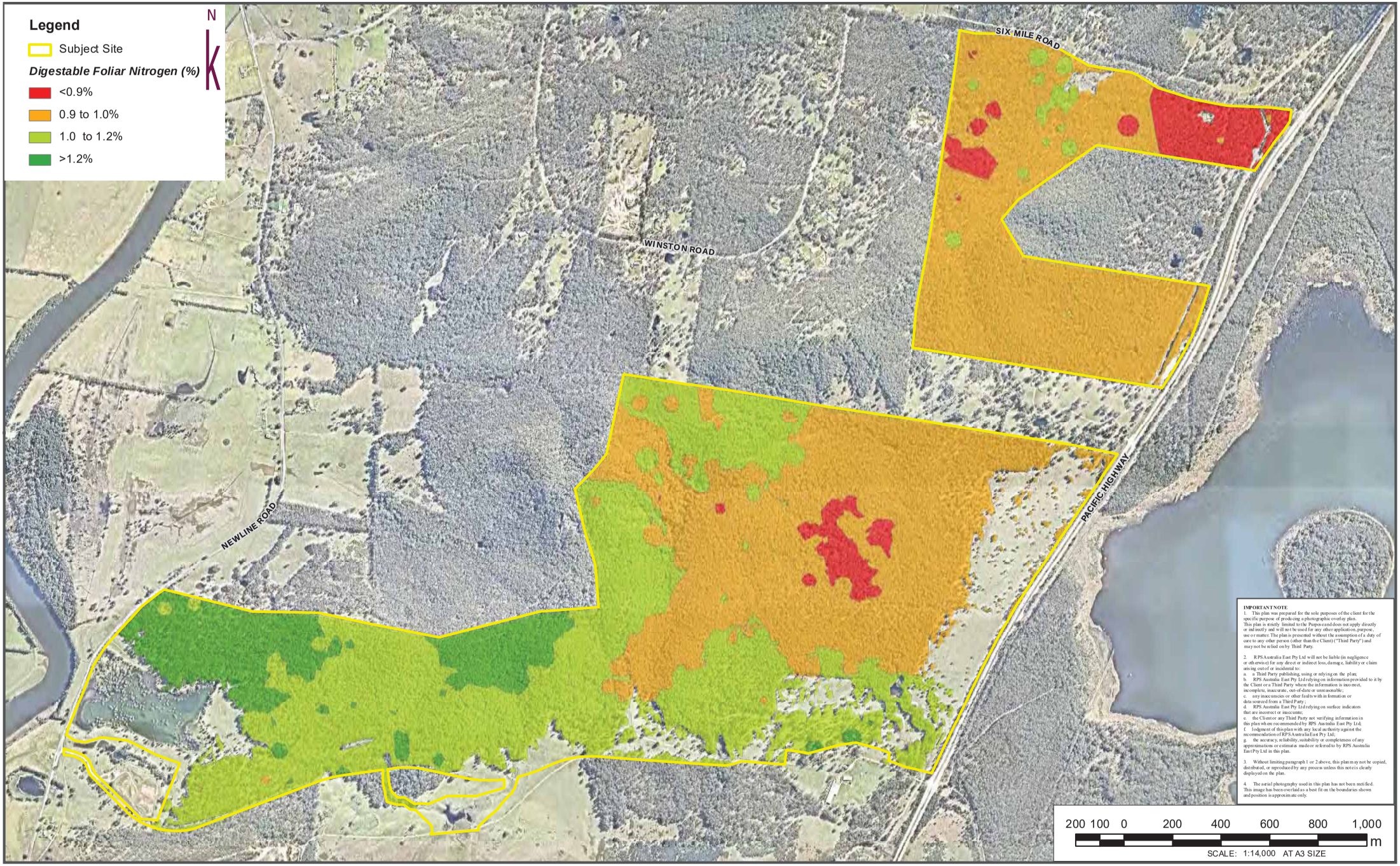
Tree distribution data obtained from the study area generally confirms this assessment as indicated in **Figures 4.30** to **4.44**. However, close scrutiny of this tree mapping indicates a heterogenous distribution of PKFTs indicating the potential for some of the site's vegetation cover to comprise locally enriched patches of higher value PKH.

One high value or primary PKFT was located within the study area (Swamp Mahogany) with the occurrence of this restricted to alluvial soils adjacent wetland 803. Secondary PKFTs were also identified these being the following species with diameter at breast height of 300mm or greater on low fertile soils (BioLink 2019a,b):

- Forest Redgum;
- Grey Gum;
- Small-fruited Grey Gum;
- Tallowwood; and
- Grey Box.

Marsh and Youngentob (2019) (**Appendix I**) confirmed the value of these tree species as having sufficient digestible nitrogen and low PSM to warrant classification as PKFT species (i.e. digestible nitrogen > 0.9% with low to moderate PSMs).

Tallowwood, which is classed as a Secondary PKFT species having high regional use (OEH 2018) and is consistently found nearby areas of high Koala activity within the study area (BioLink 2018; OWAD 2019). Due to the relative rareness of this species within the study area (i.e. only a few specimens of this species were sampled), it is possible that the importance of this species as a Secondary PKFT within the study area has been understated. Further research is required to determine if this species should be classed a high value PKFT within the study area and more broadly within the PSC LGA.



TITLE : FIGURE 4.70: PREDICTED FOLIAR NUTRIENT VALUE (I.E. DIGESTIBLE NITROGEN) EXTENT ACROSS SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/12/2019**

PURPOSE: **ECOLOGY**

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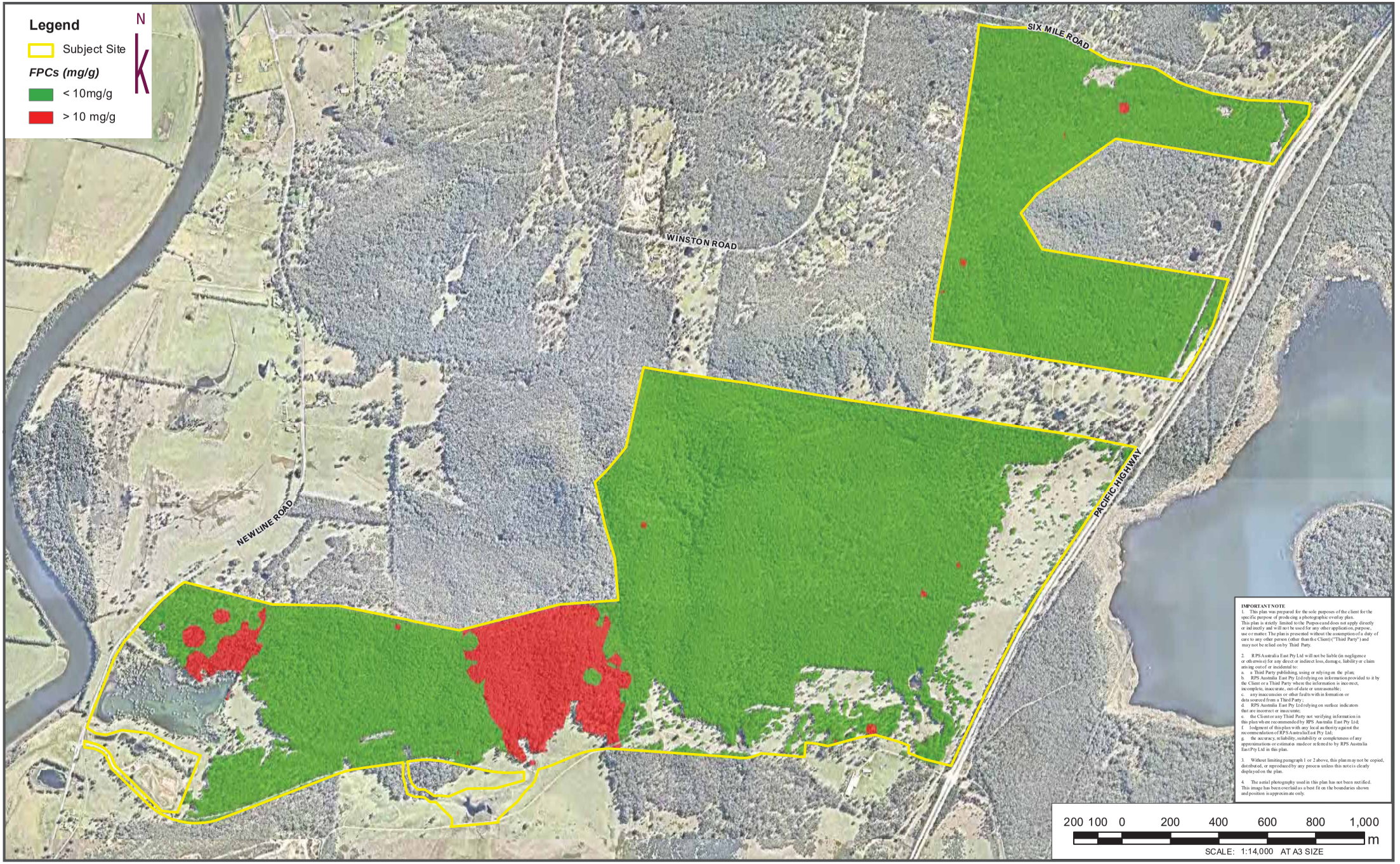

TITLE : FIGURE 4.71: PREDICTED EXTENT OF FPCS ACROSS THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **11/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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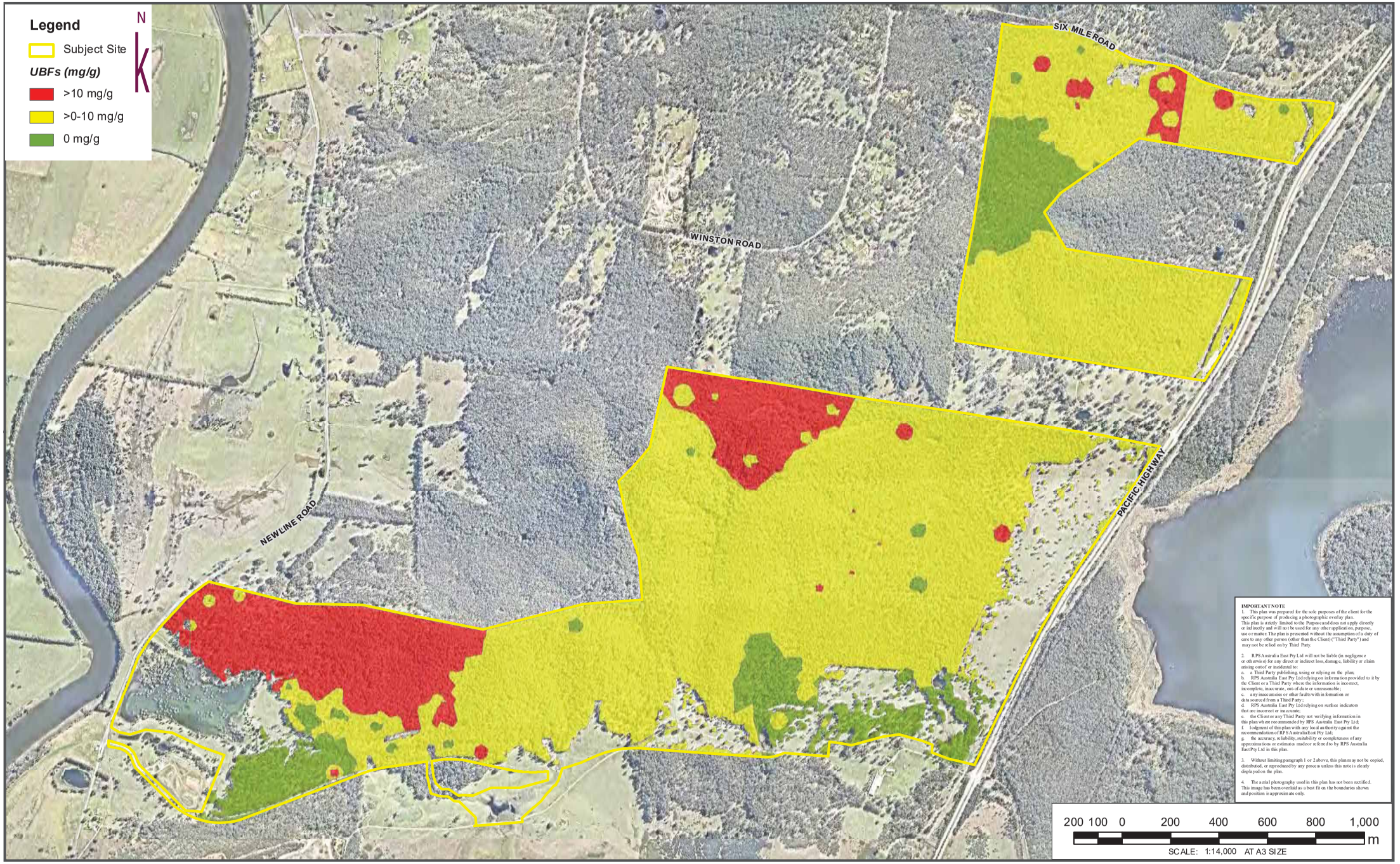

TITLE : FIGURE 4.72: PREDICTED EXTENT OF UBFS ACROSS THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **11/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.73 Predicted extent of UBFs across SS B A3 20191125.mxd

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As per BioLink (2019a) recommendation, a stadia metric survey was performed across the Proposal impact footprint to map the location of every tree that satisfies the definition for a PKFT. For this site, BioLink (2019a,b) define a PKFT as one of the following tree species with >300mm DBH:

- Forest Redgum;
- Tallowwood;
- Grey Box;
- Grey Gum; or
- Small-fruited Grey Gum.

The PKFTs recorded and mapped within the Proposal impact footprint, which totals 4,617 trees, is shown in **Figure 4.73**. Also shown are areas of natural vegetation located within the Proposal impact footprint where PKFTs are absent. A review of these mapped areas by expert Koala ecologist (BioLink 2019b; **Appendix G**) identified ~68 ha of native vegetation that does not constitute habitat for the Koala.

4.4.24.5 Additional Key Habitat Factors

Koala habitat selection is not exclusively restricted to browse preferences as Koalas are a species limited by low energy budgets from a low nutrient diet of Eucalypt foliage (Krockenberger 2003). For this reason, and where possible, Koalas preferentially select habitat that simultaneously satisfies all key habitat factors within the smallest possible area (e.g. minimise energy cost) provided the threat of predation risk is acceptable. Therefore, a more accurate habitat model that accounts for key factors additional to browse preference would include the consideration of:

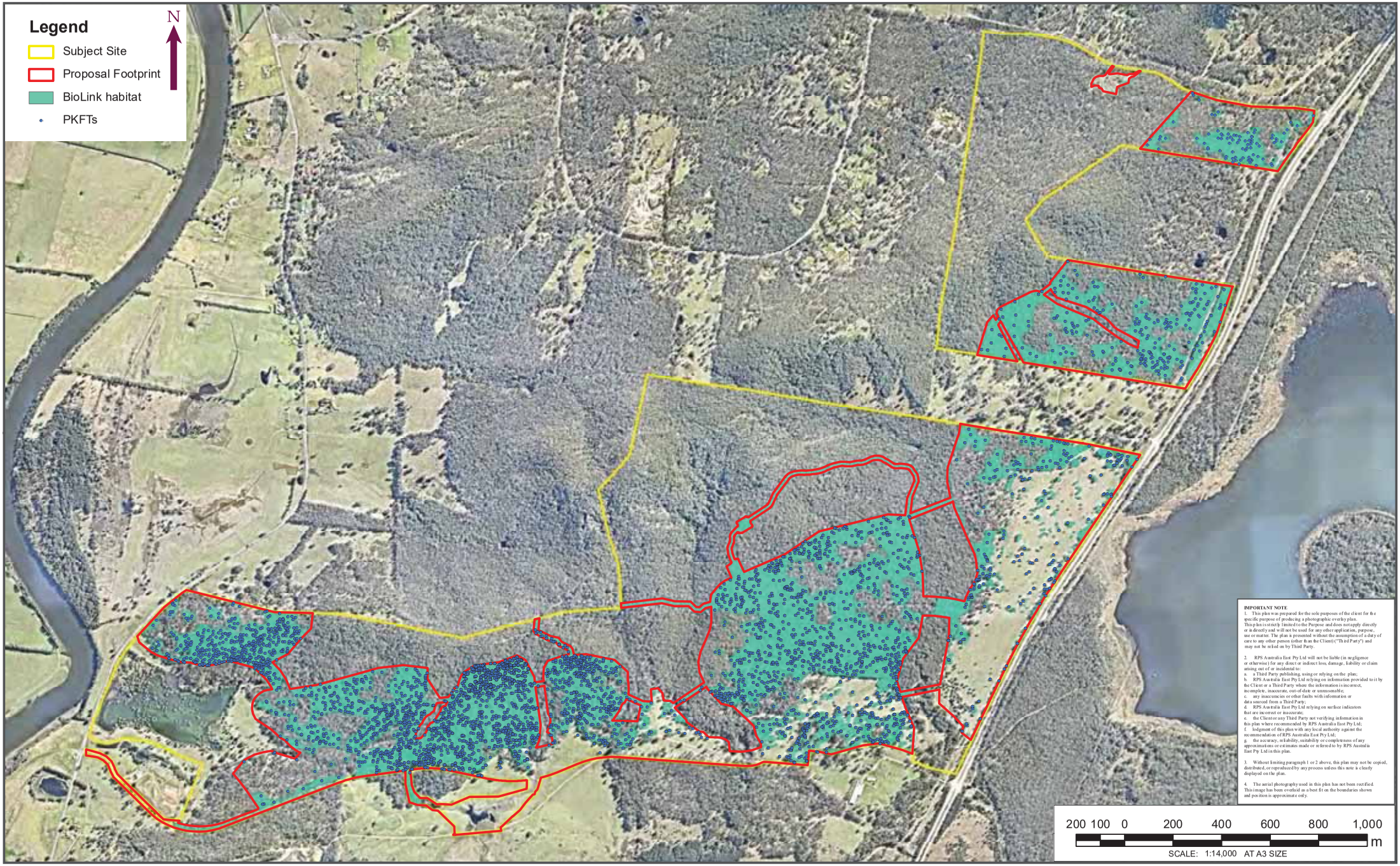
- Seasonal thermoregulation and water budget requirements (Briscoe et al 2014; Ellis et al 2011; Ellis et al 2018); and
- Threat avoidance to minimise the propensity for predation.

Habitat accommodating key habitat needs is likely to be characterised by forests comprising a variety of PKFTs with high canopy connectedness, which provides cooler microclimates for thermoregulation and sponsors inter-tree canopy movements (Goldingay and Taylor 2016) to minimise the threat of predation. These areas of habitat are also likely to comprise larger trees, which also provide additional shelter from predators and shade from the summer heat (Moore and Foley 2005; Matthews et al. 2007).

A regional Koala habitat model prepared at a 250 m scale applicable to the study area (Law et al 2016) has considered the main key habitat needs of the Koala and is shown in **Figure 4.74**. An improved study area scale interpretation of this model has been gained by overlaying higher resolution supplementary information that identifies areas of high foliage projected cover; an environmental factor integral to the regional model (Law et al 2016). This supplementary information, produced from recent Sentinel-2 satellite imagery (bands 4 and 8) at a spatial resolution of 10 m, was generated by:

- Numerical calculations of vegetation cover density using an Enhanced Vegetation Index 2 (EVI2) (Jiang et al 2008); and
- Mean EVI2 values coincident with recorded Koala activity within the study area to describe the range of EVI2 values that the Koala is known to occupy [i.e. mean EVI2 = 1.47 ± 0.11 (n=47)].

This polygon, as shown in **Figure 4.74**, encapsulates most Koala locations recorded within the study area and shows strong spatial correlation with the regional Koala model (Law et al 2017); thus providing a reliable improvement in interpreting regional scale habitat modelling. Importantly, the polygon generally confirms the value of mid to upper slope and ridge geomorphological features identified by Law et al (2017), another factor positively correlated with Koala habitat occupancy. The combined consideration of foliage projected cover, browse preferences and eucalypt nutritional value outlined in the preceding sections, provides greater insight into likely habitat occupancy within the study area.



TITLE : FIGURE 4.73: MAPPED INCIDENCE OF PKFTS AND BIOLINK HABITAT AREA WITHIN THE PROPOSAL IMPACT FOOTPRINT

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.73 PKFTs within SSD A3 20200720.mxd

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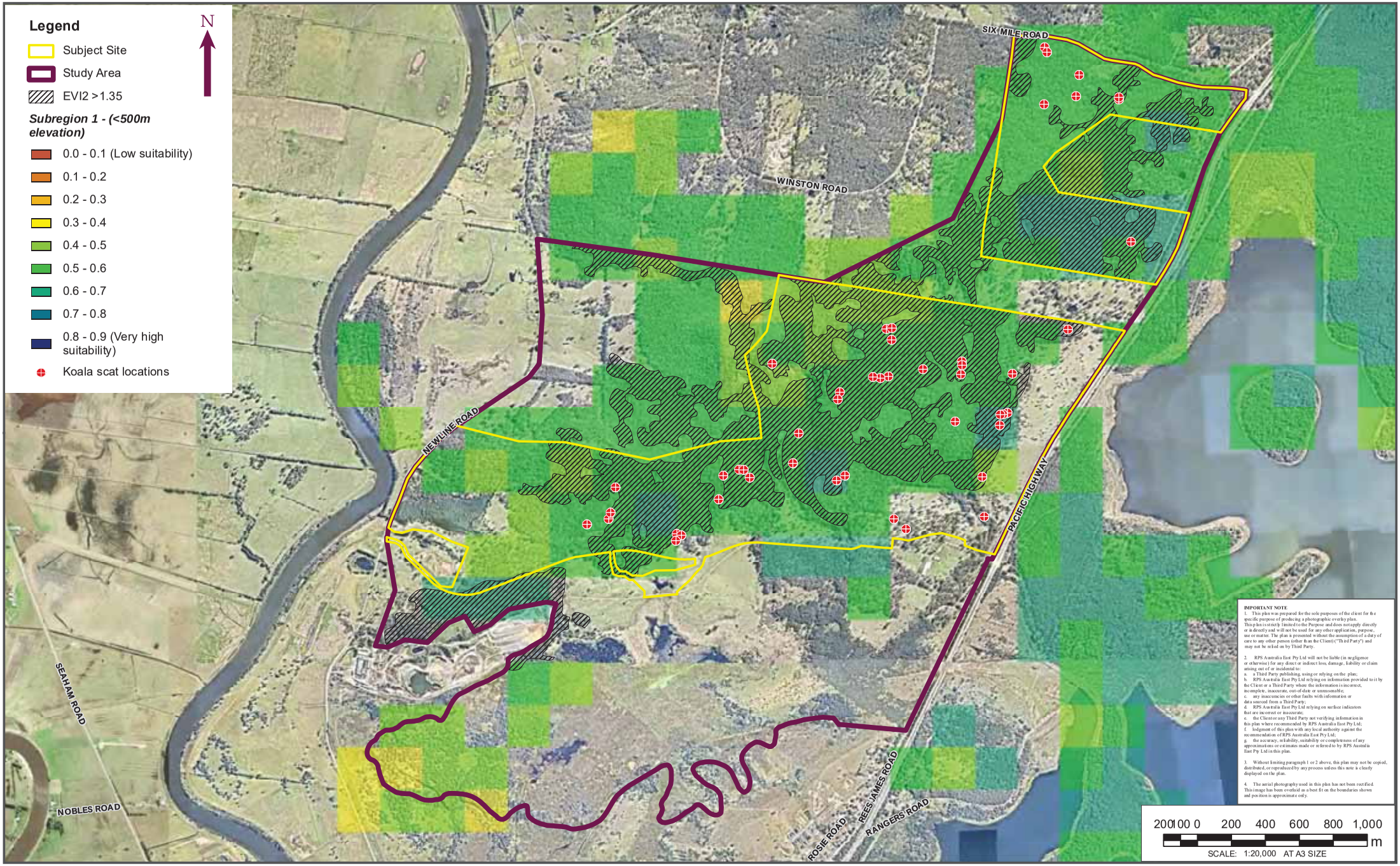

TITLE : FIGURE 4.74: REGIONAL KOALA HABITAT MODEL (LAW ET AL 2016), HIGH FPC (EVI2 >1.36) AND KOALA RECORDS WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.74 Regional Koala Habitat Model_High FPC and Koala records within SA C A3 20200720.mxd

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4.4.24.6 Koala Individuals and Relative Koala Activity Levels

OWAD (2019a) reported the occurrence of at least 10 individual Koalas within the study area, including four females and six males, from 12 genetic samples submitted for genetic profiling. Two pairs of closely related individuals were identified and are likely to represent parent-offspring pairs. The distribution of these individual Koalas, including gender, is shown in **Figure 4.75**.

The location of female Koalas closely coincides with numerous high value PKFTs and Tallowwood; a regionally important species (OEH 2018). There is also close proximity to forested areas with high canopy foliage projected cover, which would provide high value shelter for thermoregulation and predator protection. These occurrences also generally coincide with relatively high Koala activity and potential evidence of breeding activity [i.e. presence of pap scats; OWAD (2019)], as shown in **Figure 4.76**.

Observations of individual Koalas and relative activity indicate the importance of habitat occurring in the elevated parts of the study area, this being broadly consistent with:

- Findings presented in BioLink (2018);
- Habitat suitability factors identified by Law et al (2017);
- Coincidence with high value PKFTs (i.e. Forest Redgum, Grey Gum and Small-fruited Grey Gum) and the regionally important Tallowwood; and
- Low PSM levels.

From this it is reasonable to assume the home range of individual Koala should primarily overlap with these areas of high value habitat within this part of the study area.

4.4.24.7 Regional Koala Genetics

A second sampling program was therefore undertaken in the broader landscape within Port Stephens LGA to provide greater insight into the relative significance of the individuals sampled within the Kings Hill site and, if possible, obtain a preliminary understanding of contemporary Koala population structure in the area (OWAD 2019b; **Appendix H**).

The sampling program was conducted in July 2019 at seven sites including Mambo Wetlands, Wanda Wetlands, Stoney Ridge Reserve, Karuah BioBank, Grahamstown Dam West (north), Grahamstown Dam West (centre) and Boomerang Park as shown in **Figure 4.77**. Koala scat samples containing genetic material were obtained from these lands in order to further investigate Koala genetic indicators, so as to assess the relevance of the Kings Hill site for the Koala in the region. Supplementary genetic material was obtained from individuals in care with Port Stephens Koalas; some of these individuals were rescued (or last rescued) by carers outside of the July 2019 subject lands (e.g. Clarence Town and Anna Bay).

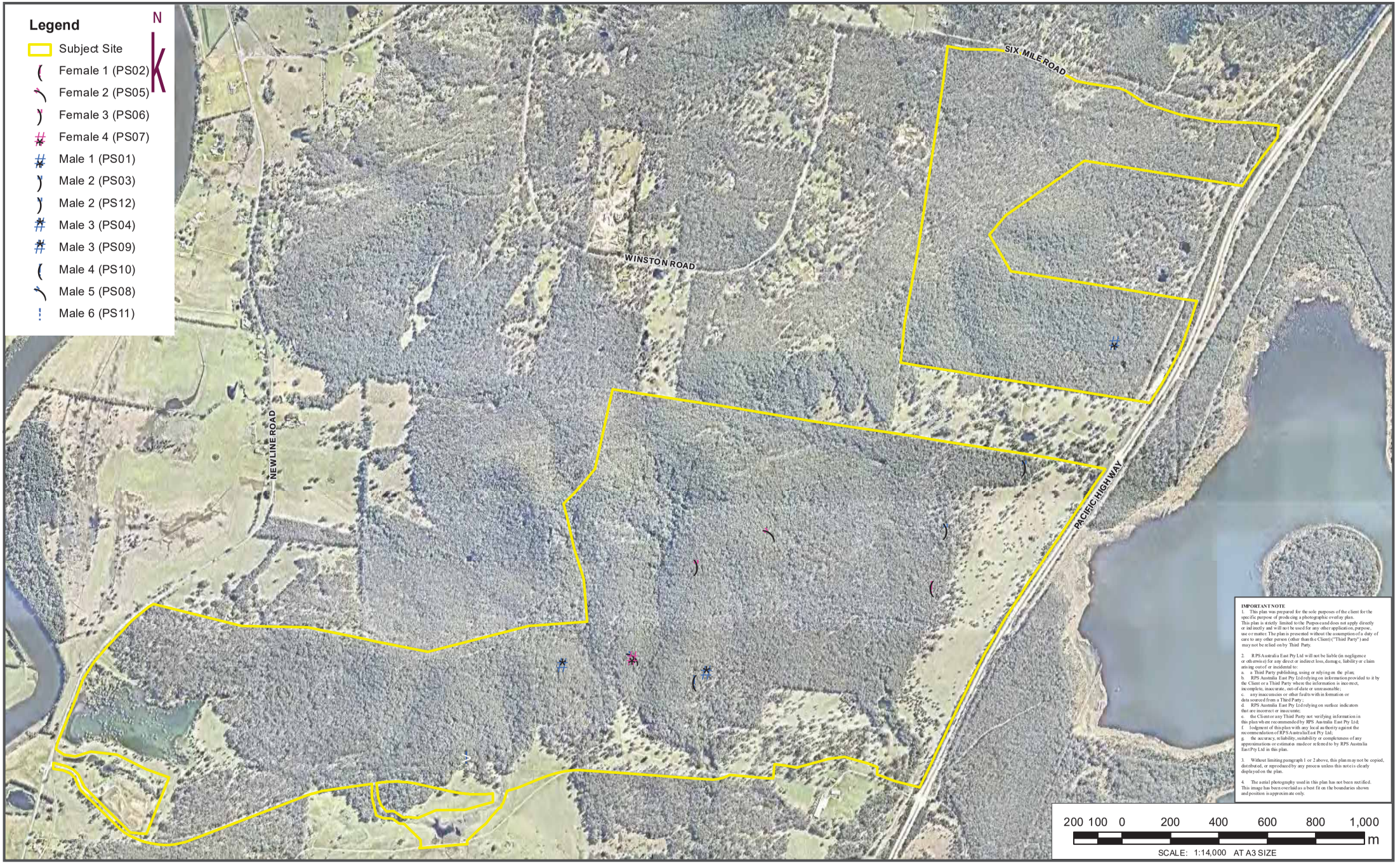
A total of 33 unique individuals have now been sampled and successfully profiled from Port Stephens LGA from the 2018 and 2019 surveys, being 17 females and 16 males. 30% of individuals (10/33) tested positive for *Chlamydia pecorum*, while 100% (33/33) tested positive for Koala retrovirus KoRV-A.

Overall, the findings of this study suggest that:

- Two genetic clusters representative of two separate Koala populations referred to as:
  - Port Stephens 1 - Tomaree Peninsula (PS1)
  - Port Stephens 2 – Western Port Stephens (including Kings Hill) (PS2).

  The genetics of PS2 currently show connection to other populations in the greater landscape, including a known population 200km north (Port Macquarie) and at Barrington Tops. Koala samples obtained from Booral and Clarence Town form part of the PS2 genetic cluster and are inferred to form part of that population.

- PS2 has high genetic diversity with relatively greater diversity found at Kings Hill site when compared to Grahamstown Dam West and Karuah. Management should aim to maintain and restore gene flow where possible so as to avoid further possible genetic differentiation within Port Stephens LGA;



TITLE : FIGURE 4.75: RESULTS OF KOALA DNA PROFILES WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **11/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.76 Location of Koala DNA profiles within the SS BA3 20191125.mxd

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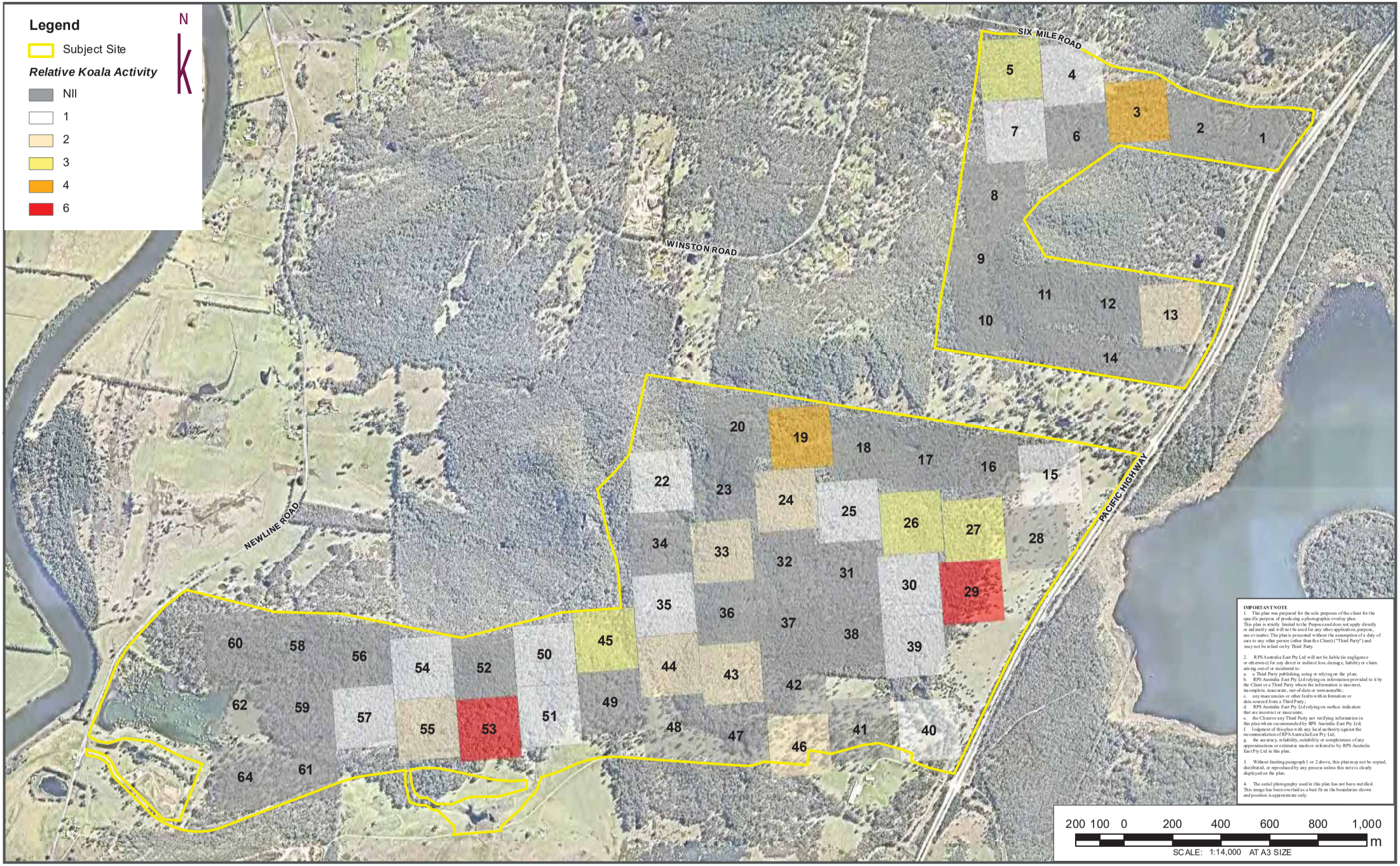

TITLE : FIGURE 4.76: RELATIVE KOALA ACTIVITY WITHIN THE SUBJECT SITE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **11/12/2019**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.77 Relative Koala Activity within the SS B A3 20191125.mxd

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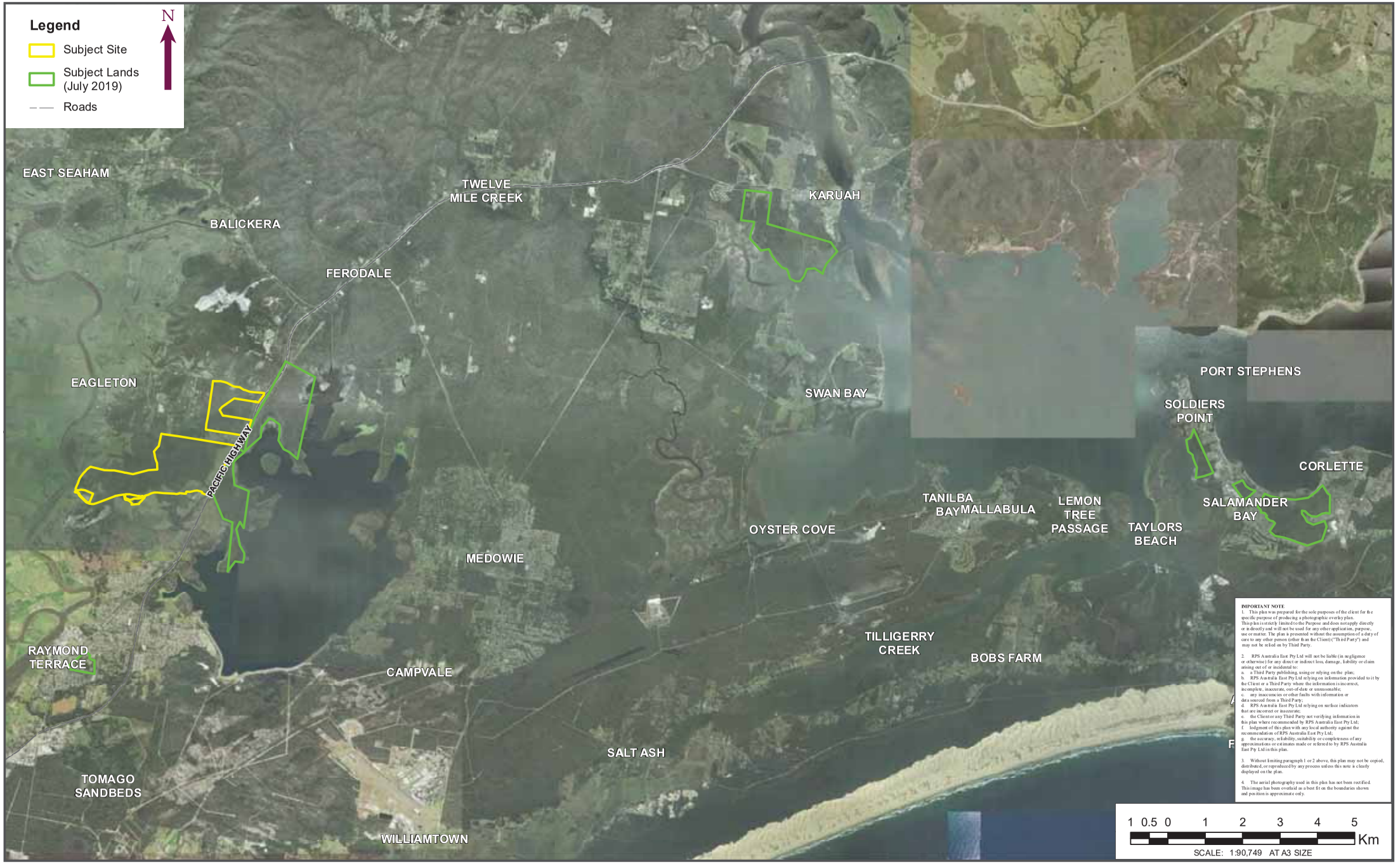

TITLE : FIGURE 4.77: SAMPLE SITED FOR REGIONAL KOALA GENETICS STUDY

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **21/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.77 Sample Sites for Regional Koala Genetics B A3 20200721.mxd

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- Population cluster PS1 (Tomaree Peninsula) is isolated and has lower genetic diversity than PS2. In the absence of intensive and targeted management measures, this population may be at risk of being lost; and
- Koalas on the Kings Hill site showed the least concerning indicators of all lands assessed whether in terms of genetic indicators or in terms of Koala activity levels detected. Management should aim to minimise and mitigate impacts to Koalas on this land.

Further details on genetic assessment methods and results referred to in this report are currently being prepared for publication in a peer-reviewed journal.

4.4.24.8 Carrying Capacity

Previous work by ANU found a strong relationship between foliage quality (particularly the concentrations of digestible nitrogen and FPCs) and the density of koalas in populations for which there is reliable, long-term density data (see **Appendix I**). The proportion of Symphyomyrtus to Monocalyptus species at sites was also related to koala density. **Figure 4.78** shows that, if they were considered to be independent, different transects at the Kings Hill site could be predicted to support different densities of koalas; from around 0.4 to 1.5 koalas per hectare.

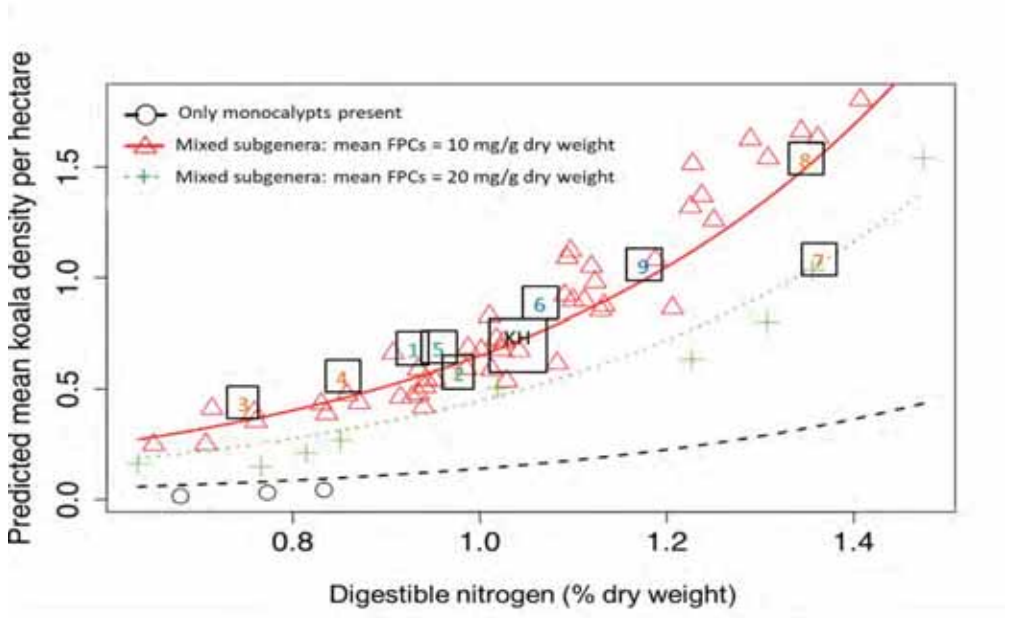
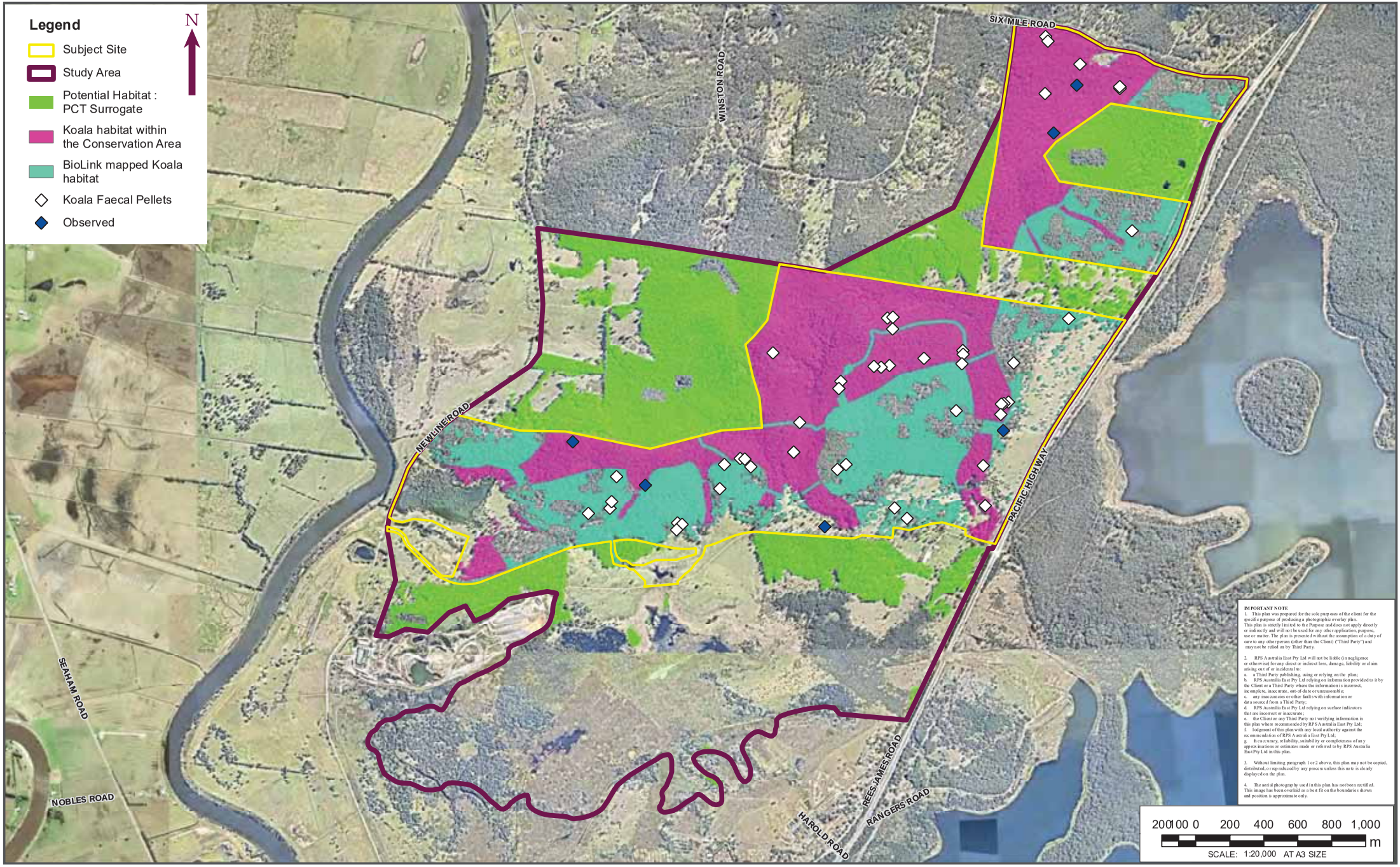


Figure 4.78 Predicted mean Koala density per hectare versus digestible nitrogen (%)

It is unlikely, however, that transects at Kings Hill are independent, because koala home-ranges can be easily larger than the area represented by each 250 m transect as was shown by the DNA profiling of koala scats collected at Kings Hill (OWAD 2019). If the mean of all trees collected at Kings Hill is used to infer the quality of the site as a whole, **Figure 4.78** suggests that, on average, the Kings Hill site could support Koalas in densities of up to 0.5 to 0.75 animals per hectare.

4.4.24.9 Habitat Polygon

The Koala habitat polygon shown in **Figure 4.79** represents the consideration of PKFT mapping (**Figure 4.73**) and dense canopy cover for refugia (**Figure 4.74**). The total habitat area for the Koala, as calculated by BioLink (2019b), is ~152 ha.



TITLE : FIGURE 4.79: KOALA HABITAT AND RECORDED LOCATIONS WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.79 Potential Koala Habitat and recorded locations within SA D A3 20200720.mxd

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4.4.25 Brush-tailed Phascogale

The Brush-tailed Phascogale broadly prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter; although is also known in rainforest and wet sclerophyll forest (OEH 2019b). This species preferentially uses a habitat complex comprising groundcover layer features (e.g. fallen logs) and arboreal features such as tree-bearing trees for denning and *"rough barked trees of 25 cm DBH or greater"* (OEH 2019b) for foraging.

A high value habitat, referred to here as 'arboreal surface roughness', is presumably an indicator of forage resource availability (e.g. increased abundance of prey species such as invertebrates). This habitat factor is consistent with findings presented in local studies on this species (Firebird 2013), where the species was observed in several Ironbark trees, including *Eucalyptus crebra* (Narrow-leaved Ironbark), *E. siderophloia* (Grey Ironbark) and *E. fibrosa* (Red Ironbark); a finding consistent with OEH (2019b). A den site locate to the northwest of the Conservation Area was located in a dead hollow-bearing 'stag' tree.

Data representing the distribution of 'rough-barked trees' species with a DBH of 30 cm or more was used to model habitat that is most likely to represent high value foraging habitat for this species. Tree species used to model 'arboreal surface roughness', as shown in **Figure 4.80**, are listed below:

- Grey Gum and Small-fruited Grey Gum;
- White Mahogany;
- White Stringybark;
- Blackbutt;
- Red Bloodwood; and
- All ironbark species.

The combined consideration of key habitat features [i.e. fallen logs (**Figure 4.27**), hollow-bearing trees (**Figure 4.28**) and arboreal surface roughness (**Figure 4.80**)] represents the likely extent of habitat of importance to the Brush-tailed Phascogale within the subject site (i.e. breeding and high value foraging habitat), as shown in **Figure 4.81**.

4.4.26 Spotted-tailed Quoll

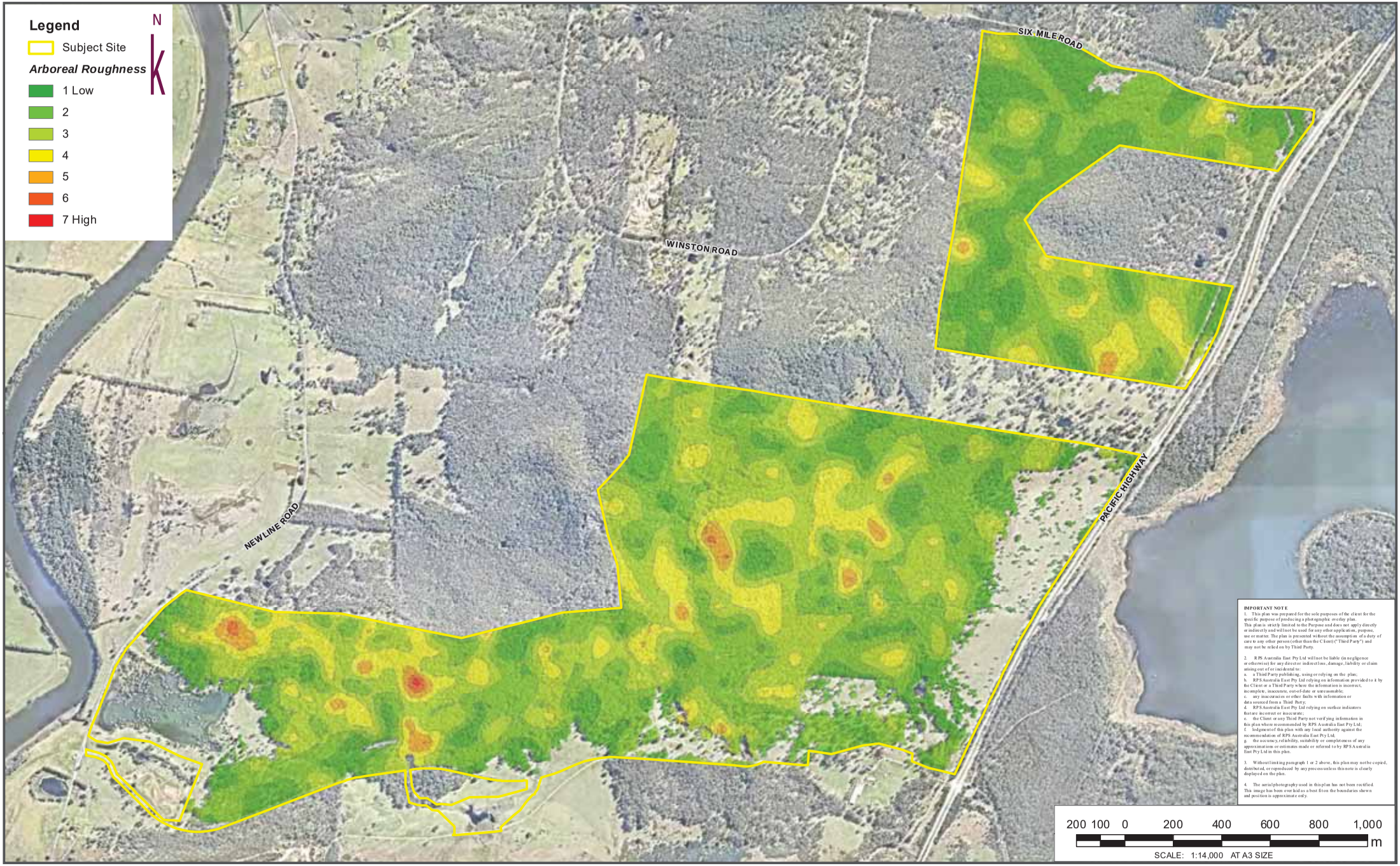
The Spotted-tailed Quoll is recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock outcrops and rocky-cliff faces as den sites.

A generalist predator with a preference for medium-sized (500g-5kg) mammals including gliders, possums, small wallabies, rats, birds, bandicoots, rabbits, reptiles and insects. Also eats carrion and takes domestic fowl. Mostly nocturnal, although will hunt during the day; spends most of the time on the ground, although also an excellent climber and will hunt possums and gliders in tree hollows and prey on roosting birds.

Use communal 'latrine sites', often on flat rocks among boulder fields, rocky cliff-faces or along rocky stream beds or banks. Such sites may be visited by multiple individuals and can be recognised by the accumulation of the sometimes characteristic 'twisty-shaped' faeces deposited by animals.

Females occupy home ranges up to about 750 hectares and males up to 3,500 hectares. Are known to traverse their home ranges along densely vegetated creek lines. Average litter size is five; both sexes mature at about one year of age. Life expectancy in the wild is about 3-4 years.

Remote camera and dog detection surveys failed to detect any occurrence of the Spotted-tailed Quoll within the subject site. The extent of potential habitat is modelled on vegetation formations, which shows a greater preference for wet sclerophyll and rainforest vegetation types over dry sclerophyll vegetation as shown in **Figure 4.82**.



TITLE : FIGURE 4.80: ARBOREAL SURFACE ROUGHNESS WITHIN SUBJECT SITE

LOCATION : KINGS HILL

DATUM: GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **10/03/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (mark.aitkens)

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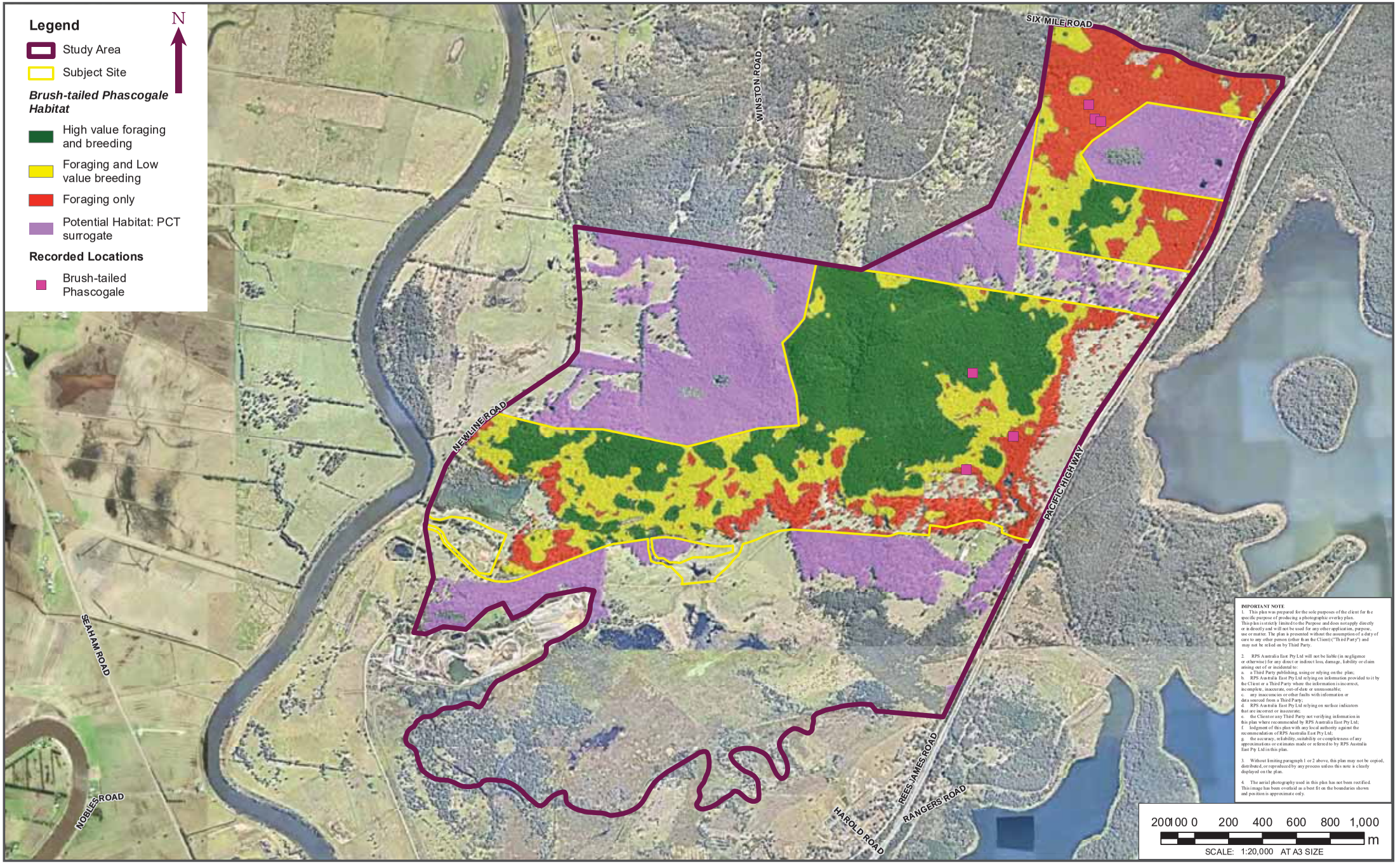

TITLE : FIGURE 4.81: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE BRUSH-TAILED PHASCOGALE WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.81 Potential habitat and recorded locations of the Brush-tailed Phascogale within the SA C A3

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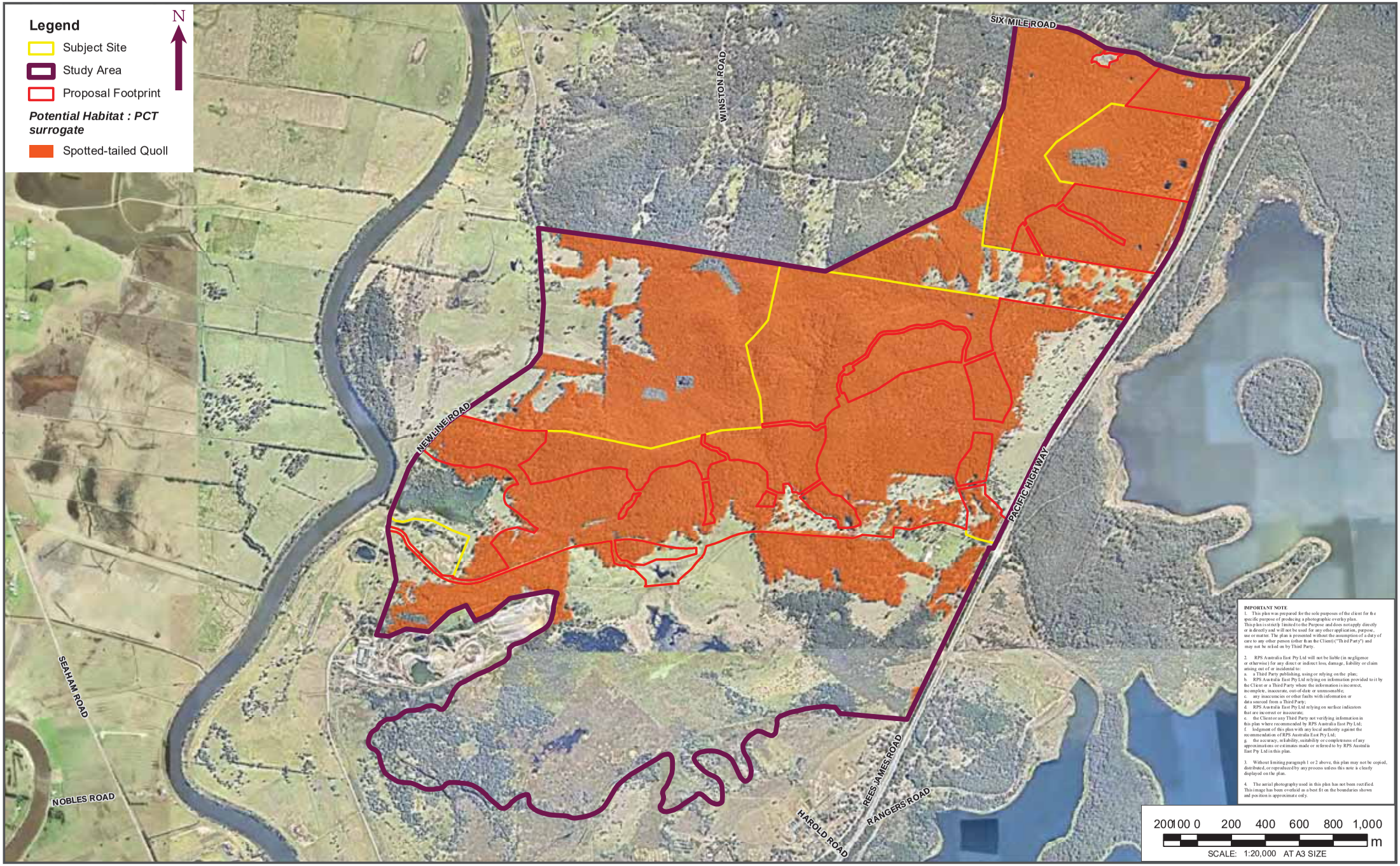

TITLE : FIGURE 4.82: POTENTIAL HABITAT OF THE SPOTTED-TAILED QUOLL WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.82 Potential habitat of the Spotted-tailed Quoll within the SA C A3 20200720.mxd

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4.4.27 Grey-headed Flying-fox

According to DoE (2017c), Grey-headed Flying-fox has historically occupied forests and woodlands in the coastal lowlands, tablelands and slopes of south-eastern Australia, from Bundaberg in Queensland to Geelong in Victoria, with rare sightings outside its range. More recently, camps have established in Adelaide, the Australian Capital Territory and inland areas of central and southern New South Wales and Victoria.

Australian flying-foxes are seasonal, synchronous and polygamous breeders (DECCW 2009a, Eby 2008 as cited by GeoLINK 2013). Mating behaviour in Grey-headed Flying-foxes commences in January with conception occurring in April / May (Nelson 1965, Martin et al. 1996). They have a low reproductive rate, with a single pup generally born from October to December (Martin and McIlwee 2002; Divljan 2008 as cited by, DoE 2017c). Individuals reach sexual maturity in the second year of life, but typically do not successfully raise young until the third year (McIlwee and Martin 2002; as cited by DoE 2017c).

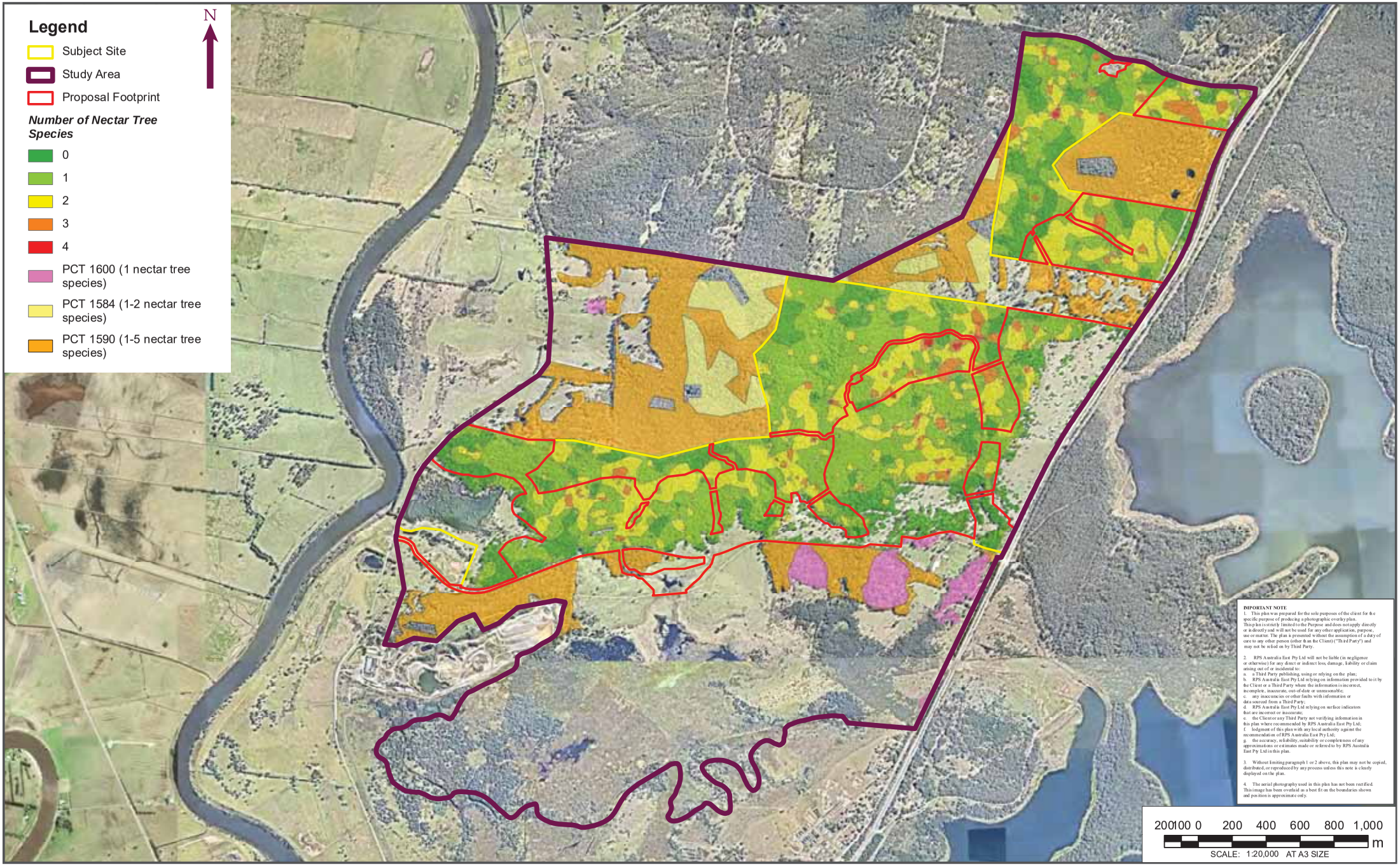
GeoLINK (2013) identified that the Lower Hunter supports 20 known camps of the GHFF, seven of which are identified as critical to the survival (CTS) of the GHFF in the Lower Hunter: Millfield, Martinsville, Morisset, Blackbutt Reserve, Anna Bay, Medowie and Tocal. Six camps were identified as not CTS of the GHFF these being: Black Hill, Belmont, Glenrock, Hannan Street, Italia Road and Raymond Terrace. However, in a review of the Raymond Terrace camp, PSC (2017) identified this camp to qualify as CTS.

The flowering phenology described by Eby and Law (2008), as adjusted for the Lower Hunter region (GeoLINK 2013), for important feed tree species present on site are listed in **Table 4.11** according to their bi-monthly flowering phenology. Scores for duration represent the length in months of individual flowering events. The winter and spring food bottleneck, which is shaded in **Table 4.11**, is a sensitive period for the Grey-headed Flying Fox as this period coincides with gestation and immediately precedes birth and lactation.

Table 4.11 Flowering Phenology for Grey-headed Flying Fox Important Nectar Species

Species	D-J	F-M	A-M	J-J	A-S	O-N	Duration
Corymbia gummifera			x				1
Corymbia maculata			x	x	x		≤3
Eucalytpus acmenoides	x					x	1
Eucalytpus fibrosa	x					x	2
Eucalytpus molucanna		x					2
Eucalyptus pilularis	x	x					2
Eucalytpus propinqua	x	x					2
Eucalyptus punctata	x	x					1
Eucalyptus robusta			x	x			≥3
Eucalyptus siderophloia	x					x	2
Eucalyptus tereticornis					x	x	2

The distribution of nectar feed tree species according to bimonthly phenology outlined in **Table 4.11** was modelled for the subject site using the modelled tree species distributions provided in **Section 4.3.2.3.4** and is shown in **Figures 4.83** to **4.88** for each period. Regional vegetation mapping for the study area (NPWS 2003) has been used to supplement this analysis (i.e. no tree mapping data for modelling purposes is available for this broader area), with the predicted number of nectar tree species present generalised to PCT level.



TITLE : FIGURE 4.83: MODELLED GREY-HEADED FLYING FOX NECTAR SOURCES: DECEMBER TO JANUARY

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.83 Grey-headed Flying Fox Nectar Sources Dec_Jan C A3 20200720.mxd

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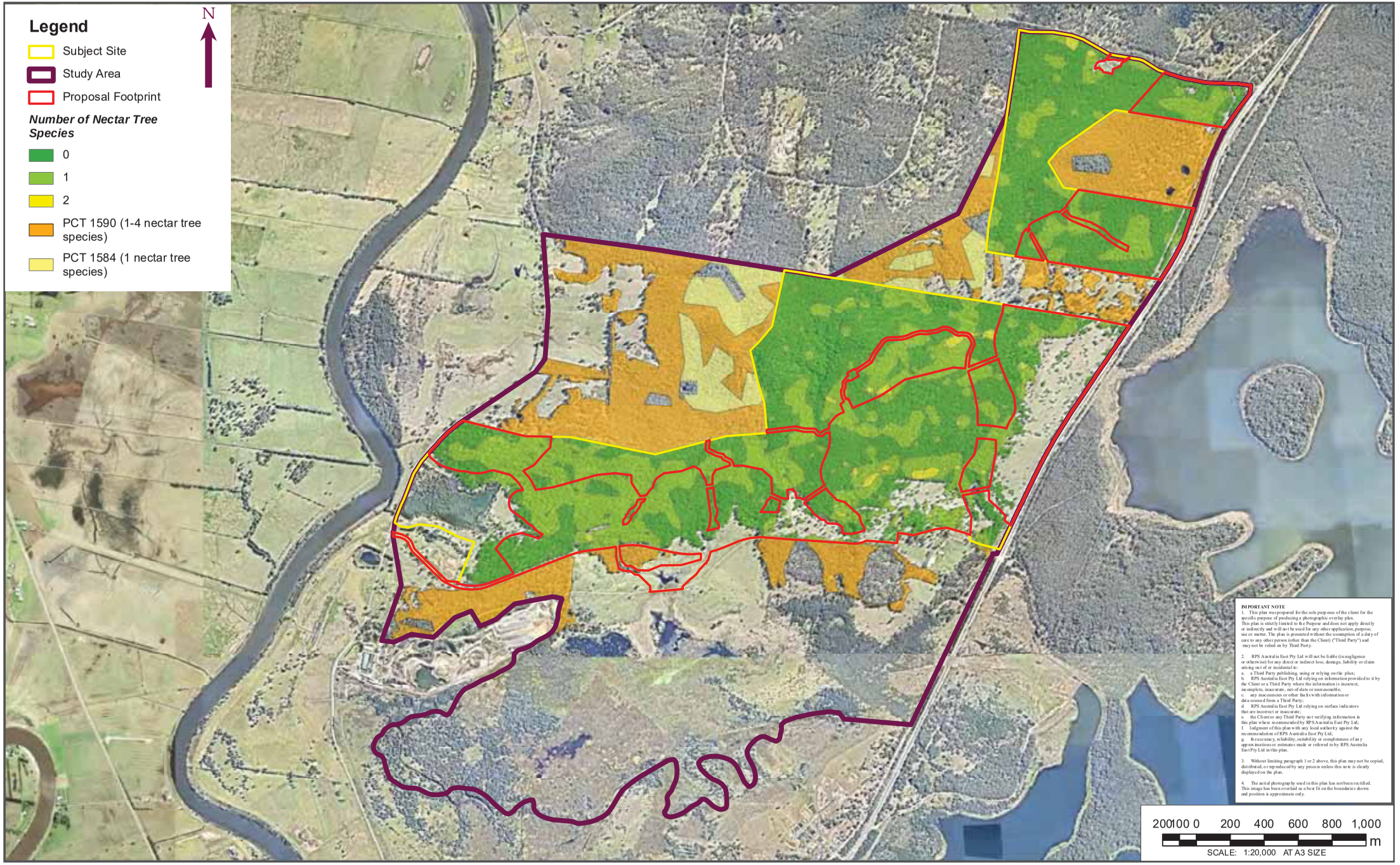

TITLE : FIGURE 4.84: MODELLED GREY-HEADED FLYING FOX NECTAR SOURCES: FEBRUARY TO MARCH

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

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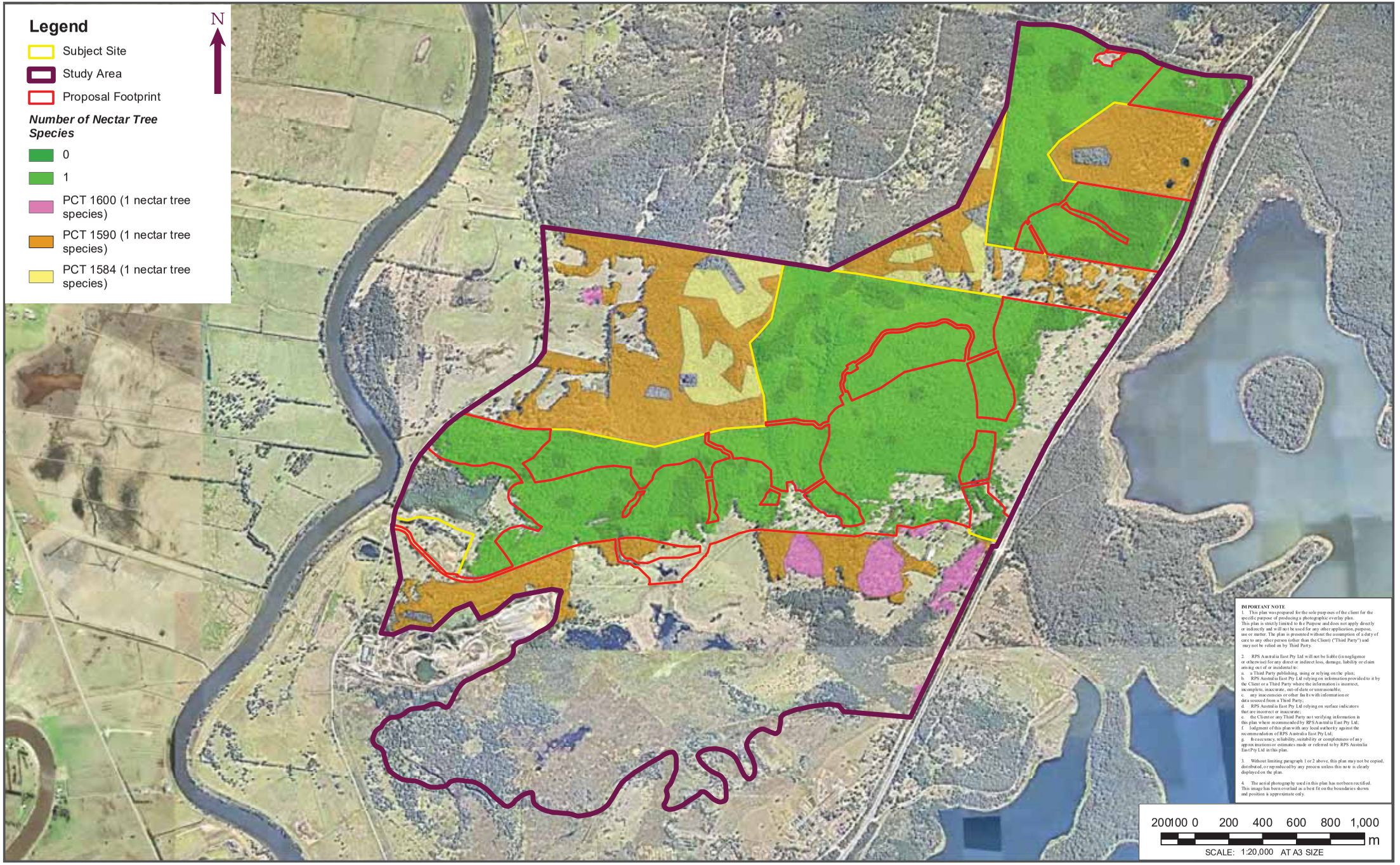

TITLE : FIGURE 4.85: MODELLED GREY-HEADED FLYING FOX NECTAR SOURCES: APRIL TO MAY

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.85 Bi-monthly Phenology of Grey-headed Flying Fox preferred diet species within the SA April

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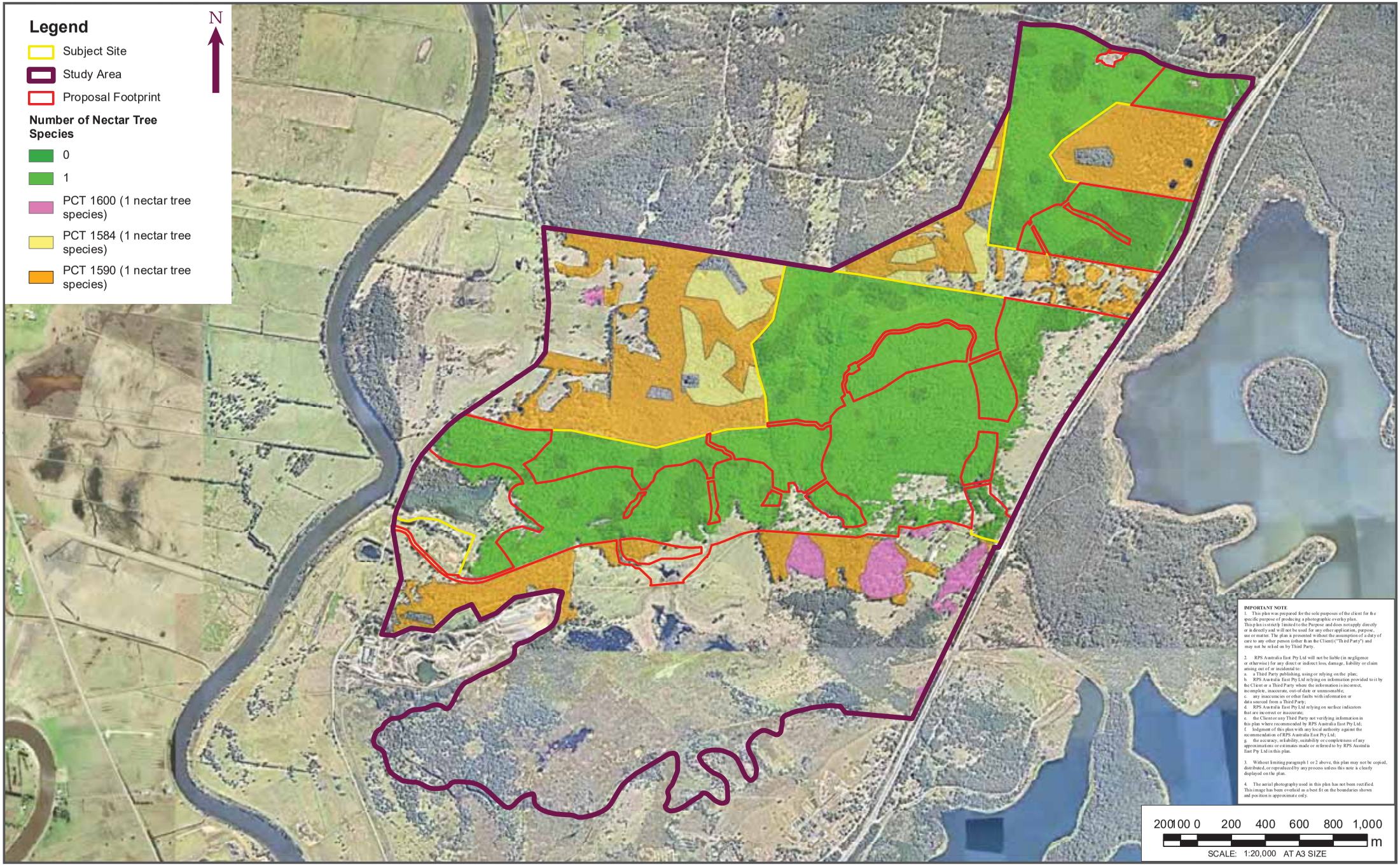

TITLE : FIGURE 4.86: MODELLED GREY-HEADED FLYING FOX NECTAR SOURCES: JUNE TO JULY

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20191030 SIS REVISED FINAL\130430 Figure 4.86 Bi-monthly Phenology of Grey-headed Flying Fox preferred diet species within the

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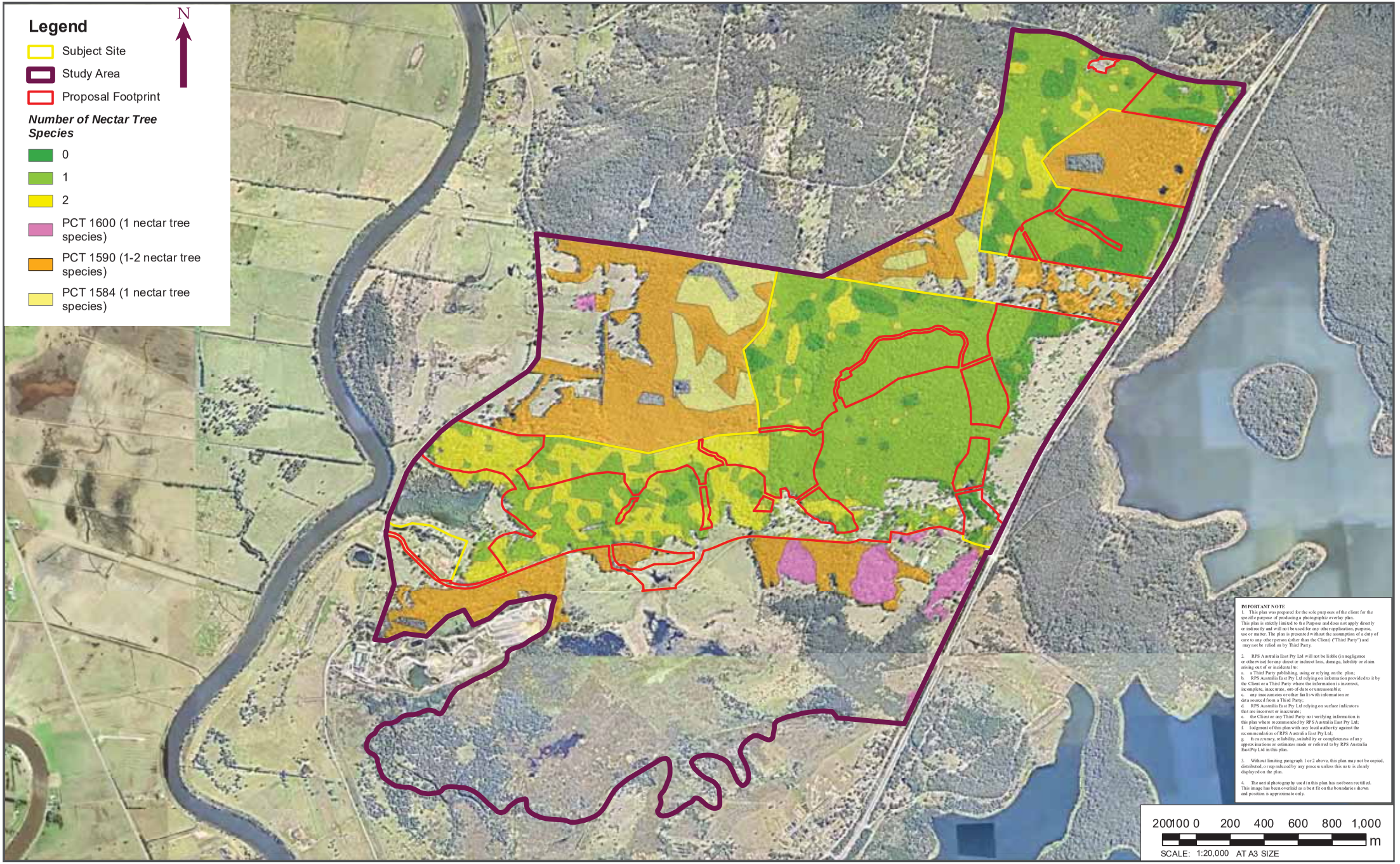

TITLE : FIGURE 4.87: MODELLED GREY-HEADED FLYING FOX NECTAR SOURCES: AUGUST TO SEPTEMBER

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

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PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report3. SIS\20200719 SIS Final Version\130430 Figure 4.87 Grey-headed Flying Fox Nectar Sources Aug_Sep B A3 20200720.mxd

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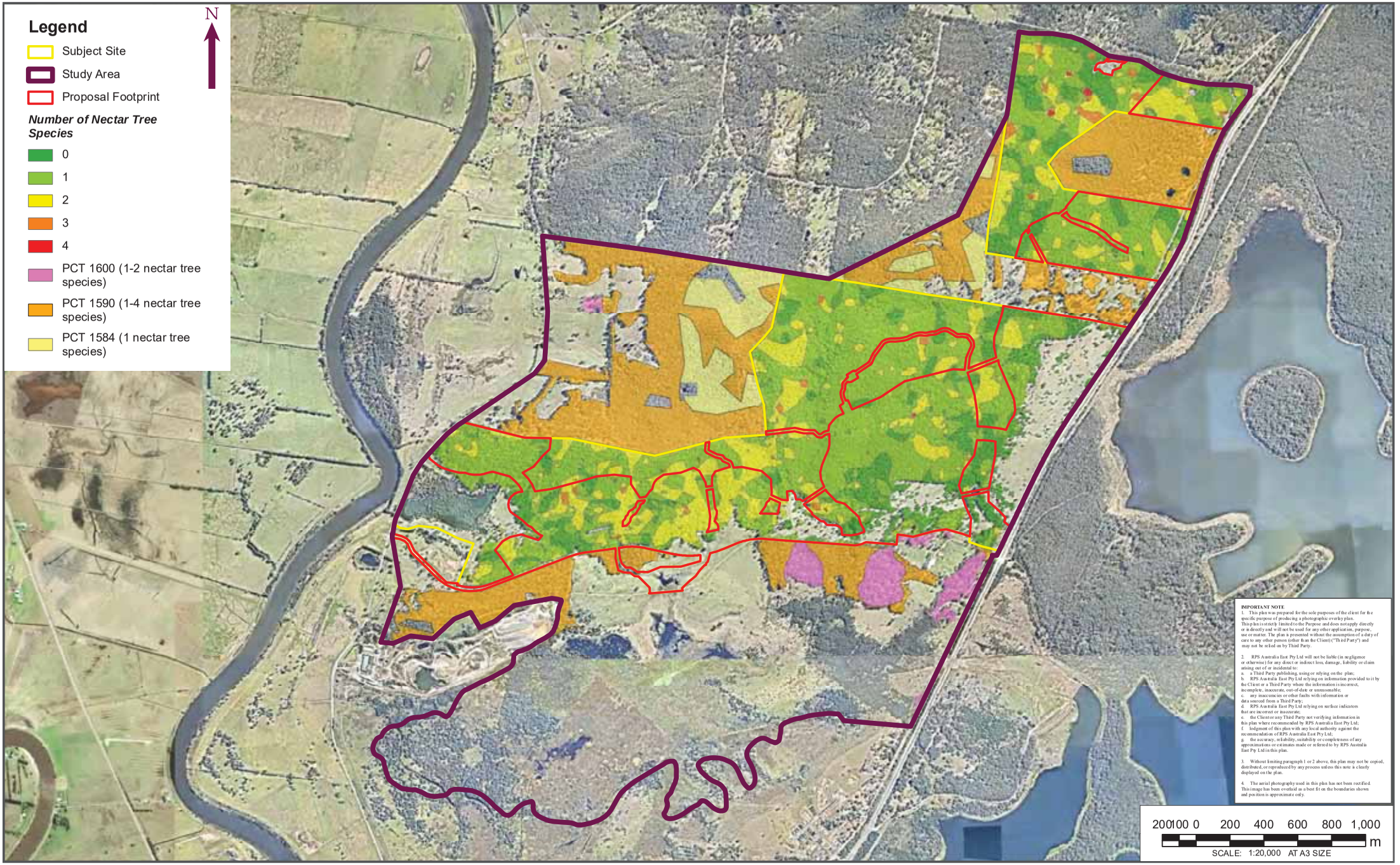

TITLE : FIGURE 4.88: MODELLED GREY-HEADED FLYING FOX NECTAR SOURCES: OCTOBER TO NOVEMBER

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.88 Grey-headed Flying Fox Nectar Sources Oct_Nov B A3 20200720.mxd

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4.4.28 Microchiropteran bats

1. Cave dependent species

The Eastern Bentwing-bat and Little Bentwing-bat are cave roosting microbat species. Whilst caves are the primary roosting habitat of this species, it also uses derelict mines, storm-water tunnels, buildings and other man-made structures (OEH 2019b). The Little Bentwing-bat can also roost in tree hollows, tunnels, abandoned mines, stormwater drains, culverts, bridges and buildings (OEH 2019b). The Little Bentwing-bat can be found in moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub and forage at night for small insects beneath the canopy of densely vegetated habitat (OEH 2019b).

Both microbat species have been recorded within the locality, seven being the Eastern Bentwing-bat and 69 Little Bentwing-bat records. One Eastern Bentwing-bat record is located adjacent to the study area and two Little Bentwing-bat records fall within the study area. Suitable habitat for both species exists within the study area where sandstone rock outcropping and boulders occur, mostly on the ridgetops and upper slopes. These provide potential roost sites for these species. The study area comprises a range of vegetation types including moist eucalypt forest and dry sclerophyll forest, providing suitable foraging habitat for both species. Both bat species were positively identified within the study area. Potential habitat and recorded locations of the Eastern Bentwing-bat and Little Bentwing-bat are shown in **Figure 4.89**.

2. Hollow dependent species

The Eastern Freetail-bat, Eastern False Pipistrelle, Yellow-bellied Sheath-tail Bat and Greater Broad-nosed Bat are species of microbats that primarily roost in tree hollows. The former also roosts under bark or in man-made structures (OEH 2019b) and the latter also has been found in buildings (OEH 2019b).

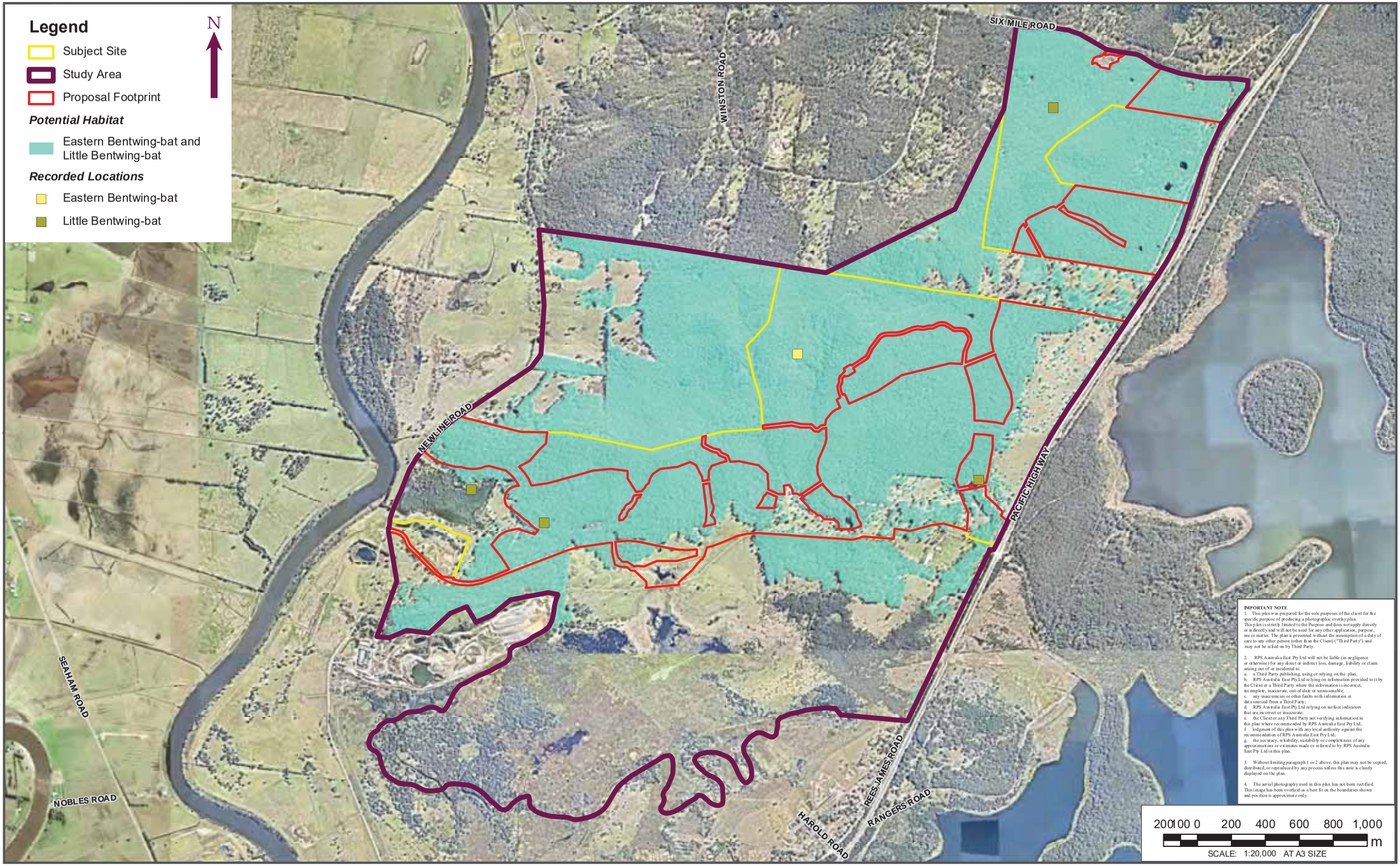
The Eastern Freetail-bat, Eastern False Pipistrelle and Greater Broad-nosed Bat occur in a range of habitats including dry sclerophyll forest, moist eucalypt forest, rainforest, woodland and swamp woodland; however, are most commonly found in tall wet forest (OEH 2019b). The Yellow-bellied Sheath-tail Bat is less commonly found in coastal districts and is mostly associated with drier vegetation types. These species forage at night searching for insects, predominantly along creek and river corridors (OEH 2019b).

The Eastern Freetail-bat, Eastern False Pipistrelle and Greater Broad-nosed Bat are known to occur in the locality and have been recorded within the study area. Potential habitat for these species includes both roosting and foraging habitat and are shown in **Figure 4.90**, along with the recorded locations. The preferred habitat area for the Yellow-bellied Sheath-tail Bat aligns with drier conditions and is shown in **Figure 4.91**.

3. Southern Myotis

The Southern Myotis generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. The species forage over streams and pools catching insects and small fish by raking their feet across the water surface. In NSW females have one young each year usually in November or December.

Potential habitat for the Southern Myotis include both roosting and foraging habitat and is shown in **Figure 4.92**. This mapped area reflects potential foraging habitat (i.e. dams, pools and wetlands) and adjacent areas where hollow-bearing trees broadly occur.



TITLE : FIGURE 4.89: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE EASTERN BENTWING-BAT AND LITTLE BENTWING-BAT WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.89 Potential habitat and recorded locations of the Eastern Bentwing-bat and Little Bentwing-bat

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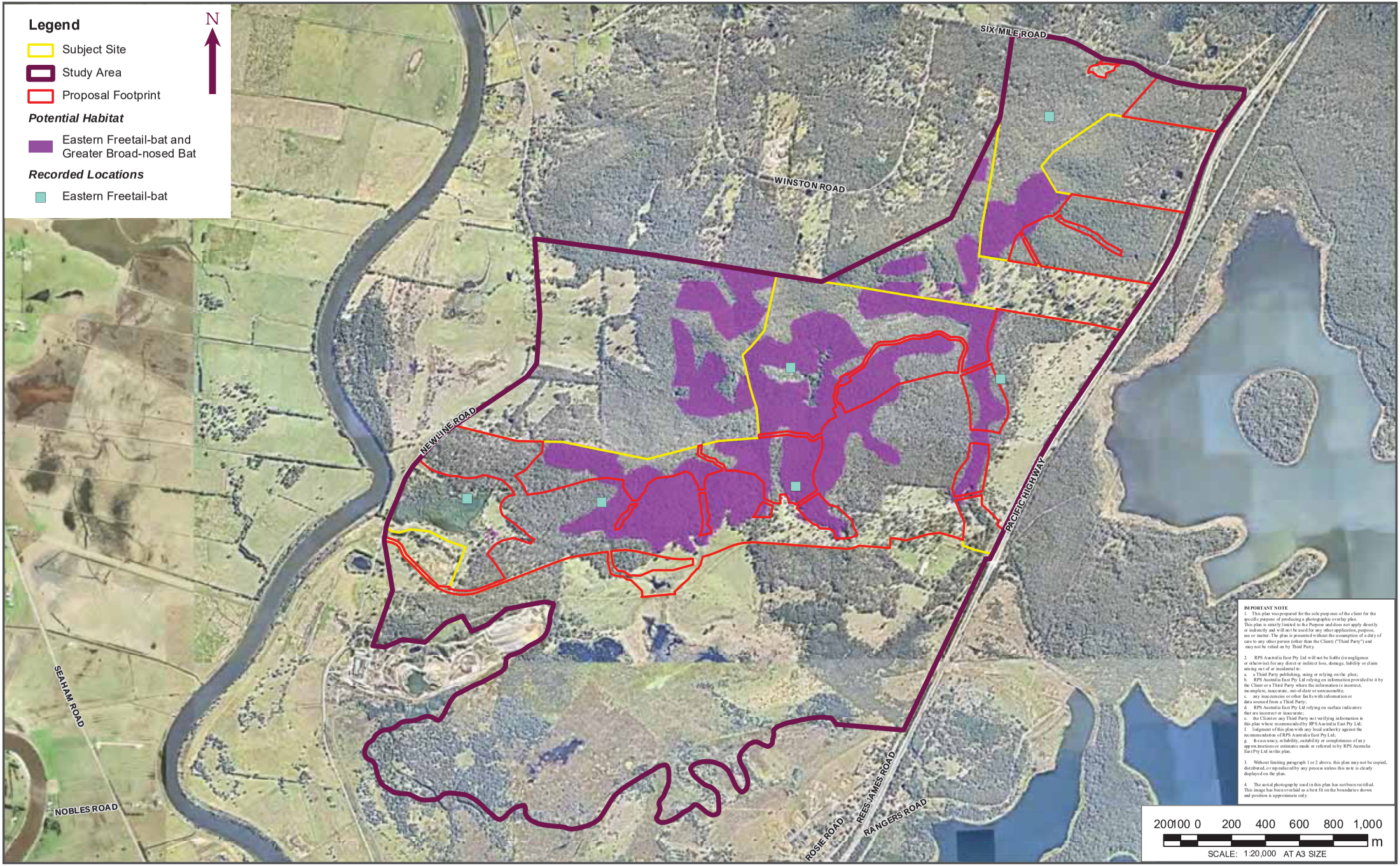

TITLE : FIGURE 4.90: POTENTIAL HABITAT AND RECORDED LOCATIONS OF THE EASTERN FREETAIL-BAT, EASTERN FALSE PIPISTRELLE AND GREATER BROAD-NOSED BAT SPECIES WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.90 Potential habitat and recorded Eastern Freetail-bat_Pipistrelle_Greater Broad-nosed Bat

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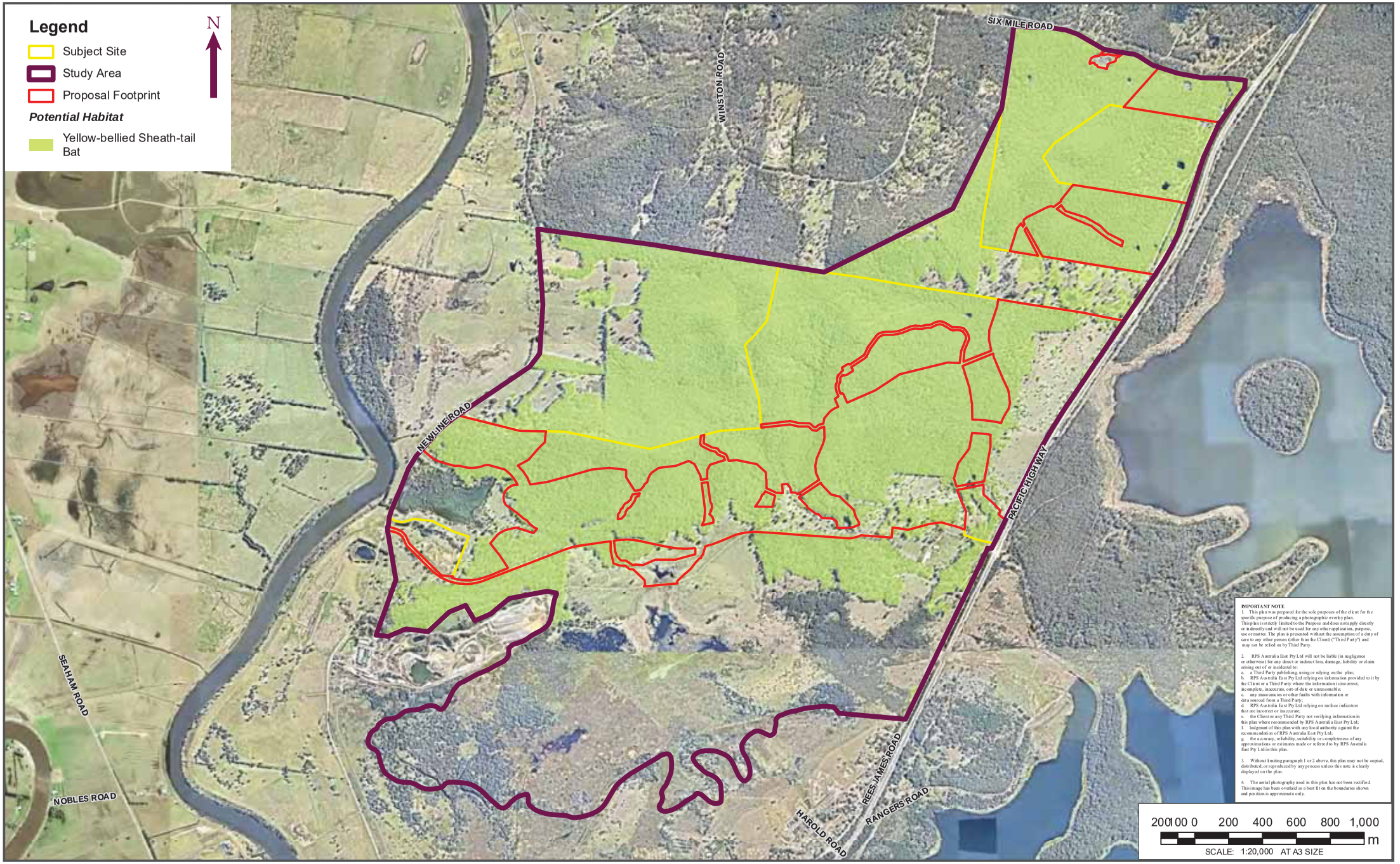

TITLE : FIGURE 4.91 POTENTIAL HABITAT OF THE YELLOW-BELLIED SHEATH-TAIL BAT SPECIES WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

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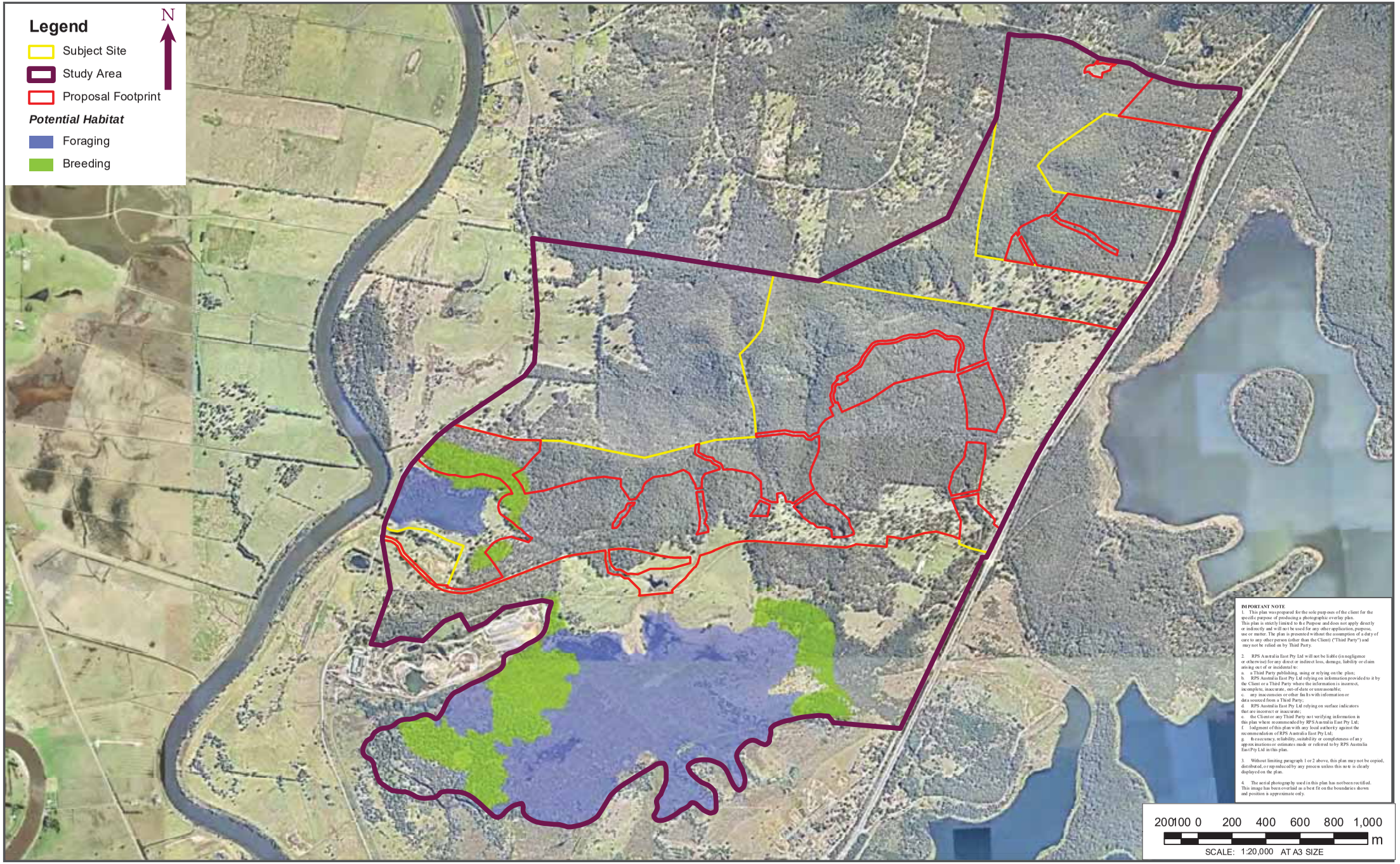

TITLE : FIGURE 4.92: POTENTIAL HABITAT OF THE SOUTHERN MYOTIS WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.92 Potential habitat of the Southern Myotis within the SA CA3 20200720.mxd

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4.4.29 Green and Golden Bell Frog

The Green and Golden Bell Frog occurs mainly along coastal lowland areas of eastern NSW and Victoria, with its distribution restricted to isolated remnant populations of varying sizes (DEC 2005). Within the NSW, Hunter region the species is now believed restricted to four key populations including:

1. Sandgate on the margins of Hexham Swamp;
2. Kooragang Island in the delta of the Hunter River;
3. Gillieston Heights/East Maitland, Ravensdale areas and also incorporating Wentworth Swamp; and
4. Ravensworth/Liddell/Bayswater.

The habitat preference and requirements of the Green and Golden Bell Frog are not well understood and difficult to define (Mahony, 1999), in fact the species has the propensity, on occasion, of turning up in the most unlikely locations (DEC 2005). The species has been detected utilising a wide range of waterbodies and this includes both natural and man-made structures (Pyke and White, 1996).This species is most commonly recorded within coastal swamps, marshes, dune swales, lagoons, lakes and other estuary wetlands as well as riverine floodplain wetlands and billabongs (DEC 2005), however constructed water bodies such as storm water detention basins, farm dams, bunded areas, drains, ditches and other excavations capable of capturing water are also considered habitat for the Green and Golden Bell Frog (DEC 2005).

Other associated terrestrial habitat attributes that also appear to favour the species include extensive grassy areas and an abundance of shelter sites such as rocks, logs, tussock forming vegetation and other cover (Pyke and White, 1996; Mahony, 1999; Patmore, 2001; Pyke and White, 2001). There is also a clear preference shown by this species for sites with a complexity of vegetation structure (Patmore, 2001; Hamer et al., 2002). These habitat features are often but not always found peripheral to breeding habitat and are considered foraging and/or refuge habitat (DEC 2005). Green and Golden Bell Frogs have been recorded utilising shelter amongst dense tussock forming vegetation, amongst rocks, underground holes or burrows, within rotting logs or timber piles and other human refuse such as sheet iron, bricks etc (DEC 2005).

A small part of the subject site and a large expanse of the southern half of the study area provides habitat for this species as shown in **Figure 4.92.**

4.4.30 Wallum Froglet

Wallum Froglets are found along the coastal margin from Litabella National Park in south-east Queensland to Kurnell in Sydney (OEH 2019b). Wallum Froglets are found in a wide range of habitats, usually associated with acidic swamps on coastal sand plains. They typically occur in sedgelands and wet heathlands; however, can also be found along drainage lines within other vegetation communities and disturbed areas, and occasionally in swamp sclerophyll forests (OEH 2019b). The species has been recorded sheltering under leaf litter, vegetation, other debris or in burrows of other species. Shelter sites are wet or very damp and often located near the water's edge (OEH 2019b).

Wallum Froglets breed in swamps with permanent water as well as shallow ephemeral pools and drainage ditches. Breeding is thought to peak in the colder months but can occur throughout the year following rain. Eggs require water with a pH of <6 (OEH 2019b).

A small part of the subject site and a large expanse of the southern half of the study area provides habitat that may be suitable for this species as shown in **Figure 4.93**.

TITLE : FIGURE 4.93: POTENTIAL HABITAT OF THE GREEN AND GOLDEN BELL FROG WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

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TITLE : FIGURE 4.94: POTENTIAL HABITAT OF THE WALLUM FROGLET WITHIN THE STUDY AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 4.94 Potential habitat of the Wallum Froglet within the SA C A3 20200720.mxd

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5 ASSESSMENT OF LIKELY IMPACTS ON THE THREATENED SPECIES AND POPULATIONS

This chapter covers the following Chief Executive Requirements:

DGR 5 ASSESSMENT OF LIKELY IMPACTS ON THREATENED SPECIES AND POPULATIONS

5.1 Assessment of Likely Impacts

5.1.1 Direct Impacts of the Proposal

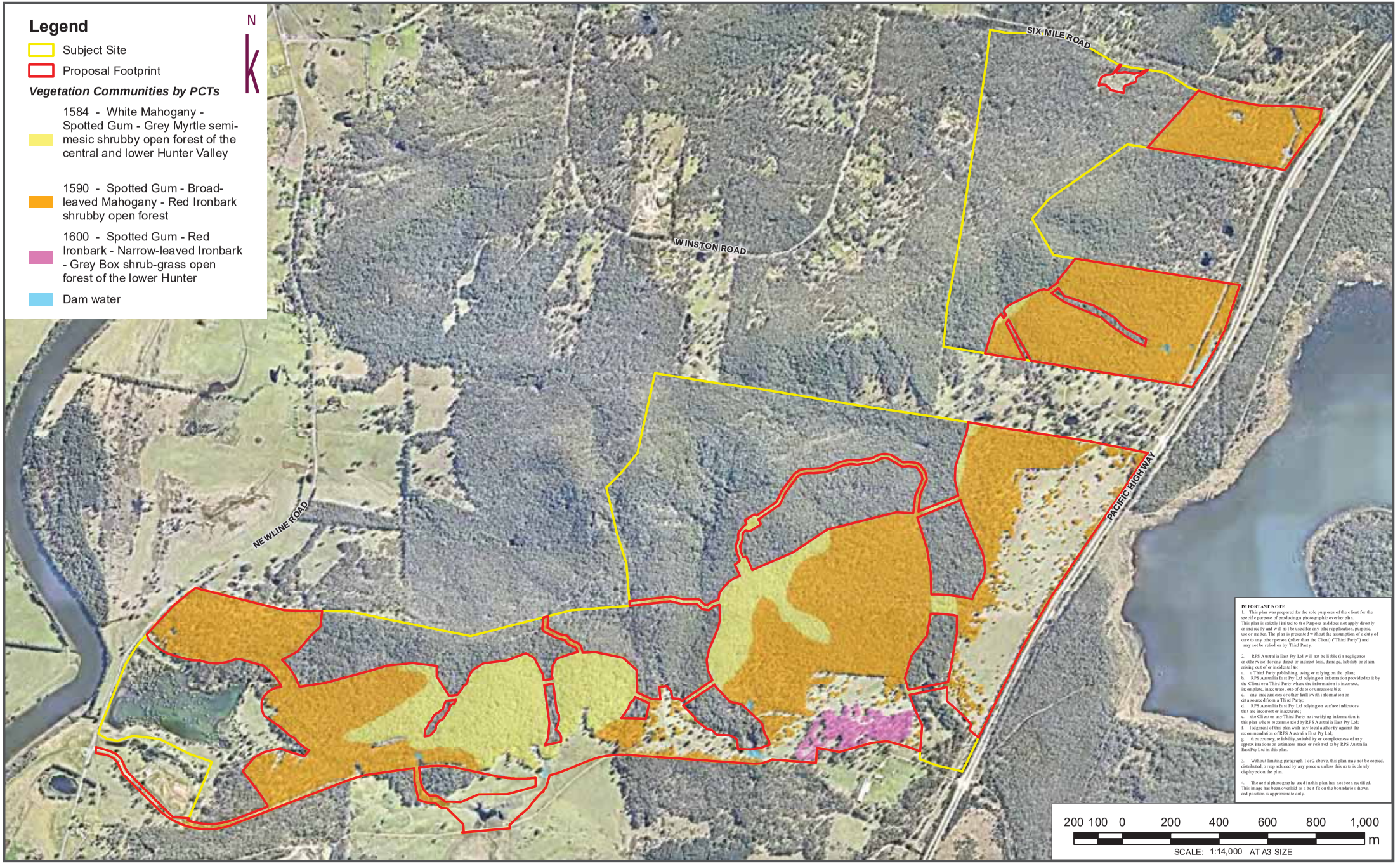
5.1.1.1 Vegetation communities

Native vegetation/ habitat retention and loss arising from the Proposal is shown in **Figure 5.1** and **Table 5.1**.

Table 5.1 PCT Area (ha) by Phase (Impact) and Protection (Conservation Area)

PCT	Condition	Impact Area (ha)	Conservation Area (ha)
Phase 1 (1-3 years)			
783 Coastal freshwater swamps of the Sydney Basin Bioregion	moderate good high	-	9.21
1525 Sandpaper Fig - Whalebone Tree warm temperate rainforest	moderate good high	-	2.42
1230 Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	moderate good poor	-	0.15
1584 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	moderate good high	17.67	101.51
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good high	47.56	108.83
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good medium	-	2.15
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good poor	5.50	0.38
1600 Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter	moderate good medium	5.15	1.05
1728 Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast	moderate good poor	-	5.49
Sub Total		**75.88**	**231.19**
Phase 2 (>3-8 years)			
1584 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	moderate good high	10.51	-
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good high	38.20	-
Sub Total		**48.71**	
Phase 3 (>8 + years)			
1584 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	moderate good high	19.76	-
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good high	67.79	-
Sub Total		**87.55**	
Total		**212.14**	**231.19**

A synoptic view of site preparation works is provided in **Figures 5.2**, **5.3** and **5.4** with **Figure 5.5** showing the extent retained in the Conservation Area.



TITLE : FIGURE 5.1: IMPACT OF THE PROPOSAL ON NATIVE VEGETATION AND HABITAT

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

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PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 5.1 Impact of the Proposal on Native Vegetation and Habitat b A3 20200720.mxd

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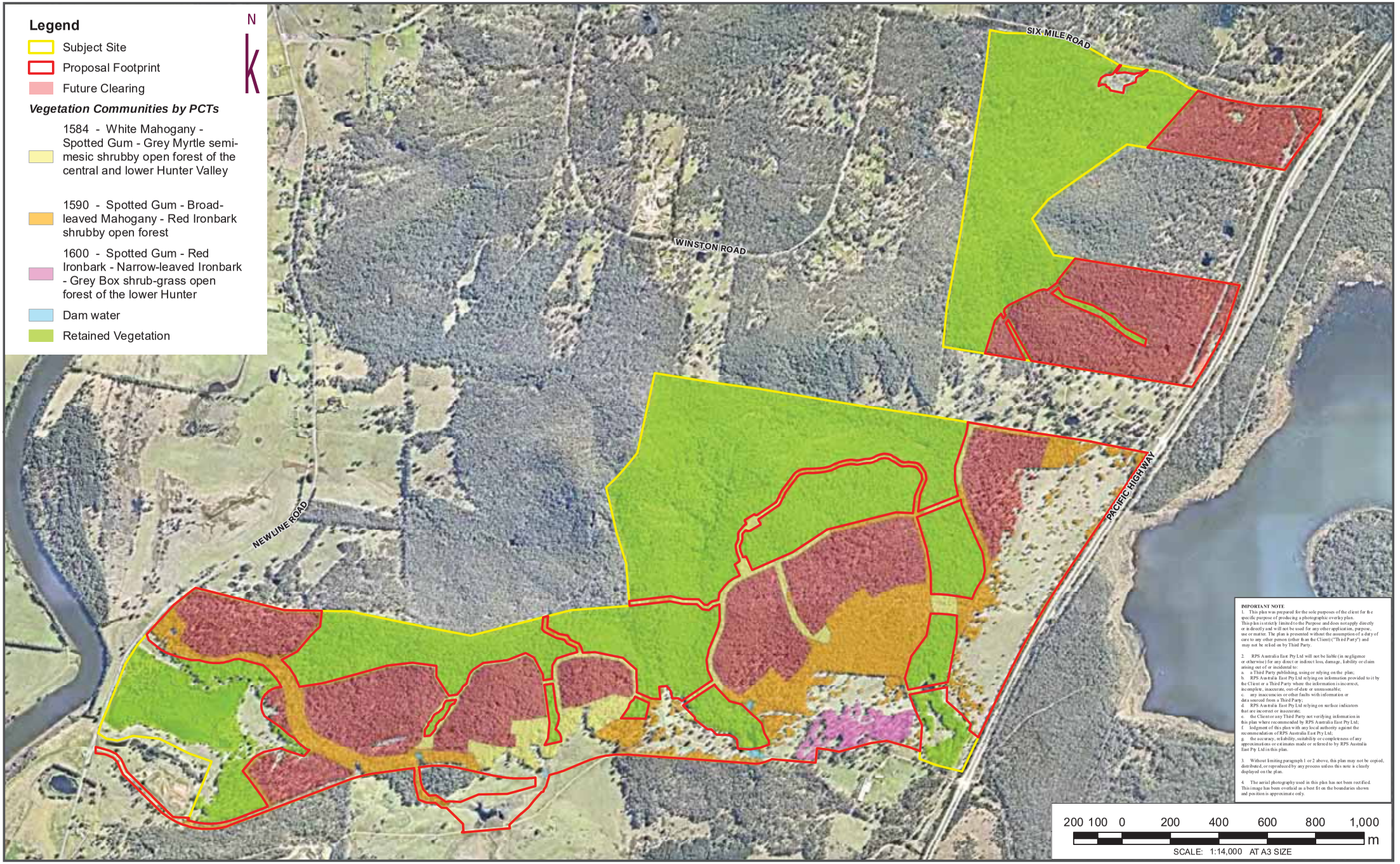

TITLE : FIGURE 5.2: NATIVE VEGETATION AND HABITAT LOSS: PHASE 1

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 5.2 Native Vegetation and Habitat loss PHASE 1 D A3 20200720.mxd

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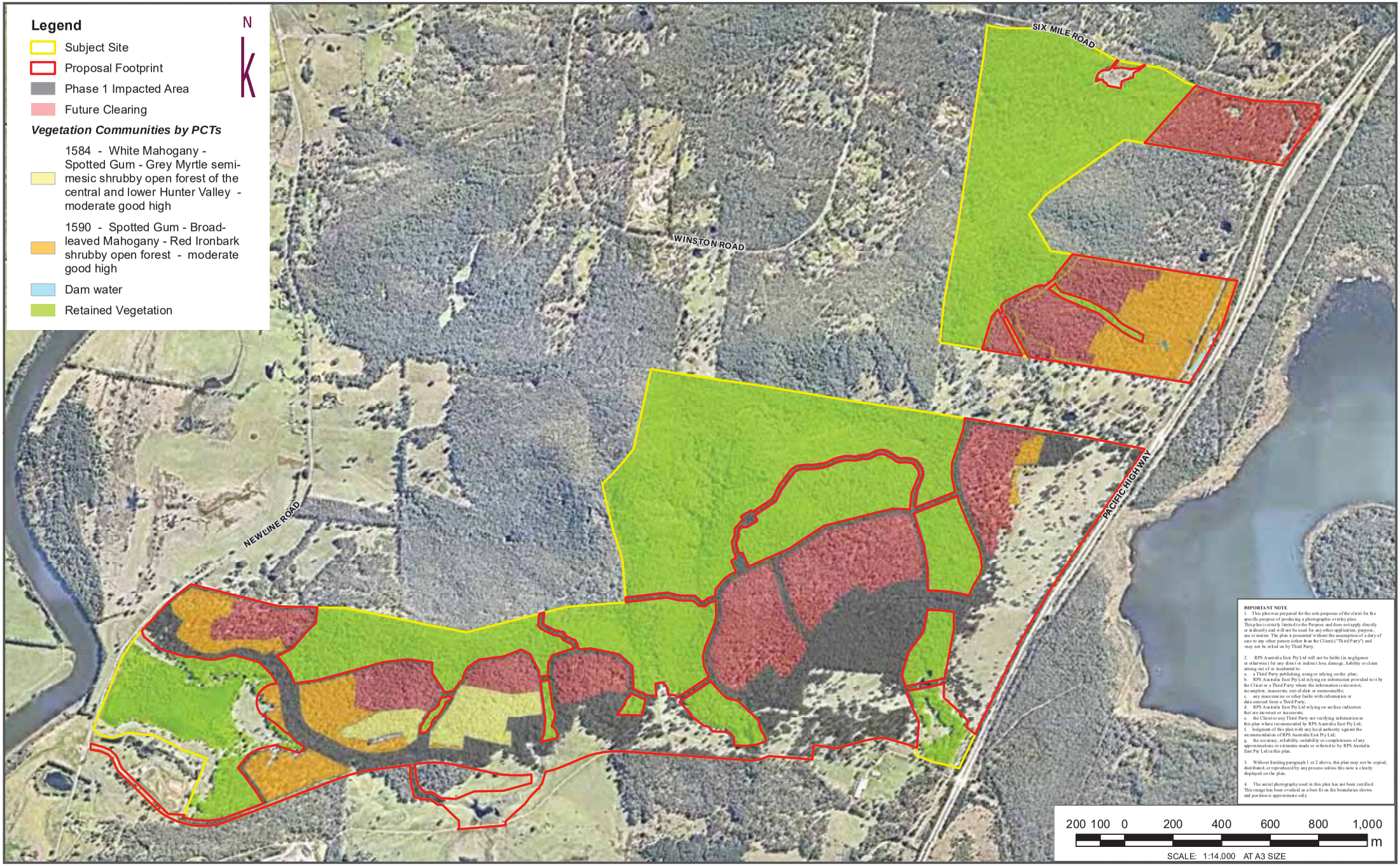

TITLE : FIGURE 5.3: NATIVE VEGETATION AND HABITAT LOSS: PHASE 2

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 5.3 Native Vegetation and Habitat Loss PHASE 2 D A3 20200720.mxd

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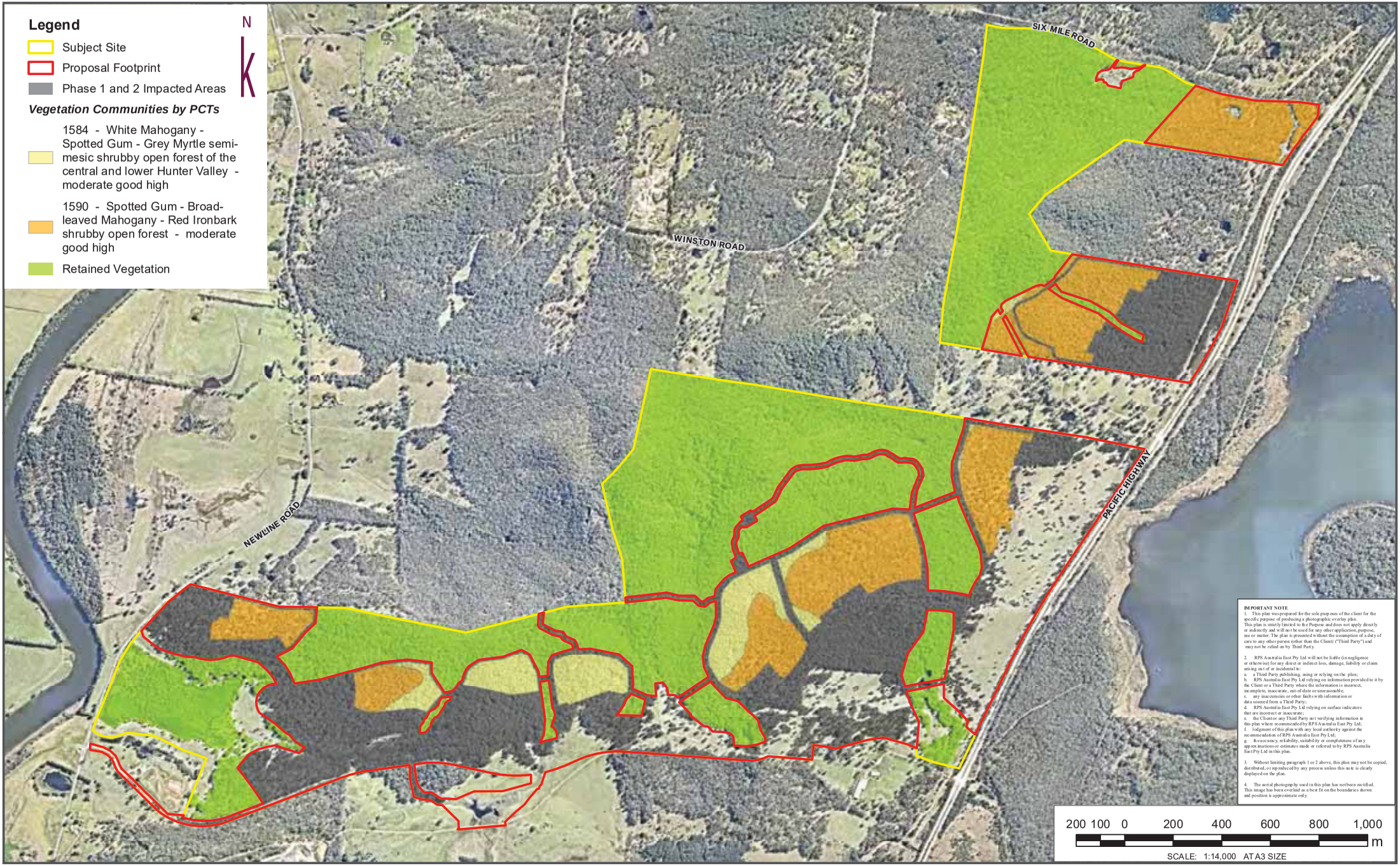

TITLE : FIGURE 5.4: NATIVE VEGETATION AND HABITAT LOSS: PHASE 3

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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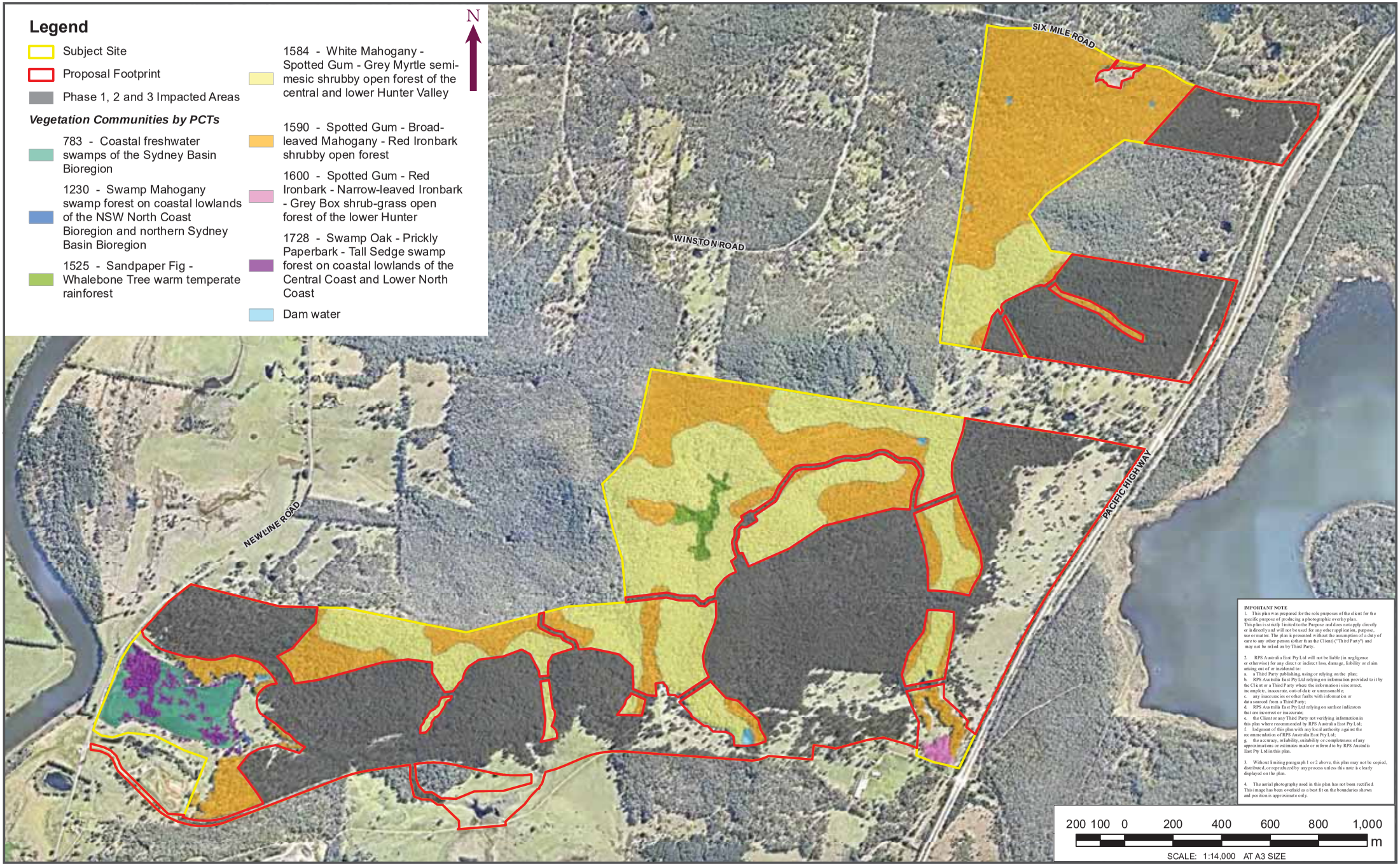

TITLE : FIGURE 5.5: RETAINED NATIVE VEGETATION AND HABITAT (CONSERVATION AREA)

LOCATION :KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 5.5 Retained Native Veg and Habitat B A3 20200720.mxd

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5.1.1.2 Loss of Specific Habitat Features

The following key threatening process apply to the Proposal:

- Removal of dead timber and trees;
- Loss of hollow-bearing trees; and
- Clearing of native vegetation.

A brief outline of these impacts is outlined below.

5.1.1.2.1 Loss of dead timber

Dead wood and dead trees provide essential habitat for a wide variety of native animals and are important to the functioning of many ecosystems. Dead wood and dead trees often contain hollows used by many native species for shelter, breeding and predator avoidance. Dead wood is essential for maintaining forest and woodland ecosystems. Along with the living understorey, leaf litter and soil components is vital for maintaining ecological processes. A diverse range of specialised insects (and other invertebrates) and fungi species depend on dead wood for their survival. These species can have complex interactions with plants and other animals. Declines in one group of species will have indirect impacts on a range of other species and ecosystem processes.

5.1.1.2.2 Loss of hollow-bearing trees

In NSW, terrestrial vertebrate species that are reliant on tree hollows for shelter and nests include at least 46 mammals, 81 birds, 31 reptiles and 16 frogs with at least 40 species being listed as threatened. Although large hollow-bearing trees are rare, vertebrate species strongly select them as nest and roost sites. For instance, bat roost selection is consistently in large hollow-bearing trees (NSW Scientific Committee 2007).

The density of hollow-bearing trees required to sustain viable populations of vertebrates is a function of the diversity of competing fauna species at a site, population densities, number of hollows required by each individual over the long-term, and the number of hollows with suitable characteristics occurring in each tree. These factors vary spatially among habitats and temporally throughout the year with, for example, the demand for nests increasing greatly during the spring breeding season (NSW Scientific Committee 2007).

A range of direct and indirect processes contribute to the ongoing loss of hollow-bearing trees, with the relative importance of these processes varying in accordance with past and current land management regimes. Owing to the slow process of hollow development, and the particular value provided by large old trees, adverse effects from the continuing loss of old hollow-bearing trees will take centuries to fix (NSW Scientific Committee 2007).

5.1.1.2.3 Clearing of native vegetation

Clearing of native vegetation may have significant impacts on biological diversity such as:

- Loss of local populations of individual species;
- Fragmentation;
- Expansion of dryland salinity;
- Riparian zone degradation;
- Increased greenhouse gas emissions;
- Increased habitat for invasive species;
- Loss of leaf litter layer;
- Loss or disruption of ecological function; and
- Changes to soil biota.

5.1.1.3 Threatened species

The Proposal would directly impact the habitat of subject species assessed in **Section 4.4**. The impact area calculated for each subject species reflects an intersect of the Proposal and individual subject species mapping provided in **Section 4.4** and is provided in **Table 5.2**.

Table 5.2 Threatened Species Habitat Area Estimates: Impact Area and Conservation Area

Species	Habitat Description	Habitat mapping method	Impact Area (ha)				Conservation Area (ha)[20]
			Phase 1	Phase 2	Phase 3	Total	
Red Helmet Orchid	Occupied habitat	Area of extent (i.e. 30 m buffer to each plant)	1.52	0.00	3.14	4.66	8.62
Small Water-ribbons	Occupied habitat	Area of extent (i.e. 30 m buffer to each plant)	0.08	0.00	0.00	0.08	0.15
Taree Rustyhood Orchid	Occupied habitat	Area of extent (i.e. 30 m buffer to each plant)	0.85	0.28	0.28	1.41	4.36
Glossy-black Cockatoo	Foraging habitat	Area of *Allocasuarina* spp.	0.00	19.08	10.75	29.83	0.00
Brown Treecreeper	Foraging and breeding habitat	Extent of PCTs 1230, 1584, 1590[21], 1600	70.38	48.71	87.55	206.64	214.07
Varied Sittella	Foraging and breeding habitat	Extent of PCTs 1230, 1584, 1590[21], 1600	70.38	48.71	87.55	206.64	214.07
Little Lorikeet	Foraging and breeding habitat	Extent of PCTs 1230, 1584, 1590, 1600	75.88	48.71	87.55	212.14	214.07
Grey-crowned Babbler	Foraging and breeding habitat	Extent of occupied habitat	9.74	13.17	9.30	32.21	12.44
White-bellied Sea-Eagle	Foraging and breeding habitat	250 m radius from nest tree	3.23	3.48	2.97	9.68	9.99
Square-tailed Kite	Foraging and breeding habitat	Extent of PCTs 1230, 1584, 1590, 1600	75.88	48.71	87.55	212.14	214.07
Osprey	Breeding habitat	Extent of PCTs 783, 1230, 1728	0.00	0.00	0.00	0.00	14.85
Magpie Goose	Foraging and breeding habitat	Extent of PCTs 783, 1230, 1728	0.00	0.00	0.00	0.00	14.85
Australian Bittern	Foraging and breeding habitat	Extent of PCTs 783, 1230, 1728	0.00	0.00	0.00	0.00	14.85
Black Bittern	Foraging and breeding habitat	Extent of PCTs 783, 1230, 1728	0.00	0.00	0.00	0.00	14.85
Dusky Woodswallow	Foraging and breeding habitat	Extent of PCTs 1230, 1584, 1590, 1600, 1728	75.88	48.71	87.55	212.14	219.56
Black-necked Stork	Foraging and breeding habitat	Extent of PCTs 783, 1230, 1728	0.00	0.00	0.00	0.00	14.85
Powerful Owl	Foraging and breeding habitat	Extent of PCTs 1230, 1525, 1584, 1590[21], 1600	70.38	48.71	87.55	206.64	216.49

[20] Excludes likely benefit from revegetation works of 19.30 ha for Koala, Grey-headed Flying Fox, Squirrel Glider, Little Lorikeet, Grey-crowned Babbler, Regent Honeyeater and Swift Parrot

[21] Excludes vegetation mapped as moderate good poor condition (i.e. isolated Melaleuca spp. in areas of exotic grassland)

Species	Habitat Description	Habitat mapping method	Impact Area (ha)				Conservation Area (ha)[20]
			Phase 1	Phase 2	Phase 3	Total	
Masked Owl	Foraging and breeding habitat	Extent of PCTs 1230, 1525, 1584, 1590[21], 1600	70.38	48.71	87.55	206.64	216.49
Regent Honeyeater	Foraging habitat	Extent of PCTs 1230, 1584, 1590, 1600	75.88	48.71	87.55	212.14	214.07
Swift Parrot	Foraging habitat	Extent of PCTs 1230, 1584, 1590, 1600	75.88	48.71	87.55	212.14	214.07
Scarlet Robin	Foraging and breeding habitat	Extent of PCTs 1584, 1590[21], 1600	70.38	48.71	87.55	206.64	213.92
Squirrel Glider	Foraging and breeding habitat	Extent of PCTs 1230, 1584, 1590[21], 1600	70.38	48.71	87.55	206.64	214.07
Koala	Foraging and breeding habitat	As per BioLink (2019b)	59.79	32.41	59.03	152.00	189.46
Brush-tailed Phascogale	Foraging only habitat	Area of rough-barked trees with low hollows	22.94	19.34	18.01	60.49	55.38
	Foraging and breeding habitat	Area of rough-barked trees with high hollows	44.96	29.26	69.11	143.11	161.11
Spotted-tailed Quoll	Foraging and breeding habitat	Extent of PCTs 1230, 1525, 1584, 1590[21], 1600	70.38	48.71	87.55	206.64	216.49
Grey-headed Flying-fox	Foraging habitat	Extent of PCTs 1230, 1525, 1584, 1590, 1600	70.38	48.71	87.55	212.14	216.49
		Bi-monthly phenology (feed tree modelling)					
		• December – January	46.46	38.54	77.65	162.65	166.81
		• February – March	32.77	20.83	36.55	90.76	72.30
		• April – May	58.61	28.62	68.85	156.08	178.39
		• June – July	58.61	28.62	68.85	156.08	178.39
		• August – September	63.40	32.85	71.48	167.73	187.95
		• October – November	51.69	39.93	73.38	165.00	176.76
Eastern Bentwing-bat	Foraging habitat	Extent of PCTs 1230, 1525, 1584, 1590, 1600	70.38	48.71	87.55	212.14	216.49
Little Bentwing-bat	Foraging habitat	Extent of PCTs 1230, 1525, 1584, 1590, 1600	70.38	48.71	87.55	212.14	216.49
Eastern Freetail-bat	Foraging and breeding habitat	Extent of PCTs 1230, 1584	17.67	10.51	19.76	47.94	101.66
Greater Broad-nosed Bat	Foraging and breeding habitat	Extent of PCTs 1230, 1584	17.67	10.51	19.76	47.94	101.66
Yellow-bellied Sheath-tail Bat	Foraging and breeding habitat	Extent of PCTs 1590, 1600	58.21	38.20	67.79	164.20	112.41
Eastern False Pipistrelle	Foraging and breeding habitat	Extent of PCTs 1525, 1584	17.67	10.51	19.76	47.94	103.93
Southern Myotis	Foraging habitat	Extent of PCT 783	0.00	0.00	0.00	0.00	9.21
	Breeding habitat	Native vegetation within 200m of PCT 783	4.92	5.45	1.21	11.58	12.44
Green and Golden Bell Frog	Foraging and breeding habitat	Extent of PCTs 783, 1230, 1728	0.00	0.00	0.00	0.00	14.85
Wallum Froglet	Foraging and breeding habitat	Extent of PCTs 783, 1230, 1728	0.00	0.00	0.00	0.00	14.85

5.1.1.4 Weed Management

The Proposal incorporates provisions for the control of exotic flora (i.e. terrestrial and aquatic) as described in the BMP (**Appendix C**) and **Section 7.1.1.4**. Ecological benefit is expected in the Conservation Area including:

- Improved recruitment of tree canopy species, particularly in areas of high Lantana and African Olive infestation;
- Increased ground layer flora diversity and vegetation structure; and
- Improved native flora diversity and structure condition within aquatic environments particularly in areas of Alligator Weed infestation.

Changes in vegetation structure and floristics towards a more natural state are aims to enhance habitat conditions for both native flora and fauna. An overall beneficial outcome is expected as a consequence of these works, particularly favouring threatened flora species such as *Maundia triglochinoides* around the wetland 803 precinct.

5.1.1.5 Feral Fauna Management

The Proposal incorporates provisions for the control of feral fauna species (i.e. wild dog and feral deer) as described in the BMP (**Appendix C**) and **Section 7.1.1.5**. These works have the specific aim of reducing the impact of herbivory on native groundcover layer and predation on mammals such as the Koala. Reduced herbivory by feral deer is expected to result in improved understorey plant species diversity and vegetation structure. No adverse impacts on affected species are expected.

5.1.1.6 Revegetation

The Proposal incorporates provisions for the revegetation of 19.30 ha of treeless lands and detention basins using known high value PKFT species (i.e. Forest Redgum, Swamp Mahogany, Grey Gum and Tallowwood) as described in the BMP (**Appendix C**) and **Section 7.1.1.1**. These works have the specific aim of increasing the habitat area for the Koala, with ecological benefit expected within 7-20 years of these works (Kavanagh and Stanton 2012). These works are proposed as a partial mitigation measure for the loss of Koala habitat occurring within the Proposal impact footprint. Revegetation works are to start prior to vegetation clearing and aim to deliver measurable benefit during Phase 2. The revegetation works will also have benefit for other species such as the Squirrel Glider and Grey-headed Flying Fox (i.e. winter and spring nectar supplies during food bottleneck periods), Regent Honeyeater and Swift Parrot (i.e. winter nectar supplies) and insectivorous species such as Brush-tailed Phascogale and microchiropteran bats. No adverse impacts on affected species are expected.

5.1.1.7 Tree Canopy Foliar Nutrient Enrichment

The Proposal incorporates provisions for the enrichment of tree canopy foliar nutrient value through intra forest tree plantings within a 143 ha management area as detailed in **Section 7.1.1.2** and the BMP (**Appendix C**). A mean planting rate of 70 trees/ ha is proposed, meaning an average of 1 tree per 143 m^2. This planting prescription is likely to be matched by the thinning of a single tree to provide a canopy gap for sunlight. The thinning process will result in the depositing of a log on ground to improve ground habitat values. Local provenance seed is to be used for tree plantings. The following sections outline the likely impact of these proposed modifications.

5.1.1.7.1 Forest Tree Density

Tree species diversity in the Conservation Area varies within and between PCTs. The nearest neighbour tree dataset collected for 187 plots showed a considerable range in tree species diversity (i.e. species presence and stem densities); an observation reflective of natural environmental factors (e.g. aspect, slope, soil conditions), absence of fire, influences from unmanaged exotic flora and fauna (e.g. herbivory by feral deer

and dense cover of Lantana) and past land use (e.g. historical logging and clearing). The latter two factors represent anthropogenic influences on canopy species diversity with the impacts mostly negative [i.e. simplification of tree species richness (i.e. dominance by a few species) and tree age class].

The mean stem density recorded from the nearest neighbour tree dataset for the study area was 180 ± 150 stems/ ha; a value well below stem densities typically observed in Hunter – Macleay Dry Sclerophyll Forests (i.e. 516 ± 135 stems/ ha) (Kerle 2005). This conservatively indicates a difference of 30-200 less trees per hectare, thereby indicating capacity for the manipulation of tree canopy constituents without substantially altering stand structure and diversity. By using tree species that naturally occur within the relevant vegetation types, impacts on the broader biodiversity values of the existing forest are likely to be minimal.

5.1.1.7.2 Flora Considerations

The thinning and planting prescriptions will have the effect of modifying tree overstorey composition and structure by initially selectively removing lower nutrient tree species (e.g. Spotted Gum and White Mahogany) to make 'canopy gaps' that would allow for the growth of planted PKFTs such as Forest Redgum, Grey Gum, Grey Box and Tallowwood. Such changes are also likely to coincide with weed management actions.

The natural flora species composition of PCTs 1584 and 1590 is described by MUs 12 and 16 in NPWS (2003). Measures for frequency (i.e. the amount of times the tree species is recorded in a flora plot) and cover abundance (i.e. combined measure of numbers and percent cover) are provided in the vegetation profiles for these vegetation types. The predicted pre and post overstorey frequency and cover abundance is provided in **Table 5.3** together with a comparison of NPWS (2003) values to evaluate the possible effect of enrichment works within the Conservation Area. Species in bold are classed as positive diagnostic species.

Table 5.3 Predicted Before and After Tree Species Frequency and Cover Abundance for PCTs 1584 and 1590 following Enrichment Plantings

PCT	Tree Species	NPWS (2003)		Before Enrichment		After Enrichment	
		Frequency	Cover Abundance	Frequency	Cover Abundance	Frequency	Cover Abundance
1584	***Corymbia maculata***	**44%**	**3**	**>90%**	**5**	**>90%**	**4-5**
	Eucalyptus crebra	40%	2	<5%	1	<5%	1
	Eucalyptus punctata	**40%**	**3**	**5-10%**	**1-2**	**20-30%**	**2-3**
	Eucalyptus fibrosa	5%	3	<5%	1	<5%	1
	Eucalyptus acmenoides	17%	3	>80%	5	>80%	4-5
	Eucalyptus globoidea	13%	2	10-20%	5	10-20%	4-5
	Eucalyptus siderophloia	23%	3	10-20%	4-5	10-20%	4-5
	Eucalyptus tereticornis	13%	3	0-50%	1-6	10-50%	2-6
1590	***Corymbia maculata***	**100%**	**3**	**>90%**	**4-5**	**>90%**	**4-5**
	Eucalyptus crebra	**45%**	**3**	**<5%**	**1**	**<5%**	**1**
	Eucalyptus punctata	**45%**	**2**	**5-10%**	**1-2**	**20-30%**	**2-3**
	Eucalyptus fibrosa	**40%**	**2**	**<5%**	**1**	**<5%**	**1**
	Eucalyptus acmenoides	31%	2	20-30%	1-3	20-30%	1-3
	Eucalyptus moluccana	31%	2	<5%	1	10-20%	2
	Eucalyptus siderophloia	31%	2	20-30%	1-5	20-30%	1-5
	Eucalyptus tereticornis	31%	2	0-50%	1-6	10-50%	2-6

Minor changes in cover abundance are predicted for species that are to be subject to thinning activities (i.e. localised loss of 5-10% cover abundance, but to an extent that would compromise stand structure as compared to NPWS (2003) statistics for these vegetation types. A similar small effect is expected in the cover abundance and frequency of species planted in place of those thinned. Again, the proposed changes are not likely to alter conditions away from natural conditions measured by NPWS (2003). Accordingly, with minimal change in overstorey structure it is considered that the modification to the vegetation stand is unlikely to have any quantifiable effect on understorey floristics.

5.1.1.7.3 Fauna Considerations

An appraisal on the likely effect of thinning and planting prescription for enrichment foliar nutrient levels was provided by Dr Frank Lemckert (**Appendix L**). In this appraisal it was noted that the thinning / planting prescription rates are at the lower end of typical planting densities apparently as a means of minimising the extent of disturbance.

Assuming the relative composition of species remains within benchmark levels, and trees of local genetic provenance are used, the evaluation concluded that the manipulation of the tree composition to increase the overall number of trees with higher nutrient value foliage should have a positive impact on fauna across a range of species. Importantly, the enrichment prescription will be very unlikely to have a negative impact on the local environment as most species would be positively impacted by the presence of more easily obtained nutrients.

Common arboreal species such as the Common Ringtail and Common Brushtail Possums eat significant levels of leaf material and will also benefit from increased foliar nutrient value and reduced toxin levels allowing them to increase growth rates and maintain denser populations. This will be an advantage to local carnivores that eat arboreal prey including the Powerful Owl and Spotted-tailed Quolls. Furthermore, insect abundance has been found to be positively correlated with leaf nutrient levels (Majer et al 2006), which will have significant benefits for a large range of species that eat insects including the Squirrel Glider and Brush-tailed Phascogale.

5.1.1.8 Koala Fence

The Proposal includes the establishment of a Koala fence at the interface between the Conservation Area and urban environment specifically of the purposes of restricting Koala activity to the Conservation Area to minimise the likelihood of mortality from domestic dog attack, vehicle strike and drowning in swimming pools. The specification for this is provided in **Section 7.1.1.6**. The separation of Koalas from the urban environment is a positive impact and is consistent with the performance measures specified in the PSC CKPoM.

5.1.2 Indirect Impacts of the Proposal

5.1.2.1 Habitat fragmentation

One of the primary indirect impacts from vegetation loss is habitat fragmentation. Habitat fragmentation is the process whereby habitat loss results in the division of large, continuous habitats into small, isolated habitat fragments (Ewers and Didham, 2006). The area between fragments is typically man-made and largely uninhabitable by the species that previously existed in the area. The ecological impacts of habitat fragmentation include (Andrews, 1990):

- Changes in the number of species in fragments;
- Changes to the composition of faunal assemblages; and
- Changes to ecological processes in fragments such as food chains, predator-prey interactions, plant-animal pollination and dispersal associations.

The Proposal would result in the loss of 212.14 ha of native vegetation/habitat thereby raising the potential for habitat fragmentation impacts. This loss is countered by the retention of 250.49[22] ha within the Conservation Area. Following strategic incorporation of impact avoidance areas into the Conservation Area (e.g. vegetation along 2nd and 3rd order streams), the Proposal has resulted in a substantial widening of corridors throughout the subject site as shown in **Figure 5.5**.

The vegetation and associated habitats in the study area and locality are currently affected by fragmentation due to rural and rural residential development. The proposed removal of this small area of vegetation and marginal habitat would very minimally add to fragmentation further than current conditions. Vegetation will be retained along drainage lines to retain fauna corridors across the study area.

5.1.2.2 Edge effects

The 'edge effect' describes a collection of factors and processes that influence the presence and abundance of species at a boundary such as natural boundaries (e.g. ecotones) or a disturbance of some kind (e.g. cleared lands). Edges can occur naturally within ecosystems such in common boundaries between ecological communities or burnt and unburnt vegetation. Biodiversity often adapt to the effects of an edge, with some species becoming reliant on this effect. The following edge effects can occur (Murcia, 1995):

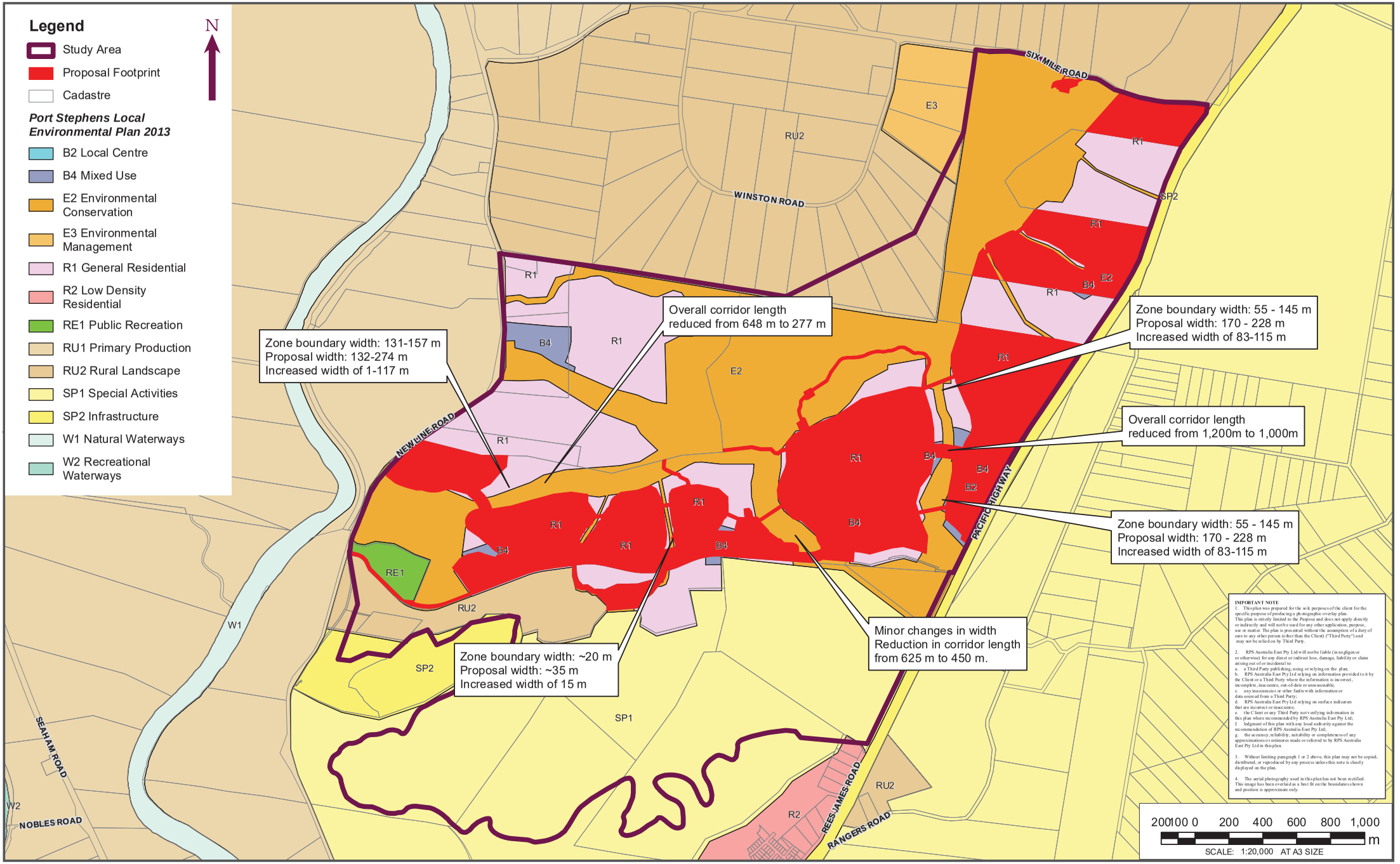
- Abiotic effects, involving changes in the environmental conditions that result from proximity to a structurally dissimilar matrix;
- Direct biological effects, which involve changes in the abundance and distribution of species caused directly by the physical conditions near the edge; and
- Indirect biological effects which involve changes in species interactions, such as predation, competition, herbivory and biotic pollination and seed dispersal.

Bali (2005) identifies the following key considerations in the evaluation of edge effects:

- Microclimate (e.g. localised changes in temperature, wind, light, humidity);
- Hydrology (i.e. localised changes in surface and subsurface water flows);
- Altered fire frequency and intensity;
- Invasion by exotic plant and animal species;
- Alteration of soil conditions (e.g. increased sedimentation and nutrient availability); and
- Alteration of vegetation structure (e.g. tree death and increased shrub densities).

On average, edge effects have been estimated to occur up to 50 metres from the road edge (Bali 2005), although much greater distances have been recorded in some road studies (Forman et al. 2003). Edge effects are particularly pronounced in patches where a large edge to area ratio exists (i.e. small vegetation patches with a proportionally large perimeter). Such conditions often result in the simplification of biodiversity values in favour of generalists or edge specialist species.

[22] Retained native vegetation (231.19 ha) plus revegetation works (19.30 ha)



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TITLE : FIGURE 5.6: CORRIDOR WIDTHS: THE PROPOSAL COMPARED TO ZONE BOUNDARIES

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 5.6 Corridor Analysis B A3 20200720.mxd

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JOB REF: **PR130430**

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MAKING COMPLEX EASY

Potential edge effects promoted by the Proposal may include:

- Establishment of weeds along boundaries between native vegetation and cleared lands and potential for weed incursions into adjacent native vegetation;
- Modification of habitat attributes, through increased light and noise levels, and changes to vegetation structure, soil nutrient levels and plant species diversity;
- Changes to fauna assemblages, including alteration of woodland and forest bird assemblages by edge specialists; and
- Increased predation of vertebrate fauna by predator species that use forest edges for foraging.

Of the above potential edge effects it is considered that establishment of weeds and modification of habitat attributes (i.e. light and noise levels and vegetation structure) are the most likely tangible impacts that may arise from the Proposal.

5.1.2.2.1 Exotic flora

Potential exists for the Proposal to introduce weeds through equipment use and soil disturbance. Further, without the use of appropriate weed management protocols, the Proposal has the potential to facilitate the spread of weeds into adjoining native vegetation. Mitigation measures to be implemented during the construction and operational Phases of the Proposal are recommended to manage and control the incidence and effect of noxious and environmental weeds on the receiving environment. There is potential for high threat weeds observed within and adjacent to the Proposal to benefit from construction works and, as such, the management of these species would be desirous in lowering any indirect impacts on the adjoining environment.

5.1.2.2.2 Artificial Light levels

Natural darkness has a conservation value in the same way that clean water, air and soil has intrinsic value. Artificial light at night is increasing globally by about two per cent per year. Animals perceive light differently from humans and artificial light can disrupt critical behaviour and cause physiological changes in wildlife. For example, hatchling marine turtles may not be able to find the ocean when beaches are lit, and fledgling seabirds may not take their first flight if their nesting habitat never becomes dark. Tammar wallabies exposed to artificial light have been shown to delay reproduction and clownfish eggs incubated under constant light do not hatch (DoE 2019).

The future developed environment will contain artificial light. Emitted light will be consistent with standards that apply to the developed landscape for human occupation and generally does not take into consideration the adverse effects on wildlife. This light may spill into the Conservation Area and in so doing represents a potential indirect impact on wildlife occupying this area.

Best practice lighting design principles are recommended for consideration when developing the urban landscape. DoEE (2019) identifies important principles that should be considered in guiding a reduction in this indirect impact, which are listed below:

- Start with natural darkness and only add light for specific purposes.
- Use adaptive light controls to manage light timing, intensity and colour.
- Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill.
- Use the lowest intensity lighting appropriate for the task.
- Use non-reflective, dark-coloured surfaces.
- Use lights with reduced or filtered blue, violet and ultra-violet wavelengths.

These principles ought to be considered in the subdivision design process that would follow Stage 1 works.

5.1.2.2.3 Vegetation Structure

Alteration in vegetation structure, particularly along new edges, can result in increased light penetration onto the groundcover layer. Increased light and wind may influence plant species composition and abundance through localised changes in soil moisture, propagule dispersal and interspecific competition.

Edges with a southeast to southwest aspect are unlikely to receive any substantial increase in groundcover layer light penetration as these the sun angle is the northern half of the sky for most of the year. Edges of this aspect represent the majority of those created by the Proposal with the exception of edges created in the northern and western parts of the subject site. Change in the understorey is likely to be minimal in these newly created edges, although some alteration in plant composition and abundance may occur (e.g. may influence *C.* × *dowlingii*).

To this end, vegetation screening using medium sized dense shrubs (e.g. *Melaleuca nodosa*) can be used intercept light thus minimise any micro-climatic changes. This prescription may be applied to edged deemed sensitive to changes in micro-climatic conditions such as the edge of the Conservation Area that adjoins patches of *C.* × *dowlingii* and west facing edges located in the west of the site. East facing edges along the eastern and northern parts of the subject site are likely to be less effected as the vegetation and time of day of light penetration is not likely to be problematic.

5.1.2.3 Alteration to hydrological regimes

Changes to drainage lines can affect the integrity, structure and composition of habitat and thus, have secondary impacts on the species that rely on them. Changes in catchment dynamics can alter runoff volume and impact downstream environments. The following sections represent a summary of information contained within the Alluvium (2019) wetlands study prepared for wetlands 803 and 804 (see **Appendix E**).

5.1.2.3.1 Catchments

Changes in mean annual runoff volume provide a coarse indicator of the catchment hydrology changes associated with the Kings Hill development. Three catchments are considered on this basis are outlined below:

- Kings Hill East sub-catchment including all future development areas (and forested areas draining through these areas) that will drain into Irrawang Swamp (wetland 804) via the:
  - Original Grahamstown Dam spillway through a diversion drain being constructed on the eastern side of the Pacific Highway in Hunter Water owned land. This drain would divert runoff that currently drains directly to Grahamstown Dam to the original spillway.
  - Existing ephemeral creek between the existing Riding for the Disabled site and the Pacific Highway. This creek transitions to a section of concrete channel parallel to the original Grahamstown Dam spillway.
- The Kings Hill South sub-catchment includes all future development areas (and forested areas draining through these areas) that drain through three existing ephemeral gullies into the northern side of Irrawang Swamp via an existing closed depression formed by a constructed earthen wall with an all weather road.
- Kings Hill West catchment, which drains into Wetland 803 located adjacent to New Line Road. The hydrology of Wetland 803 is currently influenced by catchment inflows from the Kings Hill West catchment and occasional tidal inflows from the Williams River.

Both receiving waters (wetlands 803 and 804) exhibit drying cycles that peak in late summer and early autumn. Wetland 803 has a greater propensity for emptying during this period as it is a smaller shallower wetland with a smaller overall catchment. Wetland 804, while exhibiting drying patterns, is less likely to completely desiccate, rather form a variegated network of wet and dry areas.

5.1.2.3.2 Critical Drying Period

The critical drying period for wetlands 803 and 804 is from September to March when average monthly potential evapotranspiration typically exceeds average monthly rainfall at this location (Alluvium 2019; **Appendix E**). It is during this period that rainfall and associated runoff to the wetland would be lower enabling soils to partially dry in areas of a wetland to support new plant growth. Treatments applied to future development within the Proposed footprint would need to consider this part of the cycle so as to minimise any alteration in this cyclical event.

5.1.2.3.3 Wetland 803

Temporal water balance modelling for Wetland 803 from 1989 to 2008 shows considerable difference between the existing and developed catchment where no treatments are applied. Importantly, the water management treatments specified by Northrop (2019) provide a temporal water balance outcome that largely mirrors the existing conditions for at least 50% of the time as shown in **Figure 5.7**.

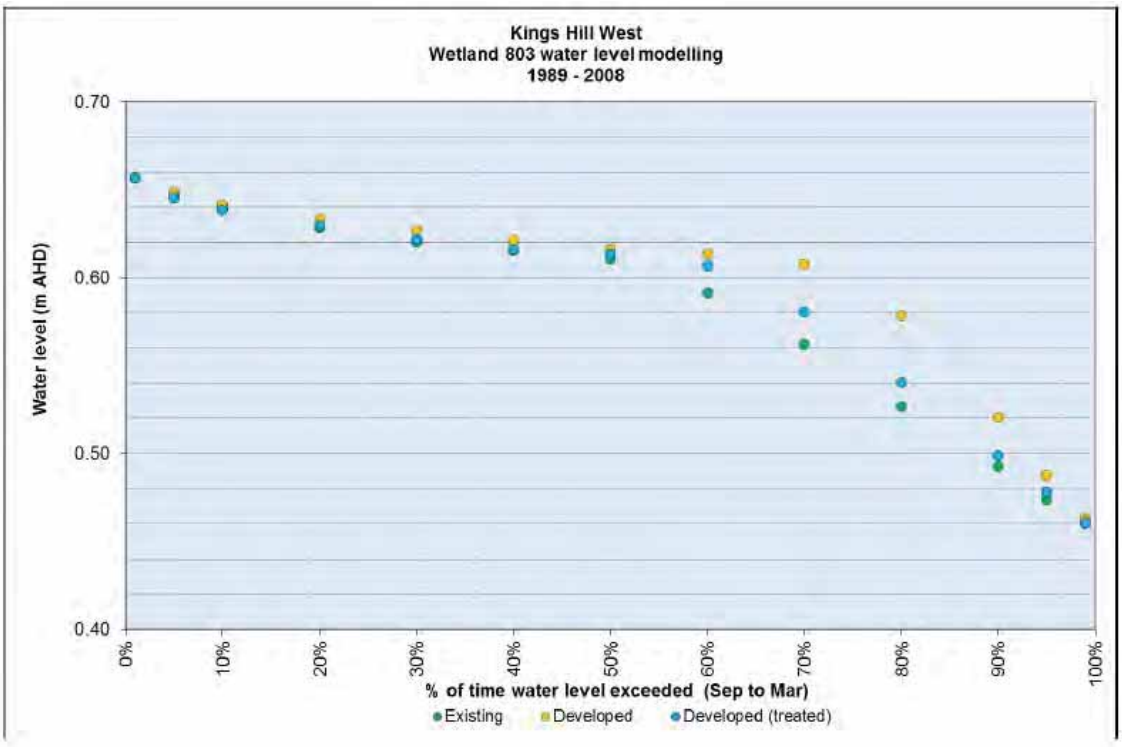


Figure 5.7 Kings Hill West: Wetland 803 water level modelling 1989 – 2008 (Alluvium 2019)

For the other 50% of the time, results indicate the water levels in the wetland would be elevated and similar for existing and developed conditions. This period would be at the opposite end of the drying cycle and coincide with the early spring period where initial water levels would be high in the wetland from winter rainfall and evapotranspiration is lower. Above the 95% range, existing and developed condition water levels would be similar as this range would represent a period closer to the end of summer where runoff from development areas would be low and evapotranspiration rates high (Alluvium 2019; **Appendix E**).

The developed (with treatment) results indicate that the proposed WSUD strategy would reduce impacts on water levels. This reduction is achieved through the application of rainwater tanks that will be effective at harvesting a high proportion of roof runoff during the critical drying period. In addition, the proposed bioretention measures would also absorb a high proportion of additional runoff during the drier periods. The treatment strategy also incorporates a proposal to divert over 5% of the Kings Hill West catchment around the wetland.

5.1.2.3.4 Wetland 804

Dry spell curves have been modelled to show differences between existing conditions and developed (untreated and treated) to demonstrate how active the catchment is likely to be in delivering flows into Wetland 804. These curves indicate that the length of the maximum annual dry spell is expected to reduce following development for the full range of dry to wet years (e.g. as shown by the green line in **Figure 5.8**, there will be a 10% chance in any year that the maximum dry spell will exceed 32 days for developed conditions and 190 days for the existing conditions). **Figures 5.8** and **5.9** show the dry spell curves for the Kings hill South and East catchments respectively.

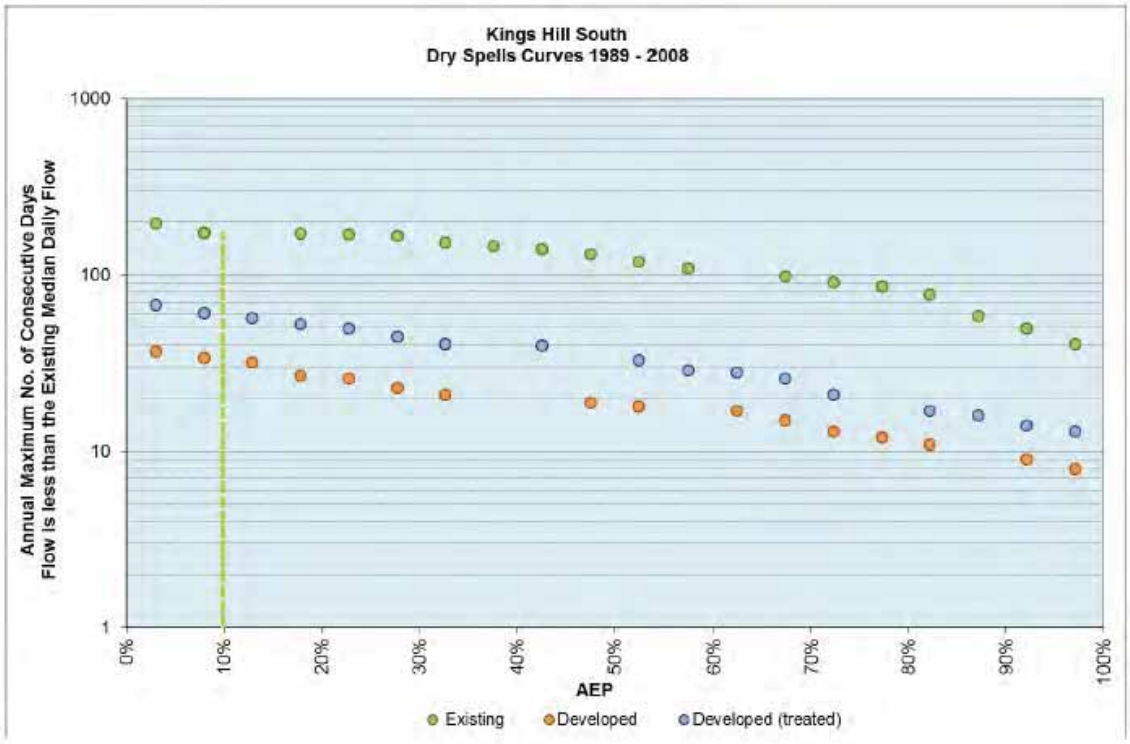


Figure 5.8 Kings Hill South: Dry Spell Curves 1989 – 2008 (Alluvium 2019)

The dry spells curves indicate that the length of the maximum annual dry spell is expected to reduce following development for the full range of dry to wet years. However, it is important to note that the stormwater management strategy proposed (Northrop 2019) would partially mitigate reductions in dry spells (i.e. provision of 5 kL rainwater tanks, biofiltration systems and urban lakes throughout the development).

Low and high flow frequency curves were modelled for Wetland 804 from 1989 to 2008 to evaluate the likely contribution of water ingress into this wetland during existing conditions and post development including treatment. The 30 day low flow frequency curve for Kings Hill East and South catchments are provided in **Figures 5.10** and **5.11** respectively. The 670 day moving average low flow charts are provided in **Appendix E**.

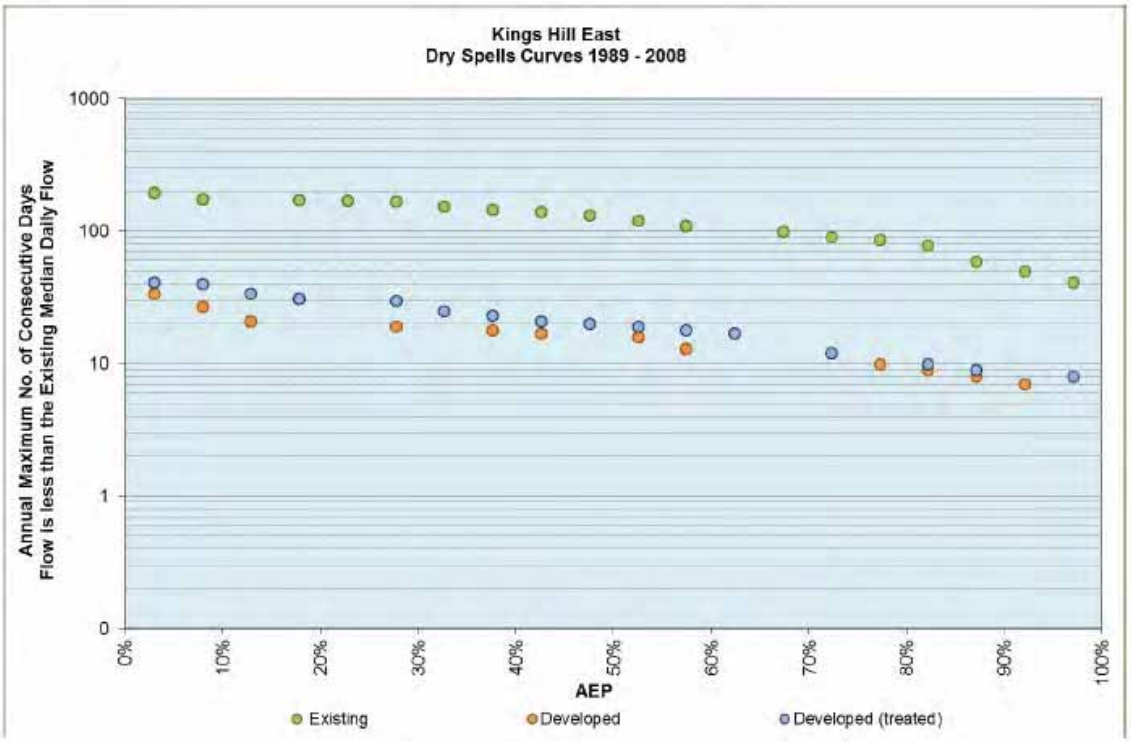


Figure 5.9 Kings Hill East: Dry Spell Curves 1989 – 2008 (Alluvium 2019)

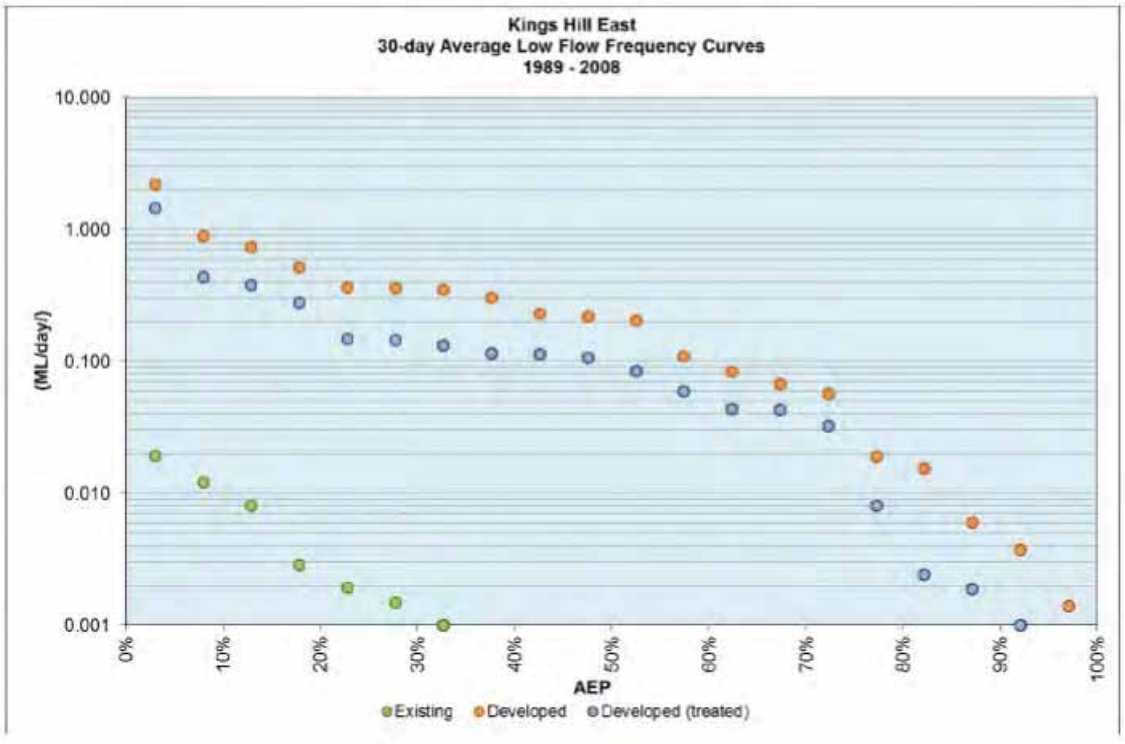


Figure 5.10 Kings Hill East: 30 day Average Low Flow Frequency Curve 1989 – 2008 (Alluvium 2019)

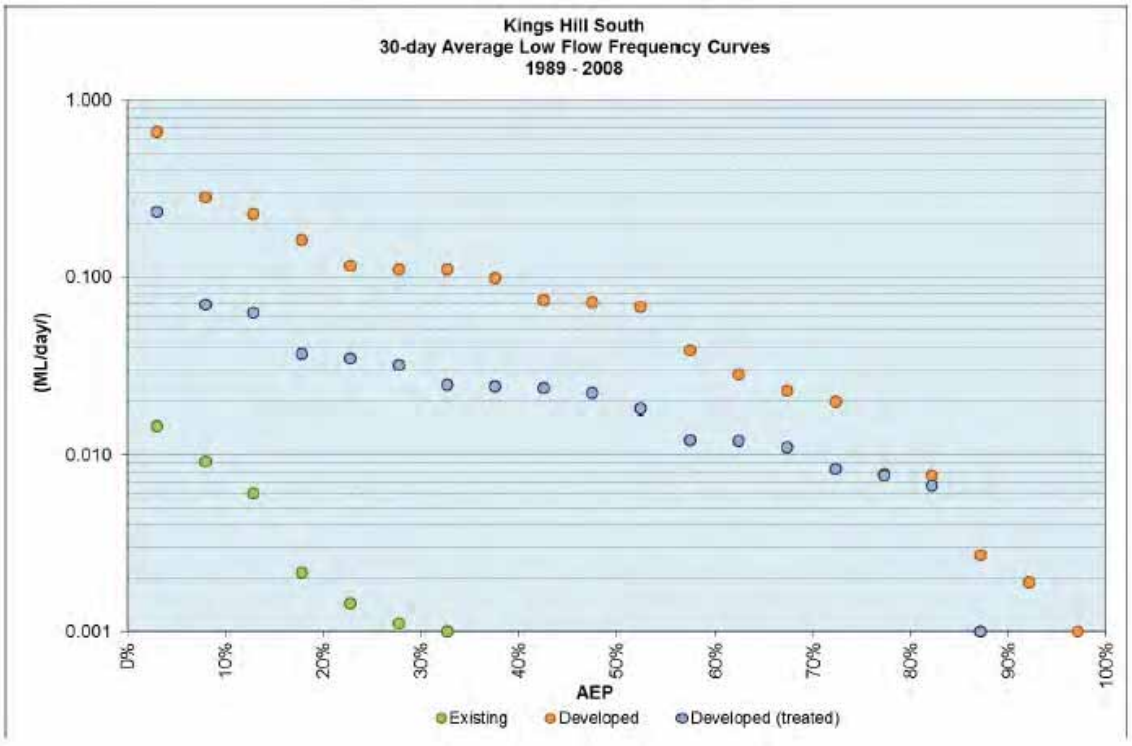


Figure 5.11 Kings Hill South: 30 day Average Low Flow Frequency Curve 1989 – 2008 (Alluvium 2019)

The low flow frequency curves indicate that the average daily flow during the 30 and 60-day low flow periods is expected to increase following development for the full range of dry to wet rainfall years. Again the stormwater management strategy proposed Northrop (2019) partially mitigates these increased low flows. For developed conditions, it is estimated that for all but very dry years, runoff will discharge into Irrawang Swamp from the developed catchments during the critical drying period. Whilst low flow discharges are likely to occur, the magnitude of the increased low flows and associated impacts on wetland vegetation inundation are expected to be low.

High flow conditions are expected to generate runoff volumes from Kings Hill South and Kings Hill West that will not change significantly from existing conditions as these would generally align with periods where soils would be saturated or close to saturation for extended periods. The main change from developed conditions would be that increased high flows from Kings Hill East will be directed to Irrawang Swamp along the diversion channel, whereas under existing conditions, these high flows will discharge directly into Grahamstown Dam. Although, during periods when dam storage levels in Grahamstown Dam are close to the spillway level, existing high flow discharges from Kings Hill East to Grahamstown Dam may indirectly discharge to Irrawang Swamp through the spillway (Alluvium 2019; **Appendix E**).

In a high rainfall year (10% AEP), as shown in **Figure 5.12**, the Kings Hill East development is estimated to increase average 7-day high flows by approximately 85 ML/day (600 ML over the 7 day period). For a typical rainfall year (50% AEP), the model results indicate that the Kings Hill East development and diversion drain would increase average 7-day high flows by approximately 40 ML/day (280 ML over the 7-day period) from Kings Hill East. Mitigation from treatment is not expected to have any significant effect (Alluvium 2019; **Appendix E**).

An increase in flow volume of 280 ML over 7 days represents an average depth of approximately 65mm across the total area of the swamp (estimated to be 450 ha from the SEPP 2018 mapping). This increased flow as a proportion of the average annual spillway flow from Grahamstown Dam to Irrawang Swamp is approximately 10%. This increase in flow is considered a conservative estimate, as it assumes that high flows from Kings Hill East that current drain to Grahamstown Dam do not contribute to existing spillway flows.

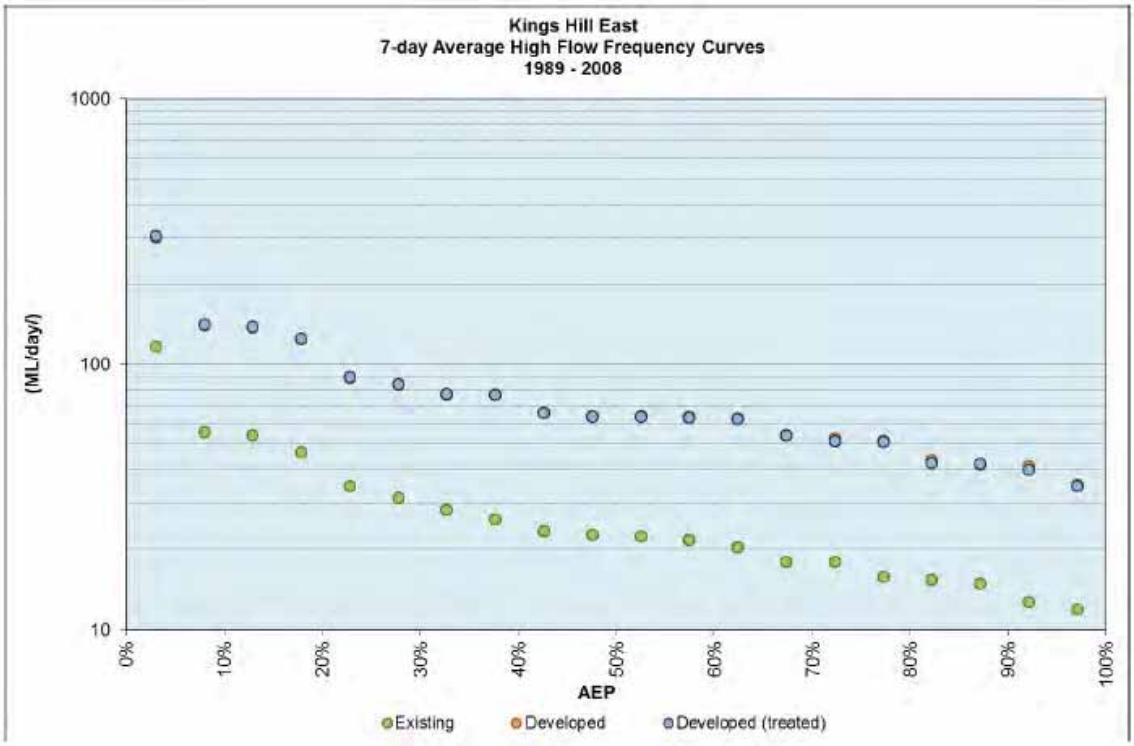


Figure 5.12 Kings Hill East: 7 day Average High Flow Frequency Curves 1989 – 2008 (Alluvium 2019)

In terms of the likely timing of these events, it is important to note that most spills from Grahamstown Dam to Irrawang Swamp have occurred during the wetter April to August period. It is during this period that increased high flow discharges from Kings Hill East are likely to occur and coincide with spills from Grahamstown Dam into Irrawang Swamp. Inflows from direct rainfall on the swamp and other local catchment inflows are also elevated resulting in wide-spread inundation across Irrawang Swamp (Alluvium 2019; **Appendix E**).

5.1.2.3.5 Impacts on Wetland Hydrology and Ecology

Irrawang Swamp and Wetland 803 contain a number of vegetation species that are susceptible to impacts from altered hydrological regimes. McManus et al (2007) outlines drying and flooding hydrology management targets for a range of wetland categories represented in Irrawang Swamp include Shallow Marsh, Deep Marsh and Forest Swamp - Ephemeral. These key vegetation communities will be most susceptible to changes in the drying hydrology over the critical September to March period (Alluvium 2019; **Appendix E**).

The dominant risks to the vegetation in Irrawang Swamp and Wetland 803 from hydrological changes include:

- Increases in periods of increased inundation depth; and
- Reductions in seasonal drying patterns.

Whilst the total runoff volume from Kings Hill East will increase, a high proportion of the increased runoff volume is expected to flow efficiently through and discharge out of the wetland through the existing flood gates to the Williams River. During critical drying periods, low flows from Kings Hill East would be significantly lower than the Pennington Drain capacity. It is expected that even with consideration of infilling of the channel over time, increased low flows from Kings Hill East will continue to drain in a relatively linear manner through Irrawang Swamp to the flood gates. It is expected that these diverted low flows would not impact on the northern Seasonal Swamp Meadow and Melaleuca Woodlands.

Increased annual high flow volumes from King Hill South are estimated to be minor and would have an insignificant impact on increasing water levels in Irrawang Swamp during high flow periods. There will continue to be seasonal dry periods in the Swamp Oak and Melaleuca Woodlands and Seasonal Swamp Meadow areas and estimated changes in inundation depths are within the ecological tolerance range of the vegetation communities.

The Swamp Oak Woodland in Coastal Wetland 803 in Kings Hill West reduced in extent and density by approximately 30% between 1954 and 2019. It is clear that the condition of this wetland has been impacted due to increased water retention resulting from construction of a bund across its outlet and cattle grazing. Controlling additional runoff to this wetland alone is unlikely to improve conditions for the remnant wetland vegetation. To improve conditions for this wetland, ensuring seasonal flow patterns and lowering of the existing outlet weir would be crucial for controlling seasonal water levels to reflect more natural levels. This would enable regeneration and healthy growth of the *Casuarina glauca* in the wetland that is more representative of natural conditions. Without removal of the cattle and lowering of the current water levels restoring the wetland to a more natural ecological condition is unlikely to be feasible (Alluvium 2019; **Appendix E**).

Notwithstanding, Alluvium (2019) indicate that increased runoff volumes could potentially create opportunities that support the HWC (2012) management objectives for Irrawang Swamp including:

- Increased flows support the ongoing management actions in Irrawang Swamp which aim to reduce the drainage efficiency of the wetland and increase retention of water in the landscape to assist the wetland to transition back to a more natural state.
- Increased runoff volumes could potentially be diverted from urban lakes and other stormwater storages in the Kings Hill development to irrigate additional habitat and biobanking areas on the fringes of Irrawang Swamp. Harvested stormwater during summer would assist with irrigating young plants and further reduce low flows closer to existing conditions.
- Increase availability of water within the wetland would provide opportunities for increased resilience during extended period of drought and as predicted climate change impacts occur.
- The flows replicate the existing conditions to seasonally saturate the soils in the Swamp Oak and Paperbark Woodland areas of Irrawang Swamp, providing the soil conditions for these vegetation communities ensuring their survival.

Incorporation of effective water sensitive urban design (WSUD) into all stages of the Kings Hill development will be very important for managing water quantity and quality from development areas. Water quantity management strategies should focus on reducing stormwater runoff during frequent smaller rainfall events. Measures including disconnecting impervious areas, oversized BASIX rainwater tanks, infiltrating biofiltration systems, stormwater retention and harvesting systems would all have a role to play at appropriate locations within the development. Ensuring that the majority of future runoff passes through appropriately sized stormwater retention/detention measures will be important for protecting ephemeral watercourses from erosion (Alluvium 2019; **Appendix E**).

Management of stormwater runoff quality will also be important for preventing coarse sediment, dissolved nutrients, fine sediment and other diffuse source stormwater pollutants from impacting on the wetland ecology. This includes effective measures (including regular inspections) in the subdivision construction, building construction and post development Phases (Alluvium 2019; **Appendix E**).

5.1.2.4 Increased sedimentation and erosion

The removal of vegetation, including both trees and grasses would increase the risk of sediment laden storm-water run-off that can smother vegetation, cause dieback of herbs and shrubs and reduce regeneration of groundcover species. Sediment and eroded material can also contain weed matter and nutrients. Operational activities also increase the risk of spills into the environment, specifically petroleum

based materials (e.g. fuel and hydraulic oils). Matters at greatest risk to terrestrial biodiversity that may be impacted by this factor are species and ecological communities that depends on water.

The site preparation works are to be managed in accordance with the VMP (**Appendix D**). The three steps in the vegetation clearing procedure are to have regard for the management of sediment and erosion through the retention of a minimum amount of vegetation cover to prevent soil erosion and mobilisation of sediment.

Notwithstanding, an effective water sensitive design is proposed (Northrop 2019) to manage water flowing through and off the site. Water is to be initially detained in 'detention basins' (Northrop 2019) then passed through biofiltration basin to remove sediment and reduce nutrient loading. Design and capacity of these systems are to be sufficient to meet agreed water quality targets for discharge into the environment. Music modelling by Northrop (2019) and wetland assessment by Alluvium (2019) (**Appendix E**) show that runoff from the site can be suitably managed from a volume and quality perspective such that downstream pathways are not adversely impacted.

5.1.3 Cumulative Impacts

The Proposal, which is situated within a broader precinct referred to as the Kings Hill urban release area (KHURA), comprises a large area of lands zoned for residential and business use nested within an area of environmental protection. The zoning of this land was gazetted in 2010 after consideration of impacts using the BioBanking Assessment Methodology (DECC 2009) as applied by EcoBiological (2009); a method integrating the consideration of landscape and site scale information. An overview of the EcoBiological (2009) assessment is provided in the following sections.

5.1.3.1 KHURA Rezoning Assessment

PSC commissioned EcoBiological in 2009 to evaluate the broader impacts of the KHURA. This was performed by reviewing existing fauna and flora studies for the KHURA including the consideration of supplementary ecological investigations, constraints assessment and the identification of a suitable offsets strategy. This review was based on the "maintain or improve test", as defined by Part 7A of the TSC Act, which quantifies and integrates the above landscape scale impacts into the assessment.

The EcoBiological (2009) assessment for the entire KHURA was performed in accordance with the BioBanking Assessment Methodology (DECC 2009) and was guided by three options, of which the current rezoning boundary (i.e. subject site boundary) reflects the second (i.e. inclusion of small reductions in the developable area accompanied by substantial offsets strategy). Option 2, as described by EcoBiological (2009) is as follows:

Option 2 – Adopt small reductions in developable area/provide substantial offset strategy package

Another strategy by which the development may proceed and receive successful concurrence of an SIS is by the adoption of a series of small reductions in the developable area, accompanied by a substantial offsets strategy package (both on- and off-site).

Several key areas for retention are discussed in section 5.1 and shown in Figure 9. Any reduction of bushland/wetland in the developable area will reduce the level biodiversity credits required and offset ratio using the BioBanking assessment methodology.

This option must be accompanied by an extensive offset and mitigation strategy as recommended in section 5.2. These are:

- *o Preparation of a Weed Management Plan*
- *o Revegetation of wildlife corridors*
- *o Offsite vegetation enhancement for the Koala*
- *o Rehabilitation of SEPP 14 wetlands on-site*
- *o Feral animal control plan*

- *o Koala overpass*
- *o Stock management*
- *o Nestbox program*
- *o Threatened species monitoring/research programs*

Of note is the general consistency between the above recommendations and the scope for this SIS as specified in the CERs for the Proposal. These matters are addressed in detail in **Section 7.1.2** of this report.

The third option considered by EcoBiological (2009) was a revised master plan to avoid all ecological constraints. For this option, EcoBiological (2009) concluded:

"If all the ecological constraints are excluded from the developable area, it is considered likely that a SIS would not be required" EcoBiological (2009).

However, this option required the exclusion of development in the western half of the KHURA. This was not adopted in the final zone boundaries for the KHURA, as Option 2 as reported in EcoBiological (2009), was regarded by PSC Council and Department of Planning and Environment at the time as the best 'on balance' option to promote the development of Kings Hill (i.e. use of limited amount of key habitat retention along with a significant offsetting package).

5.1.3.2 Landscape Factors

The BioBanking Assessment performed by EcoBiological (2009) used the following landscape scale factors as a proxy for the consideration of cumulative impacts:

- Remnant patch size;
- Width of connective pathways;
- Native vegetation cover within the local area; and
- Native vegetation per cent cleared for the corresponding Mitchell Landscape (**Section 2.1.2.1**).

A brief outline of these factors is provided in the following sections.

5.1.3.2.1 Remnant patch size

The size of the remnant patch used in the EcoBiological (2009) assessment was not stated. However, the rules that define the characterisation of the remnant patch size would preclude vegetation located east of the Pacific Highway and west of the Williams River floodplain (i.e. hostile barriers), but would include all vegetation north from wetland 804 to Italia Road. The vegetation cover within this area is ~2,266 ha (NPWS 2003), of which 2,009 ha is either dry/ wet sclerophyll forest or rainforest vegetation. Approximately 1,657 ha of this vegetation cover consists of MU 12 (Hunter Valley Moist Forest) or MU 16 (Seaham Spotted Gum Ironbark Forest), which are both classed as secondary habitat for the Koala (BioLink 2019d) and the two main vegetation types located within the Proposal impact footprint.

5.1.3.2.2 Width of connective pathways

EcoBiological (2009) did not state the width of the connective pathways, however, it is noted that in their recommendations that the KHURA should consider the integration of 100-150 m wide corridors. It is assumed that the maximum width class was assigned in the assessment (i.e. <500 m), with rezoning indicating a significant erosion in wildlife connective pathways to <30 m in places.

5.1.3.2.3 Local native vegetation cover

BioBanking assessments use assessment circles (i.e. 100 and 1,000 ha circles centred on the area of greatest change) to calculate nett change in vegetation cover at the landscape scale. The two assessment

circles used by EcoBiological (2009) broadly align with the extent of the study area used in this SIS with two notable differences:

- Vegetation located between Grahamstown Dam and the Pacific Highway is included in one of the assessment circles; and
- A large percentage of vegetation contained within the Eagleton rural-residential precinct is included in both assessment circles.

With the exception of lands in the Grahamstown Dam precinct, the calculation of the remnant patch size in the Eagleton rural-residential precinct overlap in the assessment.

5.1.3.2.4 Mitchell Landscape native vegetation

Overcleared (i.e. >70% to 90% of pre-European vegetation) and highly overcleared (i.e. >90% of pre-European vegetation) are quantitative thresholds that signify substantial loss in biodiversity values for a given region that comprises a set of similar climatic, soil and topographic conditions. As indicated in **Section 2.1.2.1**, the study area is located within the Newcastle Coastal Ramp Mitchell Landscape which has an area of ~150,508 ha.

Regional vegetation mapping indicates that 54% of the pre-European native vegetation cover is now absent from the Newcastle Coastal Ramp Mitchell Landscape. A further ~24,000 ha of native vegetation would need to be cleared for this Mitchell Landscape to be reclassed as overcleared. However, it is important to note that the local area comprises a disproportionate representation of the remaining vegetation in this Mitchell Landscape with at least 7% occurring in local conservation reserves/ state forest (i.e. Wallaroo National Park, Karuah National Park/ Nature Reserve, Medowie State Conservation Area, Columbey National Park and Wallaroo State Forest).

5.1.3.3 Regulatory Considerations

5.1.3.3.1 Coastal SEPP

In addition to the avoidance of impacts on wetlands, EcoBiological (2009) recommended a 50 m buffer around wetland 803 for the purposes of protect these habitats from indirect impacts. The Proposal has met and/ or exceeded this requirement. Sensitive stormwater management is proposed as part of the Proposal to minimise impacts from water inflows into wetland 803 and 804 to an extent that negligible indirect impacts are expected (Alluvium 2019; **Appendix E**). Revegetation works around wetland 803 are proposed to further improve the habitat integrity of this part of the site. Finally, the wetland 803 is to be integrated into a managed Conservation Area for in-perpetuity protection.

5.1.3.3.2 PSC CKPoM

The PSC CKPoM operates for the entire PSC LGA. All development having an impact on koala habitat is to be assessed in accordance with this management plan to avoid, minimise and mitigate any impacts on the Koala. The majority lands north of the subject site are mapped as Supplementary B/C Koala habitat meaning that Council is required to consider the protection of Koala habitat in that area. Given the known presence of Koalas in the area, mapped extent of habitat and the development controls applicable to the development of these lands and land zoning it is considered that the likely ongoing degradation/ loss of habitat within the local area is likely to be low. Therefore, it is considered that future cumulative impacts will be managed for the benefit of the Koala.

5.1.3.3.3 *Biodiversity Conservation Act* 2016

The *Biodiversity Conservation Act* 2016 has effect for all development requiring approval under the EP&A Act (Section 1.7 of the EP&A Act). Thresholds tests are applied to determine the level of assessment required under Part 7 of the Biodiversity Conservation Act 2016. Threshold tests applied to determine if a development or activity is “likely to significantly affect threatened species” are listed below:

- Impacts exceed the biodiversity offsets scheme thresholds (Section 7.2 of the BC Act); or
- Impacts are likely to significantly affect threatened species or ecological communities, or their habitats (Section 7.3 of the BC Act); or
- Impact on declared area of outstanding biodiversity value.

'Yes' to any of the above triggers a requirement for an impact assessment performed in accordance with the Biodiversity Assessment Methodology (BAM) by an Accredited Person (Section 7.7 of the BC Act).

In relation to 'exceeding the biodiversity offset scheme thresholds', two thresholds tests are applied, these being:

- Area cleared criteria; and
- Clearing within a mapped are of biodiversity Value.

The area cleared threshold generally restricted the clearing of vegetation to small areas for the purposes of building a residential dwelling or the like and associated bush fire asset protection zones. Clearing above and beyond these levels will result in a requirement for a detailed assessment under Part 7 of the BC act and an offset requirement. The same circumstance applies to development occurring within the biodiversity values map as shown in **Figure 5.13**.

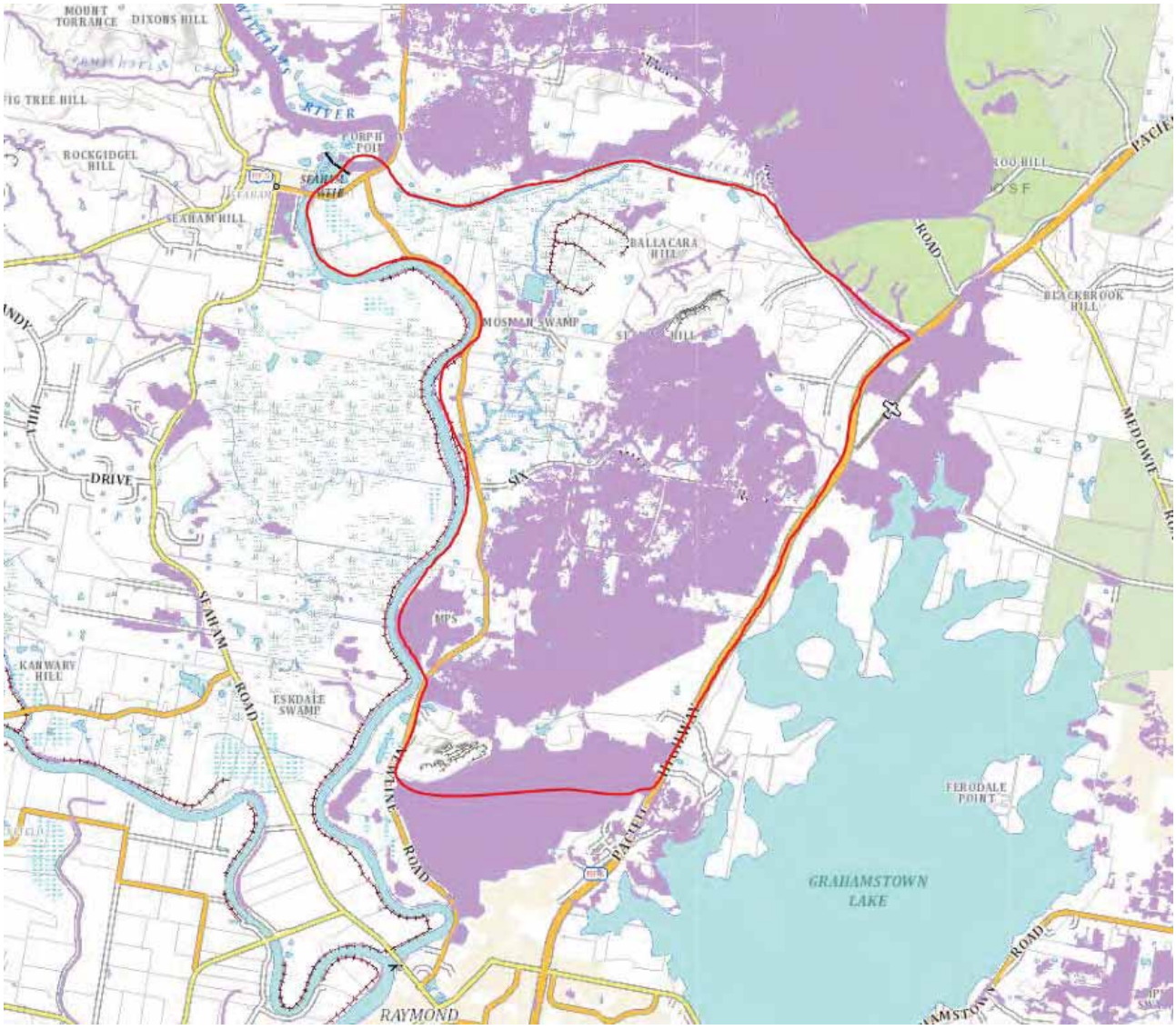


Figure 5.13 Biodiversity Values Map for the Locality (accessed 27 February 2020)

Based on the land zoning, land tenure and land capability it is considered unlikely that future large clearing events are to occur within the local area to an extent that would substantially alter the extent of native vegetation and habitat within the locality. Therefore it is considered that the propensity for land clearing and habitat loss will be limited and localised with associated cumulative impacts being of a minor and inconsequential effect.

5.1.3.4 Other Considerations

Other considerations included in the evaluation of cumulative impacts of the Proposal include:

- Lands owned by HWC to the south, which comprises a coastal wetland and natural areas, may be incorporated into an in-perpetuity conservation agreement at some point in the future; and
- Significant tracts of native vegetation north of the study area occur on private land holdings. Development on these lands are subject to the operation of various regulatory controls as described in **Section 5.1.3.3**.

It is considered that ongoing future land clearing and habitat loss will be limited and localised with associated cumulative impacts being of a minor and inconsequential effect.

5.1.4 PSC CKPoM

The Proposal is expected to result in the loss of 4,469 PKFTs over three phases, as outlined below:

- Phase 1 = 1,835 trees
- Phase 2 = 961 trees
- Phase 3 = 1,673 trees

Revegetation works are proposed to counter this loss of PKFTs as outlined below:

- **Revegetation planting in Phase 0 (Revegetation of cleared lands within the Conservation Area)**
  - Primary habitat creation: ~13,700 trees to be thinned to ~4,000 trees by year 10 (start of phase 3)
  - Secondary habitat creation: ~8,734 trees to be thinned to ~2,500 trees by year 10 (start of phase 3)
- **Revegetation in Phase 1 (detention basins)**
  - Primary habitat creation: ~1,700 trees to be thinned to ~500 trees by year 5 (start of phase 3)
- **Enrichment Plantings in Phase 0**
  - Secondary habitat creation = ~10,400 trees with ~80% success rate

The aim of this revegetation/ enrichment program is to establish ~4,500 trees classed as primary habitat and ~10,820 classed as secondary habitat by the start of Phase 3, resulting in the following outcomes:

- Establishment of Primary Koala habitat in place of Secondary Koala habitat loss comprising usable trees that exceeds the total number cleared (i.e. 4,469 PKFT loss and 4,500 PKFT gain);
- Enriched Secondary Koala habitat where at least 10,400 PKFTs are added to the Conservation Area for improved habitat utilisation and carrying capacity.

The 'carrying capacity' of the Conservation Area, as implied by the eucalypt nutrition analysis (Ford and Youngentob 2019; **Appendix I**), is sufficient to manage the short to medium term buffer for temporal impacts experienced during site preparation. That is, the Conservation Area has capacity to accommodate Koala use with minimal disruption to the Koala lifecycle and movement needs.

The following tables provide an assessment of the Proposal against the PSC CKPoM (PSC 2002), with the conclusion being the Proposal is consistent with the performance indicators specified in the CKPoM.

Table 5.4 Port Stephens CKPoM (2002): Information to Accompany Applications

Information Requirement	Response
An assessment of koala habitat, by a suitably qualified person, in accordance with the attached 'Guidelines for Koala Habitat Assessment', which appear in Section 5.5 (of the CKPoM)	The assessment of Koala habitat was prepared by known Koala experts including Dr Steve Phillips (BioLink), Ms Olivia Woosnam (OWAD), Dr Kara Youngentob, Dr Karen Marsh (ANU) and Dr Fiona Hogan (WildDNA). The assessment is a four step process (i.e. Preliminary Assessment, Vegetation Mapping, Koala Habitat Identification and Assessment of Proposal). This assessment is provided in **Table 5.5**.
Clear details concerning which vegetation is to be cleared or disturbed and that which is to be retained.	The Proposal will result in the removal of 212.14 ha of native vegetation comprising 152 ha of Koala habitat (BioLink 2019b) over an 8+ year timeframe. This habitat removal comprises 4,469 preferred feed trees over three Phases (Phase 1 = 1,835 trees, Phase 2 = 961 trees and Phase 3 = 1,673 trees). Refer to **Section 5.1.1** of the SIS for further details on the timing of vegetation removal by Phase. The Proposal will retain 231.19 ha of existing native vegetation (inclusive of 38.47 ha of impact avoidance measures) and 19.40 ha of revegetated lands with the majority of this vegetation to be retained in an in-perpetuity Conservation Area for the Protection of Koala habitat. The objective of the revegetation works is to provide high value Koala feed tree species [i.e. Swamp Mahogany (*Eucalyptus robusta*), Forest Redgum (*E. tereticornis*), Grey Gum (*E. punctata*), Grey Box (*E. moluccana*) and Tallowwood (*E. microcorys*)]. Refer to **Section 7.1.1.1** for further details on the revegetation process and expected benefit. No area of land is to be disturbed for the establishment of bushfire asset protection zone purposes (i.e. all vegetation retained in the Conservation Area is to be conserved as native vegetation and not encumbered by Bushfire APZs). Approximately 143 ha of vegetation within the Conservation Area is to be modified through intra forest tree plantings to 'enrichment' foliar nutrient at the stand scale. This long term mitigation has the purpose of increasing 'digestible nitrogen levels' at the forest stand scale for the purposes of improving retained vegetation as habitat for the Koala. Intra-forest plantings will include Forest Redgum (*E. tereticornis*), Grey Gum (*E. punctata*), Grey Box (*E. moluccana*) and Tallowwood (*E. microcorys*). Refer to **Section 7.1.1.2** of the SIS for further details on the enrichment process and expected benefit.
Details of any proposed building envelopes and fire fuel reduction zones and the means by which they are to be enforced	No building envelopes are proposed within areas of retained native vegetation. Allowances for bush fire APZs are within the Proposal impact footprint with no requirement for asset protection related fuel management within the Conservation Area. Fire management proposed in the Conservation Area are for the purposes of biodiversity management and are not relied on for the protection of assets within the Proposal impact footprint.
Proposed measures to restore or rehabilitate koala habitat, including measures which will result in the net gain of koala habitat	The Proposal includes the revegetation of 19.40 ha of cleared lands with the majority of this vegetation to be retained in an in-perpetuity Conservation Area for the Protection of Koala habitat. The objective of the revegetation works is to provide high value Koala feed tree species [i.e. Swamp Mahogany (*Eucalyptus robusta*), Forest Redgum (*E. tereticornis*), Grey Gum (*E. punctata*), Grey Box (*E. moluccana*) and Tallowwood (*E. microcorys*)]. Refer to **Section 7.1.1.1** for further details on the revegetation process and expected benefit. Approximately 143 ha of vegetation within the Conservation Area is to be modified through intra-forest tree plantings to 'enrichment' foliar nutrient at the stand scale. This long term mitigation has the purpose of improving 'digestible nitrogen levels' at the forest stand scale for the purposes of improving retained vegetation as habitat for the Koala. Intra-forest plantings comprising ~10,400 tree plantings will include high value preferred Koala feed tree species such as Forest Redgum (*E. tereticornis*), Grey Gum (*E. punctata*), Grey Box (*E. moluccana*) and Tallowwood (*E. microcorys*). Refer to

Information Requirement	Response
	Section 7.1.1.2 of the SIS for further details on the intra-forest tree planting enrichment process and expected benefit. The BMP (**Appendix C**) for the Conservation Area outlines how these plantings are to be implemented and managed. A nett gain outcome is proposed through the Proposal. Planting estimates and timing by Koala habitat type (i.e. Primary or Secondary) and mitigation type (i.e. revegetation or enrichment) are as follows: • **Phase 0 Revegetation of cleared lands** (expected ecological benefit obtained during Phase 2) Primary habitat creation = ~13,700 trees to be thinned to ~4,000 trees by year 10 (start of Phase 3) Secondary habitat creation = ~8,734 trees to be thinned to ~2,500 trees by year 10 (start of Phase 3) • **Phase 0 Enrichment of Conservation Area** (expected ecological benefit obtained during Phase 3) Secondary habitat creation = Establishment of ~10,400 koala feed trees • **Phase 1 Revegetation of Detention Basins** (expected ecological benefit obtained during Phase 3) Primary habitat creation = ~1,700 trees to be thinned to ~500 trees by year 5 (start of Phase 3) The revegetation/ enrichment works aim to result in the following outcomes (noting the Proposal is not proposing the removal of any Primary Koala habitat): • Long term establishment of ~12,900 preferred Koala feed trees classed as 'secondary habitat'; and • Long term establishment of ~4,500 preferred Koala feed trees classed as 'primary habitat'. The Proposal will result in the removal of 4,469 preferred Koala feed trees classed as 'secondary habitat', as shown in **Figure 4.73**, over three Phases (Phase 1 = 1,835 trees, Phase 2 = 961 trees and Phase 3 = 1,673 trees). The onset of ecological benefit from feed tree plantings is expected by the end of Phase 2. At this point, the Proposal would have planted ~ 34,534 Koala feed tree species with thinning prescriptions aiming to reduce this total to ~17,400 during Phase 3. Conservatively, by the end of Phase 2, a nett neutral outcome is expected following the onset of ecological benefit generated from Primary Koala feed tree plantings (i.e. planting of ~15,400 preferred Primary Koala feed trees versus Secondary Koala feed tree loss of 2,796 trees). However, a nett gain outcome is also possible should greater utilisation of Primary Koala feed tree species occur in addition to the use of some Secondary Koala feed tree plantings (i.e. no accounting for benefit derived from Secondary Koala feed tree plantings is relied on by the end of Phase 2). By the end of Phase 3 it is expected that further ecological benefit will be obtained from additional maturation of Primary Koala feed tree species plantings. Maturation of these plantings will involve the thinning of ~15,400 preferred Primary Koala feed trees to ~4,500 trees in this Phase 3 to achieve a more natural stand density (i.e. ~300 trees per hectare). The additional ecological benefit derived from the thinned Primary Koala feed tree plantings (~4,500 trees) is likely to match the total loss of Secondary Koala feed trees (i.e. 4,469 trees). On this metric alone, it is considered that a nett neutral outcome will be achieved by the end of Phase 3. Assuming a nett neural outcome is achieved by the end of Phase 3 through the planting of Primary Koala feed trees alone, it is considered that the ecological benefit from the planting of Secondary Koala feed trees (~12,900 trees after thinning) will represent a long term nett gain. This nett gain aims to be delivered through Phase 3 and beyond, with the timing of this benefit dependent on maturation rates and corresponding Koala utilisation. This nett gain will be retained within the in-perpetuity Conservation Area, which will be managed to ensure ongoing habitat occupancy by the Koala.
Proposed measures to allow the safe movement of koalas across the site including road designs	The Proposal incorporates in-perpetuity Koala habitat protection within the Conservation Area; and area that will allow for sustained habitat occupancy and movement. Corridors for movement have been strengthened over those provided for in

Information Requirement	Response
and speed mediation measures, fence construction details where fencing is proposed, and swimming pool specifications	the 2010 zoning approval (see **Figure 5.6**), with most of these corridors also having sufficient habitat area for individual occupancy. The strategic planting of Primary Koala feed tree species in detention basins adjacent to the Conservation Area and in the southeast will further improve corridor functionality, particularly with habitat located to the south adjacent to Irrawang Swamp. These revegetation works will likely improve the frequency of north south movements hence any potential interaction with other possible local corridor improvement works associated with the Old Irrawang spillway (see **Section 7.1.2.1.3**). A Koala fence separating the urban environment from the Conservation Area is proposed to prevent Koala interactions with domesticated dogs and vehicles (see **Figure 7.14**). This action has the purpose of controlling the incidence of mortality associated with these threats. Refer to **Section 7.1.1.6** for further details on the Koala fence and associated infrastructure.
Proposed measures to mitigate the impacts on koalas by dogs	A Koala fence separating the urban environment from the Conservation Area is proposed to prevent Koala interactions with domesticated dogs and vehicles (see **Figure 7.14**). This action has the purpose of controlled in the incidence of mortality associated with these threats. Similarly, this fence aims to prevent misadventure into residential lands where swimming pools may occur. Refer to **Section 7.1.1.6** for further details on the Koala fence and associated infrastructure.
Details of any proposed program to monitor koalas and koala habitat, during and following development activity on a site.	A monitoring program is proposed to evaluate the Proposals impacts on the Koala. The framework of a Koala monitoring program is outlined in **Section 7.1.3.1** with monitoring comprising annual surveys to *determine if the Koala remains in the Conservation Area and is breeding*. Details of the monitoring program are provided in the BMP (**Appendix C**).

The Guidelines for Koala Habitat Assessment [Section 5.5 of PSC (2002)] defines the four steps to be performed in a Koala Habitat Assessment. **Table 5.5** lists these steps and an overview response with cross-referencing to parts of the SIS.

Table 5.5 Port Stephens CKPoM (2002): Guidelines for Koala Habitat Assessment

Steps	Comment
1. Preliminary Assessment	The Koala Habitat Planning Map identified part of the subject site as comprising 'Preferred' habitat, '50 m buffer over marginal' habitat, 'Link over marginal' habitat and 'marginal' habitat. Further, the site inspection determined a wider presence of preferred Koala feed trees throughout the 'marginal' habitat. On this basis, the assessment is required to progress to Step 2.
2. Vegetation Mapping	A site specific vegetation map has been prepared using a variety of methods and data sources. Vegetation mapping nomenclature is in 'Plant Community Types'; a State wide classification scheme. Vegetation mapping was variously found as being inconsistent with LGA wide mapping; a finding consistent with BioLink (2019d) (i.e. progress to Step 3a). The occurrence of preferred Koala Feed Trees (PKFTs) has been mapped for the Proposal impact footprint, as guided by BioLink (2019a), which included all occurrences of *Eucalyptus robusta*, *Eucalyptus tereticornis*, *Eucalyptus propinqua*, *Eucalyptus punctata*, *Eucalyptus moluccana* and *Eucalyptus microcorys* with >300 mm DBH. The mapped location of these PKFTs is shown in **Figure 4.73**.
3. Koala Habitat Identification	(a)(i) Definitions for 'Preferred' and 'Supplementary' as detailed by Lunney et al. (1998) were tested confirming the importance of *Eucalyptus tereticornis*, *Eucalyptus propinqua*, *Eucalyptus punctata*, *Eucalyptus moluccana* and *Eucalyptus microcorys* as PKFTs within the subject site (Marsh and Youngentob 2019). PKFTs were defined by BioLink (2019b) as *Eucalyptus tereticornis*, *Eucalyptus propinqua*, *Eucalyptus punctata*, *Eucalyptus moluccana* and *Eucalyptus microcorys* with a diameter at breast height exceeding 300 mm. These were mapped for the Proposal impact footprint (see **Figure 4.73**) to determine the loss of these PKFTs over the term of the Proposal.

Steps	Comment
	(a)(ii) Koala habitat was mapped using the stadia metric survey to locate all results with each tree buffered by 10 m. Areas void of PKFTs were identified and excluded on the basis of Koala activity. Habitat mapping was performed by BioLink (2019b) (**Appendix G**) using stadia metric survey results obtained by RPS resulted in the identification of 152 ha of Koala habitat within the Proposal impact footprint as shown in **Figure 4.79**. (a)(iii) Habitat linkages between all patches of 'Preferred Koala Habitat' have been mapped where these patches are within 800m of each other. (b) The extent of individuals of preferred koala food trees have been mapped these being *Eucalyptus tereticornis*, *Eucalyptus propinqua*, *Eucalyptus punctata*, *Eucalyptus moluccana* and *Eucalyptus microcorys*. These results require progression to Step 4.
4. Assessment of the proposal	Refer to **Tables 5.4** and **5.6** and Statement of Environmental Effects (JW Planning 2020)

A response to the performance criteria for development applications is provided in **Table 5.6**.

Table 5.6 Port Stephens CKPoM (2002): Performance Criteria for Development Applications

Performance Criteria	Comment	Cross Reference
a. Minimise the removal or degradation of native vegetation within Preferred Koala Habitat or Habitat Buffers	Areas of preferred Koala habitat located within the impact area were identified (**Figure 4.79**). Preferred Koala Habitat removal has been minimised by incorporating 38.47 ha of habitat impact into a managed in-perpetuity Conservation Area (i.e. impact avoidance). This habitat is to be managed in accordance with a BMP to prevent degradation. Enrichment plantings within the Conservation Area will further reduce the risk of habitat degradation. Revegetation of Swamp Mahogany peripheral to the Conservation Area is to provide additional localised benefit for individual Koalas to minimise the effect of habitat removal on retained habitat. Corridors have been broadened to improve functionality.	**Table 5.4** **Figure 7.1** **Section 7.1** **BMP (Appendix C)**
b. Maximise retention and minimise degradation of native vegetation within Supplementary Koala Habitat and Habitat Linking Areas	Enrichment plantings within the Conservation Area will further reduce the risk of habitat degradation. Revegetation of Swamp Mahogany peripheral to the Conservation Area is to provide additional localised benefit for individual Koalas to minimise the effect of habitat removal on retained habitat. Corridors have been broadened to improve functionality.	**Table 5.4** **Figure 7.1** **Section 7.1** **BMP (Appendix C)**
c. Minimise the removal of any individuals of preferred koala food trees, where ever they occur on a development site. In the Port Stephens LGA these tree species are Swamp Mahogany (*Eucalyptus robusta*), Parramatta Red Gum (*Eucalyptus parramattensis*) and Forest Red Gum (*Eucalyptus tereticornis*). An additional list of tree species that may be important to koalas based on anecdotal evidence is included in Appendix 8 of the Port	The removal of utilised habitat has been minimised through impact avoidance measures and retained in the Conservation Area. No area of Swamp Mahogany is to be removed by the Proposal. Conversely, the Proposal aims to preferentially use this PKFT in revegetation works to create Primary Koala habitat, which is currently absent from the subject site. These revegetation works aim to generate a nett neutral outcome and are strategically aligned with areas of high value habitat retained within the Conservation Area to minimise localised disruption of habitat reconfiguration. Forest Redgum is to be removed, notably in the western half of the subject site where observed Koala activity is low. This area of Forest Redgum is characterised by high nutrient	**Table 5.4** **Figure 7.1** **Section 7.1** **BMP (Appendix C)**

Performance Criteria	Comment	Cross Reference
Stephens Council CKPoM (as recommended by the CKPoM Consultative Committee)	value with moderate to high herbivory deterrents (i.e. high FPCs), which may in part explain the low recorded Koala activity in this area. Commensurate habitat areas comprising Forest Redgum within the central parts of the Conservation Area is characterised by having high nutrient value and low to moderate herbivory deterrents; an area coincident with the greatest amount of observed Koala activity. These areas have been targeted for impact avoidance	
d. Make provision, where appropriate, for restoration or rehabilitation of areas identified as Koala Habitat including Habitat Buffers and Habitat Linking Areas over Mainly Cleared Land. In instances where Council approves the removal of koala habitat (in accordance with dot points 1-4 of the above waive clause), and where circumstances permit, this is to include measures which result in a "net gain" of koala habitat on the site and/or adjacent land	Habitat creation (i.e. revegetation using preferred Koala feed trees in cleared lands) and habitat enrichment is included as part of the amelioration measures for the Proposal. These measures are aim to achieve a 'net gain' over the life of the Proposal. It is expected that early revegetation works involving Swamp Mahogany, Forest Redgum and Tallowwood around wetland 803 will result in the establishment of ~4,000 Primary koala habitat trees. A further ~500 Primary koala habitat trees will be planted in detention basins peripheral to the Conservation Area and available to the Koala. A loss of 4,469 PKFTs in Secondary Koala habitat would be removed representing a nett neutral outcome. Revegetation and intra forest enrichment works will result in the establishment of ~12,900 trees within areas of Secondary Koala habitat. These trees will be retained within the in-perpetuity Conservation Area and managed. The establishment of these trees represent a nett gain, with the benefit realised in the long term (i.e. in Phase 3 and beyond). The maximum carrying capacity of the Conservation Area is sufficient to accommodate the progressive impacts of habitat removal [i.e. mean carrying capacity of 0.75 koalas/ ha (Marsh and Youngentob 2019)] with current densities being ~ 0.048 koala/ ha (BioLink 2019b). Reliance on this carrying capacity is only in the short term (i.e. impacts in Phase 1 and Phase 2), with nett gain outcome expected during Phase 3.	**Table 5.4** **Section 7.1** **Figure 7.3** **Figure 7.4** **Figure 7.5** **Figure 7.6** **BMP (Appendix C)**
e. Make provision for long term management and protection of koala habitat including both existing and restored habitat	Retained and restored habitat is to be vested in the Conservation Area, which is to be established and managed in accordance with a BMP (**Appendix C**) for the benefit the Koala. Stringent monitoring and performance criteria are specified. Adaptive management measures are proposed to address unforeseen outcomes. An in-perpetuity conservation mechanism is to be applied to manage and protect the biodiversity values within the Conservation Area.	**Table 5.4** **Section 7.1** **BMP (Appendix C)**
f. Not compromise the potential for safe movement of koalas across the site. This should include maximising tree retention generally and minimising the likelihood that the proposal would result in the creation of barriers to koala movement, such as would be imposed by certain types of fencing	Preferred and Secondary Koala habitat is to be retained in the Conservation Area. Corridors of widths greater than 100 m are integrated into key movement pathways. Fencing is proposed to prevent Koala movements in urban areas where threats are at their greatest. The Proposal will not compromise the safe movement of Koalas.	**Table 5.4** **Section 7.1** **Figure 5.6** **Figure 7.1** **Figure 7.11** **Figure 7.12** **Figure 7.13** **Figure 7.14**

Performance Criteria	Comment	Cross Reference
g. Be restricted to identified envelopes which contain all buildings and infrastructure and fire fuel reduction zone	These matters are incorporated into the Proposal impact footprint. There is no reliance on the Conservation Area for bush fire protection purposes.	N/A
h. Include measures to effectively minimise the threat posed to koalas by dogs, motor vehicles and swimming pools by adopting minimum standards for these threats	Perimeter exclusion fencing to minimise threats. Direct threats posed by wild dogs are to be managed through baiting programs. Indirect threats posed by herbivory by exotic fauna and weeds are to be addressed through weed and pest management programs. Road crossing infrastructure is to be incorporated into the road design where needed to prevent vehicle strike.	**Table 5.4** **Figure 7.14** **BMP (Appendix c)**

5.2 Assessment of Species Likely to be Affected

DGR 5.1 Assessment of species likely to be affected

An assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action (Section 110(2)(b)).

Affected species are defined within the SIS as subject species and populations likely to be affected by the Proposal. The impacts include the direct impact of loss of habitat through clearing and/or indirect impacts. Those species and populations and communities selected as "affected" include threatened fauna species that are known to occur within the subject site and adjacent study area and are known or likely to occur in the subject site, based on field surveys.

The following subject species have been considered most likely to be affected by the Proposal and are therefore assessed in subsequent sections of this section:

Threatened Flora

- *Corybas dowlingii* (Red Helmet Orchid);
- *Maundia triglochinoides* (Small Water-ribbons); and
- *Pterostylis chaetophora*.

Threatened Fauna

- Glossy-black Cockatoo (known);
- Brown Treecreeper (known);
- Varied Sittella (known);
- Little Lorikeet (known);
- White-bellied Sea Eagle (known);
- Square-tailed Kite (known);
- Osprey (known);
- Magpie Goose (moderate likelihood – not detected);
- Australian Bittern (moderate likelihood – not detected);
- Black Bittern (moderate likelihood – not detected);
- Dusy Woodswallow (known);
- Black-necked Stork (known from older records);
- Grey-crowned Babbler (known);
- Powerful Owl (known);
- Masked Owl (known);
- Regent Honeyeater (moderate likelihood – not detected);
- Swift Parrot (moderate likelihood – not detected);
- Squirrel Glider (known from older records);
- Koala (known);
- Brush-tailed Phascogale (known);
- Spotted-tailed Quoll (moderate likelihood– not detected);

- Grey-headed Flying Fox (known);
- Eastern Bentwing-bat (known);
- Little Bentwing-bat (known);
- Eastern Freetail-bat (known);
- Eastern False Pipistrelle (moderate likelihood – not detected);
- Greater Broad-nosed Bat (known); and
- Southern Myotis (moderate likelihood – not detected).

This list of species has been refined from the list of subject species (see **Sections 3** and **4**) based on the listing in the CERs, their known occurrence in and around the study area, their likelihood of occurrence, specific habitat requirements, results from surveys and the extent of impacts. The remaining subject species listed in **Sections 3** and **4** are not analysed further as they are not considered likely to occur in the study area (based on general species distribution information) and/or are not known to utilise the habitat types of the subject site.

The Koala, Brush-tailed Phascogale, Grey-crowned Babbler, Powerful Owl, White-bellied Sea-eagle, Grey-headed Flying Fox, Eastern Freetail-bat, Eastern Bentwing-bat and Little Bentwing-bat are classified as "affected species" as they have been recorded within the study area during recent surveys. The Eastern False Pipistrelle, Greater Broad-nosed Bat and Southern Myotis are classified as "affected species" as they were identified as likely to occur and would occupy habitats impacted by the Proposal. These species have similar bat calls as other common bat species and could not be positively identified, and as there are recent records within the locality, they have been included in the species likely to be affected by the proposal. The Spotted-tailed Quoll is included as an "affected species" due to previous database records for this highly mobile species being located within two kilometres of the study area despite this species not being detected within the subject site (OWAD 2019).

Two threatened flora species would be directly impacted by the proposal (*C.* × *dowlingii* and *Pterostylis chaetophora*). Small Water-ribbons (*Maundia triglochinoides*) was also recorded within the study area is likely to be indirectly impacted by the Proposal, and has therefore been further assessed in the following section for indirect impacts.

5.3 Analysis of Affected Species

DGR 5.2 Discussion of conservation status

For each species or population likely to be affected, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or threat abatement plan applying to it (Section 110 (2)(e)).

An assessment of whether those species or populations are adequately represented in the conservation reserves (or other similar protected areas) in the region (Section 110 (2)(e)).

An assessment of whether any of those species or populations is at the limit of its known distribution (Section 110 (2)(e1)).

DGR 5.3 Discussion of local and regional abundance

An estimate of the local and regional abundance of those species or populations (Section 110 (2)(d)).

DGR 5.3.1 Discussion of other known local populations

DGR 5.3.2 Discussion of habitat utilisation

DGR 5.5.5 Description of vegetation

DGR 5.4 Assessment of habitat

A full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region (Section 110 (2)(f)).

DGR 5.4.1 Description of habitat values

DGR 5.4.2 Extent of habitat removal

DGR 5.4.3 Consideration of corridors

DGR 5.4.4 Impacts on Threatened Species and/or Populations in National Parks Estate

5.3.1 Red Helmet Orchid

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	*Corybas dowlingii* is listed as Endangered under Schedule 1 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect *Corybas dowlingii*: • Clearing of native vegetation • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
c)	Habitat requirements	*Corybas dowlingii* forms clonal colonies and typically grows in gullies in tall open forest on well-drained gravelly soil at elevations of 10-200m (Jones 2004). It has been recorded within the local government areas of Cessnock, Great Lakes, Port Stephens and Hastings.
d)	Other documentation	No recovery or threat abatement plan has been prepared for *Corybas dowlingii*. Recent genetic research on the genus Corybas has identified that *Corybas dowlingii* as a natural stable hybrid between *C. aconitiflorus* and *C. barbarae* (i.e. *C.* × *dowlingii*) (see **Appendix K**). Wagner et al (2020) assess the conservation status of *C.* × *dowlingii* and determined it to be of 'least concern'. Following publication of this research, Dr Mark Clements is of the mind to recommend to the New South Wales, Threatened Species Scientific Committee that *C. dowlingii* be delisted as a "threatened" species from the New South Wales and Australian flora (Dr Clements pers coms).
e)	Assessment of adequacy of reservation	This species is under represented within conservation reserves. The species is known to occur within Columbey National Park (Bell 2019), Stoney Creek Reserve (Port Stephens Council reserve), Khappinghat Nature Reserve and Lake Innes Nature Reserve (Wagner et al 2020). It also occurs within a protected area at Alum Mountain (Bulahdelah) following translocation as part of the Bulahdelah bypass. The lack of records could also be due to insufficient surveys being undertaken for this species within conservation areas.
f)	Limit of known distribution	*Corybas dowlingii* is restricted to New South Wales where it is currently known from 4 localities including Port Stephens (2 localities), Bulahdelah and Freemans Waterhole south of Newcastle (NSW Scientific Committee 2008). Recent surveys have identified other occurrences in Columbey National Park (Bell 2019) and Awaba – Fassifern (RPS 2019).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	The known localities of *Corybas dowlingii* encompass a total extent of occurrence less than 1,000 km^2. Populations of the orchid at three of these locations occupy areas of less than a few hectares, while one of the populations at Port Stephens occupies approximately 50 ha. The geographic distribution of the species is therefore highly restricted. The Bulahdelah population of *C.*

DGR Matter	Comment
	dowlingii includes approximately 3,400 plants (Roads and Traffic Authority 2004), while the Port Stephens population at Soldiers Point includes approximately 15,000 plants (Okada 2006). The size of the Freemans Waterhole population is unknown. In relation to the latter, a recent study for 1,000 ha of native vegetation near Freemans Waterhole in the Awaba – Eraring locality resulted in the detection of an estimated 325,000 individuals of *C. dowlingii* at 2,132 locations (i.e. mean ~152 plants/ location) (RPS 2019 in prep.). This is in addition to numerous finds of this species in the Mandalong valley (RPS 2014). While not noted to occur in the conservation reserve network (NSW Scientific Committee 2007), *C. dowlingii* Bell (2009) has recorded it within Columbey National Park with a portion of the above-mentioned Awaba – Eraring population occurring within the Lake Macquarie City Council administered BioBank site. The number of individuals in Lake Innes Nature Reserve is unknown.
b) Discussion of habitat utilisation	Counts have identified 1,585 *Corybas dowlingii* individuals to occur within the subject site, which would constitute a 11% increase to the number of individuals known to occur in the Port Stephens LGA (15,000). This species is known to occur in sheltered areas such as gullies and southerly slopes in tall open forest on well-drained gravelly soil at elevations of 10-200 m. Survey information indicates *Corybas dowlingii* occurs in moist vegetation dominated by White Mahogany and Spotted Gum with well developed litter layer and low abundance of shrubs including Lantana. Incidence seems to reduce rapidly within and increasing occurrence of Lantana cover.
c) Description of vegetation	*Corybas dowlingii* is known to occur in dry sclerophyll forests (shrubby sub-formation), wet sclerophyll forests (grassy sub-formation) and wet sclerophyll forests (shrubby sub-formation).
3) Description of habitat values	The habitat occupied by this species is characterised by White Mahogany and Spotted with scattered Grey Gum. The understory is grassy herbaceous with well developed leaf litter layer. The presence of Lantana is limited and is seemingly more dense in peripheral areas where the species does not occur. The habitat has been previously influenced by logging and is currently impacted by feral deer grazing.
4) Extent of habitat removal	The Proposal will remove 4.66 ha of occupied habitat (30 m buffer from known individuals) comprising ~118 plants, with localised habitat avoidance achieved through sensitive design principles and micro-siting such as the use of existing tracks. Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. The majority of the habitat removal (i.e. greater than 66%) is to occur in Phase 3 following an initial isolated habitat loss of 1.52 ha in Phase 1. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 8.62 ha of occupied habitat containing ~1,467 individuals. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

DGR Matter	Comment
	The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the *Corybas dowlingii* in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.2 Small Water-ribbons

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	*Maundia triglochinoides* is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect *Maundia triglochinoides*: • Clearing of native vegetation • Herbivory and environmental degradation caused by feral deer • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
c)	Habitat requirements	This species occurs in permanent swamps and wetlands on the central and north coasts of NSW (NSW Scientific Committee, 2011d). It also occurs in lagoons, dams, channels, creeks or shallow freshwater 30-60 cm deep on heavy clay with low nutrients (OEH 2019b). It is known to be associated with other wetland species such as *Triglochin procerum* (OEH 2019b).
d)	Other documentation	No recovery or threat abatement plan has been prepared for *Maundia triglochinoides*.
e)	Assessment of adequacy of reservation	This species is well represented within conservation reserves with recorded locations in the Port Stephens LGA (Moffats Swamp Nature Reserve). The species is recorded in Moffats Swamp Nature Reserve, Lake Innes Nature Reserve, Goolawah National Park, Hat Head National Park, Yuraygir National Park and Everlasting Swamp National Park.
f)	Limit of known distribution	*Maundia triglochinoides* is restricted in its distribution to coastal New South Wales, also extending into southern Queensland (NSW Scientific Committee 2011d). The current southern limit is Wyong (OEH 2019a).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	A total of 18 records for *Maundia triglochinoides* occur within the Port Stephens LGA, with the known occurrences of this species occurring in public or private lands, with individuals located near Seaham, Medowie, Tomago and Williamtown. It also occurs within Hexham Swamp. There are no mapped occurrences of this species within conservation reserves in the LGA. An estimated 500 plants have been recorded near the intersection of Newline Road and Six Mile Road. A further 1,000 individuals have been recorded at Medowie and 1,000 in the Balickera Channel to the north. Plants are known to occur within the Tomago aluminium smelter buffer zone and are likely secure and excluded from impact (Kleinfelder 2019).
b)	Discussion of habitat utilisation	*Maundia triglochinoides* naturally occurs on floodplains in coastal districts throughout its range with much of this habitat now modified for agriculture. This species generally occurs in lagoons, dams, channels, creeks or shallow freshwater 30-60 cm deep on heavy clay with low nutrients (OEH 2019b). Further, the species is quite palatable to livestock (Mark Aitkens pers com.) and as such is preferentially grazed when occurring within modified agricultural precincts. Habitat occupancy by this species outside its natural undisturbed habitat of coastal swamps and lagoons is often associated with drains and dams in agricultural precincts. Several wetlands and dams occur within the study area where habitat is available for this species to occupy. Surveys have found this species in three closed depressions (dams) with one of these elevated well above the floodplain and nested within dry sclerophyll forest. Individuals occupying the dams on or adjacent to the floodplain are exposed to constant livestock grazing and have consequently suffered. The number and extent of these plants varies considerable in accordance with fodder availability, with heavy grazing trampling observed during dry times as livestock

DGR Matter	Comment
	frequently enter the water bodies as it dries. The third occurrence elevated well above the floodplain is less frequented by livestock and consequently supports a larger number of plants.
c) Description of vegetation	Within the study area *Maundia triglochinoides* occurs in anthropogenic made closed depressions and as such is imbedded in various PCTs where it is not naturally occurring. It occurs with other native macrophytes commonly found in closed depressions such as *Cycnogeton microtuberosum* and *Typha orientalis*. The presence of Alligator Weed is also noted and is possibly impacting its occupancy of available habitat.
3) Description of habitat values	Permanent water is a required component for the survival of this species. Wetlands within the subject site are degraded and have high occurrences of weeds such as the Weed of National Significance, *Alternanthera philoxeroides* (Alligator Weed) that is present at all locations of Swamp Oak Forest. Cattle, horses and goats are all grazing within the subject site and frequently visit the closed depressions and wetland areas, also contributing to the decrease in condition through trampling and diminishing water volume/ area particularly during dry times.
4) Extent of habitat removal	Individuals of *Maundia triglochinoides* may be removed as a result of the Proposal through the establishment of a potential detention basin where the dam occurs. While it is a resilient species as shown by its occurrence in agricultural precincts and response to impacts from livestock (e.g. trampling and grazing), the impact of constructing detention basins is not known. Appropriate micro siting of the detention basin and mitigation measures are required to ensure minimal indirect impacts to this species. Occupied habitat located within the Conservation Area will be managed through the removal of livestock and Alligator Weed. These interventions alone aim to facilitate the re-occupation of available habitat as the effects of grazing, trampling and water loss from livestock activity will be removed. The removal of Alligator Weed is also necessary and will provide opportunity for habitat reoccupation.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.

DGR Matter	Comment
6) **Impacts on Threatened Species and/or Populations in National Parks Estate**	This proposal is considered unlikely to impact on any individuals of the *Maundia triglochinoides* in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.3 Taree Rustyhood Orchid

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Taree Rustyhood Orchid (*Pterostylis chaetophora*) is listed as vulnerable under Schedule 2 of the TSC Act
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Taree Rustyhood Orchid: • Clearing of native vegetation • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
c)	Habitat requirements	The NSW Scientific Committee (2014) describes the preferred habitat of *Pterostylis chaetophora* as "seasonally moist, dry sclerophyll forest with a grass and shrub understorey". Supplementary observations from habitat occupied as observed in the annual *Saving our Species* monitoring program (Bell 2019) provide a more regionally specific characterisation of habitat viz.: • Columbey National Park: "open forest of *Eucalyptus moluccana*, *Eucalyptus fibrosa*, *Eucalyptus umbra*, *Corymbia maculosa* and dense *Melaleuca nodosa* thickets" [EPS (2018) in Bell (2019)]; • Bundabah: "dense *Melaleuca nodosa* regrowth following a past clearing event" with widely scattered *Corymbia maculata* and *Eucalyptus fibrosa*; • Grahamstown Dam: "open area amongst tea tree forest in clay loam"; and • Black Creek: vegetation generally described as dominated by *Eucalyptus crebra* and *Corymbia maculata* on higher slopes and rises, with lower slopes and gullies dominated by *Eucalyptus tereticornis*, *Angophora floribunda* and *Eucalyptus crebra*. The fungus on which the orchid depends occurs in a matrix in bushland where it preferentially inhabits the more exposed partially bare areas of depauperate soils where there is typically less competition from other fungi and many plant species. In these micro-habitats there is sufficient cellulose material such as the dead roots of grasses or herbs for the fungus to grow and produce metabolites such as sugars. It is these nutrients that the orchids exploit through parasitising of the fungal hyphae that invade the orchid stem collar cells (Dr Mark Clements pers. comm. 2019). In addition to the importance of bare ground, observations of occupied habitat at Kings Hill and more broadly in the local area (i.e. Grahamstown West, Wallaroo State Forest and Columbey National Park) have provided insight into the identification of micro habitat conditions important to the occurrence of this fungus. These include: • Presence of tufted perennial C4 native grasses; a ground stratum structure where inter-tussock spaces appear to support the perennial presence of bare earth. Kangaroo Grass (*Themeda triandra*) was always observed in association with *Pterostylis chaetophora*. Other similar species observed include Barbed-wire Grass (*Cymbopogon refractus*). Further, it is hypothesised

DGR Matter	Comment
	that these perennial C4 grasses provide a reliable source of cellulose material, particularly in the cooler moister months where growth by the symbiont fungus is most likely. • Absence or low abundance of C3 native grasses. Typically, these grasses tend to dominate the ground surface during the winter – spring period at a time coincident with orchid emergence and reliance on the symbiont fungus. It is possible that structural crowding by these grasses and limited cellulose supply at this time of year (i.e. production of live green material) may potentially minimise fungus incidence and/ or growth at a crucial stage of the orchid's lifecycle (i.e. preparation for flowering in spring). • Absence of exotic grasses. It is hypothesised that the symbiont fungus is poorly associated with exotic grass species. • Thin and incomplete leaf litter layer that maintains the occurrence of bare earth patches. Excessive leaf litter accumulations extinguish the localised perennial presence of bare ground thereby limiting successful soil inoculation by the symbiont fungus. • A species rich mix of tree species with open forest structure and canopy gaps was routinely observed in association with *Pterostylis chaetophora* incidence. Species include Grey Box (*Eucalyptus moluccana*), Ironbarks [mostly Broad-leaved Ironbark (*Eucalyptus fibrosa*)], Forest Redgum (*Eucalyptus tereticornis*) and Spotted Gum (*Corymbia maculata*). Interestingly, the latter species was never dominant. Forests dominated by Spotted Gum are often characterised by relatively deep litter layer development due to the quantum of bark and leaf shedding often associated with this species (i.e. reduced potential for bare earth patches to develop and persist). The proximal incidence of *Melaleuca nodosa*. The presence of this species, which is likely linked to imperfectly drained soils, could represent favourable soil conditions for *Pterostylis chaetophora* locally retaining elevated soil moisture levels after sufficient autumn – winter rainfall events. This habitat preference may be important in the perennial survival of orchid tubers and also serve to activate flowering events (OEH 2017).
d) Other documentation	*Pterostylis chaetophora* belongs to group within the subtribe Pterostylidinae commonly referred to as Rustyhoods or Rufa Greenhoods (Jones 2006). In 2001 a Polish botanist created the genus *Oligochaetochilus* Szlach. Into which all species in this group have since been transferred. All subsequent detailed molecular and morphological analyses of Pterostylidinea has supported the recognition of *Oligochaetochilus* as a very strongly supported, morphologically distinct and easily recognised monophyletic group (Jones and Clements 2002; Webb et al., unpublished). Currently *Oligochaetochilus* comprises 62 described species (APNI) distributed across southern and eastern Australia from Shark Bay, Western Australia to Blenco Falls inland from Cardwell in north Queensland (Atlas of Living Australia). Species in the genus are adapted to semi-arid to arid habitat throughout these areas and are amongst the most arid loving and drought tolerant orchids in Australia. Key adaptations of this group include: • A subterranean root tuber storage organ that is replaced annually [even if the plant does not appear above ground in severe conditions] • Associated and dependence on a mycorrhizal fungus (*Ceratobasidium sp. aff. cornigerum*) that annually invades the underground stem collar cells, just below the rosette, and from which the orchid derives much of its nutrients. • Leaves forming a rosette appressed to ground protecting area of mycorrhizal activity in early part of season then, drying at the commencement of growth of the inflorescence or at anthesis. • Dull reddish-green or brown coloured flowers inconspicuous to many herbivores.

DGR Matter		Comment
		• Multiple flowers per raceme for increased likelihood of pollination • Specific Mycetophilideae Fly pollinators attracted by psueodpheromone emitted by flower and insectiform labellum that mimics female fly. • High seed production ~ 3,500-4,000 seeds per each fertilised flower from each pollination event; • Flower height (i.e. elevated position to aid in seed dispersal potential); • Dark seeds with sclerophied seed coat to resistant to desiccation during the following dispersal during the hotter drier months of the year. The germination and establishment of seedlings and continued survival of *Pterostylis chaetophora* plants is solely dependent on its relationship with the symbiotic fungus *Ceratobasidium sp. aff. cornigerum* (Dr Mark Clements pers. coms. 2019); this being consistent with findings from earlier mycorrhizal – Pterostylis studies (Warcup 1981) and numerous subsequent studies on the subject [e.g. Rasmusen (1995)]. Without this fungus, *Pterostylis chaetophora* is unable to germinate and establish new plants and continue to grow and reproduce in the wild. Nourishment gained from this fungus is through specialised cells located in the stem collar situated in the underground stem apex and below the leaf bases. Flowering is predetermined each year dependant on the size of the tubers in mature plants. Typical each year adult plants grow to maturity to facilitate sexual reproduction whilst concurrently gaining sufficient nutrients for healthy seed production and asexual reproduction through tuber replacement. In drought years, *Pterostylis chaetophora* may limit reproduction to tuber replacement only (Dr Mark Clements pers. coms. 2019).
e)	Assessment of adequacy of reservation	This species is under represented within conservation reserves, with occurrences known in Columbey National Park which is known to contain 370 plants and has potential for many thousands (Bell 2009). Occurrences is also within Wallaroo National Park, although extent and plant counts are not known.
f)	Limit of known distribution	The local occurrences of this species fall within the species extent of occurrence, where habitat occupancy is restricted to dry sclerophyll forest with a coastal/ sub-coastal distribution from Denman and North Rothbury to Gympie in Queensland (NSW Scientific Committee 2014). Database records of this species in western Sydney are incorrectly identified and should be known as *Pterostylis saxicola* (pers com Dr Mark Clements). Occurrences in the northern extent of the range are suspected to represent a different taxon (Bell 2019); however, there are no morphological indicators supporting this assertion with any difference likely to be limited to genetic variation (Dr Mark Clements pers. coms.).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	The local population is defined by specimens within the study area, Grahamstown Dam, Wallaroo State Forest and National Park and Columbey National Park. The species is known to occur within the western parts of the Grahamstown Dam catchment where 'hundreds of plants' are known from a 100 m^2 area (NSW Scientific Committee 2014). This species exhibits a widespread distribution in Columbey National Park where 370 individuals have been recently detected within 63 sub-populations (Bell 2019). Other nearby occurrences include two locations peripheral to Wallaroo State Forest (Mark Aitkens and Shawn Ryan pers obs 2019); although the total number of individual plants for this state forest and adjoining Wallaroo National Park were not recorded and remains unknown. This species is part of the '*Saving our Species'* program where it is managed at six sites known as Purfleet (Mid-Coast LGA), Columbey National Park (Dungog LGA), Bundabah (Mid-Coast LGA), Rainbow Flat (Mid-Coast LGA), Grahamstown Dam (Port Stephens LGA) and Black Creek (Cessnock LGA) (BCD 2019). Annual monitoring is performed at four of these sites (Bell 2019).

DGR Matter	Comment
b) Discussion of habitat utilisation	A disturbance history of some kind was also noted at all occupied sites indicating a possible positive relationship with this factor. Disturbances noted in occupied habitat are varied and include formed and infrequently managed electricity and road easements, wheel rutting in association with localised hard setting soils, quarrying and soil mounding. This is contrary to the NSW Scientific Committee (2014), which identifies disturbance such as road works, rubbish dumping and uncontrolled vehicle access as a threat to this species, occurrences within the study area, Grahamstown Dam, Wallaroo State Forest and Columbey National Park all indicate a with disturbance. It is possible that surface disturbances, exposing subsurface, depauperate soil layers may locally provide conditions suitable for the fungus *Ceratobasidium sp. aff. cornigerum* (i.e. extent and/ or presence of bare earths). While it is accepted that some disturbance types are detrimental (e.g. physical covering and/ or excavation of tubers), disturbances promoting the presence and/ or extent of suitable microhabitat conditions, such as removal of thick vegetation and soil surface exposure, may locally amplify orchid numbers. Time since disturbance may also be an important factor in determining occurrence. All areas occupied by *Pterostylis chaetophora* sites appear to coincide with relatively stable landforms where the effects of prior disturbance and associated erosion activity is greatly reduced. Evidence of landform stability was evident by the relatively high abundance of crypotgams (e.g. moss gardens), crust formation on bare earths (i.e. limited evidence of active erosion), high rock cover (i.e. provides abiotic rain splash protection thereby reducing the incidence of erosion) and presence of longer lived vascular plants that respond to disturbance through seed (e.g. Fabaceae: *Daviesia ulicifolia* and *Pultenaea villosa*) and root suckering (e.g. *Melaleuca nodosa*). Surveys of likely habitat within study area (i.e. PCT 1590 with suitable soil and plant species occurrences) and in Columbey National Park (Bell 2019) indicate a naturally low density within undisturbed habitat [e.g. 2.8 orchids per hectare in Bell (2019)]. In light of the broader observations outlined, this further supports positive role of disturbance in the species lifecycle (i.e. disturbance being a pulse event favouring the occurrence of synchronous close proximity flowering to maximise the likelihood of seed set, production and propagule establishment). Naturally operating disturbances may include bioturbation by ground mammals (e.g. diggings by Bandicoots and Short-beaked Echidna), tree fall involving root ball exposure and fine scale mosaiced fire patterns.
c) Description of vegetation	*Pterostylis chaetophora* is limited to PCT 1590 where micro habitats favouring the presence of *Ceratobasidium sp. aff. cornigerum* occur; a fungus this species is dependent on (Dr Mark Clements pers coms).
3) Description of habitat values	Observations from the subject site, Bell (2009) indicate *Pterostylis chaetophora* prefers Spotted Gum Ironbark forests. Factors controlling habitat occupancy depend on a suite of specific micro habitat conditions notably a mycorrhizal fungus and its habitat preferences (Dr Mark Clements pers. com.). Habitat indicators include patches of Melaleuca nodosa, bare earth with limited leaf litter cover, presence of cryptogams (i.e. mosses), occurrences of Grey Box and groundcover species such as Kangaroo Grass, Barbed Wire Grass and *Daviesia ulicifolia*, with the latter species often an indicator of some king of historical disturbance be it either nature (i.e. sheet erosion) or track construction.
4) Extent of habitat removal	The Proposal will remove 1.41 ha of occupied habitat (30 m buffer from known individuals) comprising ~20 plants. Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. The majority of the estimate habitat removal (i.e. ~60% of 1.41 ha) is to occur in Phase 1 following consecutive 20% losses in Phases 2 and 3. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 4.36 ha of occupied habitat containing ~470 individuals. The Conservation Area is to be established during Phases 0 and 1 through

DGR Matter	Comment
	implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the *Pterostylis chaetophora* in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park and Wallaroo National Park.

5.3.4 Glossy-black Cockatoo

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Glossy-black Cockatoo (*Calyptorhynchus lathami*) is listed as vulnerable under Schedule 2 of the TSC Act
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Glossy-black Cockatoo: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	The Glossy-black Cockatoo occurs in many vegetation types, from woodland and open sclerophyll to tall open wet forest and rainforest. This species can survive in fragmented landscapes, however it requires large tracts of native vegetation for breeding (OEH 2019b). However, the key limiting resource that constrain its foraging extent are Allocasuarina spp. This bird feeds almost exclusively on seeds of several species of Casuarina and Allocasuarina (collectively known as Sheoak). The Glossy-black Cockatoo feeds primarily on seeds from Black Sheoak (*Allocasuarina littoralis*) and Forest Sheoak (*A. torulosa*) in areas near the coast (OEH 2019b). Hence, PCTs that offer these Allocasuarina may constitute suitable habitat, provided these feed trees are in high enough abundance (typically dense stands of Sheoak are required). However, for optimal habitat, to satisfy both feeding and breeding requirements, Glossy-black Cockatoo requires forests and woodlands with large hollows within which it nests. Specifically, Glossy-black Cockatoo prefers to nest in large old hollows within living or dead eucalypts, located >5m above the ground (DEC 2006; OEH 2019b). These nesting sites are best located nearby these stands of *Allocasuarina* spp. to support the fledging process, whereby young require food resources nearby the nest.
d)	Other documentation	No recovery or threat abatement plan has been prepared for the Glossy-black Cockatoo. Within the Saving Our Species (SoS) program, Glossy-black Cockatoo has been assigned to the Landscape species management stream, which aims to ensure it is secure in the wild in NSW and that its NSW geographic range is extended or maintained. A targeted strategy for managing this species has been developed under the SoS program, however the subject area has not been identified as a key management site.
e)	Assessment of adequacy of reservation	Across the state, 10% of the species' distribution occurs on reserve (within NSW National Parks and Wildlife Service estate). Throughout the greater North Coast Bioregion, the Glossy-black Cockatoo occurs in many conservation reserves. These reserves include Barrington Tops National Park, Myall Lakes National Park, Wallaroo State Forest, Wallaroo Nature Reserve and Karuah National Park. Habitat conserved within these reserves offers stable and long-term security for Glossy-black Cockatoo. Combined, these nature reserves protect over 1200 km^2 of bushland, much of which is woodland and forest that can support Casuarina spp. feed trees and provide large hollows associated with old-growth Eucalyptus sp. Although adult Glossy-black Cockatoo are known to have large foraging ranges, reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the local region.

DGR Matter		Comment
f)	Limit of known distribution	The Glossy-black Cockatoo is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina. An isolated population exists on Kangaroo Island, South Australia. the subject site falls within the known distribution of this species.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	Although Glossy-black Cockatoo were not observed during the fieldwork, chewed Orts were identified within *Allocasuarina* spp. stands suggests this species at least facultatively uses the site (**Figure 4.30**). A search of species sightings within the local area (that is, within 10 km of the site), suggested that this species at least infrequently occupies the area, since 28 observations of this species have been made here. Eight of these records occurred in or very nearby the site (Atlas of Living Australia, 2019). Hence, although the size of the local population is difficult to ascertain, it appears the footprint of the Proposal does at least contribute to supporting a local population.
b)	Discussion of habitat utilisation	The records of Glossy-black Cockatoo within 10km of the site are highly dispersed, suggesting the habitat used by this local population is widespread, rather than concentrated within a particular area. Nevertheless, it is worth noting that although the habitat description for this species captures a wide range of forest and woodland habitats, the availability of dense *Allocasuarina* spp., which provides a critical food resource, and hence is a limiting factor that defines areas of its occupancy. This is consistent within the subject site, with the signs of Glossy-black Cockatoo (i.e. chewed orts) restricted only to the area where *Allocasuarina* spp. are present. HWR (2004) report two Glossy-black Cockatoos within the subject site with limited evidence of feeding activity in the limited area of *Allocasuarina torulosa* located in the north of the subject site, suggesting that the usage of the study area is minor.
c)	Description of vegetation	Habitat for Glossy-black Cockatoo exists where a dense patch of *Allocasuarina* spp occurs within part of PCT 1590. The extent of this patch of Allocasuarina spp. is 33.16 ha. This area of occupancy appears to be highly restricted to one patch of vegetation, located within the northern section of the subject site (**Figure 4.46**). This area appears to at least support foraging of this species, since signs of Glossy-black Cockatoo (i.e. chewed orts) were restricted to this area only. Although nesting or roosting was not observed, three large hollow-bearing trees within this patch of Allocasuarina spp. may infrequently support breeding of this species. Further detailed descriptions of the characteristics of this PCT can be found in **Section 4.3.2.1**. The habitat polygon for Glossy-black Cockatoo, which captures this dense stand of Allocasuarina spp. and three significant hollow-bearing trees, are shown in **Figure 4.46**.
3)	**Description of habitat values**	Two habitat values influence the occupancy of habitat by this species these being food resources (Allocasuarina spp.) and large, hollow bearing trees for breeding. Both these habitat values are present on site although very limited. Signs of foraging of foraging of this species were only observed, and not breeding, suggesting the site primarily supports foraging of this species. Notably, no breeding of Glossy-black Cockatoo was observed, despite the intensity of surveys undertaken during the nesting period for this species. Nevertheless, three large hollow-bearing trees were identified within close proximity to the dense tract of Allocasuarina spp., which periodically supporting nesting of Glossy-black Cockatoo. The foraging resources are largely constrained to a dense patch of Allocasuarina spp., located within the northern section of the subject site. However, past disturbance is likely to reduce the extent of suitable habitat on site for Glossy-black Cockatoo due to cleared for pre-existing land uses, including pastoral land and tracks. Even the uncleared areas, including the dominant varieties of Spotted Gum – Ironbark Woodland, have been exposed to varying degrees of modification and disturbance. Disturbances

DGR Matter	Comment
	have included the grazing and movement patterns of cattle, horses and goats, as well as incursion of weeds such as *Lantana camara*.
4) Extent of habitat removal	A maximum impact of 29.83 ha of suitable foraging habitat comprising three possible nesting trees (not currently utilised) will be removed as a result of the proposal, as defined above. This is limited to the fringes of larger tracts of vegetation within the study area, which have been identified as those offering Allocasuarina spp. food resources. Although breeding of Glossy-black Cockatoo was not observed on site, three large hollow bearing trees that may periodically serve as breeding habitat are to be impacted by the proposal. Based on the extent of suitable habitat on the subject site, and high availability of suitable habitat resources in the region, the habitat removal to result from the proposal is not considered to be significant to the viability of the species or nor for the survival of the species within the locality.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Glossy-black Cockatoo in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.5 Brown Treecreeper

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Brown Treecreeper (*Climacteris picumnus victoriae*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Brown-treecreeper: • Clearing of native vegetation • Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala* • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees • Predation by the Feral Cat *Felis catus*
c)	Habitat requirements	Brown Treecreeper requires hollows in standing dead or live trees and tree stumps to nest. It uses a diverse range of woodland areas to forage for insects amongst leaf litter, tussocks and fallen timber, and along trunks and lateral branches. Brown Treecreeper requires a territory rage of 1.1 to 10.7 ha (OEH 2019), however it is considered sedentary within this area.
d)	Other documentation	A targeted strategy for managing this species has been developed under the Saving Our Species program, however the subject area has not been identified as a key management site. Brown Treecreeper has been assigned to the Landscape species management stream under the Saving our Species (SoS) program, which aims to ensure it is secure in the wild in NSW and that its NSW geographic range is extended or maintained.
e)	Assessment of adequacy of reservation	Across the State, 3% of the species' distribution occurs on reserve (within NSW National Parks and Wildlife Service estate). Locally, habitat for Brown Treecreeper occurs in many conservation reserves throughout the greater North Coast Bioregion. These areas include Barrington Tops National Park, Myall Lakes National Park, Wallaroo State Forest, Wallaroo Nature Reserve and Karuah National Park. Habitat conserved within these reserve areas offers more stable and long-term security for Brown Treecreeper occupying these areas than those in areas of development. Combined, these nature reserves protect over 1200 km^2 of bushland, much of which is woodland and forest that can support Brown Treecreeper and provide hollows for nesting. Considering this species has a known foraging range of up to 10.7 ha, reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the local region.
f)	Limit of known distribution	The eastern subspecies lives in eastern NSW in eucalypt woodlands through central NSW and in coastal areas with drier open woodlands such as the Snowy River Valley, Cumberland Plains, Hunter Valley and parts of the Richmond and Clarence Valleys. Potential habitat for this occurs throughout coastal areas along the entire NSW coast, including the subject site.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	Brown Treecreeper was observed during the fieldwork. A search of species sightings within the local area (that is, within 10 km of the site), also suggests a local population is present in the local area; one record has been made immediately north of the

DGR Matter	Comment
	subject site (Atlas of Living Australia, 2019). Across the Port Stephens LGA, records of this species are scattered. Across this LGA, most Brown Treecreeper sightings were made in or nearby private properties.
b) Discussion of habitat utilisation	The Brown Treecreeper has been rarely observed during the fieldwork and nearby the site subject site. Foraging by this species was commonly associated with areas of elevated arboreal roughness (i.e. higher density of roughbark trees as shown in **Figure 4.80**). Breeding is more likely in areas of greater forest maturity where hollow abundance and vegetation structure is relatively higher (see **Figure 4.26**). Habitat occupation is most likely associated with PCT 1584 (i.e. high abundance of White Mahogany), but will also be associated with patches of PCT 1590 where ironbark and stringybark have higher relative abundance when compared to Spotted Gum (a smooth-barked tree that is less likely to be utilised by this species).
c) Description of vegetation	Habitat for this species broadly exists in PCTs 1230, 1584, 1590 and 1600 and excludes areas of native vegetation mapped as scattered trees in open paddocks (i.e. PCT 1590 in moderate good poor condition). These PCTs support the preferred habitat for nesting and foraging of the Brown Treecreeper, with shrubs and smaller saplings prevalent within the subject site. Due to the broad habitat requirements of this species, the extent of the habitat polygon created for the species extends across all forested areas at the site. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat preferred by the Brown Treecreeper primarily constitutes mature forests and woodlands (**Figure 4.26**) with localised indicators of habitat complexity such as elevated abundance of fallen logs (**Figure 4.27**) and hollow-bearing trees (**Figure 4.28**), with the latter habitat feature important for breeding. Being scansorial, the Brown Treecreeper will prefer vegetation with elevated proportions of rough-barked trees (**Figure 4.80**); a feature of its habitat that locally elevates the area of available foraging habitat (i.e. bark and rough surfaces increases the abundance and biomass of invertebrates). Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) and African Olive (**Figure 4.23**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal will remove 206.64 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species.

DGR Matter	Comment
	Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Brown-treecreeper in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.6 Varied Sittella

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Varied Sittella (*Daphoenositta chrysoptera*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Varied Sittella: • Clearing of native vegetation • Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala* • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Removal of dead wood and dead trees • Predation by the Feral Cat *Felis catus*
c)	Habitat requirements	The Varied Sittella inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. Foraging habitat for Varied Sittella constitutes crevices in rough or decorticating bark, dead branches, standing dead trees and small branches and twigs in the tree canopy. This species builds nests in upright tree forks high in the living tree canopy. They can often re-use the same fork or tree in successive years. This species is sedentary, so exhibits a restricted foraging range.
d)	Other documentation	A targeted strategy for managing this species has been developed under the SoS program, however the subject area has not been identified as a key management site. Varied Sittella has been assigned to the Landscape species management stream under the SoS program, which aims to ensure it is secure in the wild in NSW and that its NSW geographic range is extended or maintained.
e)	Assessment of adequacy of reservation	Across the state, 19% of the species' distribution occurs on reserve (within NSW National Parks and Wildlife Service estate). Locally, habitat for Varied Sittella occurs in many conservation reserves throughout the greater North Coast Bioregion. These areas include Barrington Tops National Park, Myall Lakes National Park, Wallaroo State Forest, Wallaroo Nature Reserve and Karuah National Park. Habitat conserved within these reserve areas offers more stable and long-term security for Varied Sittella occupying these areas than those in areas of development. Combined, these nature reserves protect over 1200 km^2 of bushland, much of which is woodland and forest that can support Varied Sittella. Considering this species is sedentary, and so exhibits a restricted foraging range, reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the local region.
f)	Limit of known distribution	The Varied Sittella inhabits most of mainland Australia except the treeless deserts and open grasslands. Distribution of Varied Sittella in NSW is nearly continuous from the coast to the far west. The Varied Sittella's population size in NSW is uncertain but is believed to have undergone a moderate reduction over the past several decades.
2)	**Discussion of local and regional abundance**	

DGR Matter	Comment
a) Discussion of other known local populations	There are Varied Sittella records known within the locality (OEH, 2019b). Within the Port Stephens LGA, the Varied Sittella records are highly scattered. A search of species sightings within the local area (that is, within 10 km of the site), suggests a local population is present consistently present in the local area; 21 records have been made. The closest record is just north of Six Mile Rd, adjacent to the site (Atlas of Living Australia, 2019). Hence, it appears the subject site comprises habitat regularly utilised by members of a local population of this species that is likely to extend north and east through connected habitat.
b) Discussion of habitat utilisation	The Varied Sittella was observed regularly during the fieldwork and nearby the site subject site. Foraging by this species was commonly associated with areas of elevated arboreal roughness (i.e. higher density of roughbark trees as shown in **Figure 4.80**). Breeding is more likely in areas of greater forest maturity where vegetation structure is relatively higher (see **Figure 4.26**). Habitat occupation is most likely associated with PCT 1584 (i.e. high abundance of White Mahogany), but will also be associated with patches of PCT 1590 where ironbark and stringybark have higher relative abundance when compared to Spotted Gum (a smooth-barked tree that is less likely to be utilised by this species).
c) Description of vegetation	Habitat for this species broadly exists in PCTs 1230, 1584, 1590 and 1600 and excludes areas of native vegetation mapped as scattered trees in open paddocks (i.e. PCT 1590 in moderate good poor condition). These PCTs support the preferred habitat for nesting and foraging of the Varied Sittella, with shrubs and smaller saplings prevalent within the subject site. Due to the broad habitat requirements of this species, the extent of the habitat polygon created for the species extends across most forested areas at the site. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat preferred by the Varied Sittella primarily constitutes mature forests and woodlands (**Figure 4.26**) with localised indicators of habitat complexity such as elevated abundance of fallen logs (**Figure 4.27**) and hollow-bearing trees (**Figure 4.28**). Being scansorial, the Varied Sittella will prefer vegetation with elevated proportions of rough-barked trees (**Figure 4.80**); a feature of its habitat that locally elevates the area of available foraging habitat (i.e. bark and rough surfaces increases the abundance and biomass of invertebrates). Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) and African Olive (**Figure 4.23**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal will remove 206.64 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

DGR Matter	Comment
	The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Varied Sittella in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.7 Little Lorikeet

DGR Matter	Comment
1) Discussion of conservation status	
a) Local, regional and state-wide status	The Little Lorikeet (*Glossopsitta pusilla*) is listed as vulnerable under Schedule 2 of the TSC Act.
b) Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Little Lorikeet: • Clearing of native vegetation • Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala* • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees • Predation by the Feral Cat *Felis catus*
c) Habitat requirements	Feeds mostly on nectar and pollen, occasionally on native fruits such as mistletoe. This species roosts in treetops, preferably in close proximity to feeding areas. It typically nests in hollows in the limb or trunk of smooth-barked Eucalypt. Forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in Angophora, Melaleuca and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity. Isolated flowering trees in open country (e.g. paddocks, roadside remnants and urban trees) also help sustain viable populations of the species.
d) Other documentation	A targeted strategy for managing this species has been developed under the Saving Our Species program, however the subject area has not been identified as a key management site. Little Lorikeet has been assigned to the Landscape species management stream under the Saving our Species (SoS) program, which aims to ensure it is secure in the wild in NSW and that its NSW geographic range is extended or maintained. The Little Lorikeet is also identified as a bird pollinator listed as threatened in NSW under the TSC Act. OEH (2016b) identifies the winter flower diet of this species to comprise Swamp Mahogany, Spotted Gum and Broad-leaved Paperbark with only Spotted Gum having any meaningful occurrence within the study area. Spring flowering and nectar producing tree species that are also of relevance to the subject site include Grey Box, Grey Ironbark (*Eucalyptus siderophloia*) and Forest Redgum (DIPNR 2004). Programs monitoring the ecological benefits of revegetation plantings and regeneration sites are relatively recent and generally report encouraging results on bird occupancy in young plantings (5 to 25 years old) where mobile species are able to locate and inhabit these rehabilitation sites (e.g. Kavanaugh et al. 2007; Munro et al. 2011; Law et al. 2014; Smith et al. 2015). Changes resulting in species incidence were quantitatively apparent after 10 years and reached the levels recorded in nearby remnant vegetation within 20 years (OEH 2016b). In revegetation projects, OEH 2016b) recommends various additional considerations. In addition to the timing of flowering and nectar production, another important consideration applicable to the Proposal is flower density as this can be important for attracting pollinators. Large-area plantings or plantings near existing habitat may be visited by more individuals and more species (Lindell & Thurston 2013).

DGR Matter		Comment
e)	Assessment of adequacy of reservation	Broadly, 21% of the species' distribution occurs on reserve (within NSW National Parks and Wildlife Service estate; OEH 2019b). Within the local region, habitat for Little Lorikeet occurs in many conservation reserves throughout the greater North Coast Bioregion. These areas include Barrington Tops National Park, Myall Lakes National Park, Wallaroo State Forest, Wallaroo Nature Reserve and Karuah National Park. Habitat conserved within these reserve areas offers more stable and long-term security for Little Lorikeet occupying these areas than those in areas of development. Combined, these nature reserves protect over 1200 km^2 of bushland, much of which is woodland and forest that can support Little Lorikeet. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the local region.
f)	Limit of known distribution	The Little Lorikeet is distributed widely across the coastal and Great Divide regions of eastern Australia from Cape York to South Australia. A large portion of the species' core habitat is in NSW, with lorikeets found from the cast to Dubbo and Albury in the west. Nomadic movements are common, influenced by season and food availability, although some areas retain residents for much of the year and 'locally nomadic' movements are suspected of breeding pairs.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	The Little Lorikeet has been observed within the subject site both with the Proposal impact footprint and the Conservation Area. Within the Port Stephens LGA, records of Little Lorikeet are highly scattered. Based on records nearby the site, presence of suitable habitat, and high mobility of this species, the Project area could contribute habitat to a local population of this species.
b)	Discussion of habitat utilisation	The Little Lorikeet is likely to be an inter forest patch forager moving throughout the greater forested area in search of nectar resources. The species will actively seek isolated flowering eucalypts and paperbarks with high nectar production, a feeding strategy similar to the Grey-headed Flying Fox. Riparian zones on site are also likely to provide important refugia habitat, including nesting habitat in areas with relatively high tree hollows (see **Figure 4.28**). As such, the subject site provides nesting and foraging habitat for the Little Lorikeet.
c)	Description of vegetation	Habitat for this species broadly exists in PCTs 1584, 1590 and 1600. These PCTs support the preferred habitat for nesting and foraging of the Little Lorikeet. Due to the broad habitat requirements of this species, the extent of the habitat polygon created for the species extends across most forested areas at the site. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3)	**Description of habitat values**	Habitat preferred by the Little Lorikeet primarily constitutes mature forests and woodlands (**Figure 4.26**) with localised indicators of habitat complexity such as elevated abundance of fallen logs (**Figure 4.27**) and hollow-bearing trees (**Figure 4.28**), with the latter habitat feature important for breeding. Being nectivorous and like the Grey-headed Flying Fox, the Little Lorikeet will prefer vegetation comprising trees with reliable nectar supply throughout the year (**Figures 4.83** to **4.88**); with increased abundance/ spatial extent of these trees likely to locally elevate the relative important of foraging habitat (i.e. quantum and temporal availability). Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) and African Olive (**Figure 4.23**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4)	**Extent of habitat removal**	The Proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP.

DGR Matter	Comment
	In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Little Lorikeet in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.8 White-bellied Sea-Eagle

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The White-bellied Sea-Eagle (*Haliaeetus leucogaster*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the White-bellied Sea Eagle: • Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. • Clearing of native vegetation • Ecological consequences of high frequency fires • Removal of dead wood and dead trees
c)	Habitat requirements	The White-bellied Sea Eagle is found in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands (DoE 2017a). It occupies habitat characterised by the presence of large areas of open water (larger rivers, swamps, lakes, the sea) and have been recorded in (or flying over) a variety of terrestrial habitats (DoE 2017a). This species has been recorded at or in the vicinity of freshwater swamps, lakes, reservoirs, billabongs, saltmarsh and sewage ponds. Within the locality, there are 71 recorded locations of the White-bellied Sea Eagle, scattered throughout and predominantly in association with Grahamstown Dam in the east and along larger riparian areas and wetlands. The White-bellied Sea-eagle nests are primarily built in tall emergent eucalypt trees and they may be built in a variety of sites including; bushes, mangroves, cliffs, rocky outcrops, caves, crevices, on the ground or even on artificial structures (Marchant & Higgins 1993; DoE 2015). Nest trees often have emergent dead branches which are used as 'guard roosts' (Dennis et al. 2011b; Debus et al. 2014 ; as cited by, NSW Scientific Committee 2016).
d)	Other documentation	A recovery plan has not been prepared for the White-bellied Sea-eagle.
e)	Assessment of adequacy of reservation	Habitat for White-bellied Sea-Eagle occurs in many conservation reserves throughout the greater North Coast Bioregion. These areas include Myall Lakes National Park, Wallaroo State Forest, Wallaroo Nature Reserve and Karuah National Park. Habitat conserved within these reserve areas offers more stable and long-term security for White-bellied Sea-eagle occupying these areas than those in areas of development. Combined, these nature reserves protect over 1200 km^2 of bushland, much of which is woodland and forest that can support White-bellied Sea-eagle. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the local region.
f)	Limit of known distribution	The White-bellied Sea-Eagle is distributed along the coastline (including offshore islands) of mainland Australia and Tasmania. It also extends inland along some of the larger waterways, especially in eastern Australia (DoE 2017a).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	This species is a migratory species that moves up and down the east coast of Australia. There are several locations where it has been recorded within the locality and Port Stephens LGA, most of which are associated with large permanent water bodies. Numerous records of this species have been recorded adjacent to, and in close proximity to, Grahamstown Dam and Port Stephens estuary, which are located nearby to the site.

DGR Matter	Comment
b) Discussion of habitat utilisation	Within the locality, there are 71 recorded locations of the White-bellied Sea-Eagle, scattered throughout and predominantly in association with Grahamstown Dam in the east and along river systems (i.e. Williams, Paterson and Hunter Rivers) and wetlands to the west. The White-bellied Sea-eagle utilises the subject site as foraging and nesting habitat, with a pair of individuals recorded during recent surveys and two sea-eagle nests also recorded in larger trees. Large *Eucalyptus tereticornis* trees exist in the west of the study area, in close proximity to the large wetland and just south of the subject site. One of these trees has a White-bellied Sea-eagle nest in it, with the tree itself possessing an approximate DBH of 2 m and a height of approximately 20 m. The White-bellied Sea Eagle is utilising habitat within the subject site primarily for breeding purposes. Foraging is mostly restricted to the adjacent floodplains and riverine corridors, although some foraging may opportunistically occur in the surrounding forests from time to time. Movement to and from the site will be dictated by selected foraging grounds and local wind patterns, with most approaches likely in an arc from the southeast clockwise through to the west.
c) Description of vegetation	The White-bellied Sea-Eagle is mostly reliant on water bodies in riverine, estuarine and pelagic environments for foraging. Terrestrial is needed for nesting purposes and can be in a variety of locations. Nesting of the White-bellied Sea-Eagle within the subject site could occur in any of the PCTS where sufficiently large trees occur. The nest tree used by this species is within PCT 1590. Further detailed descriptions of the characteristics of PCTs within the subject site can be found in **Section 4.3.2.1**.
3) Description of habitat values	Suitable breeding habitat occurs on site, in tall more mature eucalypt species in close proximity to water. One eucalypt tree, overlooking the wetland to the west of the subject site, was observed supporting a White-bellied Sea Eagle nest. Nests can be utilised for many seasons after initial success (Birdlife Australia 2019), suggesting that this particular tree provides suitable breeding habitat for years to come.
4) Extent of habitat removal	The Proposal is not likely to result in the removal of any important foraging habitat, which is largely associated with the waterbodies of the floodplains and riverine corridors of the lower Hunter region. However, habitat removal in close proximity to a nesting tree is proposed totalling an area of 6.50 ha (i.e. using a 250 m radius from the tree). Approximately 13.10 ha of lands within 250 m radius from the nesting tree is proposed to be retained within the Conservation Area, which has a total area of 244.25 ha. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased

DGR Matter	Comment
	length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the White-bellied Sea Eagle in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.9 Square-tailed Kite

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Square-tailed Kite (*Lophoictinia isura*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Square-tailed Kite: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Removal of dead wood and dead trees
c)	Habitat requirements	The Square-tailed Kite usually hunts by flying low over the treetops, occasionally plunging down through the foliage to snatch a bird or insect from among the leaves or twigs. The species often eats the nestlings of birds, and sometimes it will remove the entire nest to get at the young birds, and at other times may remove the tiny birds, one clutched tightly by the talons of each foot. They also catch adult birds by surprising them in the canopy of the forest. Appears to occupy large hunting ranges of more than 100km^2. Breeding is from July to February, with nest sites generally located along or near watercourses, in a fork or on large horizontal limbs (BCD 2019).
d)	Other documentation	A recovery plan has not been prepared for the Square-tailed Kite.
e)	Assessment of adequacy of reservation	The Square-tailed Kite is well represented in conservation reserve network including the Hunter Wetlands National Park, Tilligerry State Conservation Area, Myall Lakes National Park, Wallingat National Park, Khappinghat Nature Reserve, Crowdy Bay National Park, Dooragan National Park, Queens Lake Nature Reserve, Lake Innes Nature Reserve, Rawdon Creek Nature Reserve, Limburners Creek National Park, Goolawah National Park, Hat Head National Park, Yarriabini National Park, Bongil Bongil National Park, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Yuraygir National Park, Bundjalung National Park, Broadwater National Park and Bungawalbin National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the region.
f)	Limit of known distribution	The Square-tailed Kite ranges along coastal and subcoastal areas from south-western to northern Australia, Queensland, NSW and Victoria. In NSW, scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems. It is a summer breeding migrant to the south-east, including the NSW south coast, arriving in September and leaving by March (BCD 2019).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	The Square-tailed Kite records in the lower Hunter River indicate a largely riverine activity bias with many records being between Hexham and Maitland, this being consistent with the species habitat preferences and large home range.
b)	Discussion of habitat utilisation	Surveys in wetland 804, which is part of the study area, consistently identified foraging forays of the Square-tailed Kite over flowering paperbark swamps where relatively high abundance of prey is likely to be found (e.g. honeyeaters) (Mark Aitkens pers obs). However, despite considerable survey effort, the species has only been observed once within the subject site. Similarly,

DGR Matter	Comment
	the observation was linked to a patch of flowering eucalypts where passerine bird prey was locally abundant at the time. No breeding activity has been observed within the subject site.
c) Description of vegetation	Habitat for this species broadly exists in PCTs 783, 1230, 1584, 1590, 1600 and 1728. These PCTs support the preferred habitat for foraging of the Square-tailed Kite with nesting possible in suitably large trees located in PCTs 1230, 1584, 1590, 1600. Due to the broad habitat requirements of this species, the extent of the habitat polygon created for the species extends across most forested areas at the site. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat preferred by the Square-tailed Kite primarily constitutes mature forests and woodlands (**Figure 4.26**) and coastal floodplains included wooded swamps for nesting and foraging. Being a bird of prey of smaller birds, it is likely to utilise a large home range comprising trees with reliable nectar supply throughout the year (**Figures 4.83** to **4.88**); this being important in localising and concentrating foraging resources. This species was routinely foraging over flowering Melaleuca linariifolia located within wetland 804 where substantial smaller passerine bird activity was concentrated. The species was observed only once moving over the forested parts of the Conservation Area. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.

DGR Matter	Comment
6) **Impacts on Threatened Species and/or Populations in National Parks Estate**	This proposal is considered unlikely to impact on any individuals of the Square-tailed Kite in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.10 Osprey

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Osprey (*Pandion cristatus*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Osprey: • Clearing of native vegetation • Ecological consequences of high frequency fires • Removal of dead wood and dead trees
c)	Habitat requirements	The Osprey is a fish dependent species meaning its habitat is limited by the presence of waterbodies capable of sustaining any fish species of typical weight range 150-300g. The Osprey nests in live and dead trees near large tracts of suitable foraging habitat (e.g. large riverine corridors) and is also able to use artificial structures.
d)	Other documentation	A recovery plan has not been prepared for the Osprey.
e)	Assessment of adequacy of reservation	The Osprey is well represented in conservation reserve network including the Hunter Wetlands National Park, Tilligerry State Conservation Area, Karuah Nature Reserve, Myall Lakes National Park, Wallingat National Park, Khappinghat Nature Reserve, Crowdy Bay National Park, Dooragan National Park, Queens Lake Nature Reserve, Lake Innes Nature Reserve, Rawdon Creek Nature Reserve, Limeburners Creek National Park, Goolawah National Park, Hat Head National Park, Yarrahapinni Wetlands National Park, Bongil Bongil National Park, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Yuraygir National Park, Bundjalung National Park, Broadwater National Park, Ballina Nature Reserve, Tyagarah Nature Reserve and Bungawalbin National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the region.
f)	Limit of known distribution	The Osprey has a global distribution with four subspecies previously recognised throughout its range. However, recent studies have identified that there are two species of Osprey - the Western Osprey (*P. halietus*) with three susbpecies occurring in Europe, Asia and the Americas and the Eastern Osprey (*P. cristatus*) occurring between Sulawesi (in Indonesia), Australia and New Caledonia. Eastern Ospreys are found right around the Australian coastline, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. There are a handful of records from inland areas.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	Species records of the lower Hunter valley indicate a high abundance of the species in Hexham Swamp through to the Hunter River outfall into the Tasman Sea and the shoreline of Port Stephens. Scattered records upstream of the Hunter River from Hexham appear to suggest infrequent activity in these more inland areas, which may be potentially linked to a decreased supply of foraging resources.
b)	Discussion of habitat utilisation	The Osprey has only been observed flying over the site (wetland 803). It is not likely to use the site for foraging (i.e. absence of target prey species), but, due to the proximity to the Williams River may use the site for nesting (particularly around Wetland 803).

DGR Matter	Comment
c) Description of vegetation	The Osprey is reliant on water bodies in riverine, estuarine and pelagic environments for foraging. Terrestrial vegetation is needed for nesting purposes and can be in a variety of locations. Osprey nesting within the subject site could occur in any of the PCTS where sufficiently large trees occur. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	As for the White-bellied Sea Eagle, the Osprey may use parts of the subject site for besting (breeding) due to proximity to waterbodies located within the floodplain and riverine corridors of the lower Hunter Valley. The species has not been observed nesting within the subject site, with infrequent fly overs being the only notable presence within the subject site.
4) Extent of habitat removal	The Proposal will not remove any habitat for this species. Indirect impacts through hydrological changes will have a negligible impact on the habitat of this species within the study area (Alluvium 2019). In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 14.85 ha of habitat suitable for this species (PCTs 783, 1230 and 1728). The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Osprey in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.11 Magpie Goose

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Magpie Goose (*Anseranas semipalmata*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Magpie Goose: • Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. • Clearing of native vegetation • Herbivory and environmental degradation caused by feral deer • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
c)	Habitat requirements	The Magpie Goose is found in a variety of open wetland areas such as floodplains and swamps. It is fairly sedentary apart from some movement during the dry season. They are colonial breeders and are gregarious outside of the breeding season when they can form large and noisy flocks of up to a few thousand individuals.
d)	Other documentation	A recovery plan has not been prepared for the Magpie Goose.
e)	Assessment of adequacy of reservation	The Magpie Goose is well represented in conservation reserve network including the Hunter Wetlands National Park, Lake Innes Nature Reserve, Broadwater National Park, Tyagarah Nature Reserve, Brunswick Heads Nature Reserve, Marshall Creek Nature Reserve and Cudgen Nature Reserve. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the region.
f)	Limit of known distribution	This species is known to occur throughout Australia, with patchy occurrences in NSW. In NSW, it has been commonly recorded in coastal environments, but increasing records are occurring throughout the central and northern parts of NSW.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	Species records of the lower Hunter valley indicate a high abundance of the species in Hexham Swamp area and at Seaham. Scattered records elsewhere in the lower Hunter River to suggest infrequent activity in these more inland areas, which may be potentially linked to a limited supply of suitable habitat.
b)	Discussion of habitat utilisation	The Magpie Goose has not been observed within the subject site, although records indicate presence in wetland 804 to the south in the study area. These observations are generally consistent with the distribution of suitable habitat for this species within the study area. Habitat in and around wetland 803 is considered marginal due to the reduced plant biomass available in that swamp and the propensity for this swamp to dry out during the summer-autumn period (Alluvium 2019).
c)	Description of vegetation	Habitat for this species broadly exists in PCTs 783, 1230 and 1728. These PCTs support preferred habitat for foraging activity. The general absence of macrophytic vegetation means foraging is likely to be opportunistic and of no real value for breeding. Due to the broad habitat requirements of this species, the extent of the habitat polygon created for the species extends across the wetland areas and peripheral vegetation. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3)	**Description of habitat values**	Habitat preferred by the Magpie Goose primarily constitutes wetlands and open areas of water such as floodplains and swamps less than 1 m deep. This species has also been known to occupy terrestrial habitats including grazing land, to feed on grains,

DGR Matter	Comment
	grasses and bulbs. Breeding typically occurs in monsoonal areas, with breeding in south-eastern NSW being considered unlikely.
4) Extent of habitat removal	The Proposal will not remove any habitat for this species. Indirect impacts through hydrological changes will have a negligible impact on the habitat of this species within the study area (Alluvium 2019). In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 14.85 ha of habitat suitable for this species (PCTs 783, 1230 and 1728). The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Magpie Goose in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate.

5.3.12 Australasian Bittern

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Australasian Bittern (*Botaurus poiciloptilus*) is listed as endangered under Schedule 1 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Australasian Bittern: • Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. • Clearing of native vegetation • Herbivory and environmental degradation caused by feral deer • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
c)	Habitat requirements	The Australasian Bittern is a cryptic and partly nocturnal species that inhabits densely vegetated wetlands. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Eleocharis* spp.).
d)	Other documentation	A recovery plan has not been prepared for the Australasian Bittern.
e)	Assessment of adequacy of reservation	The Australasian Bittern is well represented in conservation reserve network with habitat occupation occurring within the Hunter Wetlands National Park, Tilligerry State Conservation Area, Columbey National Park, Myall Lakes National Park, Wallingat National Park, Booti Booti National Park, Crowdy Bay National Park, Lake Innes Nature Reserve, Limeburners Creek National Park, Hat Head National Park, Bollanolla Nature Resereve, Bongil Bongil National Park, Ulidarra National Park, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Yuraygir National Park, Bundjalung National Park, Broadwater National Park, Tyagarah Nature Reserve, Whian Whian State Conservation Area. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the region.
f)	Limit of known distribution	It is found in south-western and south-eastern Australia, Tasmania, New Zealand, New Caledonia and Ouvea.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	Four records from the Tomago – Heatherbrae area to the south and two from the Clarence Town area to the north, with the majority of observed occurrences being in the Kooragang – Hexham swamp area. Not previously observed within the subject site despite monthly surveys of wetland 803 since March 2016 (n=38 surveys) (Birdata 2019).
b)	Discussion of habitat utilisation	Habitat in and around wetland 803 is considered marginal due to the reduced plant biomass available in that swamp and the propensity for this swamp to dry out during the summer-autumn period (Alluvium 2019). Usage is likely to be temporary, irregular and align only with the occurrence of denser vegetation.
c)	Description of vegetation	Habitat for this species broadly exists in PCTs 783, 1230 and 1728. These PCTs support preferred habitat for foraging activity. The general absence of macrophytic vegetation means foraging is likely to be opportunistic and of no real value for breeding. Due to the broad habitat requirements of this species, the extent of the habitat polygon created for the species extends across the wetland areas and peripheral vegetation. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3)	**Description of habitat values**	The vegetation within wetland 803 is largely restricted to scattered Swamp Oak, Prickly Paperbark and low growing forbs and herbs. The general absence of tall and dense macrophytic vegetation is a limitation on habitat quality and is likely to limit

DGR Matter	Comment
	occurrence to infrequent (rare) visitation. Conversely, the vegetation of wetland 804 is diverse and comprises areas of dense macrophytic vegetation that is likely to suit this species.
4) Extent of habitat removal	The Proposal will not remove any habitat for this species. Indirect impacts through hydrological changes will have a negligible impact on the habitat of this species within the study area (Alluvium 2019). In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 14.85 ha of habitat suitable for this species (PCTs 783, 1230 and 1728). The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Australasian Bittern in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate.

5.3.13 Black Bittern

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Black Bittern (*Botaurus poiciloptilus*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Black Bittern: • Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. • Clearing of native vegetation • Herbivory and environmental degradation caused by feral deer • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
c)	Habitat requirements	The birds are mainly found in freshwater wetlands, where they inhabit dense emergent vegetation of reeds and sedges, and inundated shrub thickets. They are also occasionally found in brackish and saline wetlands such as mangrove swamps, Juncus-dominated salt marsh and the wooded margins of coastal lagoons (Marchant and Higgin 1991).
d)	Other documentation	A recovery plan has not been prepared for the Black Bittern.
e)	Assessment of adequacy of reservation	Black-backed bitterns are listed as Near Threatened nationally in Australia, and as Endangered in Victoria. The global population has been estimated to comprise about 5,000 mature individuals, mainly within Australia, including a sub-population of more than 1,000 individuals in south-western Western Australia. Threats include various ongoing wetland degradation factors such as salinisation, drainage and the diversion of water for irrigation, as well as the destruction of nesting habitat by inappropriate burning regimens (Garnett and Crowley 2000).
f)	Limit of known distribution	In Australia the Black Bittern is found in the south-east of the continent, with most records deriving from the Murray-Darling Basin, as well as patchily along the east coast, and in south-west Western Australia where it is locally common on the Swan Coastal Plain. Some scattered records are given from elsewhere, including coastal locations in the Kimberley region, the Top End and the Torres Strait islands (Marchant and Higgin 1991).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	Eight records including Columbey National Park and Medowie area. Not previously observed within the subject site despite monthly surveys of wetland 803 since March 2016 (n=38 surveys) (Birdata 2019).
b)	Discussion of habitat utilisation	Habitat in and around wetland 803 is considered marginal due to the reduced plant biomass available in that swamp and the propensity for this swamp to dry out during the summer-autumn period (Alluvium 2019). Usage is likely to be temporary, irregular and align only with the occurrence of denser vegetation.
c)	Description of vegetation	Habitat for this species broadly exists in PCTs 783, 1230 and 1728. These PCTs support preferred habitat for foraging activity. The general absence of macrophytic vegetation means foraging is likely to be opportunistic and of no real value for breeding. Due to the broad habitat requirements of this species, the extent of the habitat polygon created for the species extends across the wetland areas and peripheral vegetation. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.

DGR Matter	Comment
3) Description of habitat values	The vegetation within wetland 803 is largely restricted to scattered Swamp Oak, Prickly Paperbark and low growing forbs and herbs. The general absence of tall and dense macrophytic vegetation is a limitation on habitat quality and is likely to limit occurrence to infrequent (rare) visitation. Conversely, the vegetation of wetland 804 is diverse and comprises areas of dense macrophytic vegetation that is likely to suit this species.
4) Extent of habitat removal	The Proposal will not remove any habitat for this species. Indirect impacts through hydrological changes will have a negligible impact on the habitat of this species within the study area (Alluvium 2019). In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 14.85 ha of habitat suitable for this species (PCTs 783, 1230 and 1728). The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Black Bittern in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate.

5.3.14 Dusky Woodswallow

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Dusky Woodswallow (*Botaurus poiciloptilus*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Dusky Woodswallow: • Clearing of native vegetation • Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala* • Ecological consequences of high frequency fires • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees • Predation by the Feral Cat *Felis catus*
c)	Habitat requirements	The Dusky Woodswallow is often reported in woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including regenerating forests; very occasionally in moist forests or rainforests (Higgins and Peter 2002). At sites where Dusky Woodswallows are recorded the understorey is typically open with sparse eucalypt saplings, acacias and other shrubs, including heath (Higgins and Peter 2002). The ground cover may consist of grasses, sedges or open ground, often with coarse woody debris (Higgins and Peter 2002). Birds are also often observed in farm land, usually at the edges of forest or woodland or in roadside remnants or wind breaks with dead timber (Higgins and Peter 2002; M. Schulz in litt. November 2014). In western New South Wales this species is primarily associated with River Red Gum/Black Box/Coolibah open forest/woodland associated with larger river/creek systems and is less common and far more patchily distributed in other communities such as mallee and cypress-pine woodland (M. Schulz in litt. November 2014).
d)	Other documentation	A recovery plan has not been prepared for the Dusky Woodswallow.
e)	Assessment of adequacy of reservation	The Dusky Woodswallow is well represented in conservation reserve network including the Hunter Wetlands National Park, Worimi National Park, Karuah National Park, Myall Lakes National Park, The Glen Nature Reserve, Booti Booti National Park, Wallingat National Park, Khappinghat Nature Reserve, Crowdy Bay National Park, Dooragan National Park, Queens Lake Nature Reserve, Lake Innes Nature Reserve, Rawdon Creek Nature Reserve, Limeburners Creek National Park, Maria River National Park, Goolawah National Park, Hat Head National Park, Ngambaa Nature Reserve, Dorrigo National Park, Bongil Bongil National Park, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Yuraygir National Park, Fortis Creek National Park, Bundjalung National Park, Broadwater National Park and Whian Whian State Conservation Area. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the region.
f)	Limit of known distribution	The Dusky Woodswallow is widespread in eastern, southern and southwestern Australia (Higgins and Peter 2002; Barrett et al. 2003). In New South Wales it is widespread from coast to inland, including the western slopes of the Great Dividing Range and farther west. It is sparsely scattered in, or largely absent from, much of the Upper Western region (Higgins and Peter 2002).
2)	**Discussion of local and regional abundance**	

DGR Matter	Comment
a) Discussion of other known local populations	Scattered records in the local area with ~20 observations at Butterwick to the west, three in the Tomago - Heatherbrae area, Wallaroo National Park and Columbey National Park. Observed once within the subject site during monthly surveys of wetland 803 since March 2016 (n=38 surveys) (Birdata 2019) and recently by RPS in October 2019.
b) Discussion of habitat utilisation	Nesting in the Dusky Woodswallow occurs from late September to late February, with eggs present between September and January, although most eggs are present between October and early December (Higgins and Peter 2002). The nest is an open shallow untidy cup (Higgins and Peter 2002), frequently in an open hollow, crevice or stump. The Dusky Woodswallow primarily eats invertebrates, mainly insects, which are captured whilst hovering and sallying above the canopy or over water (Higgins and Peter 2002). Unlike other woodswallows, it also frequently hovers, sallies and pounces under the canopy, particularly over leaf litter and dead timber. Occasionally nectar, fruit and seed are also ingested (Higgins and Peter 2002). Due to its foraging mode, this species has been classified as an aerial insectivore (Loyn et al. 2010; Birdlife Australia in litt. June 2015).
c) Description of vegetation	A relatively dense tree canopy and various dense understory (where invaded by Lantana and African Olive) is likely to limit the utility of the dry and wet sclerophyll vegetation (PCTs 1590 and 1584) for this species. Open vegetation in the west adjacent wetland 803 provides higher value vegetation for foraging and breeding, particularly along cleared edges of the native vegetation. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat preferred by the Dusky Woodswallow primarily constitutes mature forests and woodlands (**Figure 4.26**), particularly with a drier more open canopy and grassy understory such as the Forest Redgum dominated parts of PCT 1590 in the western parts of the subject site. Being an aerial insectivore, the Dusky Woodswallow will prefer vegetation along vegetation edges and open canopies above water, which collectively acts locally elevate the available foraging resources (i.e. the abundance and biomass of invertebrates). These conditions are particularly pronounced in the western part of the subject site where Swamp Oak Woodland occurs (i.e. periphery of wetland 803), which lies adjacent to the Forest Redgum dominated parts of PCT 1590. Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) and African Olive (**Figure 4.23**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a similar quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value

DGR Matter	Comment
	(key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Dusky Woodswallow in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.15 Black-necked Stork

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Black-necked Stork (*Ephippiorhynchus asiaticus*) is listed as endangered under Schedule 1 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Black-necked Stork: • Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. • Clearing of native vegetation • Herbivory and environmental degradation caused by feral deer • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
c)	Habitat requirements	This species inhabits tropical and warm-temperate terrestrial wetlands, estuarine and littoral habitats and occasionally grassland and wooded areas (Marchant and Higgins 1990). Foraging occurs in fresh or saline waters up to 0.5m deep, preferring extensive sheets of shallow freshwater over grassland or sedgeland; shallow swamps with short emergent vegetation and abundant aquatic flora and permanent billabongs and pools on floodplains (Marchant and Higgins 1990). Less common in intertidal waters, littoral and estuarine mudflats or areas of fringing mangroves (Marchant and Higgins 1990).
d)	Other documentation	A recovery plan has not been prepared for the Black-necked Stork.
e)	Assessment of adequacy of reservation	The Black-necked Stork is well represented in conservation reserve network with habitat occupation occurring within the Hunter Wetlands National Park, Tilligerry State Conservation Area, Karuah National Park, Columbey National Park, Myall Lakes National Park, Wallingat National Park, Booti Booti National Park, Khappinghat Nature Reserve, Crowdy Bay National Park, Lake Innes Nature Reserve, Rawdon Creek Nature Reserve, Limeburners Creek National Park, Hat Head National Park, Yarrahapinni Wetlands National Park, Yarriabini National Park, Bongil Bongil National Park, Tuckeon Nature Reserve, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Yuraygir National Park, Everlasting Swamp National Park, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Tyagarah Nature Reserve, Billinudgei Nature Reserve, Stotts Island Nature Reserve and Ukerebagh Nature Reserve. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the region.
f)	Limit of known distribution	The distribution of this species is generalised as northern and eastern Australia, with occurrences south of from a line between the Macquarie Marches and Port Macquarie being restricted to coastal districts reaching a southern limit at Nowra.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	There are scores of records in the lower Hunter estuary and wetlands notably around Tomago and Kooragang – Hexham Swamps. Recently observed breeding in Tomago, this representing uncommon southern breeding activity as the species typically breeds in northern Australia. Sighted infrequently on four occasions since 2016 in wetland 803 and 804 during monthly surveys of these wetlands since March 2016 (Birdata 2019). Likely to associated with higher value habitat in the Tomago and Kooragang – Hexham Swamps where vegetation and foraging values are comparatively better.
b)	Discussion of habitat utilisation	A recent and unusual breeding event has been observed at Tomago. A nest was built in a Narrow-leaved Paperbark (*Melaleuca linariifolia*) approximately three metres tall, growing in wetland dominated by Common Reed (*Phragmites australis*). The tree had multiple trunks and the crown was broad and flattened at the top (Lindsey 2019).

DGR Matter	Comment
	The infrequent occurrences of this species within the subject site since 2016 are restricted to wetland 803 where it is likely to have been moving through the locality for opportunistic foraging purposes. While the propensity for this swamp to dry out during the summer-autumn period (Alluvium 2019) may benefit the species (i.e. aggregate foraging resources into a smaller waterbody), the frequency of drying events and the restricted connectivity with permanent water such as the Williams River means the quantum and reliability of foraging resources in this wetland is likely to be low.
c) Description of vegetation	Habitat for this species broadly exists in PCTs 783, 1230 and 1728. These PCTs support preferred habitat for foraging activity. The general absence of macrophytic vegetation means foraging is likely to be opportunistic and of no real value for breeding. Due to the broad habitat requirements of this species, the extent of the habitat polygon created for the species extends across the wetland areas and peripheral vegetation. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	The vegetation within wetland 803 is largely restricted to scattered Swamp Oak, Prickly Paperbark and low growing forbs and herbs. The lack of diversity in vegetation cover as indicated by the general absence of tall and dense macrophytic vegetation is a limitation on habitat quality and is likely to limit occurrence. Conversely, the vegetation of wetland 804 is diverse and comprises areas of dense macrophytic vegetation that is likely to suit this species.
4) Extent of habitat removal	The Proposal will not remove any habitat for this species. Indirect impacts through hydrological changes will have a negligible impact on the habitat of this species within the study area (Alluvium 2019). In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 14.85 ha of habitat suitable for this species (PCTs 783, 1230 and 1728). The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.

DGR Matter	Comment
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Black-necked Stork in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate.

5.3.16 Grey-crowned Babbler

DGR Matter	Comment
1) Discussion of conservation status	
a) Local, regional and state-wide status	The Grey-crowned Babbler (*Pomatostomus temporalis temporalis*) is listed as vulnerable under Schedule 2 of the TSC Act.
b) Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Grey-crowned Babbler: • Clearing of native vegetation • Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala* • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants • Removal of dead wood and dead trees • Predation by the Feral Cat *Felis catus*
c) Habitat requirements	The Grey-crowned Babbler can be found in open Box-Gum Woodlands on the slopes, Box-Cypress pine and open Box Woodlands on alluvial plains and in woodlands on fertile soils in coastal regions (OEH 2019b). Woodlands typically have regenerating trees, tall shrubs and an intact ground cover of grass and forbs (NSW Scientific Committee, 2011c). Nests for this species are dome-shaped and built from sticks and are usually located in shrubs or saplings, and may also be built on the outermost leaves of low branches of larger eucalypts (OEH 2019b).
d) Other documentation	A recovery plan has not been prepared for the Grey-crowned Babbler. The Grey-crowned Babbler is primarily an insectivore that occasionally eats seed. It is terrestrial and arboreal species favouring the latter behaviour when compared to other babbler species. Foraging forays are commonly seen on the ground where it turns leaf litter, bark and small stones to uncover prey and also low shrubs and trees in feeding flocks of 2-15 birds. Feeding flocks maintain a tight association and rarely separated by more than 30 m at any one time for social and predator evasion reasons (Higgins and Peter 2002). Co-operatively breeding groups comprise a breeding pair and several non-breeding birds who are helpers of auxiliaries. Helpers or auxiliaries aid in the building/ maintenance of dome shaped brood and roost nests in addition to feeding young. Nests often

DGR Matter		Comment
		build in tall shrubs and small trees (saplings), with *Casuarina glauca* and *Melaleuca styphelioides* favoured on site. Groups often roost in one nest for warmth and predator evasion reasons (Higgins and Peter 2002). Groups typically comprise 4-12 birds with declining populations often identified by small groups of 1-3 birds and linked to fragmentation (i.e. >300m separation between habitat patches), predation and habitat simplification (i.e. burning for fuel reduction, tree dieback, removal of fallen timber/ logs, cattle grazing and invasion of pasture grasses/ exotic plants). Habitat simplification is often denoted by the loss of important resources for feeding and nest building through depletion of an accumulated leaf litter layer, increase in groundcover plant species and loss of shrub layer (Higgins and Peter 2002). Groups live in permanent territories, often adjoining others, which are aggressively defended throughout the year. Home ranges or territories vary in area (e.g. 1.5 to 50 ha) with territory size dependant on resource availability and quality and not necessarily the number of birds. Offspring often stay with the breeding pair for up to two years, with dispersal occurring into neighbouring unoccupied habitat thereafter and form new breeding groups once sexually mature (i.e. 2-4 years) (Higgins and Peter 2002).
e)	Assessment of adequacy of reservation	The Grey-crowned Babbler is well represented in conservation reserve network with habitat occupation occurring within the Wallaroo National Park, Columbey State Conservation Area, Worimi National Park, Chaelundi National Park, Guy Fawkes State Conservation Area, Sherwood Nature Reserve, Yuraygir National Park, Yuraygir State Conservation Area, Fortis Creek National Park, Bundjalung State Conservation Area, Bungawalbin National Park, Tabbimobile Swamp Nature Reserve, Tucjeon Bature Reserve, Broadwater National Park and Ramournie National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the region.
f)	Limit of known distribution	The range of the Grey-crowned Babbler extends from north Queensland to southern Victoria and into the south-eastern corner of South Australia. In NSW it is most abundant on the western slopes and plains with scattered populations east of the Great Dividing Range (Higgins and Peter 2002).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	According to Birdata (2019) the Grey-crowned Babbler is locally abundant in suitable habitat to the north of the subject site including localities such as Duns Creek, Butterwick, Seaham, Balickera and Wallaroo National Park. At Balickera this species was observed 114 times over a 14 year period (2000-2014; Birdata 2019) with 2017 records combined with little change in local vegetation conditions indicating ongoing persistence. A similar observation history exists for Butterwick with 111 sightings over a similar period. Generally, this species is persisting in the locality despite prevailing tenure and land use (i.e. agriculture/ grazing). Recent surveys of the study area have recorded two Grey-crowned Babbler groups and numerous nests in close proximity to wetlands 803 and 804. Historical sightings within the subject site (HWR 2004) are generally consistent with these observations, although there appears to have been contraction in habitat occupancy in the parts of the subject site (i.e. no longer occupying the more eastern locations as recorded by HWR (2004)). It is possible that the absence of fire and the extensive growth of Lantana has adversely influenced local conditions for this species. Habitat for this species appears to be generally concentrated to the vegetated margins of wetland 803 where a complex of young trees and understory structure provide suitable nesting opportunities. These conditions are also apparent in association with a second flock located on the periphery of wetland 804 to the south west where five birds have been consistently seen (Mark Aitkens pers obs 2019; Birdata 2019). Birdata (2019) shows a consistent history of Grey-crowned Babbler activity in this area with a single flock consistently observed around wetland 803. Since 2016, there has been a mean observation of 5.5 birds over 20 separate monthly survey events with

DGR Matter	Comment
	the range of bird sightings being between 1 and 12 birds. Recent observations from surveys supporting this SIS indicate the presence of seven birds in this area.
b) Discussion of habitat utilisation	The Grey-crowned Babbler is utilising the drier open and grassier western portion of PCT 1590 where the tree canopy comprising Forest Redgum, Spotted Gum and White Stringybark meets regenerating Swamp Oak on the floodplain adjacent to and surrounding wetland 803. Nesting activity is currently within in the regenerating Swamp Oak located within the Conservation Area. Foraging forays were observed in the drier adjacent patch of PCT 1590 where it surrounds wetland 803. From regular observations, it appears that one flock of birds actively uses this part of the subject site foraging and breeding with no other area within the subject site being utilised by this species. Very similar conditions are associated with a second Grey-crowned Babbler flock located on the northern boundary of wetland 804 (and outside the subject site). This flock was seen nesting in *Melaleuca stypheloides* and Swamp Oak fringing the wetland boundary. Foraging forays were regularly observed around this nest site into the partially cleared lands upslope and into an open paperbark swamp dominated by *Melaleuca linariifolia*. The species is absent from PCT 1584.
c) Description of vegetation	The Grey-crowned Babbler is utilising the drier open and grassier western portion of PCT 1590 where the tree canopy comprising Forest Redgum, Spotted Gum and White Stringybark meets regenerating Swamp Oak on the floodplain adjacent to and surrounding wetland 803. The species is not utilising habitat within the denser parts of PCT 1590 perhaps due to the occurrence of Lantana and paucity of subshrubs for nesting. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat preferred by the Grey-crowned Babbler primarily constitutes drier woodlands and open forest, particularly with smaller trees and shrubs and grassy herbaceous groundcover such as the Forest Redgum dominated parts of PCT 1590 in the western parts of the subject site. The Grey-crowned Babbler prefers vegetation with smaller trees and shrubs for nesting purposes and a groundcover incorporating patches of leaf litter and logs, which collectively acts locally elevate the available foraging resources (i.e. the abundance and biomass of invertebrates). These conditions are particularly pronounced in the western part of the subject site where regenerating Swamp Oak Woodland occurs (i.e. periphery of wetland 803) adjacent to the Forest Redgum dominated parts of PCT 1590. Areas of woody weed growth appear to have locally reduced habitat quality [e.g. Lantana (**Figure 4.22**) and African Olive (**Figure 4.23**)], as the dominance of this vegetation provides no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a similar quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal is likely to result in the loss of mainly foraging habitat across the three Phases of site preparation works. Phase 1 is estimated to result in the loss of 9.74 ha that is likely to be preferred for foraging purposes, with a road to intersect part of the remaining habitat. Phase 2 is expected to result in the loss of 13.17 ha of habitat mostly preferred for foraging purposes although there are some abandoned nests in part of this area. Phase 3 is predicted to result in the loss of 9.30 ha of mostly foraging habitat. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 12.44 ha of habitat utilised by this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. This habitat is to be retained around wetland 803, which appears to be heavily utilised by the Grey-crowned Babbler. Approximately 9.40 ha of revegetation works comprising Swamp Mahogany, Forest Redgum and Tallowwood, with some localised use of Broad-leaved Paperbark and Snow-in-summer (*Melaleuca linariifolia*) prior to any vegetation loss (Phase

DGR Matter	Comment
	0), with this area in total expected to supplement foraging and breeding activity within five years of establishment and prior to Phase 2 impacts. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This Proposal is considered unlikely to impact on any individuals of the Grey-crowned Babbler in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.17 Powerful Owl

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Powerful Owl (*Ninox strenua*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Powerful Owl: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	The Powerful Owl inhabits a range of vegetation types from woodland and open sclerophyll forest to tall open wet forest and rainforest (OEH 2019b). It typically utilises large areas of connected woodland or forest habitat, however, it can also occur in fragmented habitats.
d)	Other documentation	The recovery plan described optimum habitat as "Habitat for this species is widespread and primarily tall, moist productive eucalypt forests of the eastern tableland edge and the mosaic of wet and dry sclerophyll forests occurring on undulating, gentle terrain nearer the coast. Optimal habitat includes a tall shrub layer and abundant hollows supporting high densities of arboreal marsupials" (DEC 2006). Roosting habitat is characterised by DEC (2006) as "groves of dense mid-canopy trees or tall shrubs in sheltered gullies, typically on wide creek flats and at the heads of minor drainage lines, but also adjacent to cliff faces and below dry waterfalls. Species commonly used for roosting include the She-oaks Allocasuarina spp., rainforest species such as Coachwood *Ceratopetalum apetalum*, Lilly Pilly *Acmena smithii* and Sassafras *Doryphora sassafras*, Black Wattle *Acacia melanoxylon*, Turpentine *Syncarpia glomulifera* and eucalypts. Roosting sites are commonly among small groves of up to 2 ha of similar-sized trees with dense foliage in the height range 3-15 m. DEC (2006) describes optimum nesting habitat as "old hollow eucalypts in unlogged, unburnt gullies and lower slopes within 100 m of streams or minor drainage lines, with hollows greater than 45 cm diameter and greater than 100 cm deep; surrounded by canopy trees and subcanopy or understorey trees or tall shrubs. Hollow entrances are greater than 6 m above ground, commonly more than 20 m where the forest permits, in trees of at least 80 cm diameter at breast height. A pair is generally faithful to a traditional nesting hollow, but also sometimes uses alternative hollows in the nesting gully". DEC (2006) state that habitat clearing and fragmentation resulting in small (less than 200 ha) forest fragments that are more than 1 km from large areas of forest are not used by Powerful Owls, but may provide marginal habitat for non-breeding Masked Owls. The likely ability of the owls to disperse over tens of kilometres through a mosaic of forested and cleared land suggests that there are unlikely to be any barriers to gene flow within NSW. Owl populations are unlikely to have declined or been fragmented to the point where their genetic integrity is threatened. The LMCC (2014) identify specific conservation priorities for Large Forest Owls with reference to nest and/or breeding roost tree habitat. Habitats for conservation priority include:

DGR Matter		Comment
		• Confirmed nest sites (including a 100m buffer), breeding roost trees (including a 50m buffer) and sustainable home range extant habitat around such sites; • Riparian habitat; • Corridor connectivity along riparian corridors and between major habitat fragments; and • Old growth forest.
e)	Assessment of adequacy of reservation	Estimated minimum population size in NSW is 2000 pairs or at least 10,000 individuals, with the majority of individuals in the north-east of NSW (DEC 2006). The Powerful Owl is well represented in conservation reserve network with habitat occupation occurring within the Tilligerry State Conservation Area, Medowie State Conservation Area, Wallaroo National Park, Karuah National Park, Columbey National Park, Worimi National Park, Karuah Nature Reserve, Tomaree National Park, Myall Lakes National Park, Black Bulga State Conservation Area, Wallingat National Park, Booti Booti National Park, Khappinghat Nature Reserve, Talawahl Nature Reserve, Crowdy Bay National Park, Middle Brother National Park, Dooragan National Park, Queens Lake Nature Reserve, Lake Innes Nature Reserve, Rawdon Creek Nature Reserve, Limeburners Creek National Park, Maria River National Park, Kumbatine National Park, Hat Head National Park, Yarrahapinni Wetlands National Park, Yarriabini National Park, Ngambaa Nature Reserve, Bellinger River National Park, Dorrigo National Park, Bongil Bongil National Park, Tuckeon Nature Reserve, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Yuraygir National Park, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Nightcap National Park, Whian Whian State Conservation Area, Mebbin National Park, Fortis Creek National Park, Nymboid-Binderay Natonal Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the region.
f)	Limit of known distribution	The Powerful Owl is distributed from Mt Gambier in South Australia east through Victoria (excluding Mallee districts in the north), the Riverina and coastal districts in the south of NSW (excluding Alpine districts) through to the northern NSW border encapsulating tablelands and coastal districts and into Queensland through to Rockhampton and scattered inland occurrence. Genetic studies indicate that this range encapsulates one genetic cluster inferred as a population (Dr Fiona Hogan pers coms). Occurrence in the Mackay area is disconnected and potentially represents a separate genetic cluster/ population.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	The Powerful Owl, which is more than twice as abundant in north-eastern NSW as in south-eastern NSW (DEC 2006), is frequently recorded in the Medowie – Tilligerry – Tomaree areas with occasional observations in the Fern Bay – Tomago area. The species is commonly observed in and near the Hunter Botanic Gardens. Records also indicate a widespread observation history in the Wallaroo – Columbey – Karuah National Park area to the north of the study area. A bird monitoring location at Balickera Channel has a continuous record of this species (63 time independent observations) from 1999-2016. Other than for the records mentioned in this SIS, there are no records for this species within the study area; presumably due to the lack of survey effort for this area.
b)	Discussion of habitat utilisation	The Powerful Owl forages in open or closed sclerophyll forest or woodlands and may also hunt in open habitats (OEH 2019b). As a hunter of arboreal prey, the Powerful Owl feeds predominantly on Common Ringtail Possums, Common Brush-tailed Possums, Greater Gliders and Sugar Gliders (Bain et al., 2014). Large eucalypts that are at least 150 years old, with hollows at least 0.5m deep are the primary nesting habitat for this species (OEH 2019b). Smaller trees with hollows and a shrub layer within which prey species reside are also habitat components for the Powerful Owl (OEH 2019b). Moist forest in unlogged corridors in gully systems is used for nesting and roosting (DEC 2006). Optimal breeding habitat contains; mature forest stands

DGR Matter	Comment
	with large hollow bearing trees, dense understorey shrubs for fledglings and high densities of arboreal marsupials (Schodde and Mason 1980, McNabb 1996, Kavanagh 1997, Higgins 1999; as cited by, DEC 2006). HWR (2004) report a Powerful Owl roost site in Conservation Area through identification of feathers and white wash. This observation was in dense vegetation and not conclusively linked to a nesting hollow (John-Paul King pers com 2019). The extensive stag watching survey of possible nest sites performed in the 2019 breeding season throughout the Proposal impact footprint did not identify a nesting tree utilised by this species for breeding. A single Powerful Owl was observed in the east during this survey on one night and appeared to be moving through the tree canopy in foraging mode as it showed no interest in the hollows in the survey area. Carter et al (2019) identify riparian vegetation, especially those with high normalised difference vegetation index scores, as being critical for owl movements in the early evening when the species is likely to be most actively foraging. These riparian corridors become less important in the latter parts of the night where movement becomes less constrained, with Powerful Owls more likely to venture into less vegetated landscapes including urban areas (Powerful Owl Coalition 2018).
c) Description of vegetation	Habitat for this species broadly exists in PCTs 1230, 1584, 1590 and 1600 and excludes areas of native vegetation mapped as scattered trees in open paddocks (i.e. PCT 1590 in moderate good poor condition) as these areas do not support prey species. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat preferred by the Powerful Owl primarily constitutes mature forests and woodlands (**Figure 4.26**) with localised indicators of habitat complexity such as elevated abundance of fallen logs (**Figure 4.27**) and hollow-bearing trees (**Figure 4.28**), with the latter habitat feature particularly important in determining the abundance of prey species and suitable breeding habitat (i.e. large hollows in trees often with a DBH > 80 cm). Dense vegetation in gullies is important for daytime roosts and movement with the species only utilising hollows during the breeding period. Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal will remove 206.64 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along

DGR Matter	Comment
	drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Powerful Owl in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.18 Masked Owl

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Masked Owl (*Tyto novaehollandiae*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Masked Owl: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	The Masked Owl (*Tyto novaehollandiae*) is a large forest owl that occupies dry eucalypt forests and woodlands from sea level to 1,100 m. Pairs have a large home-range of 500 to 1,000 hectares and is not a species exhibiting seasonal variation in its distribution. It roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting with a preference for vertical hollows in large trees.
d)	Other documentation	The recovery plan described optimum habitat as "dry eucalypt forests of the tablelands, western slopes and the undulating wet-dry forests of the coast. Optimal habitat includes an open understorey and a mosaic of sparse (grassy) and dense (shrubby) ground cover on gentle terrain" (DEC 2006). Roosting habitat is characterised by DEC (2006) as "hollows in live or occasionally dead eucalypts; dense foliage in gullies; and caves or recesses in cliffs. Hollow sites can be in a variety of topographic positions, from gully to upper slope, and are also used as nest sites or have similar characteristics to those used for nesting. Roost sites in trees are greater than 5 m above the ground". DEC (2006) describes optimum nesting habitat as "old hollow eucalypts, live or dead but commonly live, in a variety of topographic positions from gully to upper slope, with hollows greater than 40 cm wide and greater than 100 cm deep; there is no relationship with distance to streams. Nest sites may be subject to a variety of disturbance regimes, which make nest trees susceptible to loss (wind throw and burning). Hollow entrances are at least 3 m above ground, in trees of at least 90 cm diameter at breast height. The pair is faithful to a traditional nesting hollow, but may also use alternative hollows in the breeding territory in different years".
e)	Assessment of adequacy of reservation	Estimated minimum population size in NSW is 1500 pairs or at least 8,000 individual (DEC 2006). The Masked Owl is well represented in conservation reserve network with habitat occupation occurring within the Tilligerry State Conservation Area, Medowie State Conservation Area, Karuah National Park, Columbey National Park, Tomaree National Park, Ghin-Doo-Ee National Park, Myall Lakes National Park, Black Bulga State Conservation Area, Wallingat National Park, Booti Booti National Park, Talawahl Nature Reserve, Crowdy Bay National Park, Middle Brother National Park, Dooragan National Park, Queens Lake Nature Reserve, Lake Innes Nature Reserve, Limeburners Creek National Park, Maria River National Park, Kumbatine National Park, Hat Head National Park, Yarriabini National Park, Ngambaa Nature Reserve, Joaningga Nature Reserve, Bellinger River National Park, Dorrigo National Park, Bongil Bongil National Park, Sherwood Nature Reserve, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Yuraygir National Park, Bundjalung National Park,

DGR Matter	Comment
	Bundjalung State Conservation Area, Broadwater National Park, Nightcap National Park, Whian Whian State Conservation Area, Mebbin National Park, Fortis Creek National Park, Nymboid-Binderay National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this bird in the region.
f) Limit of known distribution	The range of the Masked Owl is a broad coastal band around most of mainland Australia and throughout Tasmania, and for the most part is less than 300 km from the coast.
2) Discussion of local and regional abundance	
a) Discussion of other known local populations	Not unexpectedly there are few records of the Masked Owl are within the locality due to the large home range of the species and the limited quantum of suitable habitat to the west and south across the Williams River floodplain. A recent roadkill observed near Heatherbrae (2019) (Birdata 2019) and historical roadkill near the old Irrawang Spillway (HWR 2004) indicate broad habitat usage in the local area and propensity to move over partially cleared lands. The observation within the subject site, which was within a densely vegetated part comprising high density of hollow-bearing trees and fallen logs, is the first observation of this species within the study area.
b) Discussion of habitat utilisation	Masked Owls feed mainly on small mammals, such as rodents, rabbits and bandicoots. Other prey animals include possums, reptiles, birds and insects, with hunting taking place in the early hours of night. The birds sit on low perches listening for prey which, once detected, is taken from the ground or from the tree branches. A Masked Owl was heard calling in the western part of the Conservation Area during an extensive stag watching survey of possible nest sites performed in the 2019 breeding season. This is the only record of this species within the subject site despite considerable survey effort performed for this SIS and historically (HWR 2004; BIOCM 2018; Cumberland Ecology 2019).
c) Description of vegetation	Habitat for this species broadly exists in PCTs 1230, 1584, 1590 and 1600 and excludes areas of native vegetation mapped as scattered trees in open paddocks (i.e. PCT 1590 in moderate good poor condition). Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat preferred by the Masked Owl primarily constitutes mature forests and woodlands (**Figure 4.26**) with localised indicators of habitat complexity such as elevated abundance of fallen logs (**Figure 4.27**) and hollow-bearing trees (**Figure 4.28**), with the latter habitat feature particularly important in determining the abundance of prey species and suitable breeding habitat (i.e. large hollows in trees often with a DBH > 80 cm). Dense vegetation in gullies can be important for daytime roosts although the species mostly utilises hollows for diurnal roosts and breeding. Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal will remove 206.64 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.

DGR Matter	Comment
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Masked Owl in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.19 Regent Honeyeater

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Regent Honeyeater (*Anthochaera phrygia*) is listed as critically endangered under Schedule 1A of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Regent Honeyeater: • Clearing of native vegetation • Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners Manorina melanocephala. • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants • Predation by the Feral Cat *Felis catus*
c)	Habitat requirements	Regent Honeyeaters are typically associated with box-ironbark eucalypt associations, where the species seems to prefer more fertile sites with higher soil water content, including creek flats, broad river valleys and lower slopes. Other forest types regularly utilised by Regent Honeyeaters include wet lowland coastal forest dominated by Swamp Mahogany (*Eucalyptus robusta*), spotted gum-ironbark associations and riverine woodlands (where it is known to feed on nectar from *Amyema cambagei*) (DoE 2016).
d)	Other documentation	This species has been assigned to the Site-managed species management stream under the SoS program, aimed to secure the species in the wild for 100 years and maintain its conservation status. The Subject Site is outside the Lower Hunter Valley management zones targeted by this plan (i.e. Spotted gum forests bounded in the east by Wallis Creek, including Singleton, Broke and Cessnock areas) being the nearest Priority Management Site. A NSW recovery plan has not been prepared for the Regent Honeyeater. However, the National Recovery Plan prepared for this species (DoE 2016) identifies habitat critical to the survival of this species as: • Any breeding or foraging areas where the species is likely to occur. • Any newly discovered breeding or foraging locations. The objectives of this recovery plan are to: • Reverse the long-term population trend of decline and increase the numbers of regent honeyeaters to a level where there is a viable, wild breeding population, even in poor breeding years; and to • Enhance the condition of habitat across the regent honeyeaters range to maximise survival and reproductive success, and provide refugia during periods of extreme environmental fluctuation.

DGR Matter		Comment
		The Regent Honeyeater is also identified as a bird pollinator listed as threatened in NSW under the TSC Act. OEH (2016b) identifies the winter flower diet of this species to comprise Swamp Mahogany, Spotted Gum and Broad-leaved Paperbark with only Spotted Gum having any meaningful occurrence within the study area. Spring flowering and nectar producing tree species that are also of relevance to the subject site include Grey Box, Grey Ironbark (*Eucalyptus siderophloia*) and Forest Redgum (DIPNR 2004). Programs monitoring the ecological benefits of revegetation plantings and regeneration sites are relatively recent and generally report encouraging results on bird occupancy in young plantings (5 to 25 years old) where mobile species are able to locate and inhabit these rehabilitation sites (e.g. Kavanaugh et al. 2007; Munro et al. 2011; Law et al. 2014; Smith et al. 2015). Changes resulting in species incidence were quantitatively apparent after 10 years and reached the levels recorded in nearby remnant vegetation within 20 years (OEH 2016b). In revegetation projects, OEH 2016b) recommends various additional considerations. In addition to the timing of flowering and nectar production, another important consideration applicable to the Proposal is flower density as this can be important for attracting pollinators. Large-area plantings or plantings near existing habitat may be visited by more individuals and more species (Lindell & Thurston 2013).
e)	Assessment of adequacy of reservation	The Regent Honeyeater is not regarded as having adequate reservation anywhere within its natural distribution.
f)	Limit of known distribution	Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. the subject site falls within the known distribution of this species. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years, flocks converge on flowering coastal woodlands and forests. The current distribution of the Regent Honeyeater is extremely patchy, with a small number of known breeding sites. Bendigo, in central Victoria, is now its western limit. On the western edge of its New South Wales range it occurs as far inland as Narrabri, Warrumbungle National Park, Dubbo, Parkes and Finley (DoE 2016). Regent Honeyeaters may use different areas in different years depending on food resources. They may move large distances to do this although more research is required to confirm the regularity and extent of this behaviour (DoE 2016). Within its current distribution there are four known key breeding areas where the species is regularly recorded. These are the Bundarra-Barraba, Capertee Valley and Hunter Valley districts in New South Wales, and the Chiltern area in north-east Victoria. Breeding has also been regularly recorded in the Cement Mills-Durakai area west of Warwick, southern Queensland and in the Australian Capital Territory (DoE 2016).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	There are no known breeding populations of this species within the local area. Breeding in the lower Hunter Valley region is largely limited to spotted gum ironbark forests in the Cessnock – Quorrobolong – Kurri Kurri area and Goulburn River catchment. When present in the local area, the Regent Honeyeater is often sighted in winter prior to onset of the breeding period, which is typically between September and January. There are scattered and infrequent records of Regent Honeyeater throughout the Port Stephens LGA. The nearest of these records was at Seaham, about 6km northwest of the Subject Site (BCD 2019) and Hunter Botanic Gardens; approximately 9km

DGR Matter	Comment
	south of the Subject Site). Based on the low number and spread of records, it appears that this species sporadically uses such coastal regions for feeding on flowering coastal woodlands and forests.
b) Discussion of habitat utilisation	Occurrences of the Regent Honeyeater along the NSW coastline are typically in winter and generally associated with non-breeding regional migrations in search of nectar resources. In the lower Hunter, these resources are typically associated with Spotted Gum, Swamp Mahogany and Broad-leaved Ironbark and mistletoe. Spotted Gum is present across most of the subject site both within the Proposal impact footprint and Conservation Area.
c) Description of vegetation	Foraging habitat for this species broadly exists in PCT 1584, 1590 which broadly describes the extent of Spotted Gum. These PCTs present some potential foraging options for this species during flowering (i.e. select *Eucalyptus* sp. and mistletoe), with nesting habitat unlikely given the distance to known breeding locations. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat preferred by the Regent Honeyeater primarily constitutes mature forests and woodlands (**Figure 4.26**) with localised indicators of habitat complexity often associated with an elevated abundance of mistletoe. Being nectivorous and like the Grey-headed Flying Fox, the Little Lorikeet will prefer vegetation comprising trees with reliable nectar supply throughout the year (**Figures 4.83** to **4.88**); with increased abundance/ spatial extent of these trees likely to locally elevate the relative important of foraging habitat (i.e. quantum and temporal availability). Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) and African Olive (**Figure 4.23**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint. Habitat values present with in the subject site are foraging opportunities only, with known nesting/ breeding of this species to occurring to the west (i.e. Quorrobolong – Cessnock area, Capertee and Barraba). In addition to Swamp Mahogany and Spotted Gum, flowering of stringybark species and Broad-leaved Ironbark are known to contribute important nectar flows at times within the lower Hunter Valley Region. This species may also feed on nectar and fruit from the mistletoes, such as *Amyema miquelii*, *A. pendula* and *A. cambagei*. Habitat that historically occurred around wetland 803 was likely to have been heavily used by the Regent Honeyeater (i.e. an area that once comprised Swamp Mahogany). An assessment of habitat suitability for the Reagent Honeyeater throughout the Lower Hunter region was undertaken by Roderick et al. (2013). Habitat mapping by Roderick et al. (2013) shows the Subject Site is located within an area classed as providing low value habitat for the Regent Honeyeater.
4) Extent of habitat removal	The Proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 214.07 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp Mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).

DGR Matter	Comment
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Regent Honeyeater in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.20 Swift Parrot

DGR Matter	Comment
1) Discussion of conservation status	
a) Local, regional and state-wide status	The Swift Parrot (*Lathamus discolor*) is listed as critically endangered under Schedule 1A of the TSC Act.
b) Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Swift Parrot: • Clearing of native vegetation • Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala* • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants • Predation by the Feral Cat *Felis catus*
c) Habitat requirements	Migrates to the Australian south-east mainland between February and October, where it forages in areas where eucalypts are flowering profusely or where there is abundant lerp (from sap-sucking bugs) infestations. (OEH 2019b). Favoured feed trees include winter flowering species such as Swamp Mahogany (*E. robusta*), Spotted Gum, Red Bloodwood, Forest Red Gum, Mugga Ironbark (*E. sideroxylon*) and White Box (*E. albens*). Commonly used lerp infested trees include Inland Grey Box (*E. microcarpa*), Grey Box (*E. moluccana*), Blackbutt (*E. pilularis*), and Yellow Box (*E. melliodora*) (OEH 2019b).
d) Other documentation	A NSW recovery plan has not been prepared for the Regent Honeyeater. This species has been assigned to the Landscape species management stream under the Saving our Species (SoS) program. This action statement aims to ensure that the species is secure in the wild in NSW and that its NSW geographic range is extended or maintained. The Subject Site is outside the management zones targeted by this plan, with the Central Coast being the nearest Priority Management Site. The Swift Parrot is also identified as a bird pollinator listed as threatened in NSW under the TSC Act. OEH (2016b) identifies the winter flower diet of this species to comprise Swamp Mahogany, Spotted Gum and Broad-leaved Paperbark with only Spotted Gum having any meaningful occurrence within the study area. Spring flowering and nectar producing tree species that are also of relevance to the subject site include Grey Box, Grey Ironbark (*Eucalyptus siderophloia*) and Forest Redgum (DIPNR 2004). Programs monitoring the ecological benefits of revegetation plantings and regeneration sites are relatively recent and generally report encouraging results on bird occupancy in young plantings (5 to 25 years old) where mobile species are able to locate and inhabit these rehabilitation sites (e.g. Kavanaugh et al. 2007; Munro et al. 2011; Law et al. 2014; Smith et al. 2015). Changes resulting in species incidence were quantitatively apparent after 10 years and reached the levels recorded in nearby remnant vegetation within 20 years (OEH 2016b). In revegetation projects, OEH 2016b) recommends various additional considerations. In addition to the timing of flowering and nectar production, another important consideration applicable to the Proposal is flower density as this can be important for attracting pollinators. Large-area plantings or plantings near existing habitat may be visited by more individuals and more species (Lindell & Thurston 2013).

DGR Matter		Comment
e)	Assessment of adequacy of reservation	State wide, 12% of the species' distribution occurs on reserve (within NSW National Parks and Wildlife Service estate). Throughout the greater North Coast Bioregion, winter flowing eucalyptus, which provide key foraging habitat for Swift Parrots, occurs in many conservation reserves. These reserves include Barrington Tops National Park, Myall Lakes National Park, Wallaroo State Forest, Wallaroo Nature Reserve and Karuah National Park. Habitat conserved within these reserves offers stable and long-term security for the Swift Parrot. Combined, these nature reserves protect over 1200 km^2 of bushland, much of which is woodland and forest that support winter flowering *Eucalyptus* sp. Reservation of such a large area of potential foraging habitat suggests the above reserves provide considerable habitat protection for this bird in the local region.
f)	Limit of known distribution	The Swift Parrot breeds in Tasmania during spring and summer, migrating in the autumn and winter months to south-eastern Australia from Victoria and the eastern parts of South Australia to south-east Queensland. In NSW mostly occurs on the coast and south west slopes. The subject site falls within the known distribution of this species during winter months.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	There are ~ 30 scattered records of Swift Parrots throughout the Port Stephens LGA (BCD 2019). One of these records was located near the northeastern corner of the Subject Site, suggesting this species sporadically uses this area. Also sighted nearby to the site was 40 individuals at Raymond terrace. Both these records were made during or toward the end of winter, which coincides with end of winter flowering of *Eucalyptus* sp. in the region.
b)	Discussion of habitat utilisation	Based on the sporadic nature of sightings in the local area, the habitat is likely to provide an infrequent source of food for Swift Parrot only. Winter flowering *Eucalyptus* sp. located on site, which may provide a source of food during the winter migration for Swift Parrot, include Spotted Gum, with tree species flowering in early spring also of potential value such as Red Bloodwood, Forest Red Gum and Grey Box.
c)	Description of vegetation	Foraging habitat for this species broadly exists in PCT 1584, 1590 which broadly describes the extent of Spotted Gum. These PCTs present some potential foraging options for this species during flowering (i.e. select *Eucalyptus* sp. and mistletoe).Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3)	**Description of habitat values**	Winter flowering nectar producing trees present foraging habitat for this species. Specifically, Spotted Gum is the most dominant nectar species within the study area. Other species that may flower in late winter early spring could be used such as Red Bloodwood, Forest Red Gum and Grey Box. No breeding habitat is available, as this species reproduces in Tasmania, and migrates north through the winter only.
4)	**Extent of habitat removal**	The Proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 214.07 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).

DGR Matter	Comment
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Swift Parrot in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.21 Scarlet Robin

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Scarlet Robin (*Petroica boodang*) is listed as vulnerable under Schedule 2 of the BC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Scarlet Robin: • Clearing of native vegetation • Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners Manorina melanocephala. • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants • Removal of dead wood and dead trees • Predation by the Feral Cat *Felis catus*
c)	Habitat requirements	The Scarlet Robin lives in dry eucalypt forests and woodlands; it is known to associate with 663 PCTs across NSW. The understorey is usually open and grassy with few scattered shrubs. This species lives in both mature and regrowth vegetation. It occasionally occurs in mallee or wet forest communities, or in wetlands and tea-tree swamps. Scarlet Robin habitat usually contains abundant logs and fallen timber: these are important components of its habitat. The Scarlet Robin breeds on ridges, hills and foothills of the western slopes, the Great Dividing Range and eastern coastal regions; this species is occasionally found up to 1000 m in altitude. The Scarlet Robin is primarily a resident in forests and woodlands, but some adults and young birds disperse to more open habitats after breeding. In autumn and winter many Scarlet Robins live in open grassy woodlands, and grasslands or grazed paddocks with scattered trees. This species' nest is an open cup made of plant fibres and cobwebs and is built in the fork of tree usually more than 2 m above the ground; nests are often found in a dead branch in a live tree, or in a dead tree or shrub.
d)	Other documentation	A NSW recovery plan has not been prepared for the Scarlet Robin. A targeted strategy for managing this species has been developed under the SoS program, however the subject area has not been identified as a key management site. Scarlet Robin has been assigned to the Landscape species management stream under the SoS program, which aims to ensure it is secure in the wild in NSW and that its NSW geographic range is extended or maintained.
e)	Assessment of adequacy of reservation	Across the state, 28% of the species' distribution occurs on reserve (within NSW National Parks and Wildlife Service estate). Locally, habitat for the Scarlet Robin occurs in many conservation reserves throughout the greater North Coast Bioregion. These areas include Barrington Tops National Park, Myall Lakes National Park, Wallaroo State Forest, Wallaroo Nature Reserve and Karuah National Park. Habitat conserved within these reserve areas offers more stable and long-term security for the Scarlet

DGR Matter		Comment
		Robin occupying these areas than those in areas of development. Combined, these nature reserves protect over 1200 km^2 of bushland, much of which is woodland and forest that can support the Scarlet Robin. Considering this species frequents many dry eucalypt forests and woodland, it is expected that reservation of such a large area of suitable bushland habitat provides considerable habitat protection for this bird in the local region.
f)	Limit of known distribution	Within eastern Australia, the Scarlet Robin is found from south east Queensland to south east South Australia. In NSW, it occurs from the coast to the inland slopes. It also occurs in in Tasmania and south west Western Australia.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	A search of database records found the nearest record of a Scarlet Robin was made north of Six Mile Rd (OEH 2019a). Across the Port Stephens LGA, records of the Scarlet Robin are infrequent and scattered. In total, only seven records have been made; which extend from 1984 to 2013.
b)	Discussion of habitat utilisation	Based on the habitat requirements of the Scarlet Robin, suitable habitat has been identified across the forested areas of the site as this species' habitat requirements are general. That is, areas dominated by eucalypt species with regenerating eucalypts and some shrub cover may constitute suitable habitat, which typifies most of the vegetation on site. The exception is that some parts of the study area are dense with Lantana and/ or simplified ground habitat (i.e. few fallen logs), which are likely to preclude this species from these areas.
c)	Description of vegetation	Habitat for this species broadly exists in PCTs 1230, 1584, 1590 and 1600 and excludes areas of native vegetation mapped as scattered trees in open paddocks (i.e. PCT 1590 in moderate good poor condition). Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3)	**Description of habitat values**	Habitat preferred by the Scarlet Robin primarily constitutes mature forests and woodlands (**Figure 4.26**) with localised indicators of habitat complexity such as elevated abundance of fallen logs (**Figure 4.27**). Being an insectivore, the Scarlet Robin will prefer vegetation with elevated perching platforms; a feature of its habitat that locally elevates the area of available foraging habitat (i.e. bark and rough surfaces increases the abundance and biomass of invertebrates). Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) and African Olive (**Figure 4.23**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4)	**Extent of habitat removal**	The Proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 213.92 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5)	**Consideration of corridors**	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader

DGR Matter	Comment
	habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Scarlet Robin in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.22 Squirrel Glider

DGR Matter	Comment
1) Discussion of conservation status	
a) Local, regional and state-wide status	The Squirrel Glider (*Petaurus norfolcensis*) is listed as vulnerable under Schedule 2 of the TSC Act.
b) Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Squirrel Glider: • Clearing of native vegetation • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees • Predation by the Feral Cat *Felis catus*
c) Habitat requirements	This species prefers a range of dry and moist sclerophyll forest, swamp forest, and woodland vegetation communities typically including Blackbutt-Bloodwood forest with heath understorey in coastal areas (BCD 2019). Winter flowering eucalypts or flowering banksias are important (Quin et al. 2004; Sharpe 2004; Sharpe & Goldingay 2010, HWR Ecological 2003), or summer flowering eucalypts with an understorey of acacia species that provide edible gum exudates in winter (e.g. *A. irrorata, A. parramattensis* and *A. longifolia*) (Smith and Murray, 2003). Squirrel gliders eat nectar from flowers, pollen and sugary plant and insect exudates (LMCC 2015). In addition to pollen and nectar, arthropods are an important food source (Sharpe & Goldingay 1998; Dobson, Goldingay & Sharpe 2005; Ball et al. 2009).
d) Other documentation	A NSW recovery plan has not been prepared for the Squirrel Glider. LMCC (2014) indicate the minimum habitat patch size that will be occupied by squirrel gliders is strongly influenced by habitat quality. Squirrel gliders occupy very small patches if habitat quality is high, and much larger habitat patch sizes in lower quality habitat. However, the probability of a patch being occupied by squirrel gliders decreases with remnant size. Modelling predicts that density and occurrence begins to decline when patch size falls below 100 ha depending on time since isolation, remnant shape, and distance to nearby habitat. In Wyong, the largest known remnant of suitable habitat without squirrel gliders is 30 ha. Habitat patches of less than 4 ha are considered unsuitable for permanent occupancy. Small habitat patches of 4 ha to 30ha, are considered at high risk of local extinction. Minor habitat patches of 30 ha to 100 ha, are considered at moderate to low risk in the short-term, and high risk in the long-term; and major habitat patches, 100 ha to 1,000 ha are considered at no risk in the short-term, (50 yrs to 100 yrs), and low to moderate risk in the long term (Smith 2002 as cited in LMC 2014).

DGR Matter		Comment
		The Squirrel Glider is also identified as a mammal pollinator listed as threatened in NSW under the TSC Act. OEH (2016b) identifies the winter flower diet of this species to comprise Swamp Mahogany, Spotted Gum and Broad-leaved Paperbark with only Spotted Gum having any meaningful occurrence within the study area. Spring flowering and nectar producing tree species that are also of relevance to the subject site include Grey Box, Grey Ironbark (*Eucalyptus siderophloia*) and Forest Redgum (DIPNR 2004). Programs monitoring the ecological benefits of revegetation plantings and regeneration sites are relatively recent and generally report encouraging results on pollinator occupancy in young plantings (5 to 25 years old) where mobile species are able to locate and inhabit these rehabilitation sites (e.g. Kavanaugh et al. 2007; Munro et al. 2011; Law et al. 2014; Smith et al. 2015). Changes resulting in species incidence were quantitatively apparent after 10 years and reached the levels recorded in nearby remnant vegetation within 20 years (OEH 2016b). In revegetation projects, OEH 2016b) recommends various additional considerations. In addition to the timing of flowering and nectar production, another important consideration applicable to the Proposal is flower density as this can be important for attracting pollinators. Large-area plantings or plantings near existing habitat may be visited by more individuals and more species (Lindell & Thurston 2013).
e)	Assessment of adequacy of reservation	The Squirrel Glider is well represented in conservation reserve network with habitat occupation occurring within the Tilligerry State Conservation Area, Medowie State Conservation Area, Worimi National Park, Karuah National Park, Karuah Nature Reserve, Columbey National Park, Tomaree National Park, Myall Lakes National Park, Booti Booti National Park, Knappinghat Nature Reserve, Crowdy Bay National Park, Queens Lake Nature Reserve, Lake Innes Nature Reserve, Rawdon Creek Nature Reserve, Limeburners Creek National Park, Maria River National Park, Willi Willi National Park, Hat Head National Park, Yarrahapinni Wetlands National Park, Yarriabini National Park, Joaningga Nature Reserve, Bellinger River National Park, Bongil Bongil National Park, Sherwood Nature Reserve, Nymboid-Binderay National Park, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Yuraygir National Park, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Border Ranges National Park, Wollumbin National Park, Fortis Creek National Park, Richmond Range National Park and Ramornie National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.
f)	Limit of known distribution	Squirrel gliders are sparsely distributed in eastern Australia, from northern Queensland to western Victoria (OEH 2019b).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	Squirrel Glider occurrences are highly localised and dependent on availability of suitable foraging habitat with tree hollows. Colonies require multiple den trees within their home ranges (LMCC 2015). This narrative appears to be evident on the local distribution of this species with noteworthy dense observed occurrences in the Tomago, Balickera, Medowie and Brandy Hill areas. The historical recorded occurrence within the subject site is ~16 years ago (HWR 2004); an observation that has not been reproduced in recent surveys. Results from then and now appears to point to a low density of individuals or absence, with the latter supported by the relatively poor habitat conditions observed (i.e. lack of swamp forest and woodland vegetation communities typically including Blackbutt-Bloodwood forest with heath understorey in coastal areas).

DGR Matter	Comment
b) Discussion of habitat utilisation	Recent surveys performed as part of this SIS indicate the Squirrel Glider may be absent from the subject site notwithstanding the presence of marginal habitat such as nectar resources restricted to the eucalypt canopy in the lower parts of the landscape (HWC 2004).
c) Description of vegetation	Habitat for this species broadly exists in PCTs 1230, 1590 and 1600 and excludes areas of native vegetation mapped as scattered trees in open paddocks (i.e. PCT 1590 in moderate good poor condition). Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Preferred habitat within the subject site is likely to be of suboptimal value and associated with the forested hills (HWR 2004), which would coincide mostly with PCT 1584. Highest value habitat patches are likely to comprise a diverse range of seasonal nectar such as Forest Redgum (i.e. spring-summer), Grey Ironbark (i.e. summer), Grey Gum (i.e. summer-autumn) and Spotted Gum (i.e. autumn to winter). Forested hills with these conditions are limited to the western half of the subject site, notably the elevated terrain where all these species occur in close proximity to each other in combination with relatively dense patches of hollow-bearing trees.
4) Extent of habitat removal	The Proposal will remove 206.64 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.

DGR Matter	Comment
6) **Impacts on Threatened Species and/or Populations in National Parks Estate**	This proposal is considered unlikely to impact on any individuals of the Squirrel Glider in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.23 Koala

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Koala (*Phascolarctos cinereus*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Koala: • Clearing of native vegetation • Human-caused Climate Change • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants • Predation and Hybridisation by Feral Dog (*Canis lupis familiaris*)
c)	Habitat requirements	The Koala is predominantly found in eucalypt woodlands and forests and feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species (OEH 2019b), but will select preferred food trees based on foliage nutrient value (OEH 2018; Marsh and Youngentob 2019). The nutritional quality of eucalypt leaves for koalas (*Phascolarctos cinereus*) is determined by a combination of nutrients and plant secondary metabolites (PSMs). Protein is one of the most important nutritional aspects of forage quality because it is considered a limiting nutrient for many herbivores (Mattson 1980). Protein is required in adequate amounts to support animal growth and reproduction, but it is present at relatively low concentrations in eucalypts (Wallis et al. 2010). However, even eucalypts that contain adequate protein may not always be good food for koalas. This is because PSMs can limit the ability of animals to access protein, either because some PSMs (e.g. tannins) bind to proteins and make them indigestible (Marsh et al. 2003, DeGabriel et al. 2008, Wallis et al. 2010), or because others (e.g. formylated phloroglucinol compounds and unsubstituted B-ring flavanones) have toxic properties that limit the amount of leaves that animals can eat (Marsh et al. 2007, Marsh et al. 2015, Marsh et al. 2019). Koalas also require suitable areas for thermoregulation. Trees suitable for foraging may not be adequate for thermoregulatory purposes. Denser forests with higher leaf area values and tree types such as smooth barks are often favoured as diurnal rest sites especially during the hotter months.
d)	Other documentation	A recovery plan has been prepared for the Koala. The overall aim of the recovery plan is to reverse the decline of the koala in NSW, to ensure adequate protection, management and restoration of koala habitat, and to maintain healthy breeding populations of koala throughout their current range (DECC 2008). DoE (2014) report the main threats to coastal populations of the Koala: • Loss, fragmentation and degradation of habitat, including dispersal habitat.

DGR Matter	Comment
	• Mortality due to vehicle strikes, dog attacks and disease. • High-intensity fire. Interim recovery objectives are: • Protect and conserve large, connected areas of koala habitat, particularly large, connected areas that support koalas that are: – Of sufficient size to be genetically robust / operate as a viable sub-population OR – free of disease or have a very low incidence of disease OR – breeding. • Maintain corridors and connective habitat that allow movement of koalas between large areas of habitat. The Port Stephens Council Comprehensive Koala Plan of Management (CKPoM) (Port Stephens Council 2002), which supersedes the requirements of SEPP 44 for the investigation of potential and core koala habitat, provides detailed information on the assessment of development impacts on the Koala including the evaluation of net gain and threats. Further details of this are provided in **Section 7.1.2**. DPIE (2019) have classified koalas within the subject site as forming part of the Wang Wauk SF ARKS, which has a total area of 174,864 ha with moderate resilience and security.
e) Assessment of adequacy of reservation	The Koala is well represented in conservation reserve network with habitat occupation occurring within the Tilligerry State Conservation Area, Worimi National Park, Tomaree National Park, Medowie State Conservation Area, Karuah National Park, Karuah Nature Reserve, Columbey National Park, Wallaroo National Park, Black Bulga State Conservation Area, Myall Lakes National Park, The Glen Nature Reserve, Wallingat National Park, Booti Booti National Park, Talawahl Nature Reserve, Khappinghat Nature Reserve, Killabakh Nature Reserve, Middle Brother National Park, Killabakh Nature Reserve, Dooragan National Park, Crowdy Bay National Park, Queens Lake Nature Reserve, Queens Lake State Recreation Area, Lake Innes Nature Reserve, Limeburners Creek National Park, Rawdon Creek Nature Reserve, Cooperabung Nature Reserve, Goolabah National Park, Maria River National Park, Kumbatine National Park, Dunggir National Park, Willi Willi National Park, Hat Head National Park, Yarriabini National Park, Ngambaa Nature Reserve, Bellinger River National Park, Dorigo National Park, Bongil Bongil National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Ulidarra National Park, Bindarri National Park, Sherwood Nature Reserve, Cascade National Park, Nymboid-Binderay National Park, Yuraygir National Park, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Bungawalbin National Park, Bungawalbin State Conservation Area, Mt Pikapene National Park, Border Ranges National Park, Wollumbin National Park, Mount Neville Nature Reserve, Nightcap National Park, Whian Whian State Conservation Area, Mebbin National Park, Richmond Range National Park, Fortis Creek National Park, Tyagarah Nature Reserve, Billinundgei Nature Reserve, Mooball National Park, Cudgen Nature Reserve, Toonumbar National Park, Mt Jerusalem National Park and Ramornie National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.
f) Limit of known distribution	The Koala is found along the east coast of Australia, from north-eastern Queensland to the south-east corner of South Australia. In NSW, the Koala mainly occurs on the central and north coasts with some populations in the west of the Great Diving Range (OEH 2019b). The study area falls within the known distribution of this species.
2) Discussion of local and regional abundance	

DGR Matter	Comment
a) Discussion of other known local populations	BioLink (2017) tentatively identifies a number of localities within the Port Stephens LGA as potential population 'hubs', which are an adaption of a concept known as Areas of Local Koala Significance (ALKS) as described by Rennison (2017a). If proven, these hubs may provide a long term sustainable management structure for koala population viability (BioLink 2017). BioLink (2017) identify a number of probable/ potential 'hubs' within the Port Stephens LGA including one overlapping with the subject site (known as the Kings Hill hub). BioLink (2019a) further investigates the Kings Hill hub and concludes it is an active hub implying a population of > 50 koalas and available habitat of > 900 ha; although, the metrics used to define an active hub are not supported in the literature. There is an adjacent hub to the east known as Grahamstown Dam hub and others further east at Medowie, Williamtown East, Williamtown West, Tomago-Heatherbrae, Tilligerry and Anna Bay – Soldiers Point (Tomaree). Two probable hubs occur to the west at Seaham and Butterwick - Seaham (BioLink 2017). A Koala genetic study for selected sites within Port Stephens LGA (OWAD 2019b) identified at least two genetic clusters thereby providing evidence for the delineation of at least two local populations. Port Stephens 1 (PS1) is geographically restricted to the east in the Tomaree area, with little evidence of genetic flow occurring within the Port Stephens 2 (PS2) population. The PS2 population includes Koalas sampled within the subject site, east of the Pacific Highway in the Grahamstown Dam precinct and at Karuah and north of the subject site near Clarence Town and Booral. Further afield, there is evidence of genetic flow between Koalas that form part of the PS2 population and those that occur at Barrington Tops and at Port Macquarie indicating a population boundary somewhere in the intervening area. While the northern extent of the PS2 population remains unknown, it is possible that the boundary to this population lay somewhere in the Manning – Camden Haven catchments (Dr Steve Phillips pers coms).
b) Discussion of habitat utilisation	The Koala was recorded in the study area by PEA Consulting (2012), Cumberland Ecology (2019), RPS in 2018 and 2019, ANU (2019), BioLink (2018) and OWAD (2019). The Koala appears to be occupying the more densely forested parts of the subject site where there are many preferred Koala feed trees present. BioLink (2019a) estimates 27 Koala individuals to occur within the subject site and 8 to occur within the Proposal impact footprint within a habitat area of 152 ha. OWAD (2019a) found 10 individuals within the subject site using DNA profiling methods. There were four females and six males, with evidence of breeding (i.e. close kin relations). These Koalas form part of a larger population that including includes individuals east of the Pacific Highway within the Grahamstown Dam precinct, Karuah, Booral and Clarence Town. Koalas at Kings Hill form part of a population that is unrelated to the isolated Koala population located on the Tomaree peninsula.
c) Description of vegetation	Within the study area, the Koala was recorded across several PCTs although mostly in PCTs 1584 and 1590. Important canopy species defined as Secondary preferred feed trees [i.e. preferred trees located on low nutrient soils include Forest Redgum, Small-fruited Grey Gum, Grey Gum, Grey Box and Tallowwood (BioLink 2019)]. The distribution of these tree species is not even across the subject site as shown by the results of a stadia metric survey for the above PKFTs with DBH > 300mm, as recommended by BioLink (2019b). Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Marsh and Youngentob (2019) confirmed the value of Forest Redgum, Tallowwood, Grey Box, Grey Gum and Small-fruited Grey Gum as PKFTs on site (sufficient digestible nitrogen levels). BioLink (2019a,b) confirms the site comprises Secondary B/C habitat with PKFT including Forest Redgum, Tallowwood, Grey Box, Grey Gum and Small-fruited Grey Gum with a DBH >300mm. OWAD (2019a) identifies koala activity in drainages presumably associated with use of refugia and possible

DGR Matter	Comment
	movement. The majority of Koala activity is located on ridges to mid slopes and associated riparian zones; this generally reflective of dense aggregations of PKFTs and suitable proximal refugia.
4) Extent of habitat removal	A stadia metric survey performed identified 4,617 PKFTs within Proposal impact footprint which was calculated by BioLink (2019b) to equate to ~152 ha of koala habitat. The Proposal will result in the removal of this habitat over three Phases. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp Mahogany in detention basins will be nested within the Proposal impact footprint with some of this available for foraging purposes following maturation.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Koala in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.24 Brush-tailed Phascogale

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Brush-tailed Phascogale (*Phascogale tapoatafa*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Brush-tailed Phascogale: • Clearing of native vegetation • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees • Predation by the Feral Cat *Felis catus*
c)	Habitat requirements	The Brush-tailed Phascogale broadly prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter; although is also known in rainforest and wet sclerophyll forest (OEH 2019b). This species preferentially uses a habitat complex comprising groundcover layer features (e.g. fallen logs) and arboreal features such as hollow-bearing trees for denning and “rough barked trees of 25 cm DBH or greater” (OEH 2019b) for foraging.
d)	Other documentation	A NSW recovery plan has not been prepared for the Brush-tailed Phascogale.
e)	Assessment of adequacy of reservation	The Brush-tailed Phascogale is well represented in conservation reserve network with habitat occupation occurring within the Tilligerry State Conservation Area, Worimi National Park, Tomaree National Park, Karuah Nature Reserve, Columbey National Park, Wallaroo National Park, Black Bulga State Conservation Area, Myall Lakes National Park, The Glen Nature Reserve, Talawahl Nature Reserve, Wallamba Nature Reserve, Khappinghat Nature Reserve, Goonook Nature Reserve, Middle Brother National Park, Dooragan National Park, Crowdy Bay National Park, Queens Lake Nature Reserve, Queens Lake State Recreation Area, Limeburners Creek National Park, Bago Bluff National Park, Cooperabung Nature Reserve, Goolawah National Park, Maria River National Park, Hat Head National Park, Ngambaa Nature Reserve, Bellinger River National Park, Dorrigo National Park, Fortis Creek National Park, Nymboid-Binderay National Park, Wombat Creek State Recreation Area, Yuraygir National Park, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Bungawalbin National Park, Bungawalbin State Conservation Area, Bungawalbin Nature Reserve, Yarringully State Conservation Area, Mt Pikapene National Park, Mallanganee National Park, Wollumbin National Park, Mebbin National Park and Richmond Range National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.

DGR Matter		Comment
f)	Limit of known distribution	The Brush-tailed Phascogale has a patchy distribution around the coast of Australia. In NSW it is mainly found east of the Great Dividing Range although there are occasional records west to the divide (OEH 2019b).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	The distribution pattern of the Brush-tailed Phascogale is likely controlled by the seasonal reliability of rainfall and diversity of food resources (Scarff et al 1998), with abundance in its habitat being highly variable over time and most likely in response to the distribution of key habitat features (e.g. hollows and rough-barked trees) at a range of scales (Mansfield et al 2017). Local ecological studies and threatened species assessments performed within and adjacent the Conservation Area have recorded the occurrence of the Brush-tailed Phascogale (e.g. HWR Ecological 2004; 2005; EcoBiological 2010). Firebird (2013) identified the presence of actively breeding individuals in Spotted Gum Ironbark vegetation located immediately to the north of the Conservation Area and noted a likely broad and connected occurrence in the locality north through to Wallaroo State Forest and National Park. There are at least 25 recorded observations of the Brush-tailed Phascogale north from the Conservation Area to the Balickera Channel (Italia Road). To the west there are at least 40 recorded occurrences between the Williams River to Paterson and north to Clarence Town, with reporting frequency in this area likely associated with a relatively greater number of ecological studies for development applications. To the east there are numerous reported occurrences along the northern shoreline of Port Stephens and Grahamstown Dam. Given the propensity of this species to disperse, the abundance of habitat connections north from the Conservation Area to large areas of habitat known comprising this species (Firebird 2013), it is considered that this species is widely distributed locally throughout numerous habitat patches. The maintenance of habitat suitability and connections there between represent the main conservation focus for the local population of this species.
b)	Discussion of habitat utilisation	The Brush-tailed Phascogale is a scansorial species (i.e. adapted to climbing) and forages on trees for invertebrates. High value habitat comprises vegetation with high invertebrate biomass and is linked to 'arboreal surface roughness' (i.e. tree trunks with high habitat values for invertebrates), and is thus an indicator of forage resource availability (e.g. increased abundance of prey species such as invertebrates). This habitat factor is consistent with findings presented in local studies on this species (Firebird 2013), where the species was observed in several Ironbark trees, including *Eucalyptus crebra* (Narrow-leaved Ironbark), *E. siderophloia* (Grey Ironbark) and *E. fibrosa* (Red Ironbark). A den site located to the northwest of the Conservation Area was located in a dead hollow-bearing 'stag' tree. Brush-tailed Phascogale within the subject site will preferentially occupy vegetation in hollow rich areas, particularly where trees are >80cm DBH, and where coincident with a high occurrence of rough-barked trees suitable for foraging (see **Figure 4.80**).
c)	Description of vegetation	Habitat for this species broadly exists in PCTs 1230, 1584, 1590 and 1600 and generally excludes areas of native vegetation mapped as scattered trees in open paddocks (i.e. PCT 1590 in moderate good poor condition). Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3)	**Description of habitat values**	Habitat preferred by the Brush-tailed Phascogale primarily constitutes mature forests and woodlands (**Figure 4.26**) with localised indicators of habitat complexity such as elevated abundance of fallen logs (**Figure 4.27**) and hollow-bearing trees (**Figure 4.28**), with the latter feature important for diurnal refugia and breeding. Being scansorial, the Brush-tailed Phascogale will prefer vegetation with a high proportion of rough-barked trees (**Figure 4.80**); a feature of its habitat that locally elevates the area of available foraging habitat (i.e. bark and rough surfaces increases the abundance and biomass of invertebrates). Areas of

DGR Matter	Comment
	woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) and African Olive (**Figure 4.23**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal will remove 206.64 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 214.07 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Brush-tailed Phascogale in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.25 Spotted-tailed Quoll

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Spotted-tailed Quoll (*Dasyurus maculatus*) is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Spotted-tailed Quoll: • Clearing of native vegetation • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	The Spotted-tail Quoll inhabits a variety of habitats, including dry to moist open forests or closed forests containing rock caves, hollow logs or trees for denning and foraging. Viable populations of the Spotted-tail Quoll occupy complex overlapping individual home ranges comprising numerous individuals. Females occupy smaller ranges (mean 500 hectares) comprising an abundance of resources with males occupying larger home ranges (Belcher, 2008). Ideal habitat for this species is generally represented by large undisturbed connected tracts of intact native vegetation, which are under threat through the range of this species. Recorded occurrences have high coincidence with old growth forests; a class of vegetation known to contain high habitat values for this species (DEC 2004). The Spotted-tailed Quoll occupies home ranges of several hundred to several thousand hectares in size. Spotted-tailed Quolls use multiple dens (possibly in excess of 20) and usually move between them every 1–4 days (DoE 2016b). Recorded den sites include rock crevices, hollow logs, hollow tree buttresses, tree hollows, windrows, clumps of vegetation, caves and boulder tumbles, under buildings and underground burrows, including those of rabbits and wombats (DoE 2016b). Maternal den sites include rock crevices, caves, boulder tumbles, hollow logs, hollow tree roots and burrows (DoE 2016b). Habitat that is critical to the survival of the Spotted-tailed Quoll includes large patches of forest with adequate denning resources and relatively high densities of medium-sized mammalian prey (DoE 2016b). However, the threshold densities of these critical components required to support quoll populations are unknown.
d)	Other documentation	A NSW recovery plan has not been prepared for the Spotted-tailed Quoll. The species has been categorised as a 'Landscape' species under the NSW SoS program. The Spotted-tailed Quoll National Recovery Plan (DoE 2016b) details the species' distribution, habitat, conservation status, threats, and recovery objectives and actions necessary to ensure the long-term survival of the Spotted-tailed Quoll. The strategy for recovery will be to focus on reducing the impact of threatening processes throughout the species' range and subsequently halt the current decline in its distribution and abundance. DoE (2016b) identifies the major threats to the Spotted-tailed Quoll to include habitat loss, modification and fragmentation, timber harvesting, poison baiting, competition and predation from introduced carnivores, deliberate killing, road mortality, bushfire and prescribed burning, poisoning by Cane Toads and climate change.

DGR Matter	Comment
	Important populations located within the NSW North Coast include those in Yuragir, Maria and Limeburners National Parks (DoE 2016b).
e) Assessment of adequacy of reservation	The Spotted-tail Quoll has a wide area of occupancy through the North Coast bioregion and is known to occur within most conservation reserves of this bioregion. The highest recorded densities occur within reserves located at moderate to high elevation (e.g. Barrington Tops National Park, Mount Royal National Park, Nowendoc National Park) where prey densities are at their greatest (Glenn and Dickman, 2011). The Spotted-tailed Quoll is well represented in conservation reserve network with habitat occupation occurring within the Tilligerry State Conservation Area, Medowie State Conservation Area, Karuah National Park, Columbey National Park, Wallaroo National Park, Tomaree National Park, Black Bulga State Conservation Area, Myall Lakes National Park, Wallingat National Park, Booti Booti National Park, Talawahl Nature Reserve, Middle Brother National Park, Killabakh Nature Reserve, Dooragan National Park, Queens Lake Nature Reserve, Lake Innes Nature Reserve, Limeburners Creek National Park, Kumbatine National Park, Willi Willi National Park, Hat Head National Park, Yarriabini National Park, Ngambaa Nature Reserve, Bellinger River National Park, Bongil Bongil National Park, Dorrigo National Park, Bindarri National Park, Garby Nature Reserve, Sherwood Nature Reserve, Cascade National Park, Nymboid-Binderay National Park, Yuraygir National Park, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Border Ranges National Park, Wollumbin National Park, Banyabba Nature Reserve, Mount Neville Nature Reserve, Nightcap National Park, Whian Whian State Conservation Area, Mebbin National Park, Richmond Range National Park and Ramornie National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.
f) Limit of known distribution	Occurs from western Victoria and along the Great Dividing Range to the east then north through coastal, tableland and western slopes of NSW into southeastern Queensland. Also occurs throughout Tasmania with far north Queensland animals belonging to a separate subspecies. The subject site is within the extent of occurrence.
2) Discussion of local and regional abundance	
a) Discussion of other known local populations	Numerous observations of the Spotted-tailed Quoll are to the north of the subject site on private and public reserve land. Occurrences are associated with large vegetation patches such as Wallaroo National Park – Wallaroo State Forest and Columbey National Park. Observations are also along riverine corridors and roads. Recorded occurrences within the northern part of the subject site are old and have 10 km accuracy. A third reported occurrence in the Eagleton rural residential estate is from 2004 and is considered old. More recent observations in Raymond Terrace may be associated with dispersing juveniles from the local stronghold north of the subject site. Detailed dog detection surveys performed within the subject site failed to identify any denning or latrine locations for this species (OWAD 2019a).
b) Discussion of habitat utilisation	Moist vegetation (i.e. PCT 1584 and 1525), which often comprises high densities of prey species, and riparian zones for movement represents the main area of high value foraging and denning habitat suitable for the Spotted-tailed Quoll (Belcher, 2008; Glenn and Dickman, 2011); a conclusion supported by habitat survey data (i.e. high densities of fallen logs and hollows). Foraging may also occur in PCT 1590, but is likely to act as supplementary habitat due to reduced quantum of prey species and less likely to be utilised for denning and breeding.
c) Description of vegetation	Habitat for this species broadly exists in PCTs 1230, 1584, 1590 and 1600 and excludes areas of native vegetation mapped as scattered trees in open paddocks (i.e. PCT 1590 in moderate good poor condition). Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.

DGR Matter	Comment
3) Description of habitat values	Habitat preferred by the Spotted-tailed Quoll primarily constitutes mature forests and woodlands (**Figure 4.26**) with localised indicators of habitat complexity such as elevated abundance of fallen logs (**Figure 4.27**) and hollow-bearing trees (**Figure 4.28**), with the latter feature important for determining prey abundance and diurnal refugia. Riparian zones are crucial for movement and also often act as important reservoirs for preferred prey species. Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) and African Olive (**Figure 4.23**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal will remove 206.64 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Spotted-tailed Quoll in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.26 Grey-headed Flying-fox

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Grey-headed Flying-fox is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Grey-headed Flying Fox: • Clearing of native vegetation • Human-caused Climate Change • Ecological consequences of high frequency fires • Herbivory and environmental degradation caused by feral deer • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Invasion of native plant communities by exotic perennial grasses • Invasion and establishment of exotic vines and scramblers • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
c)	Habitat requirements	The Grey-headed Flying-fox regularly occurs along the eastern coastal plain of NSW extending into Queensland and Victoria. It roosts in camps, usually in dense riparian habitats. At dusk this species disperses in search of the preferred food source, mainly eucalypt blossom and rainforest fruits. Long distances are covered for up to 50 km radius from camp sites in search of food. Two periods of the year are identified as particularly important for the Grey-headed Flying-fox. The breeding period, which occurs during October to January, involves lifecycle process including final weeks of gestation, and during the weeks of birth, lactation and conception. The 'food bottle neck', which occurs during the May to August period, is a time where foraging resources are limited. Resource demands during these periods are important to the Grey-headed Flying-fox. Two types of camps are established by the Grey-headed Flying-fox these being temporary and permanent camps. Temporary camps are not occupied throughout the year and typically established during the summer period to access habitat resources as they become available. These camps may coincide with breeding activity. Permanent camps are occupied throughout the year and are generally central to all necessary foraging resources, particularly those that occur during the winter food bottle necks.
d)	Other documentation	A NSW recovery plan has not been prepared for the Grey-headed Flying-fox. The Grey-headed Flying-fox is also identified as a mammal pollinator listed as threatened in NSW under the TSC Act. OEH (2016b) identifies the winter flower diet of this species to comprise Swamp Mahogany, Spotted Gum and Broad-leaved Paperbark with only Spotted Gum having any meaningful occurrence within the study area. Spring flowering and nectar producing tree species that are also of relevance to the subject site include Grey Box, Grey Ironbark (*Eucalyptus siderophloia*) and Forest Redgum (DIPNR 2004). Programs monitoring the ecological benefits of revegetation plantings and regeneration sites are relatively recent and generally report encouraging results on pollinator occupancy in young plantings (5 to 25 years old) where mobile species are able to locate and inhabit these rehabilitation sites (e.g. Kavanaugh et al. 2007; Munro et al. 2011; Law et al. 2014; Smith et al. 2015).

DGR Matter		Comment
		Changes resulting in species incidence were quantitatively apparent after 10 years and reached the levels recorded in nearby remnant vegetation within 20 years (OEH 2016b). In revegetation projects, OEH (2016b) recommends various additional considerations. In addition to the timing of flowering and nectar production, another important consideration applicable to the Proposal is flower density as this can be important for attracting pollinators. Large-area plantings or plantings near existing habitat may be visited by more individuals and more species (Lindell & Thurston 2013).
e)	Assessment of adequacy of reservation	The Grey-headed Flying-fox is well represented in conservation reserve network with habitat occupation occurring within the Hunter Wetlands National Park, Tilligerry State Conservation Area, Medowie State Conservation Area, Worimi National Park, Karuah National Park, Karuah Nature Reserve, Columbey National Park, Wallaroo National Park, Tomaree National Park, Black Bulga State Conservation Area, Myall Lakes National Park, Wallingat National Park, Booti Booti National Park, Talawahl Nature Reserve, Crowdy Bay National Park, Middle Brother National Park, Killabakh Nature Reserve, Dooragan National Park, Queens Lake Nature Reserve, Lake Innes Nature Reserve, Limeburners Creek National Park, Maria River National Park, Kumbatine National Park, Willi Willi National Park, Hat Head National Park, Yarrahapinni National Park, Yarriabini National Park, Ngambaa Nature Reserve, Bellinger River National Park, Bongil Bongil National Park, Dorrigo National Park, Bindarri National Park, Garby Nature Reserve, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Sherwood Nature Reserve, Cascade National Park, Nymboid-Binderay National Park, Yuraygir National Park, Bungawalbin National Park, Bungawalbin State Conservation Area, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Tuckeon Nature Reserve, Ballina Nature Reserve, Border Ranges National Park, Wollumbin National Park, Banyabba Nature Reserve, Mount Neville Nature Reserve, Nightcap National Park, Whian Whian State Conservation Area, Mebbin National Park, Richmond Range National Park and Ramornie National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.
f)	Limit of known distribution	Occurs from southeastern South Australia (Mt Gambier) east through Victoria along the Great Dividing Range then north through coastal, tableland and western slopes of NSW into southeastern Queensland, although is generally absence from mid altitudes. Also sporadically north to Cairns. The subject site is within the extent of occurrence.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	Port Stephens Local Government Area currently supports nine known flying-fox camps. The nearest camp to the Conservation Area is located at Raymond Terrace, hereafter referred to as the Ross Walbridge Reserve Camp, and is the only constantly utilised flying-fox camp in the LGA. According to Port Stephens Council (2017), the Ross Walbridge Reserve Camp contains at least 8,000 individuals (of three different species) with a maximum record of 21,000 in April 2016. Other flying-fox camps in the local government area include: • Anna Bay, Tomago (Fullerton Cove), Wallaroo NP (Italia Rd) and North of Italia Road and are currently classed as historical. • Bob's Farm (two Camps 3km apart) where a large number of animals were recorded in 2015, but no other evidence of sustained camp usage has been recorded. • Medowie where animals were recorded in 2013 and 2014, but in no other year. • Schnapper Island; where a small number of animals were observed roosting in 2014. The Ross Walbridge Reserve Camp has been permanently occupied since 2013 and due to the number of animals consistently utilising the site, it was designated a Nationally Significant Flying-fox Camp. The proportion of Grey-headed Flying Fox within

DGR Matter	Comment
	this camp has varied from 1.1-30.1% relative to the total number of individuals within the Hunter Region, with the camp occupancy routinely spiking during the cooler months (i.e. bottle food period). More recently (i.e. post 2015 winter period), camp numbers in the food bottleneck period of the year are considerably less than historical levels, presumably due to wildfire related disruptions to nectar resources throughout the Port Stephens area (Port Stephens Council 2017). Approximately 51% of land within 20 km of the Raymond Terrace site supports native forests and woodlands in patches ranging in size from small remnants to extensive tracts in conservation reserves and state forests. Rainforest is rare and rainforest fruit provides insignificant food resources for flying-foxes during late summer and autumn. By contrast, approximately 85% of the forested land within 20km of Raymond Terrace contains flowering trees visited by the animals (Port Stephens Council 2017).
b) Discussion of habitat utilisation	The usage of the subject site is expected to be limited to foraging activity only, although, it is possible in time that the vegetation surrounding wetland 803 may become more suitable for roosting purposes as the revegetation works proposed for that area mature. Foraging will be guided by the flowering time of selected nectar producing tree species, which mainly include *Corymbia gummifera, Corymbia maculata, Eucalyptus acmenoides, Eucalyptus fibrosa, Eucalyptus molucanna, Eucalyptus pilularis, Eucalyptus propinqua, Eucalyptus punctata, Eucalyptus robusta, Eucalyptus siderophloia* and *Eucalyptus tereticornis.* Tree species of importance during food bottle necks include *Corymbia maculata, Eucalyptus acmenoides, Eucalyptus fibrosa, Eucalyptus robusta, Eucalyptus siderophloia* and *Eucalyptus tereticornis.* These preferred feed trees are not evenly distributed throughout the PCTs mapped within the subject site. Contrary to the PCT mapping, there are places where tree composition may not comprise a preferred nectar producing tree species. Modelling using knowledge of bimonthly phenology (i.e. when individual tree species are likely to flower) and the distribution of individual tree species has been used to spatially estimate the extent of likely foraging areas throughout the subject site and was used to identify areas of higher foraging value.
c) Description of vegetation	Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat preferred by the Grey-headed Flying Fox primarily constitutes mature forests and woodlands (**Figure 4.26**). Being nectivorous the Grey-headed Flying Fox will prefer vegetation comprising trees with reliable nectar supply throughout the year (**Figures 4.83** to **4.88**); with increased abundance/ spatial extent of these trees likely to locally elevate the relative important of foraging habitat (i.e. quantum and temporal availability) particularly in periods of known food bottlenecks (i.e. winter to spring). Areas of woody weed growth may locally reduce habitat quality as species like Lantana (**Figure 4.22**) provide no benefit and often displace vegetation and structural complexity that would otherwise contribute to preferential habitat occupation. Proportionally, the Conservation Area encapsulates a greater quantum of these preferred habitat constituents in comparison to the Proposal impact footprint.
4) Extent of habitat removal	The Proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. Impacts calculated using PCT mapping shows progressive foraging habitat loss of 70.38 ha (Phase 1), 48.71 ha (Phase 2 and 87.55 ha (Phase 3). According to bimonthly flowering phenology, the period with the least total impact is in February – March (~90.76 ha), with the greatest total impact expected in August – September (~167.73 ha). Impacts intensity is spread across the three Phases with the greatest impact expected in Phase 3. In executing the VPA, the Proposal will retain 216.49 ha of habitat suitable for this species (PCTs 1230, 1525, 1584, 1590 and 1600) and revegetate 12.67 ha of treeless lands for future use by this species within a Conservation Area of 244.25 ha total

DGR Matter	Comment
	area. The consideration of higher value foraging areas allowed for impact avoidance measures to proportionally the amount of preferred foraging habitat within the conservation area, with at least 176.76 ha of high value foraging habitat during the food bottleneck period (i.e. June – November) being retained. This area of preferred foraging habitat for this period of the year will increase to at least 196.06 ha following flowering of revegetation works (expected within 10-20 years of plantings, which would coincide with Phase 3 impacts). The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Grey-headed Flying Fox in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.27 Eastern Freetail-bat

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Eastern Freetail-bat is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Eastern Freetail Bat: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	The Eastern Freetail-bat occurs in dry sclerophyll forest and woodland. It roosts in tree hollows and sometimes under bark or in man-made structures (OEH 2019b). No information is available on the diet and foraging of this species except that it hunts insects above the forest canopy or in clearings at the edge of the forest (Strahan, 1995).
d)	Other documentation	No recovery plan has been prepared for the Eastern Free-tail Bat.
e)	Assessment of adequacy of reservation	The Eastern Free-tail Bat is well represented in conservation reserve network with habitat occupation occurring within the Hunter Wetlands National Park, Medowie State Conservation Area, Worimi National Park, Karuah National Park, Columbey National Park, Myall Lakes National Park, Booti Booti National Park, Dooragan National Park, Lake Innes Nature Reserve, Maria River National Park, Kumbatine National Park, Willi Willi National Park, Hat Head National Park, Yarriabini National Park, Ngambaa Nature Reserve, Bellinger River National Park, Dorrigo National Park, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Sherwood Nature Reserve, Nymboid-Binderay National Park, Nymboida National Park, Yuraygir National Park, Bungawalbin National Park, Bungawalbin State Conservation Area, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Ballina Nature Reserve, Border Ranges National Park, Wollumbin National Park, Banyabba Nature Reserve, Whian Whian State Conservation Area, Mebbin National Park, Richmond Range National Park and Ramornie National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.
f)	Limit of known distribution	The Eastern Freetail Bat occurs in coastal districts along the east coast of NSW from southern Queensland to the Victorian border (OEH 2019a). The subject site falls within the known distribution of this species.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	The Eastern Freetail-bat has seven recorded locations within the locality, two located in close proximity to the study area. Recent surveys of the study area recorded six Eastern Freetail-bats across the site. This species roost in tree hollows and forages for insects above the canopy and/or in clearings at the edges of forests. It is likely that this species both forages and roosts in habitat within the subject site, as hollow-bearing trees occur across the site. Little is known about the feeding behaviour of this species however the majority of records identified within the study area are located within gullies, or in close proximity to it, where there may be a higher prevalence of insects.

DGR Matter	Comment
b) Discussion of habitat utilisation	The Eastern Free-tail Bat is likely to use hollow-bearing trees for roosting sites within the subject site including Grey Box, Spotted Gum and Forest Redgum (McConville and Law 2013), particularly in areas with the densest aggregations of hollow-bearing trees (McConville et al 2013a). Foraging is most likely to occur in the low-lying riparian habitats (McConville et al 2013b) including the wetland area.
c) Description of vegetation	The Eastern Free-tail Bat will primarily utilise habitat within PCTs 783, 1230, 1728 for foraging and roosting and may use PCTs 1525, 1584, 1590 and 1600 for opportunistic roosting, notably within riparian zones. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Roosting habitat within the subject site that provides habitat for this species includes the forest and woodland PCTs that provide foraging habitat and potential roosting habitat. Numerous hollow-bearing trees are scattered across the study area, as well as trees with decorticating bark, also used as habitat for this species. Parts of the subject site have already been cleared for pre-existing land uses. As a result the area includes many tracks and clearings. Within the uncleared areas, the subject site is dominated by varieties of Spotted Gum – Ironbark Woodland. The PCTs occurring on the subject site and study area show varying degrees of modification and disturbance. Some areas also experience the grazing and movement patterns of cattle, horses and goats which may cause disruption and degradation of potential habitat for prey species. Weeds such as *Lantana camara* are scattered throughout the subject site.
4) Extent of habitat removal	The Proposal is not expected to result in the removal of preferred habitat (i.e. retention of PCTs 783, 1230, 1728) and will have minimal impact on riparian vegetation contained within PCTs 1525, 1584, 1590 and 1600. Worst case, the proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600) in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 214.07 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp Mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased

DGR Matter	Comment
	length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Eastern Freetail Bat in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.28 Eastern Bentwing-bat

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Eastern Bentwing-bat is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Eastern Bentwing Bat: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)
c)	Habitat requirements	Eastern Bentwing-bats primarily roost in caves, but also use derelict mines, storm-water tunnels, buildings and other man-made structures (OEH 2019b). Populations usually centre on a maternity cave that is used annually in spring and summer and have very specific temperature and humidity requirements (OEH 2019b). At other times of the year, this species can travel up to 300km of maternity caves. It hunts in forested areas, catching insects flying above the canopy, and in open areas where it flies a few metres off the ground (Churchill, 2009).
d)	Other documentation	No recovery plan has been prepared for the Eastern Bentwing Bat.
e)	Assessment of adequacy of reservation	The Eastern Bent-wing Bat is well represented in conservation reserve network with habitat occupation occurring within the Hunter Wetlands National Park, Tilligerry State Conservation Area, Medowie State Conservation Area, Worimi National Park, Karuah National Park, Columbey National Park, Wallaroo National Park, Black Bulga State Conservation Area, Myall Lakes National Park, Booti Booti National Park, Talawahl Nature Reserve, Crowdy Bay National Park, Middle Brother National Park, Killabakh Nature Reserve, Lake Innes Nature Reserve, Rawdon Creek Nature Reserve, Limeburners Creek National Park, Kumbatine National Park, Goolawah National Park, Willi Willi National Park, Hat Head National Park, Yarrahapinni National Park, Yarriabini National Park, Bongil Bongil National Park, Dorrigo National Park, Bindarri National Park, Moonee Beach Nature Reserve, Coffs Coast Regional Park, Sherwood Nature Reserve, Nymboid-Binderay National Park, Yuraygir National Park, Chaelundi National Park, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Ballina Nature Reserve, Border Ranges National Park, Wollumbin National Park, Banyabba Nature Reserve, Mount Neville Nature Reserve, Nightcap National Park, Whian Whian State Conservation Area, Richmond Range National Park and Ramornie National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.
f)	Limit of known distribution	The Eastern Bent-wing Bat occurs along the east coast from southern Queensland to southern NSW (OEH 2019a). The subject site falls within the known distribution of this species.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	There is a recognised population of the Eastern Bentwing-bat in the locality. The species has been found in Wallaroo State Forest and is known to roost in the nearby Balickera Canal tunnel. There are fewer Eastern Bentwing Bats than Little Bentwing Bats utilising the Balickera tunnel, with the population estimated to reach 1,000 at maximum (Ecotone Ecological Consultants,

DGR Matter	Comment
	2000). Given the mobility of this species and the fact that few individuals have been recorded in the study area, the subject site does not form significant habitat for the Eastern Bentwing-bat.
b) Discussion of habitat utilisation	The study area comprises a cave adjacent to the Kings Hill land mark that may be used for roosting and breeding purposes. Vegetation surrounding this cave, if occupied on a permanent or infrequent basis, would be used for foraging purposes. Foraging is most likely along riparian zones and at the edges of wetlands. It is likely that the Eastern Bent-wing Bat is utilising the study area for foraging from its Balickera Channel tunnel roost site.
c) Description of vegetation	The Eastern Bent-wing Bat will broadly utilise habitat within PCTs 1230, 1525, 1584, 1590 and 1600. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	The value of the cave adjacent to the Kings Hill land mark for roosting and breeding purposes is not well understood. However, vegetation surrounding this cave is of moderate to high value for foraging purposes. Foraging is most likely along riparian zones and at the edges of wetlands where a concentration of prey items is most likely or seasonally as governed by the flowering activity of high nectar producing trees such as Forest Redgum, Spotted Gum, Grey Ironbark and Grey Gum.
4) Extent of habitat removal	The Proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). No roosting habitat is expected to be removed (i.e. caves). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.

DGR Matter	Comment
6) **Impacts on Threatened Species and/or Populations in National Parks Estate**	This proposal is considered unlikely to impact on any individuals of the Eastern Bentwing Bat in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.29 Little Bentwing Bat

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Little Bentwing Bat is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Little Bentwing Bat: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	The Little Bentwing-bat can be found in moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub and forage at night for small insects beneath the canopy of densely vegetated habitat (OEH 2019b). It roosts in caves, tree hollows, tunnels, abandoned mines, stormwater drains, culverts, bridges and buildings and forages at night for small insects beneath the canopy of dense vegetation (OEH 2019b).
d)	Other documentation	No recovery plan has been prepared for the Little Bentwing Bat.
e)	Assessment of adequacy of reservation	The Little Bentwing-bat occurs in many conservation reserves throughout the greater North Coast Bioregion. These areas include Tilligerry State Conservation Area, Myall Lakes National Park, Karuah National Park, Wallaroo National Park, Wallaroo State Forest and Medowie State Forest, among others. The individuals occurring in these areas are more secure than individuals occurring on private property close to development.
f)	Limit of known distribution	The Little Bentwing-bat is distributed along the east coast of Australia from Cape York in Queensland to Wollongong in NSW (OEH 2019b). The subject site falls within the known distribution of this species.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	There are 193 recorded locations of the Little Bentwing-bat within the LGA. This species has also been found to roost in the nearby Balickera Canal tunnel (Ecotone Ecological Consultants, 2000). This species is the most common species roosting in the tunnel, aggregations reaching the hundreds. The population using the tunnel was estimated to be approximately 8,500 individuals (Ecotone Ecological Consultants, 2000).
b)	Discussion of habitat utilisation	The study area comprises a cave adjacent to the Kings Hill land mark that may be used for roosting and breeding purposes. This cave is located outside the subject site and is in an area zoned as E2. Other potential roosts include hollow-bearing trees which occur within the subject site. Vegetation surrounding this cave, if occupied on a permanent or infrequent basis, would be used for foraging purposes. Foraging is most likely along riparian zones and at the edges of wetlands.
c)	Description of vegetation	The Little Bentwing Bat will broadly utilise habitat within PCTs 1230, 1525, 1584, 1590 and 1600. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.

DGR Matter	Comment
3) Description of habitat values	The value of the cave adjacent to the Kings Hill land mark for roosting and breeding purposes is not well understood. However, vegetation surrounding this cave is of moderate to high value for foraging purposes and may also represent roosting opportunities in hollow-bearing trees. Foraging is most likely along riparian zones and at the edges of wetlands where a concentration of prey items is most likely or seasonally as governed by the flowering activity of high nectar producing trees such as Forest Redgum, Spotted Gum, Grey Ironbark and Grey Gum.
4) Extent of habitat removal	The Proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600). No cave roosting habitat is expected to be removed however possible hollow-bearing tree roosts are to be removed. Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 216.37 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp Mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Little Bentwing Bat in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.30 Eastern False Pipistrelle

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Eastern False Pipistrelle is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Eastern False Pipistrelle: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	The Eastern False Pipistrelle prefers moist habitats, with trees taller than 20 m and the understorey is dense (Churchill, 2009; OEH 2019b). This species generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings (OEH 2019b). Foraging occurs within gaps and spaces within the forest, avoiding areas with a dense understorey, and along tracks, creeks and rivers (Churchill, 2009). Their diet is mainly comprised of beetles and moths, with occasional bugs, ants and flies (Churchill, 2009).
d)	Other documentation	No recovery plan has been prepared for the Eastern False Pipistrelle.
e)	Assessment of adequacy of reservation	The Eastern False Pipistrelle is well represented in conservation reserve network with habitat occupation occurring within the Hunter Wetlands National Park, Tilligerry State Conservation Area, Tomaree National Park, Myall Lakes National Park, Lake Innes Nature Reserve, Kumbatine National Park, Carrai National Park, Willi Willi National Park, Cascade National Park, Sherwood Nature Reserve, Nymboid-Binderay National Park, Yuraygir National Park, Chaelundi National Park, Bungawalbin National Park, Border Ranges National Park, Wollumbin National Park, Banyabba Nature Reserve, Mount Neville Nature Reserve, Nightcap National Park, Whian Whian State Conservation Area and Richmond Range National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.
f)	Limit of known distribution	The Eastern False Pipistrelle is found on the south-east coast and ranges of Australia, from southern Queensland to Victoria and Tasmania (OEH 2019b). The subject site falls within the known distribution of this species.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	There are 36 records of the Eastern False Pipistrelle in Port Stephens LGA. Most records are concentrated in the Hunter Wetlands National Park where it occupies the similar habitat as the Eastern Free-tail Bat. Other local records indicate occupation of swamp and moist forests and reflects similar local distributions as the Eastern Free-tail Bat and Greater Broad-nosed Bat.

DGR Matter	Comment
b) Discussion of habitat utilisation	Roosting habitat within the subject site that provides preferred habitat for this species includes the moist forests (PCT 1584) with drier vegetation providing foraging habitat and potential roosting habitat. Numerous hollow-bearing trees are scattered across the study area, as well as trees with decorticating bark, also used as habitat for this species.
c) Description of vegetation	The Eastern False Pipistrelle will primarily utilise habitat within PCTs 783, 1230, 1728 for foraging and roosting and may use PCTs 1525, 1584, 1590 and 1600 for opportunistic roosting, notably within riparian zones. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Roosting habitat within the subject site that provides habitat for this species includes the forest and woodland PCTs that provide foraging habitat and potential roosting habitat. Numerous hollow-bearing trees are scattered across the study area, as well as trees with decorticating bark, also used as habitat for this species. Parts of the subject site have already been cleared for pre-existing land uses. As a result the area includes many tracks and clearings. Within the uncleared areas, the subject site is dominated by varieties of Spotted Gum – Ironbark Woodland. The PCTs occurring on the subject site and study area show varying degrees of modification and disturbance. Some areas also experience the grazing and movement patterns of cattle, horses and goats which may cause disruption and degradation of potential habitat for prey species. Weeds such as *Lantana camara* are scattered throughout the subject site.
4) Extent of habitat removal	The Proposal will remove 47.94 ha of habitat suitable for this species (PCTs 1584). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 103.93 ha of habitat suitable for this species (PCTs 1230, 1584) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.

DGR Matter	Comment
6) **Impacts on Threatened Species and/or Populations in National Parks Estate**	This proposal is considered unlikely to impact on any individuals of the Eastern False Pipistrelle in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.31 Greater Broad-nosed Bat

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Greater Broad-nosed Bat is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Greater Broad-nosed Bat: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	The Greater Broad-nosed Bat roosts in tree hollows, but has also been found in buildings (OEH, 2019b). This species occurs in a range of habitats including dry sclerophyll forest, moist eucalypt forest, rainforest, woodland and swamp woodland, however is most commonly found in tall wet forest (OEH, 2019b). Foraging occurs at night searching for insects, predominantly along creek and river corridors (OEH 2019b).
d)	Other documentation	No recovery plan has been prepared for the Greater Broad-nosed Bat.
e)	Assessment of adequacy of reservation	The Greater Broad-nosed Bat is well represented in conservation reserve network with habitat occupation occurring within the Hunter Wetlands National Park, Medowie State Conservation Area, Worimi National Park, Karuah National Park, Columbey National Park, Wallaroo National Park, Myall Lakes National Park, Wallingat National Park, Booti Booti National Park, Crowdy Bay National Park, Middle Brother National Park, Bago Bluff National Park, Lake Innes Nature Reserve, Kumbatine National Park, Hat Head National Park, Yarrahapinni National Park, Yarriabini National Park, Bindarri National Park, Sherwood Nature Reserve, Chaelundi National Park, Nymboid-Binderay National Park, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Ballina Nature Reserve, Tuckeon Nature Reserve, Border Ranges National Park, Banyabba Nature Reserve, Nightcap National Park, Whian Whian State Conservation Area, Richmond Range National Park and Ramornie National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.
f)	Limit of known distribution	The Greater Broad-nosed Bat occurs from the Atherton Tableland to north eastern Victoria in gullies and river systems that drain the Great Dividing Range (OEH, 2019b). The subject site falls within the known distribution of this species.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	There are 66 records of the Greater Broad-nosed Bat in Port Stephens LGA. Most records are concentrated in the Hunter Wetlands National Park where it occupies the same habitat as the Eastern Free-tail Bat with observations noting cohabitation of the same hollows (McConville 2013). Other local records indicate occupation of swamp and moist forests, as is the case with the Eastern Free-tail Bat.

DGR Matter	Comment
b) Discussion of habitat utilisation	Roosting habitat within the subject site that provides preferred habitat for this species includes the moist forests (PCT 1584) with drier vegetation providing foraging habitat and potential roosting habitat. Numerous hollow-bearing trees are scattered across the study area, as well as trees with decorticating bark, also used as habitat for this species. Parts of the subject site have already been cleared for pre-existing land uses. As a result the area includes many tracks and clearings. Within the uncleared areas, the subject site is dominated by varieties of Spotted Gum – Ironbark Woodland. The PCTs occurring on the subject site and study area show varying degrees of modification and disturbance. Some areas also experience the grazing and movement patterns of cattle, horses and goats which may cause disruption and degradation of potential habitat for prey species. Weeds such as *Lantana camara* are scattered throughout the subject site.
c) Description of vegetation	The Greater Broad-nosed Bat will broadly utilise habitat within PCTs 1230, 1525, 1584, 1590 and 1600 with preferred use of PCTs 1584. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	The Proposal is not expected to result in the removal of preferred habitat (i.e. retention of PCTs 783, 1230, 1728) and will have minimal impact on riparian vegetation contained within PCTs 1525, 1584, 1590 and 1600. Worst case, the proposal will remove 212.14 ha of habitat suitable for this species (PCTs 1584, 1590 and 1600) in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 214.07 ha of habitat suitable for this species (PCTs 1230, 1584, 1590 and 1600) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp Mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).
4) Extent of habitat removal	The Proposal will remove 47.94 ha of habitat suitable for this species (PCTs 1584). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 103.93 ha of habitat suitable for this species (PCTs 1230, 1584) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp Mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

DGR Matter	Comment
	The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Greater Broad-nosed Bat in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.32 Yellow-bellied Sheath-tail Bat

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Yellow-bellied Sheath-tail Bat is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Yellow-bellied Sheath-tail Bat: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	The Yellow-bellied Sheath-tail bat uses hollows and buildings where it roosts singly or in groups of up to six, in tree hollows and buildings. In treeless areas they are known to utilise mammal burrows. When foraging for insects, flies high and fast over the forest canopy, but lower in more open country. Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory. Breeding has been recorded from December to mid-March, when a single young is born. Seasonal movements are unknown; there is speculation about a migration to southern Australia in late summer and autumn.
d)	Other documentation	No recovery plan has been prepared for the Yellow-bellied Sheath-tail Bat.
e)	Assessment of adequacy of reservation	The Yellow-bellied Sheath-tail Bat is well represented in conservation reserve network with habitat occupation occurring within the Hunter Wetlands National Park, Medowie State Conservation Area, Worimi National Park, Lake Innes Nature Reserve, Hat Head National Park, Nymboida National Park, Banyabba National Park, Broadwater National Park, Border Ranges National Park, Nightcap National Park, Whian Whian State Conservation Area, Wollumbin National Park and Tyagarah National Park. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this mammal in the region.
f)	Limit of known distribution	The Yellow-bellied Free-tail Bat occurs throughout NSW with the exception of higher altitude area (OEH 2019b). The subject site falls within the known distribution of this species.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	Records of the Yellow-bellied Sheath-tail Bat are infrequent in the locality with greater recorded occurrence along the axis of the Hunter Valley west from Maitland; reflective of its preference for drier vegetation types. Occupation of habitat within the locality is likely to be restricted to the driest vegetation types and possibly only on a seasonal basis (should seasonal migrations be evident in individuals of the locality).
b)	Discussion of habitat utilisation	The Yellow-bellied Free-tail Bat occurs in dry sclerophyll forest and woodland. It roosts in tree hollows and sometimes under bark (OEH 2019b). Within the subject site the Yellow-bellied Sheath-tail Bat is likely to utilise the tree canopy and space there above of drier vegetation types notably PCT 1590.

DGR Matter	Comment
c) Description of vegetation	The Yellow-bellied Sheath-tail Bat will broadly utilise habitat within PCTs 1590 and 1600. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	The Yellow-bellied Sheath-tail Bat forages in most habitats across its very wide range, with and without trees. When foraging for insects, the Yellow-bellied Sheath-tail Bat flies high and fast over the forest canopy (e.g. PCT 1590), but lower in more open country (e.g. PCT 1600). Tree roosts selected by this species are likely to be within large trees with multiple medium sized hollows including dead limbs (Clews 2017).
4) Extent of habitat removal	The Proposal will remove 164.20 ha of habitat suitable for this species (PCTs 1590 and 1600). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 112.41 ha of habitat suitable for this species (PCTs 1230, 1584) and revegetated treeless lands (i.e. 12.67 ha) for future use by this species. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program. An additional 6.63 ha of revegetation works comprising Swamp Mahogany in detention basins will be nested within the Proposal impact footprint and will be available for foraging purposes following maturation (i.e. flowering).
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Yellow-bellied Sheath-tail Bat in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.33 Southern Myotis

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Southern Myotis is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Southern Myotis: • Clearing of native vegetation • Ecological consequences of high frequency fires • Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. • Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat) • Loss of Hollow-bearing Trees • Removal of dead wood and dead trees
c)	Habitat requirements	This species roosts close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage, generally in groups of 10-15 (OEH 2019b). It forages over streams and pools, using its large feet to catch insects and small fish (Law, 2000; OEH 2019b).
d)	Other documentation	No recovery plan has been prepared for the Southern Myotis.
e)	Assessment of adequacy of reservation	The Southern Myotis occurs in limited conservation reserves throughout the NSW North Coast Bioregion, which includes Wallaroo State Forest, Chichester State Forest and Myall Lakes National Park.
f)	Limit of known distribution	This species is found along the coastal band from the north-west of Australia, across the top-end and south to western Victoria (OEH 2019b). It is rarely found more than 100 km inland, except for along major rivers (OEH 2019b).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	There are 29 records of the Southern Myotis in the Port Stephens LGA. This species has been recorded on six occasions within the locality (OEH, 2019b). A recognised population of the Southern Myotis occurs to the north at Balickera channel with roosting and foraging largely restricted to that water body and associated tunnel. Given the mobility of this species and the fact that few individuals have been recorded in the study area, the subject site does not form significant habitat for the Southern Myotis.
b)	Discussion of habitat utilisation	The Southern Myotis has five recorded locations within the locality, one located directly to the south of the study area dated from 2011 (OEH 2019b). Recent surveys of the study area identified this species as possibly occurring on the site. Calls from this species are very similar to those of other bat species and therefore cannot be discounted as occurring within the study area. This species generally roosts in caves, storm water channels, tree hollows, under buildings and in buildings in close proximity to water and forages for insects over water (OEH 2019b). It is likely that this species both forages and roosts in habitat within the subject site, as hollow-bearing trees occur across the site. Some rock outcrops and boulders also occur within the study area, which may also provide some roost habitat for this species. the subject site is not considered to be significant to the viability of the species and large areas of potential foraging and roosting habitat for this species will be retained in the study area. The species will remain viable within the locality because the subject

DGR Matter	Comment
	site comprises a very small amount of potential habitat in the locality, and the species would be utilising other areas of habitat in the locality.
c) Description of vegetation	Habitat for this species exists in PCTs within 200m of wetland 803. These PCTs provide roosting habitat for the Southern Myotis. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Habitat features within the subject site that provides habitat for this species includes the hollow roost sites in forest and woodland (i.e. within 200 m of wetland 803) and Swamp Oak Forests and freshwater wetlands that provide potential foraging habitat. The foraging habitat is likely to become unavailable during the summer-autumn drying period observed in Wetland 803, indicating that the habitat suitability of this part of the study area is less than that occurring in Wetland 804 in the southern part of the study area. Habitat in Wetland 804 is more abundant and is more likely to be occupied by the Southern Myotis for this reason. Parts of the subject site have already been cleared for agricultural land uses and are now rendered unsuitable (i.e. cleared lands within 200 m of Wetland 803). Within the uncleared areas, the subject site is dominated by varieties of Spotted Gum – Ironbark Woodland. The PCTs occurring on the subject site and study area show varying degrees of modification and disturbance.
4) Extent of habitat removal	The Proposal will remove 11.58 ha of habitat suitable for roosting by this species (i.e. native vegetation within 200 m of wetland 803). Habitat removal is to be in accordance with a Phased approach (i.e. three Phases over 8+ years), which has the purpose of proportioning impacts over time using methods and processes outlined in the VMP. In executing the VPA, the Proposal will retain 12.44 ha of habitat suitable for roosting by this species (i.e. native vegetation within 200 m of wetland 803) and foraging habitat of 9.21 ha (i.e. PCT 783) within a Conservation Area of 244.25 ha total area. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.

DGR Matter	Comment
6) **Impacts on Threatened Species and/or Populations in National Parks Estate**	This proposal is considered unlikely to impact on any individuals of the Southern Myotis in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Columbey National Park, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

5.3.34 Green and Golden Bell Frog

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Green and Golden Bell Frog is listed as endangered under Schedule 1 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Green and Golden Bell Frog: • Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands • Clearing of native vegetation • Human-caused Climate Change • Infection of frogs by amphibian chytrid causing the disease chytridiomycosis
c)	Habitat requirements	This species inhabits marshes, dams, and stream-sides (OEH 2019b). Optimum habitat for this species consists of unshaded waterbodies that have grassy area nearby, with diurnal sheltering sites available nearby (OEH 2019b). Adults feed on insects, and occasionally consume other smaller frogs. Tadpoles require algae and plant matter. It's not uncommon to find this species in highly disturbed areas, such as quarries, especially in the Greater Sydney region (OEH 2019b, DECC 2008).
d)	Other documentation	A draft recovery plan was provided by NSW Department of Environment and Conservation (2005). The document outlines a recovery plan that advocates in-situ protection, managing extant populations, and implementing habitat management initiatives. A document outlining Best Practice Guidelines Green and Bell Frog Habitat (DECC 2008). This briefly document discuss' habitat requirements of the species, and ways which exiting habitat can be managed effectively. It outlines the best survey practice, threatening processes, life cycle, and habitat preference for this species. A targeted strategy for managing this species has been developed under the SoS program. The extremities of the LGH coincide with the management area, however the subject area has not been identified as a key management site.
e)	Assessment of adequacy of reservation	The Green and Golden Bell Frog is well represented in conservation reserve network with habitat occupation occurring within the Hunter Wetlands National Park, Myall Lakes National Park, Lake Innes Nature Reserve, Limeburners National Park, Hat Head National Park, Yuraygir National Park and Tyagarah National Park (historical). Reservation of such a large area suggests the above reserves provide considerable habitat protection for this frog species in the region.
f)	Limit of known distribution	The range of distribution for the Green and Golden Bell Frog spans across lowland areas of eastern NSW and Victoria. The most northern extent of the species distribution is from Yuraygir National Park near Grafton on the North Coast of NSW while the most southern extent of the species' distribution is in the vicinity of Lake Wellington, just west of Lakes Entrance in south-eastern Victoria. The furthest inland record of the species is at a recently discovered population near Hoskinstown in the Southern Tablelands (referred to as the Molongolo population). Green and Golden Bell Frog populations occur on three offshore islands, Bowen Island in Jervis Bay, Kooragang Island and Broughton Island, north of Port Stephens (DEWHA 2009).
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	There are four recorded locations in total of the Green and Golden Bell Frog within the LGA. A large population of this species has also been recorded immediately outside the LGA perimeter, on Kooragang Island, in the delta of the Hunter River. This

DGR Matter	Comment
	population is considered to be the most robust in the region but occurs across several land tenures and its conservation is not secure as only a small portion of its habitat occurs within the islands nature reserve (DEC 2005).
b) Discussion of habitat utilisation	The Green and Golden Bell Frog has not been recorded in the study area.
c) Description of vegetation	The Green and Golden Bell Frog will broadly utilise habitat within PCTs 783, 1230, and 1728. Further detailed descriptions of the characteristics of these PCTs can be found in **Section 4.3.2.1**.
3) Description of habitat values	Preferred habitat for this species is limited to wetlands and their periphery where overwintering is possible. Wetlands 803 and 804 are not known to comprise this species. However, this species may occur in these wetlands with greater likelihood in wetland 804 due to the increased abundance of macrophytes and the complexity of the hydrological conditions. Wetland 803 is considered marginal habitat and possibly unsuitable due to the history of grazing and its effect on macrophyte growth and the lack of shelter areas in the peripheral lands.
4) Extent of habitat removal	The Proposal will not remove any habitat for this species. Indirect impacts through hydrological changes will have a negligible impact on the habitat of this species within the study area (Alluvium 2019). In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 14.85 ha of habitat suitable for this species (PCTs 783, 1230 and 1728). The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Green and Golden Bell Frog in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate.

5.3.35 Wallum Froglet

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	The Wallum Froglet is listed as vulnerable under Schedule 2 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the Wallum Froglet: • Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. • Clearing of native vegetation • Human-caused Climate Change Infection of frogs by amphibian chytrid causing the disease chytridiomycosis
c)	Habitat requirements	The Wallum Froglet inhabits freshwater, acidic swamps on coastal sand plains. The species typically occupies sedgelands and wet heathlands. Drainage lines, disturbed areas, and swamp sclerophyll can also provide habitat for this species. Breeding habitat includes permanent water as well as shallow ephemeral pools and drainage ditches. Eggs are generally only deposited into water with a pH of <6 (OEH 2019b). Wallum Froglets shelter under leaf litter, vegetation, other debris or in burrows of other species. Shelter sites are wet, or very damp, located by the water's edge (OEH 2019b).
d)	Other documentation	No recovery plan has been prepared for the Wallum Froglet.
e)	Assessment of adequacy of reservation	The Wallum Froglet is well represented in conservation reserve network with habitat occupation occurring within the Tilligerry State Conservation Area, Worimi National Park, Tomaree National Park, Myall Lakes National Park, Wallingat National Park, Darawank Nature Reserve, Crowdy Bay National Park, Lake Innes Nature Reserve, Limeburners National Park, Hat Head National Park, Bongil Bongil National Park, Moonee Beach Nature Reserve, Yaraygir National Park, Bundjalung National Park, Bundjalung State Conservation Area, Broadwater National Park, Bungawalbin Nature Reserve, Bungawalbin National Park, Bungawalbin State Conservation Area, Ballina Nature Reserve, Tyagarah Nature Reserve, Billinudgei Nature Reserve, Cudgeon Nature Reserve and Cobaki Nature Reserve. Reservation of such a large area suggests the above reserves provide considerable habitat protection for this frog species in the region.
f)	Limit of known distribution	The Wallum Froglet is distributed along coastal districts in acid swamps from Jervis Bay in the south to Bundaberg in Queensland to the north.
2)	**Discussion of local and regional abundance**	
a)	Discussion of other known local populations	The Wallum Froglet is not recorded in wetlands 803 or 804, however, is commonly observed in nearby wetland systems located in Tilligerry – Tomago area through to Tomaree. These recorded occurrences align with high value habitat.
b)	Discussion of habitat utilisation	Wallum Frog occupy acid swamps mainly on sand masses in the local area.
c)	Description of vegetation	Typically occupies Broad-leaved Paperbark – Swamp Mahogany swamp woodlands and dense forests with other Melaleuca vegetation types also occupied.
3)	**Description of habitat values**	Preferred habitat for this species is limited to wetlands and their periphery. Wetlands 803 and 804 are not known to comprise this species. However, this species may occur in these wetlands with greater likelihood in wetland 804 due to the increased abundance of macrophytes and the complexity of the hydrological conditions. Wetland 803 is considered marginal habitat and

DGR Matter	Comment
	possibly unsuitable due to the history of grazing and its effect on macrophyte growth and the lack of shelter areas in the peripheral lands.
4) Extent of habitat removal	The Proposal will not remove any habitat for this species. Indirect impacts through hydrological changes will have a negligible impact on the habitat of this species within the study area (Alluvium 2019). In executing the VPA, the Proposal will allow for an in-perpetuity protection and management outcome comprising 14.85 ha of habitat suitable for this species (PCTs 783, 1230 and 1728). The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.
5) Consideration of corridors	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensions linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
6) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the Wallum Froglet in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate such as Medowie State Conservation Area and Tilligerry State Conservation Area.

5.4 Feasible Alternatives

DGR 5.5 Description of feasible alternatives

A description of any feasible alternatives to the action, as available under the legislation that this Project is proceeding within, that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development (Section 110 (2)(h)).

Two alternatives to the Proposal to which this SIS relates (i.e. described in **Section 2.1**) are considered below:

- Do nothing; and
- Implementation of the BMP (**Appendix C**) and VMP (**Appendix D**) as varied by a reconfigured Proposal impact footprint involving:
  - Greater utilisation of the R1 zone areas, that have been avoided, for the purposes of increasing lot yield, as balanced by the securing of equivalent compensatory measures;
  - Subdivision of the E2 zoned land into 40 ha lots for the purposes of resale;
  - Place conservation mechanisms on each E2 lot specifying an in-perpetuity conservation agreement such as VPA and restriction to user under Section 88b *Conveyancing Act* 1919; and
  - Provide compensatory measures for the loss of certain affected threatened species using species and ecosystem credits as calculated by the BioBanking Credit Calculator.

These are discussed in the following sections.

5.4.1 Do Nothing

If nothing is done and no development occurs, the remnant native vegetation within the subject site is likely to survive in the long term in situ, though there is likely to be continued degradation of the native vegetation and habitat for native wildlife due to the proliferation of weed species and feral animals (wild dogs, wild deer, fox and rabbits), and the presence of cattle, horses and goats within the subject site. The landscape would effectively be unsupervised and exposed to the continuation of uncontrolled rural and peri urban activity (i.e. rubbish dumping, logging, hunting, unmanaged fire regimes), which would further exacerbate threats to biodiversity.

Socio-economic benefits would also be foregone. The expected socio-economic benefits that would be lost through the do nothing approach are outlined below.

Expected socio-economic benefits

The subject site forms a predominant (about 64%) part of the Kings Hill Urban Release Area (URA). The URA was strategically identified for population growth and change in successive urban strategies by Port Stephens Council since the early 1990s, and endorsed in 2007 as 1 of 4 priority urban release areas in the Lower Hunter by the NSW government in their Lower Hunter Urban Regional Strategy.

In 2010, the NSW state government rezoned the land from Rural to a mix of urban and conservation zones to:

- Provide affordable residential land supply close to the region's largest existing and emerging employment areas;
- maintain and support existing capacity in public and private infrastructure investment in this part of the region; and

- to provide a critical mass of population to ensure that social infrastructure and community services and facilities remain sustainable in the Port Stephens administrative centre of Raymond Terrace.

Projected Dwelling and Population Increase

The URA will lead to the construction of some 3500+ dwellings, and with an average of 2.6 persons per dwelling, some 10,000 residents will be accommodated within the URA.

The first residents are likely to be educated and qualified young families as first home buyers, and those with families seeking to upgrade to larger dwellings by relocating from within Raymond Terrace or other parts of the LGA. As the development matures relative to new stages being released, then the socio economic profile of residents will begin to diversify consistent with broader socio economic trends across Port Stephens and the Lower Hunter region.

Impact of Residential Lots

The main location for housing lots in this part of the Port Stephens LGA has been Riverview Ridge north of Raymond Terrace. The area is mostly developed with the last vacant but zoned developable area being a relatively small area off Rees James Road, across the spillway from the site.

The Kings Hill URA is the next nearest, least constrained land close to Raymond Terrace. Alternative locations are not suitable for urban use due to complex constraints such as flood plains, flight paths, ground water etc.

MacroPlan Dimasi (2019) identify that direct regional benefits attributable to the URA include:

- A timely addition of 3,500+ dwellings in a relatively difficult and constrained housing environment, providing affordable housing choices central to the region's main employment locations;
- A strengthening and diversification of the local economy – countering the region's reliance on traditional industries such as manufacturing and mining, which currently support the majority of the region's workforce but are anticipated to recede in importance over the coming decade; and
- An improved retention of young working residents – through its provision of employment opportunities in construction, professional services, education and retail trade industries.

The KHURA supports a number of Government initiatives and strategies namely through its support of population, dwelling and employment growth. The KHURA will allow this growth to be well located, supporting services in key strategic centres and job opportunities inside and outside of the KHURA (Williamtown, Tomago and Heatherbrae, Newcastle) with it also contributing to increased housing supply, open space and education.

The KHURA will support the growth of local businesses through its town centre, however it will also help support the planned focus of higher order services in Raymond Terrace by increasing its local consumer base. On completion the resident population is expected to contribute over $140 million in additional retail expenditure annually, a lot of which will be directed at local centres such as Raymond Terrace.

The development of the KHURA will generate significant direct investment into the local economy. Expenditure on upfront infrastructure expected to total $105.4 million whilst the cost of the construction of the development is expected to total $1.1 billion (2018 dollars). Expenditure on the construction of the development alone is expected to generate177 full- time equivalent jobs per annum directly in the construction industry over a 15-year period and a further 279 full-time equivalent jobs per annum indirectly. When completed, investment from businesses located in the KHURA has the potential to provide direct ongoing employment for at least 885 people generating an IVA of $71.7million per annum. This increases to $134.8 million per annum gross value-add when combined with the project's residential components.

Kings Hill will play a key role in supporting the economic growth of Port Stephens and the Lower Hunter more generally through its direct investment and support of population growth and job creation all of which will help to support the transition of Port Stephens into a strong, self-sufficient regional economy. However,

with growth comes an increasing demand for housing and without adequate supply house price hikes are inevitable. The KHURA will be critical to maintaining housing affordability in Port Stephens by ensuring a healthy demand and supply balance.

Social Infrastructure, Recreation and Community Services

The proposed subdivision will result in an increase in demand for facilities, services and infrastructure. This will include an increased demand for recreational facilities, schools, health infrastructure, emergency services, public transport, open space and community facilities.

Currently, all these facilities are located in Raymond Terrace and Heatherbrae. As future stages of the URA are released, the capacity for private sector local services and facilities to become established within the URA will increase. As one of the first stages of the URA, it is expected and accepted that future residents of this stage will be dependent upon lower and higher order facilities and services provided in Raymond Terrace. Over time, future residents will continue to obtain higher order facilities, services and employment in Raymond Terrace, Heatherbrae, RAAF Base Williamtown and Newcastle Airport and the centres of Newcastle and Maitland.

The evolution of the URA into a new town is envisaged by the Kings Hill Environmental Management Strategy, draft DCP and Draft S94 Plan and permitted under the Port Stephens LEP 2013.

The proponent for the subdivision will pay section 94 contributions towards the provision of public facilities and services in accordance with Council's applicable Local Infrastructure Contributions Plans.

Although the proposed new stage of the Kings Hill Urban Release Area represents only a minor part of the URA in its entirety, the proposal will still have a significant and sustainable positive effect on the social and economic aspects for both Kings Hills and the LGA as a whole.

These positive effects include:

- Providing the market place with diversity and greater choice in terms of location (close to employment areas of Raymond Terrace, Tomago/Heatherbrae, Williamtown airport) and housing in Port Stephens
- Increased supply of modern, energy efficient and adaptable housing;
- Adding to the critical mass of population required to sustain services and facilities;
- Additional users of existing public and private infrastructure in Raymond Terrace;
- Create a population mass suitable to sustain and/or encourage new services including public transport;
- Increased numbers of children available for the proposed school;
- Greater availability of affordable housing for low income earners and first home buyers in Port Stephens and beyond;
- An increase in population will increase the pool of volunteers to serve community organisations in the Raymond Terrace area such as Volunteer Fire Service, Riding for Disabled, State Emergency Services etc.
- Greater amount of Section 94 Contributions, based on the Kings Hill Section 94 contributions plan that ensures community infrastructure is online expediently; and
- An increase in the employment generation likely from the Urban Release Area as a result of the multiplier effect.

The Public Interest

The Proposal is in the public interest to:

- Progress implementation of the largest urban growth area in Port Stephens after 20 years of strategic planning.

- Provide additional housing to meet with demand for housing in different market sectors, leading to greater housing diversity within Port Stephens.
- Provide development in an area identified by local and regional planning strategies as a growth precinct of Port Stephens.
- Provides additional population mass to the community ensuring Raymond Terrace becomes economically and socially sustainable.
- Providing housing choice in a central location (close to employment areas of Raymond Terrace, Tomago, Heatherbrae, Williamtown airport).

5.4.2 Zone Based Development Scenario

5.4.2.1 Revised Proposal Outline

The Proposal, as described in the SEE (JW Planning 2020) and **Section 2.1**, provides for a local biodiversity outcome where potential for the coordinated management of lands with high biodiversity values (e.g. the Conservation Area plus adjoining E2 lands) is made possible. The feasible alternative to doing nothing or the Proposal, as described in **Section 2.1**, is to retain the implementation of the BMP (**Appendix C**) and VMP (**Appendix D**), as varied below:

- Reconfigure the Proposal impact footprint to utilise more of the impact avoided areas to use the residential zoned land to a greater extent (i.e. reduced impact avoidance), as balanced by the securing of equivalent compensatory measures;
- Subdivide the E2 zoned land into say, five 40 ha lots to be sold for private use;
- Place conventional conservation mechanisms on each subdivided E2 lot in the form of a conservation agreement such as VPA and restriction to user under Section 88b *Conveyancing Act* 1919; and
- Provide compensatory measures for the loss of certain affected threatened species using species and ecosystem credits as calculated by the BioBanking Credit Calculator (see **Section 5.4.2.2**).

A revised development design based on the above and the approved land zoning for the study area would substantially reduce the potential for a coordinated biodiversity management regime for significant biodiversity values at the local landscape scale. The opportunity to consolidate the E2 lands into a single management area would effectively be lost in favour of divesting these lands into multiple private ownership.

The alternative to 'do nothing option' or the Proposal, as described in **Section 2.1**, would be feasible because:

- An additional 40 ha of residential zoned land could be developed, which at 10 lots per hectare, would equate to 400 lots, and creation of five E2 zoned lots.
- Revenues under an alternative of this kind would adequately fund any associated compensatory measures required to balance the impact.

5.4.2.2 Compensatory Measures

Phase by Phase compensatory measures are proposed for *Corybas* × *dowlingii*, *Pterostylis chaetophora*, *Maundia triglochinoides*, the Koala, Brush-tailed Phascogale and Lower Hunter Spotted Gum Ironbark Forest, which is to be delivered prior to the commencement of each Phase. This offset is to be provided in advance of the impact and prior to attaining evidence of a maintain or improve outcome through implementation of the amelioration works.

Table 5.4 quantifies, by Phase, the likely extent of compensatory measures for selected affected species theses being *Corybas* × *dowlingii*, *Pterostylis chaetophora*, *Maundia triglochinoides*, the Koala, Brush-tailed Phascogale and Lower Hunter Spotted Gum Ironbark Forest. This liability was calculated using the Biobanking Credit Calculator and represents the liability that would have been incurred under that scheme

and can be scaled to accommodate any alteration in compensatory measures. Also described in **Table 5.7** are the protection outcomes required for these species within the subject site.

Table 5.7 Compensatory Measures for Impacts on Affected Species

Species	Protection Outcomes	Compensatory Measure		
		Phase 1	Phase 2	Phase 3
Corybas × dowlingii	• Retention of at least 1,200 plants within an environmental lot in combination with a Section 88b restriction of the *Conveyancing Act* 1919 to maintain the protection outcome	-	1,534[23]	-
Pterostylis chaetophora	• Retention of at least 400 plants within an environmental lot in combination with a Section 88b restriction of the *Conveyancing Act* 1919 to maintain the protection outcome	-	720[24]	-
Maundia triglochinoides	• Retention of at least 50 plants within an environmental lot in combination with a Section 88b restriction of the *Conveyancing Act* 1919 to maintain the protection outcome	-	1,300[25]	-
Koala[26]	• Retention of at least 200 ha of Koala Supplementary B/C habitat or better within environmental lots in combination with a Section 88b restriction of the *Conveyancing Act* 1919 to maintain the protection outcome	1,336	857	1,562
Brush-tailed Phascogale	• Retention of at least 200 ha of preferred habitat within environmental lots in combination with a Section 88b restriction of the *Conveyancing Act* 1919 to maintain the protection outcome	913	585	1,382
Lower Hunter Spotted Gum Ironbark Forest EEC	• None	220	-	-

The framework for how the compensatory measures is to be delivered is outlined below:

- Prior to the completion of each Phase the Proponent must retire the specified direct offset for the impact; and
- The direct offset must be equal to or greater than the quantum specified in **Table 5.3** for the corresponding species and associated Phase.

[23] Assumes loss of 118 plants. Calculated using the BioBanking Credit Calculator.

[24] Assumes loss of 20 plants. Calculated using the BioBanking Credit Calculator.

[25] Assumes loss of 50 plants. Calculated using the BioBanking Credit Calculator.

[26] Includes performance targets as recommended by BioLink (2018)

6 ASSESSMENT OF LIKELY IMPACTS ON ECOLOGICAL COMMUNITIES (ENDANGERED AND CRITICALLY ENDANGERED)

This chapter covers the following CERs:

DGR 6. ASSESSMENT OF LIKELY IMPACTS ON ECOLOGICAL COMMUNITIES (ENDANGERED AND CRITICALLY ENDANGERED ECOLOGICAL COMMUNTIES)

6.1 Determining Affected Endangered Ecological Communities

DGR 6.1 Assessment of endangered ecological communities likely to be affected

A general description of the ecological community present in the area that is the subject of the action and in any area that is likely to be affected by the action (Section 110 (3)(a)).

Section 3 identifies the following TECs as subject species:

- Lower Hunter Spotted Gum-Ironbark Forest in the Sydney Basin and North Coast Bioregions EEC;
- Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions VEC;
- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions;
- Swamp Oak Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC; and
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC.

Following the completion of detailed surveys across the subject site and limited surveys elsewhere in the study area (i.e. Hunter Water Lands), all threatened ecological communities listed above were identified as occurring within the study area. The following would be impacted by the Proposal:

- Direct impact on 5.15 ha of PCT 1600 which forms part of the *Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions* EEC.
- Indirect impact on PCT 1728, which forms part of *Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions* EEC.
- Indirect impact on PCT 783, which forms part of *Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC.*
- Indirect impact on PCT 1230, which forms part of *Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC.*

Alluvium (2019) (**Appendix E**) investigated the impacts of the Proposal on wetlands 803 and 804, where indirect impacts on three of the above EECs may occur. It was concluded in that assessment that the indirect impacts on the following EECs is likely to be minor and not likely to have any significant impact.

- Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions EEC.
- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC.
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC.

6.1.1 Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions

6.1.1.1 Classification of PCT 1600

During the course of preparing this SIS there was need to reconsider the designation of an endangered ecological community following its gazettal in May 2019. This process resulted in a mapped occurrence of PCT 1600 in the lower south-eastern corner of the subject site as being aligned with the recently listed Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions endangered ecological community (NSW Scientific Committee 2019), hereafter referred to as LHSSGIF EEC. For the purposes of understanding, the previous final determination for LHSGIF EEC (NSW Scientific Committee 2005) was not considered as the now superseded description for that listing is geographically restricted to the Sydney Basin thus precludes its potential to occur within the subject site (i.e. subject site is located within the North Coast bioregion).

The assigning of LHSGIF EEC to vegetation within the subject site has not been predicated by published relationships with PCTs. More appropriately, a merits based approach has been adopted where the description of the gazetted listing has been taken into account. In this regard, the indicators for the assigning of this classification on vegetation within the subject site are conflicting as there is evidence that the vegetation is actually a localised variant of PCT 1590, which is referred to as MU 65 in Part 4.6 of the determination and is not part of the listing.

The fundamental indicators for the positive identification of LHCGIF EEC are as follows:

- Comprises a high percentage of the prescribed 'assemblage of species' mentioned in Part 1.1 of the listing, notwithstanding the limitations mentioned in paragraph 1.2; and
- Must occur within the Sydney Basin or North Coast bioregions (Part 2.1).

LHSGIF EEC has been mapped as occurring within Columbey National Park thereby geographically raising the potential for considering the occurrence of this EEC within the subject site (i.e. Columbey National Park is to the north of the subject site). Notwithstanding, discerning the true classification of vegetation cover within the subject site relative to this listing has been confounded by condition states. Consideration of the fundamental indicators mentioned above and the additional information about the ecological community in Part 4 of the listing generates uncertainty for the following reasons:

- The vegetation is located on a very localised basalt extrusion, this being of volcanic origin and is not classed as a sediment. Part 4.2 of the listing explains that LHSGIF occurs "*principally on Permian and Carboniferous geology in the central to lower Hunter Valley*" and "*In the area of Paterson, Seaham and Clarence Town, the community occurs on Carboniferous sediments including the Wallaringa, Mt Johnstone and Seaham formations*". Carboniferous and Permian geologies are mapped for the subject site, however, the patch of LHSGIF occurs on basalt that is not a sediment;
- The tree canopy of the vegetation is characterised by Grey Box, Spotted Gum and scattered Narrow-leaved Ironbark, which is inconsistent with the dominants of LHSGIF, which are identified in Part 4.3 as Spotted Gum and Broad-leaved Ironbark. The patch is floristically modified from substantive past and ongoing disturbances (i.e. land clearing event 100-150 years ago and a long history of livestock grazing) and, within this context, the vegetation is considered to be in a derived form. Part 1.2 identifies disturbance as a factor to consider and, in this light, it is possible that the current tree cover is now a reflection of the 'other tree species' mentioned as 'infrequently recorded' with the presence of Spotted Gum being relict.
- The shrub understory is absent within the site; yet is described in Part 4.3 as '*sparse to moderately dense*' and with '*the most frequently encountered shrub species include Acacia parvipinnula, Bursaria spinosa, Daviesia ulicifolia, Lissanthe strigosa, Melaleuca nodosa and Persoonia linearis*'. Again, with reference to Part 1.2 and the effect of past land use modifiers, it is reasonable to assume that such species would now be absent. However, with the exception of *Melaleuca nodosa*, it is important to note

that none of these species are frequently encountered within the subject site. *Melaleuca nodosa* is frequently encountered in circumstances in shallow soil depths over bedrock and not within the area mapped as PCT 1600.

- Part 4.4 correctly notes the inherent structural and compositional complexity observed in LHSGIF across environmental gradients (e.g. temperature, rainfall, soils). Paragraph 4.2 identifies 'sediments' as the typical soil type and paragraph 4.5 identifies an annual rainfall range of 750 – 1,000 mm. Both these conditions are not simultaneously met within the subject site [i.e. basaltic soils and annual rainfall of 1044.6 mm at Raymond Terrace (Kinross): BOM station: 61031 (1894-2019)].
- Part 4.4 notes two forms of LHSGIF, described by Somerville (2009a, 2009b), as being readily recognised as forming part of the listing these being:
  - MU 67 (Spotted Gum/Red Ironbark/Large – fruited Grey Gum shrub/grass open forest); and
  - MU 68 (Red Ironbark/paperbark shrubby open forest).

  Again, with reference to Part 1.2, there is a need to consider how derived states of a vegetation community may become dissimilar from the vegetation in an undisturbed state. In this circumstance it is unclear what the former composition of the vegetation mapped at PCT 1600 was and therefore doubt remains as to how to interpret the current modified and disturbed state;
- Part 4.6 notes forms of 'Spotted Gum Ironbark Forest' that grade into LHSGIF that do not part of the listing. These communities include:
  - Spotted Gum/Broad-leaved Mahogany/Red Ironbark moist shrubby open forest (MU 65 of Somerville 2009b), which merges Coastal Foothills Spotted Gum Ironbark Forest and Seaham Spotted Gum Ironbark Forest (MU 15 and MU 16 of NPWS 2000); and
  - Hinterland Spotted Gum Ironbark Forest (Bell 2013).

  Other parts of the subject site have been mapped as PCT 1590, not PCT 1600 or PCT 1592, due to alignment of this vegetation with descriptions for MU 65 and Hinterland Spotted Gum Ironbark Forest and the certainty associated with the arrival at that conclusion. High confidence is placed on the PCT 1590 classification as this vegetation is in a relatively undisturbed condition thus allowing for a proper consideration of floristic composition against published descriptions for these variants (see **Section 6.1.1.2** for further information).

  Conversely, and with reference to Part 1.2, disturbance history has generated considerable uncertainty as to classification of this vegetation patch. In the absence of certainty, and in adopting the precautionary principle, this patch of highly modified and chronically disturbed vegetation was classed as PCT 1600 (a reflection of the conditions observed) and included in the LHSGIF EEC classification. Notwithstanding, within the prevailing uncertainty arising from the condition state of the vegetation, it could also be argued that the vegetation is a highly localised variant of PCT 1590 with non-disturbance related edaphic causes (i.e. localised presence of weathered basalt soils). Edaphic differences can easily explain the grassy herbaceous nature of the vegetation as opposed to the more grassy/ shrubby nature of adjoining patches of PCT 1590 on other soil types.

In conclusion, it is for reasons disturbance as outlined in Part 1.2 [i.e. influence of past and present land use impacts on Species presence and relative abundance (dominance)] and uncertainty as indicated by Part 2.2 [(i.e. intent of the NSW Threatened Species Scientific Committee that all occurrences of the ecological community (both recorded and as yet unrecorded, and independent of their condition)] that the area mapped as PCT 1600 has been included within the classification for LHSGIF EEC.

Conversely, patches of vegetation mapped as PCT 1590 for the remainder of the subject site have not been included as part of LHSGIF EEC as the influence of past and present land uses on vegetation structure and composition (Part 1.2) does not cast sufficient uncertainty so as to invoke consideration expressed in Part 2.2 of the listing. The rationale for not including PCT 1590 within the listing of LHSGIF EEC is provided in **Section 6.1.1.2**.

6.1.1.2 Classification of PCT 1590

In difference to the condition and identity uncertainties that led to the evaluation of PCT 1600 as being part of LHSGIF EEC, as outlined in **Section 6.1.1.1**, the same conclusion was not reached in the comparison of PCT 1590 with the final determination for LHSGIF EEC. Unequivocally, the combination of environmental gradients (i.e. mean annual rainfall and edaphic environmental gradients) and vegetation composition, represent clear discriminating factors in dismissing alignment between PCT 1590 and LHSGIG EEC within the subject site. Reliance is placed on the description of floristic composition provided in Section **4.3.2.1** for PCT 1590, notably the statistical analysis results provided in **Figure 4.21** and **Table 4.9**, and the environmental gradients that typify the subject site (i.e. mean annual rainfall and soils). The comparison between PCT 1590, as mapped within the subject site, and the final determination for LHSGIF EEC is provided in **Table 6.1**.

Table 6.1 Comparison of PCT 1590 and Diagnostic Characteristics of LHSGIF EEC

Listing Part	Listing Description	Comparison with PCT 1590 mapped within the subject site
1.1	LHSGIF is characterised by the assemblage of species listed below: *Acacia parvipinnula, Aristida vagans, Billardiera scandens, Bursaria spinosa, Callistemon linearifolius, Cheilanthes sieberi subsp. sieberi, Correa reflexa, Corymbia maculata, Daviesia ulicifolia, Denhamia silvestris, Dianella revoluta var. revoluta, Dichelachne micrantha, Entolasia stricta, Eragrostis brownii, Eucalyptus fibrosa, Eucalyptus punctata, Glycine clandestina, Goodenia rotundifolia, Grevillea montana Grevillea parviflora subsp. parviflora, Hardenbergia violacea, Lepidosperma laterale, Leptospermum parvifolium, Lissanthe strigosa, Lomandra filiformis, Lomandra multiflora, Macrozamia flexuosa, Melaleuca decora, Melaleuca nodosa, Microlaena stipoides, Opercularia diphylla, Ozothamnus diosmifolius, Panicum simile, Paspalidium distans, Persoonia linearis, Phyllanthus hirtellus, Platysace ericoides, Podolobium ilicifolium, Pomax umbellata, Pratia purpurascens, Pultenaea spinosa, Rytidosperma pallidum, Themeda triandra and Vernonia cinerea var. cinerea*	**Absent** (or in very low abundance and never characteristic): *Acacia parvipinnula*, *Callistemon linearifolius*, *Correa reflexa*, *Grevillea montana*, *Grevillea parviflora* subsp. *parviflora*, *Leptospermum parvifolium*, *Lissanthe strigosa*, *Macrozamia flexuosa*, *Melaleuca decora*, *Ozothamnus diosmifolius*, *Phyllanthus hirtellus*, *Platysace ericoides*, *Podolobium ilicifolium*, *Pomax umbellata*, *Pultenaea spinosa.* **Uncommon** (and never characteristic): *Bursaria spinosa*, *Daviesia ulicifolia*, *Denhamia silvestris*, *Dianella revoluta* var. *revoluta*, *Eucalyptus fibrosa*, *Goodenia rotundifolia*, *Hardenbergia violacea*, *Rytidosperma pallidum*. **Commonly encountered** (but not necessarily characteristic): *Billardiera scandens, Dichelachne micrantha, Glycine clandestina*, *Lepidosperma laterale, Panicum simile, Paspalidium distans, Persoonia linearis, Themeda triandra.* **Frequently encountered** (characteristic): *Aristida vagans, Cheilanthes sieberi* subsp. *sieberi*, *Corymbia maculata, Eragrostis brownii*, *Entolasia stricta*, *Eucalyptus punctata, Lomandra filiformis, Lomandra multiflora, Microlaena stipoides*, *Opercularia diphylla, Pratia purpurascens*, *Vernonia cinerea* var. *cinerea.*
1.2	The total species list of the community across all occurrences is likely to be considerably larger than that given above. Due to variation across the range of the community, not all of the above species are present at every site and many sites may also contain species not listed above (see section 4).	Noted. Refer to analysis against relevant Section 4 matters.
1.2	Species presence and relative abundance (dominance) will vary from site to site as a function of environmental factors such as soil properties (chemical composition, texture, depth, drainage), topography, climate and through time as	Logging within the areas mapped as PCT 1590 is likely to have been at least 50-100 years ago. Grazing pressure within this area is generally minimal as indicated by the relatively intact understorey structure and absence of exotic groundcover flora. The influences of fire are not apparent. Soil disturbances are minor and

Listing Part	Listing Description	Comparison with PCT 1590 mapped within the subject site
	a function of disturbance (e.g. fire, logging, grazing) and weather (e.g. flooding, drought, extreme heat or cold).	stabilised. It is considered that the majority of this vegetation is in a condition that is comparable to pre-disturbed state. High certainty is placed on the capacity to accurately classify this vegetation.
2.1	Lower Hunter Spotted Gum Ironbark Forest is endemic to New South Wales (NSW) and is currently found in the Sydney Basin and NSW North Coast Bioregions. The assemblage of species listed in Part 1.1 above which characterises the Lower Hunter Spotted Gum Ironbark Forest occurs within the Sydney Basin and NSW North Coast Bioregions.	The subject site is within the geographic range of the listing (i.e. North Coast Bioregion) noting the general inconsistencies observed is the assemblage of species in Part 1.1.
2.2	It is the intent of the NSW Threatened Species Scientific Committee that all occurrences of the ecological community (both recorded and as yet unrecorded, and independent of their condition) that occur within these Bioregions be covered by this Determination.	Noted. The condition of the vegetation is considered adequate for an accurate evaluation against the listing description. The certainty of arriving at an accurate conclusion is high for this vegetation.
4.1	Lower Hunter Spotted Gum Ironbark Forest is currently known to occur in the Lower Hunter Valley centred on the Cessnock-Beresfield area and approximately bounded by the towns of Paxton, Branxton, Clarence Town, Beresfield, Mt Vincent and the northern boundary of Watagans National Park. The northern and southern parts of its distribution are separated by the floodplain of the Hunter River.	The subject site is located east of a line between Clarence Town and Beresfield. Part 2.2 is noted.
4.2	Lower Hunter Spotted Gum Ironbark Forest is known to occur principally on Permian and Carboniferous geology in the central to lower Hunter Valley. The Permian substrates most commonly supporting the community belong to the Dalwood Group, the Maitland Group and the Greta and Tomago Coal Measures (NSW Department of Mines 1966, 1969). In the area of Paterson, Seaham and Clarence Town, the community occurs on Carboniferous sediments including the Wallaringa, Mt Johnstone and Seaham formations. The community is strongly associated with, although not restricted to, the yellow podsolic and solodic soils of the Lower Hunter soil landscapes of Aberdare, Branxton and Neath (Kovac and Lawrie 1991). These substrates are considered to produce 'moderately fertile' soils (Kovac and Lawrie 1991).	Mapped occurrences of PCT 1590 within the subject site occur on Carboniferous geology belonging to the Seaham formation. The vegetation is not located on yellow podsolic and solodic soils of the Lower Hunter soil landscapes of Aberdare, Branxton and Neath (Kovac and Lawrie 1991). Soil landscapes occurring within areas mapped as PCT 1590 are the Ten Mile Road and Birdsview soil landscapes. Only the Birdsview soil landscape has 'yellow podsolic' soils. See **Figure 2.6** for distribution within the subject site, noting this soil landscape does not occur within the Proposal impact footprint. The Ten Mile Road landscape is described as 'gently undulating to undulating low hills on Carboniferous sediments' with slope gradients of 5-10% (Matthei 1995). Soils are moderately deep to deep, well to imperfectly drained brown soloths, yellow soloths, and shallow, well-drained bleached loams/ lithosols (Matthei 1995). The Birdsview soil landscape (variant bia) is characterised by rolling hillcrests and midslopes on Carboniferous sediments, with a slope of 10-20% (Matthei 1995). Soils are moderately deep, well-drained yellow podsolic soils with shallow, well-drained bleached loams and lithosols on stony ridge crests and deep, well-drained red podsolic soils where siltstone and deeply weathered polymictic conglomerate outcrop (Matthei, 1995).

Listing Part	Listing Description	Comparison with PCT 1590 mapped within the subject site
4.3	Lower Hunter Spotted Gum Ironbark Forest is usually dominated by *Corymbia maculata* (Spotted Gum) and *Eucalyptus fibrosa* (Broad-leaved Ironbark), with *E. punctata* (Grey Gum) occurring less frequently. Other tree species have been recorded infrequently, including *E. crebra*, *E. moluccana*, *E. agglomerata*, *E. umbra*, *C. gummifera*, *Syncarpia glomulifera*, *E. globoidea*, *E. paniculata* subsp. *paniculata*, *E. sparsifolia*, *Angophora costata*, *E. acmenoides*, *E. fergusonii* subsp. *fergusonii, E. nubila* and *C. eximia* (NPWS 2000). None of these species are characteristic of Lower Hunter Spotted Gum Ironbark Forest.	Spotted Gum is a dominant canopy species across the subject site. Broad-leaved Ironbark is patchy and never dominant (see **Figure 37**). Grey Gum is more common and widespread than Broad-leaved Ironbark (see **Figure 4.33**). Small-fruited Grey Gum is not listed as an infrequently recorded tree species yet it is frequently recorded in the eastern parts of the subject site. The presence of this species is consistent with MU 15 (NPWS 2003), which is not part of LHSGI EEC (see response to Part 4.6 for further analysis) where it states: "To the north of the region this assemblage aligns to Forest Ecosystem 52 Foothills Grey Gum-Ironbark-Spotted Gum (NPWS, 1999a). Understorey features suggest a close resemblance although canopy species vary with *E. punctata* giving way to *E. propinqua* and *E. umbra* merging to *E. carnea* as northerly distance from the Hunter River increases".
4.3	A sparse to moderately dense shrub stratum may be present and is variable in composition depending on the soils, drainage, topography and the history of disturbance. The most frequently encountered shrub species include *Acacia parvipinnula*, *Bursaria spinosa*, *Daviesia ulicifolia*, *Lissanthe strigosa*, *Melaleuca nodosa* and *Persoonia linearis.*	With the exception of *Melaleuca nodosa,* none of these species are frequently encountered with *Acacia parvipinnula* and *Lissanthe strigosa* being absent. *Bursaria spinosa* and *Daviesia ulicifolia* occur infrequently and are localised. *Melaleuca nodosa* occurs in dense thickets and is generally restricted to stony to shallow soils where Eucalypt growth is otherwise precluded or high restricted. In contrast, and as indicated by the statistical analysis results provided in **Figure 4.21** and **Table 4.9**, the medium and high condition stats of PCT 1590 vegetation is composed of *Breynia oblongifolia, Notelaea longifolia, Leucopogon juniperinus* and *Acacia ulicifolia.* These shrub species are characteristic of MU 16 (NPWS 2003). See response to Part 4.6 for further analysis.
4.3	The ground stratum is typically diverse, and its composition also varies as a function of the factors listed above. Species frequently observed in the ground stratum include *Aristida vagans*, *Cheilanthes sieberi*, *Dianella revoluta*, *Entolasia stricta*, *Glycine clandestina*, *Hardenbergia violacea*, *Lepidosperma laterale*, *Lomandra filiformis*, *Lomandra multiflora*, *Macrozamia flexuosa*, *Microlaena stipoides*, *Panicum simile*, *Phyllanthus hirtellus*, *Pomax umbellata* and *Themeda triandra* (Somerville 2009b).	The understorey of PCT 1590 is characterised by the following species, with underlined being in common with LHSGIF listing: *Aristida vagans, Brunoniella australis, Cheilanthes sieberi, Cymbopogon refractus, Dichondra repens, Echinopogon caespitosus, Entolasia stricta, Eragrostis brownii, Eustrephus latifolius, Geitonoplesium cymosum, Glycine microphylla, Lomandra filiformis, Lomandra multiflora, Microlaena stipoides, Opercularia diphylla, Pratia purpurascens* and *Vernonia cinerea*. See response to Part 4.6 for further analysis.
4.4	Several different structural and compositional forms of Lower Hunter Spotted Gum Ironbark Forest have been identified (Bell and Driscoll 2007; Somerville 2009b; Bell 2013), however the relationships between these are complex and have not been examined quantitatively along environmental gradients (Sivertsen et al. 2011)	Noted. See response to Part 4.6 for further analysis.

Listing Part	Listing Description	Comparison with PCT 1590 mapped within the subject site
4.5	Lower Hunter Spotted Gum Ironbark Forest belongs to a continuum of related ecological communities which have been described and iteratively refined following incremental additions to a regional quantitative floristic survey dataset (NPWS 2000; Peake 2006; Somerville 2009a, 2009b; Sivertsen et al. 2011; Bell 2013). Patterns in the composition of communities dominated by Spotted Gum are broadly correlated with gradients in average annual rainfall and temperature (average minima and maxima), which are strongly influenced by elevation and distance from the coast (Bell 2013). Successive treatments have consistently recognised Lower Hunter Spotted Gum Ironbark Forest as an assemblage of species corresponding to vegetation occurring in areas approximately intermediate in this climatic range, where annual rainfall is in the range 750 – 1000 mm. However, these treatments differ in the compositional range attributed to the ecological community, and hence in the way the community is defined.	The subject site, located north of Raymond Terrace, is likely to have a mean annual rainfall total similar to that recorded at the nearby Kinross BOM weather station (i.e. 1044.6 mm/ annum).
4.6	Lower Hunter Spotted Gum Ironbark Forest grades into Spotted Gum/Broad-leaved Mahogany/Red Ironbark moist shrubby open forest (MU 65 of Somerville 2009b) in areas with similar edaphic properties but receiving a higher average annual rainfall. This community includes vegetation described as Coastal Foothills Spotted Gum Ironbark Forest, Seaham Spotted Gum Ironbark Forest (MU 15 and MU 16 of NPWS 2000) and Hinterland Spotted Gum Ironbark Forest (Bell 2013).	NPWS (2003) maps MU 16 within the subject site, a conclusion supported by the environmental gradients discussed in Parts 4.2 and 4.5 (i.e. annual rainfall and soils).
4.6	Spotted Gum/Broad-leaved Mahogany/Red Ironbark moist shrubby open forest differs from Lower Hunter Spotted Gum Ironbark Forest in the composition of the tree stratum, where *Corymbia maculata* dominates in association with *Eucalyptus umbra*, *E. fibrosa*, *E. siderophloia* and *Allocasuarina torulosa*	Canopy species composition favours alignment with MU 65 (i.e. PCT 1590) as Spotted Gum is a dominant species across the mapped extent of PCT 1590. *Eucalyptus umbra* and *E. siderophloia* are relatively common associates. *E. fibrosa* is uncommon and patchy.
4.6	Spotted Gum/Broad-leaved Mahogany/Red Ironbark moist shrubby open forest also differs in the composition of the shrub stratum, with species such as *Grevillea montana*, *G. parviflora* subsp. *parviflora*, *Melaleuca decora*, *M. nodosa* and *Pultenaea spinosa* occurring less frequently than in Lower Hunter Spotted Gum Ironbark Forest, while others (*Acacia ulicifolia*, *Breynia oblongifolia*, *Leucopogon juniperinus*, *Notelaea longifolia*) have been recorded more frequently (Somerville 2009b).	Shrub understorey species favours alignment with MU 65 (i.e. PCT 1590) as *Grevillea montana*, *G. parviflora* subsp. *parviflora*, *Melaleuca decora* and *Pultenaea spinosa* are absent. Conversely, species characteristic species of MU 65 (or PCT 1590) are common such as *Acacia ulicifolia*, *Breynia oblongifolia*, *Leucopogon juniperinus* and *Notelaea longifolia*.
4.6	Subshrubs and herbaceous species recorded less frequently in MU 65 than in Lower Hunter Spotted Gum Ironbark Forest include *Dianella revoluta*, *Dichelachne micrantha*, *Goodenia rotundifolia*, *Rytidosperma pallidum*, *Macrozamia flexuosa*, *Opercularia diphylla*, *Phyllanthus hirtellus*, *Platysace ericoides*, *Podolobium ilicifolium*, and *Pomax umbellata*. Species recorded more frequently in MU 65 include *Cymbopogon refractus*, *Desmodium rhytidophyllum*,	Groundcover species favours alignment with MU 65 (i.e. PCT 1590) as *Goodenia rotundifolia*, *Macrozamia flexuosa*, *Phyllanthus hirtellus*, *Platysace ericoides*, *Podolobium ilicifolium*, and *Pomax umbellata* are absent. Conversely, species characteristic species of MU 65 (or PCT 1590) are frequently observed such as *Cymbopogon refractus*, *Desmodium rhytidophyllum*, *Desmodium varians*, *Dianella caerulea*, *Dichondra repens*, *Echinopogon ovatus*, *Eustrephus*

Listing Part	Listing Description	Comparison with PCT 1590 mapped within the subject site
	Desmodium varians, *Dianella caerulea*, *Dichondra repens*, *Echinopogon ovatus*, *Eustrephus latifolius*, *Geitonoplesium cymosum*, *Gonocarpus tetragynus*, *Goodenia heterophylla*, *Imperata cylindrica*, *Pandorea pandorana* and *Pseuderanthemum variabile* (Somerville 2009b).	*latifolius*, *Geitonoplesium cymosum*, *Goodenia heterophylla*, *Imperata cylindrica* and *Pandorea pandorana*.

6.2 Assessment of Endangered Ecological Communities Likely to be Affected

DGR 6.2 Discussion of conservation status

For each ecological community present, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or any threat abatement plan applying to it (Section 110 (3)(b)).

An assessment of whether those ecological communities are adequately represented in conservation reserves (or other similar protected areas) in the region (Section 110 (3)(b1).

An assessment of whether any of those ecological communities is at the limit of its known distribution (Section 110 (3)(b2)).

DGR 6.2.1 Significance within a local context

DGR 6.2.2 Discussion of corridor values

DGR 6.2.3 Discussion of regional significance

DGR 6.2.4 Impacts on Ecological Communities in OEH Estate

DGR 6.3 Assessment of habitat

A full description of the type, location, size and condition of the habitat of the ecological community and details of the distribution and conditions of similar habitats in the region (Section 110 (3)(c)).

DGR 6.3.1 Description of disturbance history

DGR 6.3.2 Extent of habitat removal

6.2.1 Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin and NSW North Coast Bioregion

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregion (LHSGIF) is listed as an endangered ecological community (EEC) under Schedule 1 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the LHSGIF EEC: • High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition • Clearing of native vegetation
c)	Habitat requirements	LHSGIF EEC occurs predominantly on the Permian substrates belonging to the Dalwood Group, Maitland Group and the Greta and Tomago Coal Measures geological groups but also found on Carboniferous geologies near Vacy, Seaham and Clarence Town (NSW Threatened Species Scientific Committee 2019). It is strongly associated with, though not restricted to, the yellow podsolic and solodic soils of the Lower Hunter soil landscapes of Aberdare, Branxton and Neath (NSW Threatened Species Scientific Committee 2019). The community is generally associated with subcoastal districts where rainfall is less than the corresponding coastal areas (i.e. mean annual rainfall of between 750-1,000 mm).
d)	Other documentation	No recovery plan has been prepared for the LHSGIF EEC.
e)	Assessment of adequacy of reservation	LHSGIF EEC is present in four conservation reserves including Werakata National Park (1,818 ha), Werakata State Conservation Area (1,161 ha), Columbey National Park (419 ha) and Columbey State Conservation Area (87 ha). The combined area under formal reservation is therefore 3,541 ha, or approximately 5% of the community's pre-European distribution (NSW Threatened Species Scientific Committee 2019).
f)	Limit of known distribution	Lower Hunter Spotted Gum Ironbark Forest is currently known to occur in the Lower Hunter Valley centred on the Cessnock-Beresfield area and approximately bounded by the towns of Paxton, Branxton, Clarence Town, Beresfield, Mt Vincent and the northern boundary of Watagans National Park. The northern and southern parts of its distribution are separated by the floodplain of the Hunter River (NSW Threatened Species Scientific Committee 2019).
2)	**Significance within a local context**	The patch of Lower Hunter Spotted Gum – Ironbark Forest has a total area of 6.20 ha within the subject site and exhibits a naturally fragmented occurrence in the locality as it is restricted to a highly localised basalt extrusion. The significance of this patch of LHSGIF EEC is linked to its eastern occurrence and occurrence on basalt.
3)	**Consideration of corridors**	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area.

DGR Matter	Comment
	The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensioned linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
4) Discussion of Regional Significance	Several occurrences of this EEC exist within the locality to the south (e.g. Beresfield) and northwest (e.g. Columbey National Park) of the study area. The patch located within the study area is a small fragmented patch and restricted to a basalt extrusion. While associated with unusual edaphic conditions, the size and condition of the patch (as a consequence of disturbance) has substantially reduced the biodiversity values.
5) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the LHSGIF EEC in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate to the north.
6) Assessment of Habitat	
a) Description of habitat	A single patch of Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin Bioregion occurs in the south-east of the study area, with a total area of 6.20 ha. This community is not directly impacted by the proposal and no areas will be removed within the subject site. This community has been subjected to high levels of disturbance in the past with historical clearing for agriculture impacting on the canopy density and resulting in the ground layer in the majority of the area being dominated by exotic grasses. The occurrence of this community in the study area is a degraded example of Lower Hunter Spotted Gum – Ironbark Forest, with low species richness, low number of fauna species associated with them and a high abundance of exotic weed species. The location of the community in the study area is also in an area where cattle are grazed.
b) Disturbance history	For reasons relating to the basalt derived soils (i.e. high soil fertility), this vegetated area has previously been the subject of substantial and long term disturbances initiating with a historical clearing event 100-150 years ago) to establish grazing lands followed by ongoing livestock grazing. Combined, these land use impacts have substantially modified the understorey and altered canopy constituents directly though clearing and indirectly through the suppressing canopy regeneration. Grazing is still currently occurring with the presence of cattle, horses and feral deer. If grazing pressures were removed from the subject site, some recovery of the LHSGIF will occur; however the low recruitment of canopy species and the degree of modification already experienced it is considered that recovery will be limited and ultimately constrained by the simplification of the understorey by exotic flora species. This predicted outcome is indicated by the nMDS plot (i.e. cleared exotic grasslands being floristically similar to the patch of Lower Hunter Spotted Gum – Ironbark Forest indicating it is in a poor condition state and has limited recovery potential).
c) Extent of habitat removal	The Proposal will remove 5.15 ha of vegetation constituting LHSGIF EEC (i.e. PCT 1600) and is to be removed within Phase 1 of the Proposal.

DGR Matter	Comment
	In executing the VPA, the Proposal will retain 1.05 ha of LHSGIF EEC (i.e. PCT 1600) within a Conservation Area of 244.25 ha total area. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.

6.2.2 Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions EEC

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions EEC (SOFF) is listed as an EEC under Schedule 1 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the SOFF EEC: • High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition • Clearing of native vegetation
c)	Habitat requirements	SOFF typically occurs on unconsolidated sediments, including alluvium deposits, and where soils formed during the Quaternary period as a result of sea-level rise during the Holocene period. These are most typically hydrosols, which are saturated with water for long periods of time (typically grey-black clay-loam and/or sandy loam soils). SOFF can also occur on organosols (peaty soils). The ecological community is typically found where groundwater is saline or brackish, but can occur in areas where groundwater is relatively fresh. It is typically found on coastal flats, floodplains, drainage lines, lake margins, wetlands and estuarine fringes where soils are at least occasionally saturated, water-logged or inundated. These are typically associated with low-lying coastal alluvial floodplains and alluvial flats. Minor occurrences can be found on coastal dune swales or flats, particularly deflated dunes and dune soaks.
d)	Other documentation	No recovery plan has been prepared for the SOFF EEC.
e)	Assessment of adequacy of reservation	SOFF EEC is present in Stotts Island Nature Reserve, Ukerebagh Nature Reserve, Tuckean Nature Reserve, Bongil Bongil National Park, Myall Lakes National Park and Hunter Estuary National Park. The adequacy of reservation is considered low.
f)	Limit of known distribution	SOFF occurs along the eastern seaboard of NSW from Bermagui in the south to the Tweed in the north. SOFF occurs in coastal catchments, mostly at elevations of less than 20 m above sea-level (ASL) that are typically found within 30 km of the coast. However, this distance varies by catchment; for example, low elevations can occur as far as 40 km inland on the Hawkesbury River, or more than 100 km on the Clarence River. On the mid and north coast of NSW the ecological community may also occur up to 50 m ASL on floodplains of, or coastland flats associated with, former or current coastal river systems (NSW Scientific Committee 2005).
2)	**Significance within a local context**	SOFF has a proportionally high occurrence in the lower Hunter River catchment relative to the remaining coast line. It is well represented in local conservation reserves and is commonly associated with protected coastal wetlands including wetland 803 and 804, which occur within the study area.
3)	**Consideration of corridors**	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value

DGR Matter	Comment
	(key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensioned linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
4) Discussion of Regional Significance	Several occurrences of this SOFF EEC exist within the locality. The regional significance of this small patch is elevated by virtue of its coincidence with wetland 803, which is known to harbour occurrence of various wetland birds such as Latham's Snipe.
5) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the SOFF EEC in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate to the north.
6) Assessment of Habitat	
a) Description of habitat	The mature Swamp Oak are growing on pedestals of their own roots indicating that they have been growing under elevated water levels for a significant period of time. The healthiest Swamp Oak are seen in the north-western corner, which is a shallower area on the wetland and less "pedestaling" is seen in this area. The shallow gradient banks of Wetland 803 have a mixture of herbs, grasses and sedges including: *Paspalum distichum* (Water Couch), *Cotula coronopifolia* (Water Buttons), *Samolus repens* (Creeping Brookweed), *Triglochin* sp (Water Ribbons), *Juncus* sp, *Bolboschoenus caldwellii* (Marsh Club Rush). In some areas the bank has a sharply stepped bank (at the high water level) reducing the shallow bank vegetation extent (Alluvium 2019).
b) Disturbance history	For reasons relating to the alluvial soils (i.e. high soil fertility), this vegetated area has previously been the subject of substantial and long term disturbances initiating with a historical clearing event (100-150 years ago) to establish grazing lands followed by ongoing livestock grazing. Combined, these land use impacts have substantially modified the understorey and altered canopy constituents directly though clearing and indirectly through the suppressing canopy regeneration, which is evident in the change in extent and density of the Swamp Oak with a historic reduction of up to 30% between 1954 and 2019 (Alluvium 2019). Grazing is still currently occurring with the presence of cattle and feral deer. If grazing pressures were removed from the subject site, some natural recovery of the SOFF will occur; however the low recruitment of canopy species and the degree of modification already experienced it is considered that recovery will be limited and ultimately constrained by the simplification of the understorey by exotic flora species. Intensive management of weeds such as alligator weed is required to improve the regeneration potential of SOFF.
c) Extent of habitat removal	The Proposal will not remove vegetation constituting SOFF EEC (i.e. PCT 1728).

DGR Matter	Comment
	In executing the VPA, the Proposal will retain 5.49 ha of SOFF EEC (i.e. PCT 1728) within a Conservation Area of 244.25 ha total area. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.

6.2.3 Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (FWCF) is listed as an EEC under Schedule 1 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the FWCF EEC: • Clearing of native vegetation • Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands • Invasion of native plant communities by exotic perennial grasses • Anthropogenic climate change
c)	Habitat requirements	FWCF is dominated by herbaceous plants and have very few woody species. The structure and composition of the community varies both spatially and temporally depending on the water regime. Wetlands or parts of wetlands that lack standing water most of the time are usually dominated by dense grassland or sedgeland vegetation, often forming a turf less than 0.5 metre tall and dominated by amphibious plants including *Paspalum distichum* (water couch), *Pseudoraphis spinescens* (mud grass) and *Carex appressa* (tussock sedge). Wetlands or parts of wetlands subject to regular inundation and drying may include large emergent sedges over 1 metre tall as well as emergent or floating herbs such as *Ludwigia peploides* subsp. *montevidensis* (water primrose). As standing water becomes deeper or more permanent, amphibious and emergent plants become less abundant, while floating and submerged aquatic herbs become more abundant. These latter species include *Azolla filiculoides* var. *rubra*, *Ceratophyllum demersum* (hornwort), *Hydrilla verticillata* (water thyme) and *Lemna* spp. (duckweeds). The composition and structure of the vegetation is also influenced by grazing history, changes to hydrology and soil salinity, catchment runoff and disturbance, and may have a substantial component of exotic grasses and forbs.
d)	Other documentation	No recovery plan has been prepared for the FWCF EEC.
e)	Assessment of adequacy of reservation	FWCF EEC is poorly reserved and is known to occur in Ukerebagh Nature Reserve, Tuckean Nature Reserve, Tabbimoble Swamp Nature Reserve, Hexham Swamp Nature Reserve and Bungawalbin National Park. In the 1990s the extent remaining were: 3% in the NSW North Coast bioregion and 66% in the lower Hunter – Central coast region (NSW Scientific Committee 2011).
f)	Limit of known distribution	FWCF occurs along the eastern seaboard of NSW from Bermagui in the south to the Tweed in the north and is restricted to the coastal floodplain.
2)	**Significance within a local context**	FWCF within the subject site occurs within two mapped wetlands (wetland 803 and 804). These wetlands are protected by the Coastal SEPP and have habitat values for threatened and migratory birds. FWCF is considered to have high local value.
3)	**Consideration of corridors**	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value

DGR Matter	Comment
	(key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensioned linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
4) Discussion of Regional Significance	This wetland forms part of a complex systems of wetlands in the Williams River catchment that are mostly cleared for grazing purposes. As indicated for local significance, it is considered that the wetland and FWCF within it is of regional significance.
5) Impacts on Threatened Species and/or Populations in National Parks Estate	This proposal is considered unlikely to impact on any individuals of the FWCF EEC in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site.
6) Assessment of Habitat	
a) Description of habitat	The FWCF EEC within the subject site is largely ephemeral and comprises mostly herbaceous amphibious species as a consequence of the frequency of drying and the effects of livestock grazing. Large patches of Alligator Weed are present and is smothering native plant growth for up to 30% of the vegetated area. Livestock grazing is likely to be minimising the amount of Alligator Weed growth and, following removal, it is possible that the expansion of this weed species will occur at the expense of other natives. Shallow water column is suitable for a few water bird species such as Black-winged Stilts. The edges of the swamp are frequented by Lathams Snipe. Dusky wood swallows frequent the open air above the wetland for foraging (and possibly breeding in adjacent large Swamp Oak).
b) Disturbance history	The wetland area that comprises FWCF EEC is likely to has expanded following construction of New Line Road and the 'dam' effect it would have provided. Water levels rise and fall on a cyclical basis with complete drying routinely observed in the late summer months followed by recharge in the winter months. The outlet for water leaving the wetland is a culvert that passes beneath New Line Road as is not located at the invert (lowest point) of the wetland, meaning that drying beyond that water level is heavily related to evapotranspiration. Grazing has and remains an ongoing influence (i.e. cattle and feral deer). If grazing pressures were removed from the subject site, some recovery of the FWCF will occur; however the degree of modification already experienced and presence of Alligator Weed is likely to mean that recovery will be limited and ultimately confounded. Intensive management of Alligator Weed is required to limit the effect of this weed species on the recovery of this EEC, which is a core component of the BMP proposed for the Conservation Area.
c) Extent of habitat removal	The Proposal will not remove vegetation constituting FWCF EEC (i.e. PCT 783).

DGR Matter	Comment
	In executing the VPA, the Proposal will retain 9.21 ha of FWCF EEC (i.e. PCT 783) within a Conservation Area of 244.25 ha total area. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.

6.2.4 Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions EEC

DGR Matter		Comment
1)	**Discussion of conservation status**	
a)	Local, regional and state-wide status	Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (SSFCF) is listed as an EEC under Schedule 1 of the TSC Act.
b)	Threatening processes	The following Key Threatening Processes, listed under Schedule 3 of the TSC Act, are likely to affect the SSFCF EEC: • High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition • Clearing of native vegetation
c)	Habitat requirements	SSFCF has an open to dense tree layer of eucalypts and paperbarks although some remnants now only have scattered trees as a result of partial clearing. The trees may exceed 25 m in height, but can be considerably shorter in regrowth stands or under conditions of lower site quality where the tree stratum is low and dense. The community also includes some areas of fernland and tall reedland or sedgeland, where trees are very sparse or absent. The most widespread and abundant dominant trees include Eucalyptus robusta (*swamp mahogany*), *Melaleuca quinquenervia* (paperbark) and, south from Sydney, *Eucalyptus botryoides* (bangalay) and *Eucalyptus longifolia* (woollybutt). Other trees may be scattered throughout at low abundance or may be locally common at few sites, including *Callistemon salignus* (sweet willow bottlebrush), *Casuarina glauca* (swamp oak) and *Eucalyptus resinifera* subsp. *hemilampra* (red mahogany), *Livistona australis* (cabbage palm) and *Lophostemon suaveolens* (swamp turpentine).
d)	Other documentation	No recovery plan has been prepared for the SSFCF EEC.
e)	Assessment of adequacy of reservation	SSFCF EEC is poorly reserved and is known to occur in Ukerebagh Nature Reserve, Tuckean Nature Reserve, Tabbimoble Swamp Nature Reserve, Bongil Bongil National Park, Myall Lakes National Park, Hexham Swamp Nature Reserve and Bungawalbin National Park.
f)	Limit of known distribution	SSFCF EEC is limited to the coastal riverine floodplain of the NSW east coast from the Victorian to Queensland border.
2)	**Significance within a local context**	SSFCF EEC was once common throughout the locality particularly on the Williams River floodplain and associated wetlands. Remnant SSFCF EEC occurs within wetland 804 to the south of the subject site and along major streams on the floodplain. Remnant occurrences of this vegetation are now comparatively uncommon to rare within the locality.
3)	**Consideration of corridors**	The Wallaroo-Raymond Terrace regional corridor (Scotts, 2003) links Wallaroo National Park, Wallaroo State Forest, Grahamstown Dam and Tilligerry State Conservation Area and has been mapped as occurring across the study area and subject site. A more recent regional analysis of Koala habitat suitability (**Figure 4.75**) (Law et al 2017), a surrogate for broader habitat connectedness, validates the Scott (2003) corridor mapping. For this reason, areas of predicted high conservation value (key habitats) are found within the study area and subject site due to this corridor and proximity to nearby reserves include Wallaroo State Forest, Wallaroo National Park, Medowie State Conservation Area and Tilligerry State Conservation Area. The Proposal is not expected to interfere with the function of this regional corridor. Wildlife movements are expected to continue through appropriately dimensioned linkages as shown in **Figure 5.5**. Corridors within the subject site are to be retained along

DGR Matter		Comment
		drainage lines (and strengthen relative to approved zone boundaries), maintaining the north-south movement of this species. Corridor improvements over approved rezoned boundaries include increased width (i.e. ~57-209% increase) and decreased length (i.e. ~16-44%) with parts of these corridors having sufficient area to act as habitat for species such as the Koala and Squirrel Glider (i.e. area ~8-10 ha). These corridors are to be retained within a Conservation Area for ongoing protection. The proposed development will retain existing corridor linkages from Wallaroo National Park to Tilligerry State Conservation Area, as well as other areas of habitat within the study area. The Proposal is not likely to decrease the movement of individuals and gene flow between habitat areas throughout the locality or within or between local populations.
4)	**Discussion of Regional Significance**	Several fragmented occurrences of this EEC exist within the locality mainly within wetland 804.
5)	**Impacts on Threatened Species and/or Populations in National Parks Estate**	This proposal is considered unlikely to impact on any individuals of the SSFCF EEC in the National Park Estate, as the Proposal impacts have been locally managed through the protection of habitat and corridors within the subject site. These protections will maintain the potential for passage to and from locally occurring national park estate to the north.
6)	**Assessment of Habitat**	
d)	Description of habitat	SSFCF EEC within the subject site is in a poor condition. It is charactered by scattered trees within a largely cleared landscape, with ground cover stratum comprising a mix of native and exotic grasses and herbs commonly associated with grazed lands. Floristic diversity has been compromised by past land clearing and current livestock grazing. Fauna habitat is largely limited to values contained within the tree canopy (i.e. foliage and nectar supply).
e)	Disturbance history	SSFCF EEC has been predominantly cleared from the subject site as a consequence of historical clearing activities. Livestock grazing around wetlands 803 and 804 have had a negative impact on the recovery of remnant patches, with livestock grazing now removed from wetland 804. Vegetation patches are now small and various fragmented by historical land clearing with understorey characteristics modified by grazing.
f)	Extent of habitat removal	The Proposal will not remove vegetation constituting SSFCF EEC (i.e. PCT 1230). In executing the VPA, the Proposal will retain 0.15 ha of SSFCF EEC (i.e. PCT 783) within a Conservation Area of 244.25 ha total area. The Conservation Area is to be established during Phases 0 and 1 through implementation of the BMP (Appendix C) followed by ongoing protection through a fully funded in-perpetuity maintenance style management program.

6.3 Feasible Alternatives

DGR 6.5 Description of feasible alternatives

A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development (Section 110(3)(e)).

Where a Statement of Environmental Effects (SEE), Environmental Impact Statement (EIS) or Review of Environmental Factors (REF) deals with these matters, the SIS may refer to the relevant section of the SEE, EIS or REF.

The condition must include details of the condition and use of other parts of the subject area and why these can or cannot be considered as feasible alternatives.

There are two broad alternatives to the proposal:

- Do nothing; and
- Alternative development layout.

These are discussed below.

6.3.1 Do Nothing

See **Section 5.4.1**.

6.3.2 Zone Based Development Scenario

See **Section 5.4.2**.

7 AMELIORATIVE MEASURES

This chapter covers the following CERs:

DGR 7. AMELIORATIVE MEASURES

7.1 Description of Ameliorative Measures

DGR 7.1 Description of ameliorative measures

A full description and justification of the measures proposed to avoid or mitigate any adverse effect of the action on the species and populations and ecological communities including a compilation (in a single section of the statement) of those measures (Section 110 (2)(i) and Section 110 (3)(f)).

This section of the SIS has the objective of showing how the Proposal can deliver on the zone based land use expectations of the KHURA, as per the NSW State government rezoning approval in 2010, without having a significant impact on threatened species and ecological communities. Three principles have been used to demonstrate how this predicted outcome is to be achieved, as listed below:

1. Define an area suitable for the conservation of local biodiversity values[27] and apply the necessary establishment works required to retain these values over the long term (i.e. implementation of a Council approved BMP as provided in **Appendix C**);
2. Define an appropriate management regime that minimises the impact of the Proposal where the clearing of vegetation and habitat is involved (i.e. implementation of a Council approved VMP as provided in **Appendix D**); and
3. Provide security for the long term protection of local biodiversity values through the use of an appropriate conservation mechanism that provides in-perpetuity conservation inclusive of ongoing funded management regimes (i.e. VPA).

The KHURA was gazetted by the NSW State government in 2010 following an eight year rezoning process informed by extensive site and environmental assessments; relevantly, ecological and biodiversity assessments were performed by HWR (2004) acting for the landowners and EcoBiological (2009) acting for Port Stephens Council. The process rezoned uncontrolled Rural zoned land for a mix of urban zones to enable development (e.g. B2, B4 and R1) and environmental protection (i.e. E2) with the ultimate aim being a balance between development and biodiversity conservation.

Collectively, environmental monitoring and assessment of KHDs land has spanned a considerable period of time, being some 16 years of data collected between 2003 and 2019.

Biodiversity datasets obtained since 2010 for the KHD owned portion of the KHURA, as provided in this assessment, has allowed for an improved and contemporary understanding of biodiversity values and potential impacts arising from the gazetted land use zones. The biodiversity principle of ‘avoid, minimise and mitigate’ (a principle that did not exist at the time the land was rezoned in 2010) has been applied to further evaluate and refine the approach to development of the subject site.

Impact Avoidance

Impact avoidance is the most potent method for managing impacts on threatened species. This has been adopted in areas where there is potential for the Proposal to have a significant impact on threatened species and ecological communities and has resulted in certain areas of land zoned for urban purposes being excluded from the development footprint and earmarked for future conservation.

[27] Defined by the TSC Act as the composition, structure and function of ecosystems, and includes (but is not limited to) threatened species, populations and ecological communities, and their habitats.

Areas of high biodiversity values coincident with developable lands (i.e. B2, B4 and R1) have been mapped and, where practicable, incorporated into the Conservation Area as impact avoidance. A total of 38.47 ha or 12.9% of KHDs land zoned R1 is to be excluded from development and incorporated into conservation; an action consistent with the following EcoBiological (2009) recommendations:

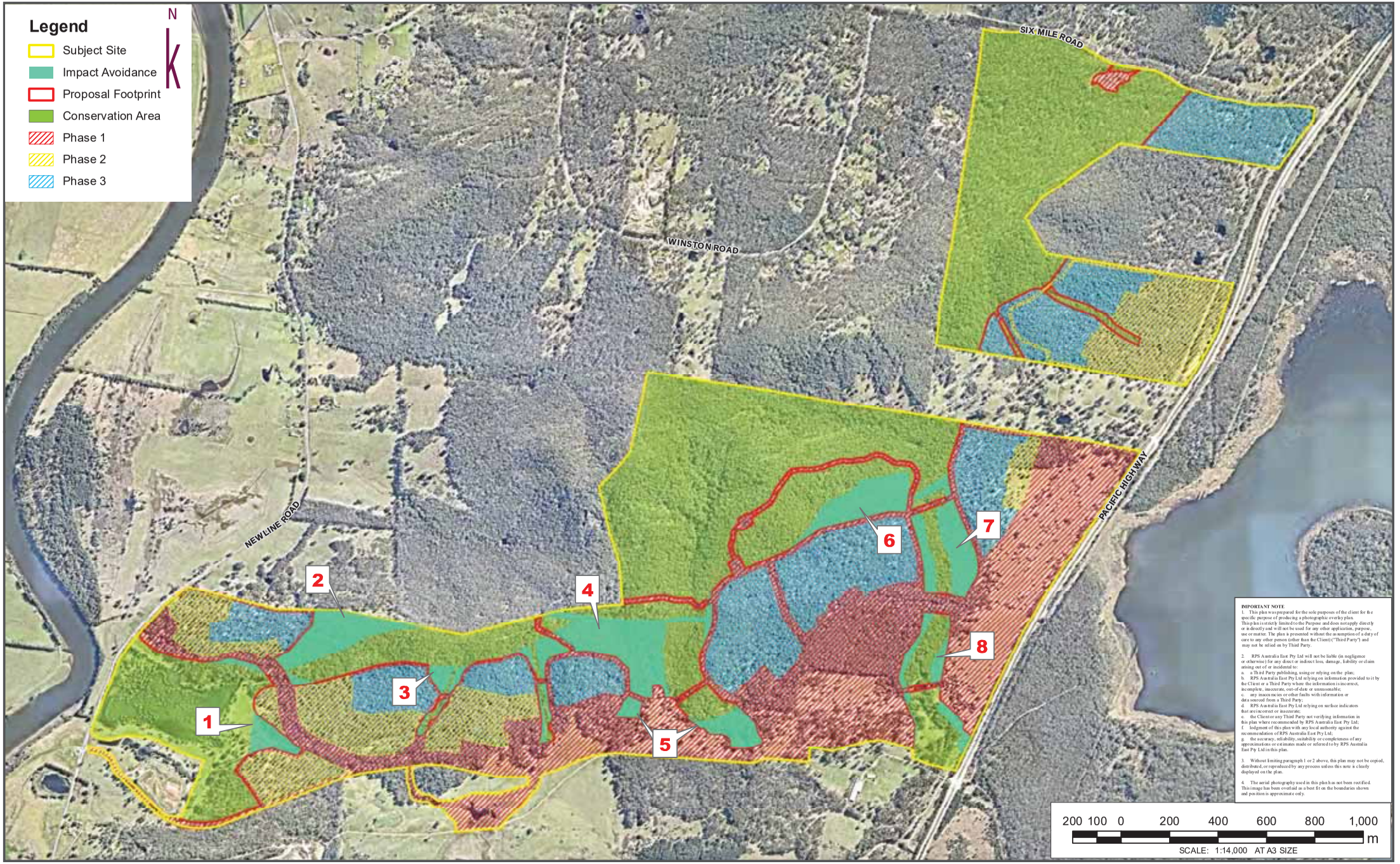
- Establish corridor zones of 100-150 m width (proposed corridor widths meet and exceed this specification). At least three corridors are proposed as recommended and are to be enhanced (enriched) with Koala-friendly vegetation;
- Retain additional preferred Koala habitat along the western ridge;
- Avoid as far as possible areas of high-value Brush-tailed Phascogale habitat and known Grey-crowned Babbler breeding areas; and
- Avoid the removal of Freshwater Wetland habitat within three key wetland locations.

Where impact avoidance is not necessary to respond to such impacts, impact minimisation and mitigation measures are adopted by the Proposal for the purposes of maintaining biodiversity values within the locality.

Impact avoidance areas are depicted in **Figure 7.1**, with the rationale for each proposed impact avoidance measure summarised in **Table 7.1**.

Table 7.1 Impact avoidance outcome relative to zone boundaries

Impact Avoidance	Rationale	Area Avoided (ha)
1	Substantially increase patch integrity by limiting edge to area ratio (i.e. reduce edge effects)	2.23
2	Avoid area with high foliage nutrient value for the Koala Avoid area with high hollow-bearing tree density Increase vegetated corridor width to wetland area	6.18
3	Avoid area with high foliage nutrient value for the Koala and area actively used by the Koala	1.31
4	Avoid area with high foliage nutrient value for the Koala and area actively used by the Koala including breeding female activity Substantially increase patch integrity by limiting edge to area ratio (i.e. reduce edge effects) Increase vegetated corridor width to vegetation situated south of the study area	11.40
5	Avoid area with high foliage nutrient value for the Koala and area actively used by the Koala	3.16
6	Avoid area with high foliage nutrient value for the Koala and area actively used by the Koala including breeding female activity Substantially increase patch integrity by limiting edge to area ratio (i.e. reduce edge effects) Avoid area with high hollow-bearing tree density Avoid the majority of habitat occupied by *Corybas* × *dowlingii*	5.36
7	Avoid area with high foliage nutrient value for the Koala and area actively used by the Koala including breeding female activity Substantially increase patch integrity by limiting edge to area ratio (i.e. reduce edge effects). Avoid area with high hollow-bearing tree density	6.11
8	Increase vegetated corridor width to vegetation situated south of the study area	2.72
Total		**38.47**



TITLE : FIGURE 7.1: CONSERVATION AREA INCLUDING AREAS OF IMPACT AVOIDANCE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **24/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (mark.aitkens)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.01 Conservation Area including areas of Impact Avoidance C A3 20200720.mxd

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A time sequenced approach to site preparation provides a framework for managing impact intensity (i.e. impact minimisation). The spatial and temporal partitioning of habitat loss has the purpose of minimising impact intensity on the Conservation Area by restricting early development stages to areas of lower biodiversity value.

In combination with the early implementation of impact mitigation, the Proposal will/ can minimise the nett impact on vegetation and habitat over time by minimising:

- Edge effects and habitat loss through the maintenance of patch integrity and connectivity;
- Disruption of species lifecycles by pre-emptively mitigating habitat loss; and
- Loss in corridor functionality at the local and regional scale by improving corridor widths.

Following completion of initial Conservation Area establishment works (i.e. impact mitigation works in Phase 0), the Proposal is to be implemented over three Phases, as shown in **Figures 5.2** to **5.4** and summarised in **Table 7.2**.

Table 7.2 Overview of Site Preparation Phases

Proposal Phases	Objective	Time (years)	Vegetation Change[28] (ha)
Phase 0: Pre-construction habitat restoration and enhancement works	• Enter a Planning Agreement to secure implementation of the following Phases • Commence BMP works to establish the Conservation Area (i.e. early implementation of amelioration measures) • Collect baseline dataset for monitoring program • Initiate research compensatory measure	-2 to 1	- 0.00 + 11.23 (Area A) + 3.27 (Area B)
Phase 1: Construction of main east – west road connecting the Pacific Highway interchange with Newline Road plus development of areas with reduced biodiversity value	• Minimise impacts on *Corybas × dowlingii* • Performance test the efficacy of amelioration measures for Phase 1 (monitoring) • Finalise establishment of Conservation Area by completing the BMP • Continue research compensatory measure • Deliver compensatory measures for the Koala, Brush-tailed Phascogale, Large Forest Owls, *Pterostylis chaetophora*, *Corybas × dowlingii* and *Maundia triglochinoides*	1 to 3	- 75.88 + 0.53 (Area A) + 1.81 (Area B) + 2.46 (Area C)
Phase 2: Selective construction of development areas with reduced biodiversity value	• Minimise impacts on *Corybas × dowlingii* • Finalise arrangements for the in-perpetuity conservation of the Conservation Area • Performance test the efficacy of amelioration measures • Conclude research compensatory measure	>3 to 8	- 48.71
Phase 3: Construction of residual approved development areas	• Maintain mitigation measures and monitoring program • Performance test the efficacy of amelioration measures	>8 +	- 87.55

[28] Native vegetation gain relates to the revegetation of lands currently void of a tree canopy

The Proposal's effect on native vegetation cover by Phase (i.e. loss or retention) is provided in **Table 7.3**.

Table 7.3 Effect of Proposal on PCTs

PCT	Existing Condition[29]	Impact Area (ha)	Conservation Area (ha)
Phase 1 (1-3 years)			
783 Coastal freshwater swamps of the Sydney Basin Bioregion	moderate good high	-	9.21
1525 Sandpaper Fig - Whalebone Tree warm temperate rainforest	moderate good high	-	2.42
1230 Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	moderate good poor	-	0.15
1584 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	moderate good high	17.67	101.51
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good high	47.56	108.83
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good medium	-	2.15
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good poor	5.50	0.38
1600 Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter	moderate good medium	5.16	1.05
1728 Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast	moderate good poor	-	5.49
Sub Total		**75.88**	**231.19[30]**
Phase 2 (>3-8 years)			
1584 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	moderate good high	10.51	-
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good high	38.20	-
Sub Total		**48.71**	
Phase 3 (>8 + years)			
1584 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	moderate good high	19.76	-
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	moderate good high	67.79	-
Sub Total		**87.55**	
Total		**212.14**	**231.19**

The biodiversity values of the Conservation Area, inclusive of the impact avoidance areas, provides a long term local conservation outcome by protecting threatened species habitat for the Koala, Brush-tailed Phascogale, Squirrel Glider, Large Forest Owls, *Pterostylis chaetophora*, *Corybas* × *dowlingii* and *Maundia triglochinoides*. Arrangements for the protection of biodiversity values for these and other native species are specified in the Voluntary Planning Agreement, which includes Conservation Area establishment (i.e. BMP; Appendix C) followed by the provision of a conservation mechanism for the in-perpetuity conservation and management of these values (See **Section 7.1.1.6**).

[29] Refer to definitions in OEH (2014)

[30] 19.30 ha of proposed revegetation works are additional yielding a conservation area of at least 250.49 ha

Impact Mitigation - Expected Ecological Benefit

Combined, the Phased site preparation works and impact avoidance strategy provides a framework that will minimise impact intensity on sensitive biodiversity values; thereby minimising the magnitude of both direct and indirect impacts associated with the listed key threatening process (KTP) 'land clearing' and corelated KTPs. The key principles that underpin this strategy are:

- Avoid impact amplification through indiscriminate habitat removal (see **Figures 5.2** to **5.4**);
- Progressively remove vegetation and habitat using sensitive time, method and area based prescriptions to permit ongoing ecosystem functioning (**Section 7.1.1.3** and **Appendix D**);
- Maintain the functionality of vegetated corridors (i.e. width and value) as shown in **Figure 7.2**;
- Increase residual patch size (i.e. revegetation works);
- Reduce edge to area ratios (i.e. managing edge effects on residual vegetation); and
- Minimising short, medium and long term impacts on sensitive biodiversity through managed retention and protection in the Conservation Area (e.g. hollow dependent species and specialist folivores).

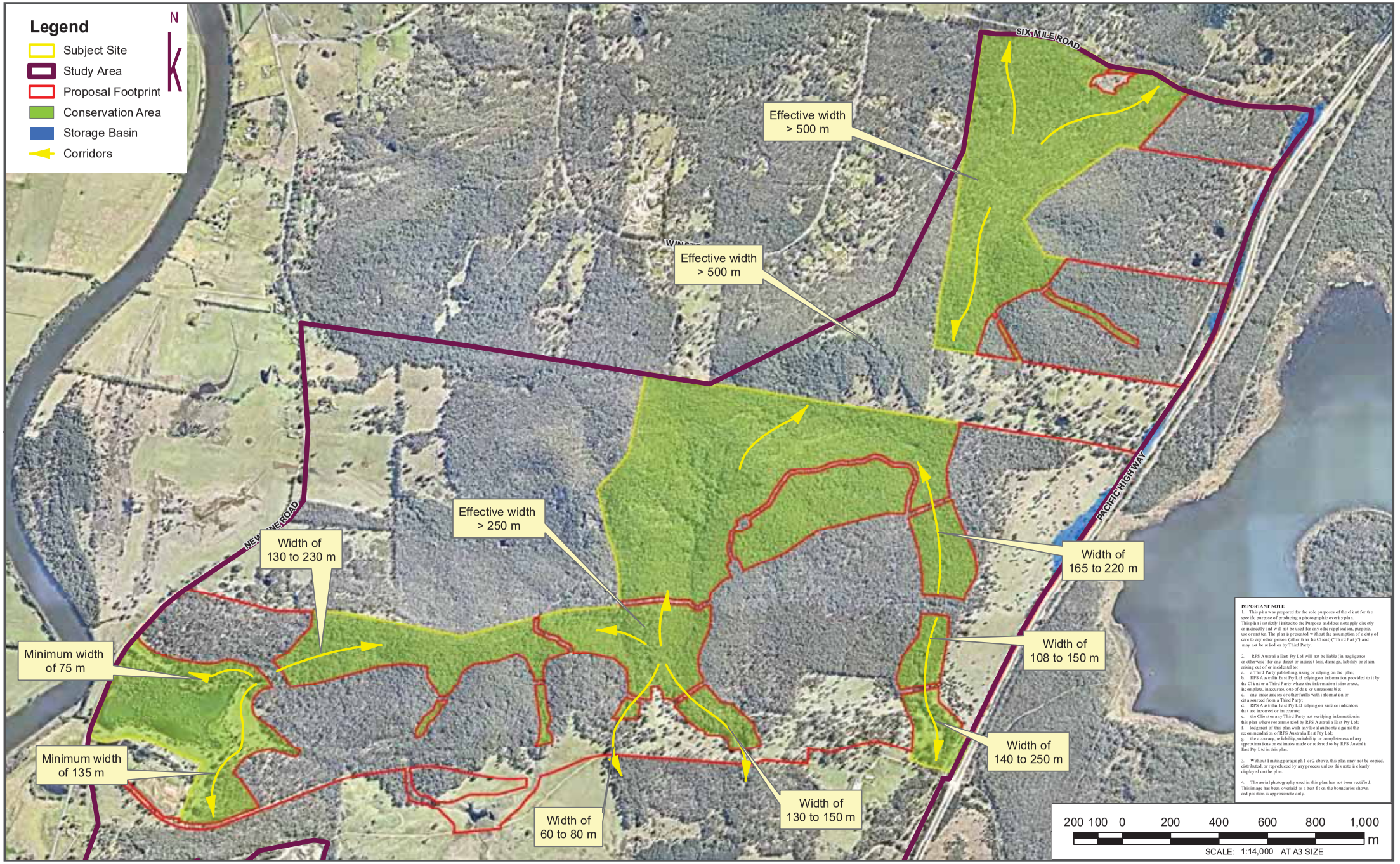
In order of focus, the amelioration strategy aims to manage impacts on the following key species:

- Koala (e.g. A long lived species with low recruitment rates sensitive to loss of habitat, corridors and amplification of key threatening process but receptive to translocation and/or habitat replacement);
- *Corybas* × *dowlingii* (e.g. receptive to benefits obtained from habitat management);
- Grey-headed Flying Fox [e.g. sensitive to habitat loss during bottleneck feeding periods but response to revegetation works comprising high value nectar trees (OEH 2016b)];
- Brush-tailed Phascogale and Squirrel Glider (e.g. species with moderate recruitment rates albeit sensitive to loss of habitat, corridor function and amplification of key threatening process but r receptive to benefits obtained from habitat management);
- *Pterostylis chaetophora* and *Maundia triglochinoides* (e.g. provide local protections from herbivory and weed management); and
- Mobile hollow-dependent species with large habitat area requirements (i.e. Large Forest Owls, Glossy-black Cockatoo, Little Lorikeet, Varied Sittella, Brown Treecreeper).

Revegetation areas identified in **Figure 7.3** (Area A), **Figure 7.4** (Area B) and **Figure 7.5** (Area C) have the specific purpose of delivering long term benefit for the Koala and nectivorous species such as the Grey-headed Flying Fox, Squirrel Glider, Little Lorikeet, Regent Honeyeater and Swift Parrot by planting tree species with known high value foraging values. The total area subject to revegetation works is 19.30 ha and is further outlined in **Table 7.4**.

Table 7.4 Revegetation Works by Area

Area	Revegetation works	Main Benefit
A (Phase 0)	Planting of Swamp Mahogany (*Eucalyptus robusta*) in suitable areas (4.57 ha) Planting of high nutrient value Forest Redgum and Tallowwood in residual areas (7.18 ha)	Winter forage for Grey-headed Flying Fox Spring forage for Grey-headed Flying Fox High value forage for Koala
B (Phase 0)	Planting of Swamp Mahogany (*Eucalyptus robusta*) in suitable areas (1.83 ha) Planting of high nutrient value Forest Redgum, Grey Gum and Tallowwood in residual areas (3.27 ha)	Winter forage for Grey-headed Flying Fox Spring forage for Grey-headed Flying Fox High value forage for Koala
C (Phase 1)	Planting of Swamp Mahogany (*Eucalyptus robusta*) in suitable areas (2.45 ha)	Winter forage for Grey-headed Flying Fox



TITLE : FIGURE 7.2: RETAINED VEGETATED CORRIDORS

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.02 Retained Vegetated Corridors D A3 20200720.mxd

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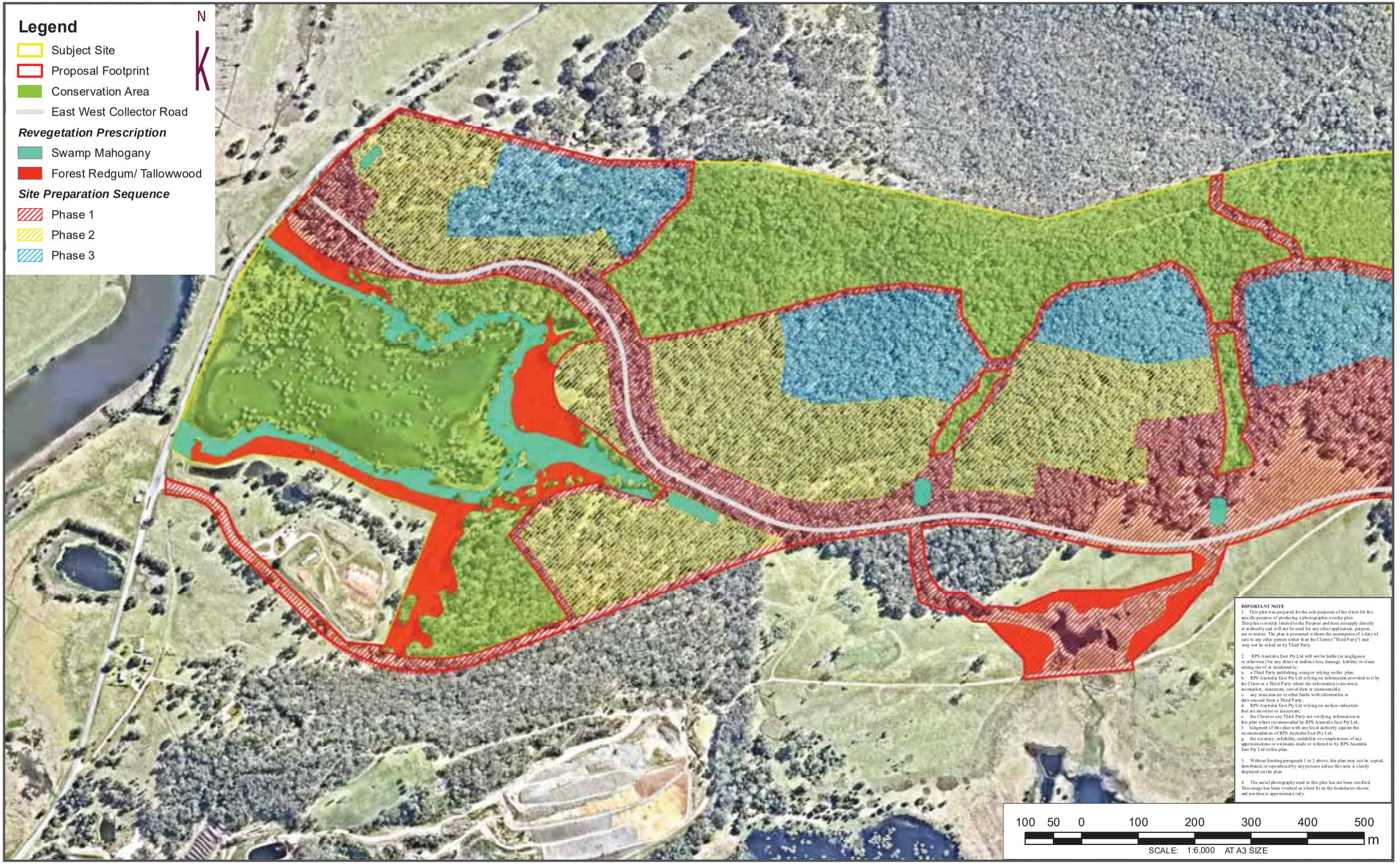

TITLE : FIGURE 7.3: REVEGETATION AREA A

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **23/07/2020**

PURPOSE: **ECOLOGY**

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PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.03 Revegetation Area A D A3 20200720.mxd

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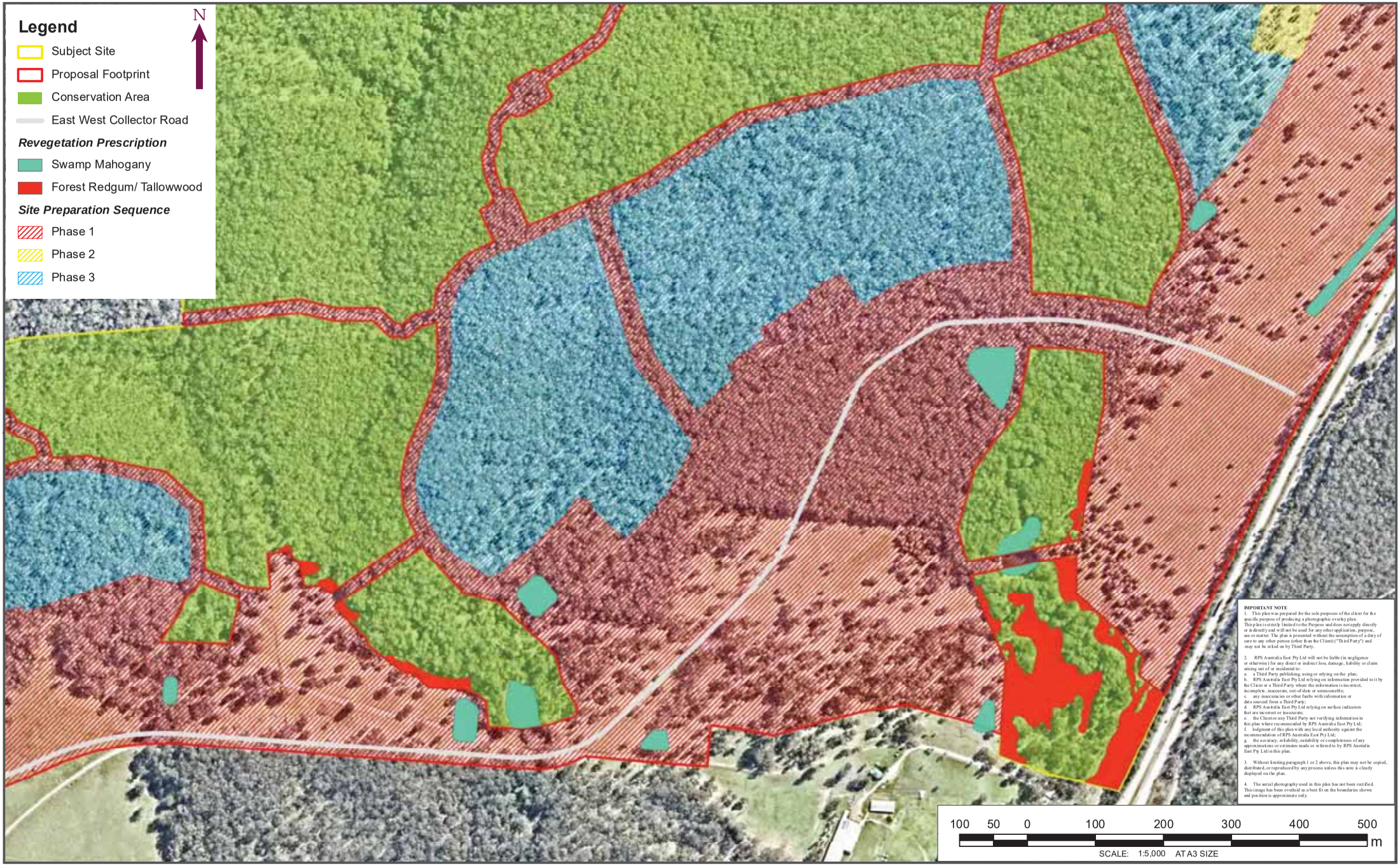

TITLE : FIGURE 7.4: REVEGETATION AREA B

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

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PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.04 Revegetation Area B D A3 20200720.mxd

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TITLE : FIGURE 7.5: REVEGETATION AREA C

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.05 Revegetation Area C D A3 20200720.mxd

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The area designated for PKFT plantings, as shown in **Figure 7.6**, has the purpose of strategically improving (enriching) browse quality for the Koala in certain parts of the Conservation Area at the forest stand scale to increase foliage nutrient levels (i.e. digestible nitrogen) particularly in areas of relatively low value. Other expected benefits include:

- Increased availability of nectar producing plants for the benefit of nectivores such as the Grey-headed Flying Fox;
- Supplement the natural regeneration response in weed management areas; and
- Improve vegetation structure to address adverse historical/ ongoing impacts from feral herbivores and logging/ land clearing.

Plantings will include species such as Forest Redgum, Grey Gum, Grey Box and Tallowwood will also benefit large forest owls such as the Powerful Owl by enriching habitat conditions for important prey species such as the Brush-tailed Possum.

Other Ameliorative Measures

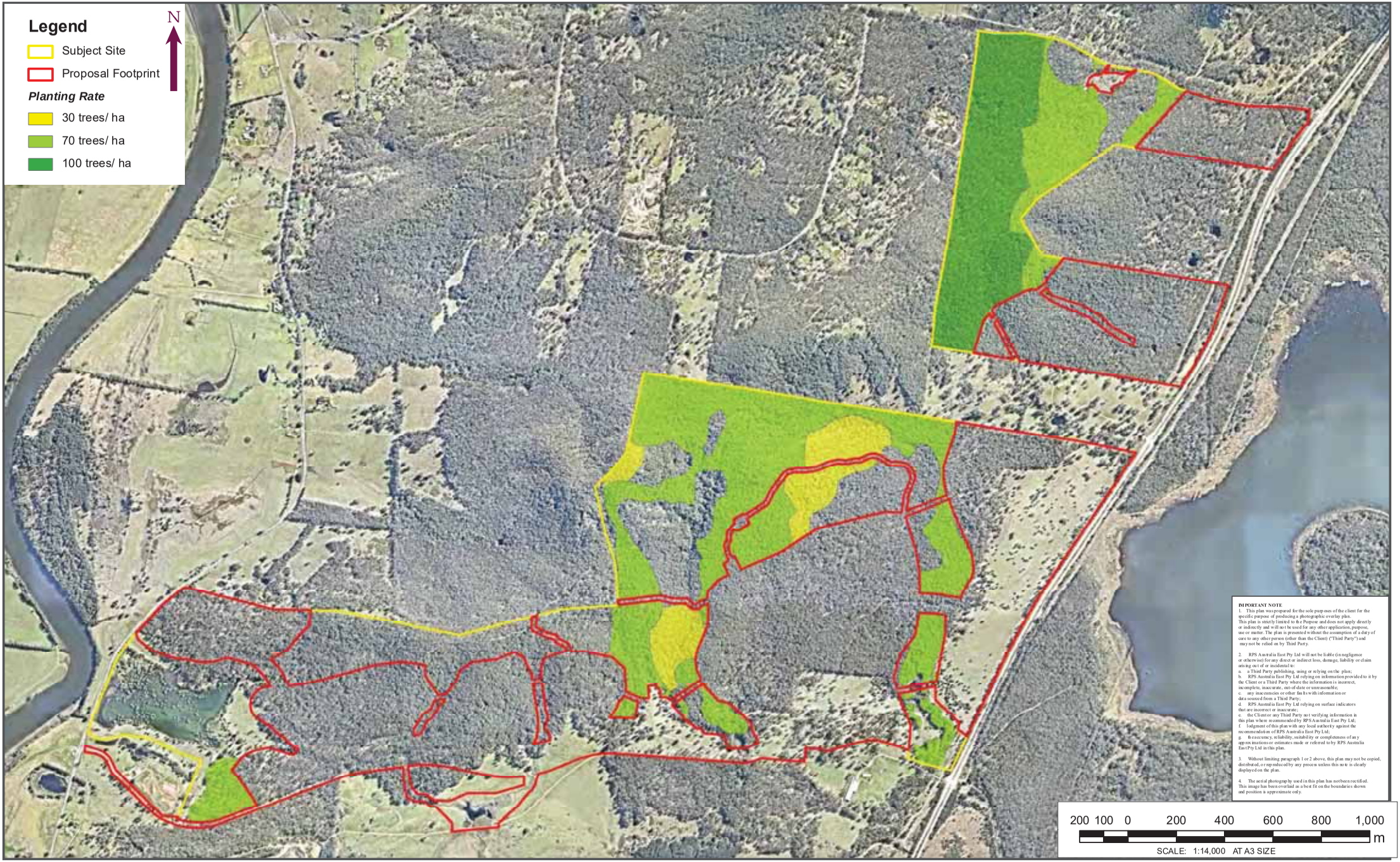
Other important amelioration measures to be implemented as part of the Proposal, as detailed in the BMP (**Appendix C**), are listed below:

- Habitat enhancement (i.e. installation of hollows and emplacement of fallen logs);
- Weed management (e.g. removal of Lantana and African Olive);
- Feral animal control (e.g. wild dogs, feral cats and deer);
- Bush fire threat management (e.g. implementation of indigenous fire practices);
- Fencing of the Conservation Area to:
  - Prevent the movement of Koalas into the urban area and domesticated dogs into the Conservation Area;
  - Curb and deter illegal and uncontrolled activities (e.g. illegal dumping, timber getting, hunting);
  - Manage existing rural activities that impact on native plants and weed dispersal (e.g. grazing by cattle, horses, goats);
- Habitat protection for threatened species; and
- Implementation of an in-perpetuity conservation mechanism through a Voluntary Planning Agreement (VPA) to locally protect and manage threatened species and their habitat.

These amelioration measures are to be delivered through the execution of the VPA, which includes implementation of the BMP (**Appendix C**) for the Conservation Area. The BMP describes the timing, locations, methods and responsibilities for management activities. Monitoring specifications are also be defined in the BMP. The VPA is also responsible for the delivery of an in-perpetuity conservation mechanism to provide protection and ongoing management for the biodiversity values contained within the Conservation Area following establishment.

Affected Species Benefiting from Ameliorative Measures

The impact avoidance and ameliorative measures overviewed above and detailed in the proceeding section (**Section 7.1.1**) have the purpose of minimising the Proposal's impacts on affected threatened species, as far as is practicable and to an extent that limits any reliance on compensatory measures. Affected species assessed in this SIS are listed in **Table 7.5** together with proposed amelioration measures and their relevance to each species. A 'before' and 'after' analysis for each affected species is also provided to illustrate the likely benefit of these measures.



TITLE : FIGURE 7.6: PKFT PLANTINGS WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.06 Tree Canopy Nutrient Enrichment of the Conservation Area D A3 20200720.mxd

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Table 7.5 Likely Effect of Amelioration Measures on Subject Species

Subject Species	Impact Avoidance	Phased Preparation	Revegetation	Habitat Enhancement	Habitat Enrichment	Weed Management	Feral Animal Management	Habitat Protection	Conservation Mechanism	Real Chance or Possibility of a Significant Impact?	
										Before Amelioration (maximum)	After Amelioration (residual)
Red Helmet Orchid	✓	✓				✓	✓		✓	High	Low
Small Water-ribbons		✓				✓	✓		✓	Moderate	Low
Pterostylis chaetophora						✓	✓	✓	✓	Low	Low
Glossy-black Cockatoo				✓		✓	✓		✓	Low	Low
Brown Treecreeper	✓	✓		✓					✓	Moderate	Low
Varied Sittella	✓	✓		✓					✓	Moderate	Low
Little Lorikeet	✓	✓	✓	✓					✓	Moderate	Low
White-bellied Sea Eagle	✓								✓	Moderate	Low
Grey-crowned Babbler						✓			✓	Moderate	Low
Powerful Owl	✓	✓	✓	✓	✓				✓	Moderate	Low
Masked Owl	✓	✓	✓	✓	✓	✓			✓	Moderate	Low
Regent Honeyeater	✓		✓						✓	Low	Low
Swift Parrot	✓		✓						✓	Low	Low
Koala	✓	✓	✓		✓	✓	✓	✓	✓	High	Low
Brush-tailed Phascogale	✓	✓		✓					✓	Moderate	Low
Spotted-tailed Quoll	✓	✓		✓					✓	Moderate	Low
Grey-headed Flying Fox	✓	✓	✓	✓	✓				✓	Moderate	Low
Eastern Freetail-bat	✓	✓	✓	✓					✓	Moderate	Low
Eastern Bentwing-bat			✓						✓	Low	Low
Little Bentwing-bat			✓						✓	Low	Low
Eastern False Pipistrelle	✓	✓	✓	✓					✓	Low	Low
Greater Broad-nosed Bat	✓	✓	✓	✓					✓	Moderate	Low

Greater detail on the scope and rationale of ameliorative measures is provided in **Section 7.1.1**.

Compensatory Measures

Compensatory measures may be used in circumstances where affected species are identified as having the potential for a significant residual impact after the consideration of all other feasible and reasonable attempts at preventing or reducing impacts. The use of compensatory measures should be evidence based and:

- Measurable;
- Targeted;
- Local (where possible); and
- Pre-emptive.

While compensatory measures are not considered necessary (i.e. the Proposal, inclusive of the amelioration measures specified in this document, is not likely to have a significant impact on affected species), compensatory measures are proposed to further safeguard and strengthen the protection of local habitat for threatened species notably the Koala, Brush-tailed Phascogale, Large Forest Owls, *Corybas* × *dowlingii, Pterostylis chaetophora, Maundia triglochinoides* and Lower Hunter Spotted Gum Ironbark Forest EEC. Managed habitat protection is to be delivered through the execution of the VPA, which will secure the

protection of local biodiversity values in-perpetuity and will support the protection of ecological benefit obtained from the amelioration measures. Further discussion of this compensatory measure is outlined in **Section 7.1.2**.

7.1.1 Long term management strategies

DGR 7.1.1 Long term management strategies

Long term management strategies are outlined in **Section 7.1** and include habitat enhancement (i.e. emplacement of nest boxes, fallen logs and revegetation using PKFTs), tree canopy nutrient enrichment using PKFTs, weed management and feral animal control. These long-term management actions are established within the Conservation Area through the successful implementation of the BMP (**Appendix C**), which prescribes the measures, locations, timing and responsibilities of implementation. Longer term management will be performed in accordance with outcomes derived from the VPA. The following sections provide greater detail on the scope and rationale for prescribed ameliorative measures for managing impacts on threatened species included expected ecological benefit.

7.1.1.1 Habitat Enhancement

Habitat enhancement works, as specified in the BMP (**Appendix C**), are to be initiated prior to site preparation works (i.e. Phase 0). The primary purpose of these works is to pre-emptively respond to impacts anticipated through Phases 2 and 3 (i.e. 3 years +) where incremental habitat loss is scheduled. Habitat enhancement works detailed in **Table 7.6** are to be initiated and maintained for the duration of site preparation works under Phase 1, with the aim of delivering tangible ecological benefit prior to impacts occurring in Phases 2 and 3.

Table 7.6 Habitat Enhancement: Purpose and Time to Ecological Benefit

Treatment	Purpose	Time to Ecological Benefit
Revegetation of existing retained treeless lands	• Increase the extent of habitat suitability for the canopy folivores[31] • Increase the extent of winter – spring flowering eucalypts for nectar dependant species[32]	7+ years (Kavanagh and Stanton 2012)
Hollow and fallen log installation	• Mitigate hollow-bearing tree loss observed mainly during Phases 2 and 3 • Preferentially use natural hollows and hollows created from logs salvaged from the Proposal impact footprint • Preferentially use hollow types that benefit sensitive threatened species such as Brush-tailed Phascogale	Unknown but estimated to be at least 3+ years

7.1.1.1.1 Revegetation

Revegetation works, as specified in the BMP (**Appendix C**), are proposed for currently treeless or heavily degraded parts of the Conservation Area as shown in **Figures 7.3**, **7.4** and **7.5**. Dense plantings of Swamp Mahogany (*Eucalyptus robusta*), Forest Redgum (*Eucalyptus tereticornis*), Tallowwood (*Eucalyptus microcorys*), Grey Box (*Eucalyptus moluccana*) and Grey Gum (*Eucalyptus punctata*) are recommended as they are all classed as preferred high value koala feed tree species and are likely to provide long term ecological benefit for the Koala (BioLink 2019b; Kavanagh and Stanton 2012), Grey-headed Flying Fox (nectar production) and Large Forest Owls (indirectly) through increased habitat occupancy by preferred prey species such as the Brush-tailed Possum.

[31] Note: Koala and Brush-tailed Possum, with the latter being an important prey species for threatened Large Forest Owls

[32] Note: Addresses winter nectar bottleneck and supplements spring nectar availability for Grey-headed Flying Fox

The revegetation prescription is to generally follow the principles outlined in *Silvicultural guidelines: Private Native Forestry Code of Practice* (DECC 2007), bearing in mind that the key revegetation objective is the rapid establishment of a tree canopy for foliage biomass production. This approach also reflects prescriptions that predicate the predicted minimum seven year timeframe to ecological benefit as observed by Kavanagh and Stanton (2012). Important revegetation prescription parameters are listed below:

- Preferential use of direct seeding in treeless areas to encourage natural species patterns;
- Planting rate of 1,100 stems per hectare (forestry tubes) where direct seeding is less suitable;
- Preferential use of Swamp Mahogany in landscapes supportive of 'Swamp Sclerophyll Forests';
- Preferential use of Forest Redgum and Tallowwood in areas directly adjoining/ fringing 'Swamp Sclerophyll Forests';
- Preferential use of Forest Redgum, Tallowwood and Grey Gum in drier terrestrial areas;
- Use of local provenance seed from trees with high measured foliage nutrient value and low PSMs levels (Ford and Youngentob 2019);
- Use appropriate establishment and management measures to maximise revegetation success; and
- Use of appropriately timed thinning practices to maintain high biomass production in the tree crown (i.e. preventing adverse impacts from conspecific competition).

Revegetation works are expected to generate high value habitat for the Koala and Grey-headed Flying Fox (19.30 ha). Supplementary benefits for Large Forest Owls are also expected where revegetation works benefit the Koala (i.e. high nutrient value foliage will also improve habitat values for preferred Powerful Owl prey species such as Brush-tailed Possum).

7.1.1.1.2 Hollow and Fallen Log Installation

The installation of hollows and co-location of fallen logs within the Conservation Area, as specified in the BMP (**Appendix C**), is to be performed in a targeted manner so as to complement/ enhance this area for hollow-dependent species. Enhancement proposed is to include a diverse array of habitat structures such as those listed below:

- Nest boxes constructed from standard building materials;
- Repurposing of hollows harvested from the Proposal impact footprint; and
- Habitat creation from logs harvested from the Proposal (see **Plate 7.1** for an example of this practice).

Plate 7.1 Example of Created Hollows [taken from Greater Sydney LLS (2015)]

Hollow placement and type are to preferentially bias Brush-tailed Phascogale habitat enhancement in the areas shown in **Figure 7.7**. These areas are characterised by low densities of natural hollow-bearing trees and presence of trees with > 80cm dbh; a factor positively correlated with Brush-tailed Phascogale nesting activity (van der Ree et al 2006). Size of hollow entrance will be constructed to allow entrance of the small Brush-tailed Phascogale but to prevent entry of larger non-target species that may compete for the resource.

Fallen log emplacements should ideally be co-located with hollow installations. Guidance on prescriptions for log emplacements are provided below:

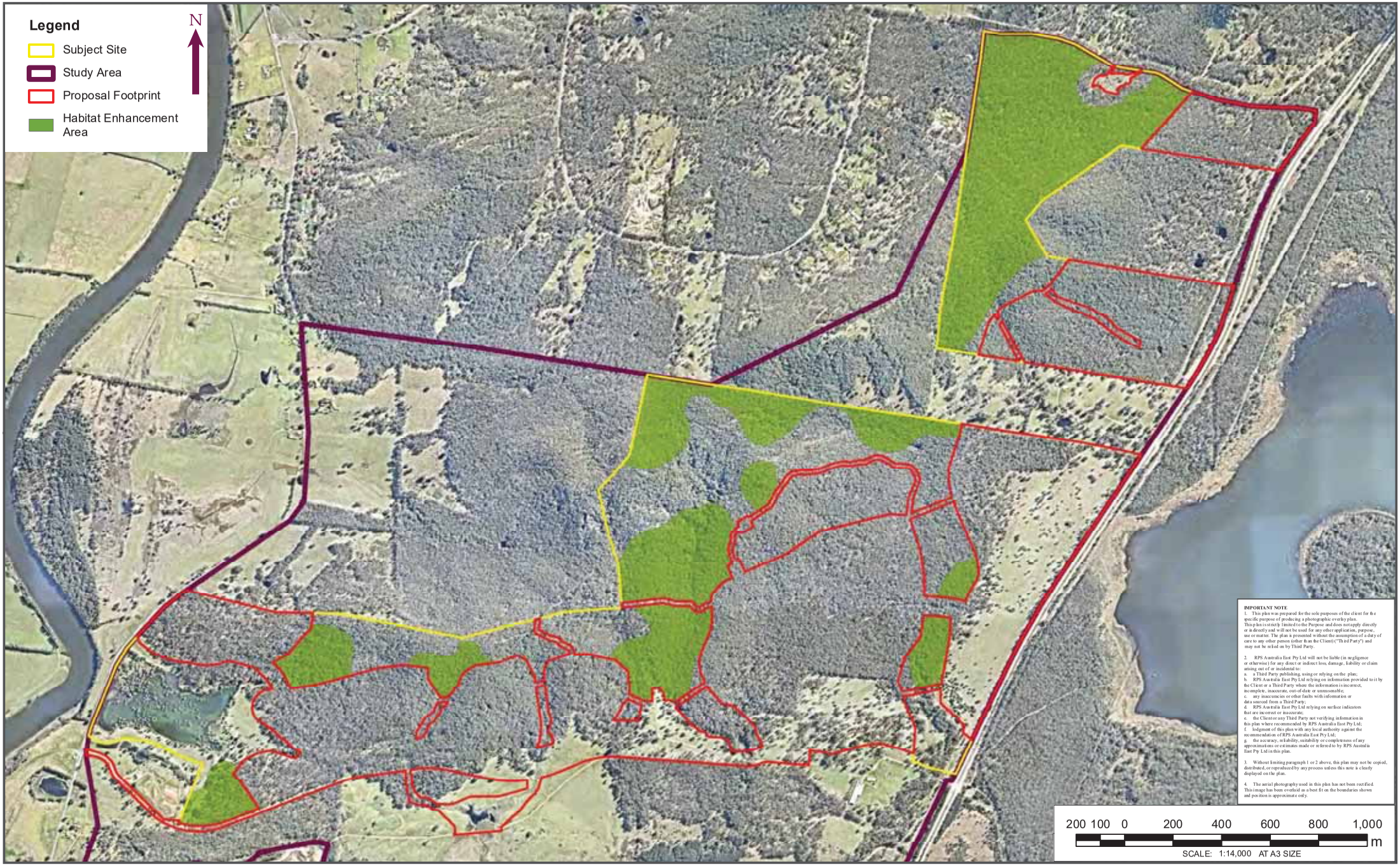
- Have greater than 20 cm dbh and at least 5 m length;
- Where possible, have hollow centres for additional habitat complexity; and
- Supplement existing fallen log lengths to an extent exceeding relevant PCT benchmarks.

The benefit of this habitat enhancement for biodiversity is illustrated in **Plate 7.2**, which shows usage of an existing fallen log within the study area by the Grey-crowned Babbler.

Plate 7.2 Example of Fallen Log use by Threatened Fauna (i.e. Grey-crowned Babbler)

This log feature was also used by eight different mammal/ bird species as indicated in **Plate 7.3**.

Plate 7.3 Example of Fallen Log use by Nocturnal Mammals (i.e. *Antechinus* sp.)



TITLE : FIGURE 7.7: HABITAT ENHANCEMENT OF THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.07 Habitat Enhancement of the Conservation Area D A3 20200720.mxd

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7.1.1.2 Tree Canopy Nutrient Enrichment

Measured eucalypt foliar chemistry for the subject site (Marsh and Youngentob 2019) was extrapolated through modelling at the forest stand scale to estimate the current forage quality across the Conservation Area. As outlined in Section **4.4.15**, digestible nitrogen was mapped using three classifications (i.e. >1.0%, 0.9-1.0% and <0.9% digestible nitrogen) to provide insight on Koala habitat suitability. Areas of relatively unsuitable Koala habitat, as shown by vegetation comprising <0.9% digestible nitrogen, represent opportunity for achieving meaningful mitigation outcomes by locally improving habitat through enrichment plantings.

Intra-forest enrichment plantings are to target areas with lower digestible nitrogen levels to maximise the effect of this mitigation while minimising any broader impacts on the environment. Enrichment plantings will only include high value koala feed tree species known to occur within the vegetation types of the targeted enrichment area, with the selection of genetic material for propagation being local provenance seed obtained from preferred Koala feed tree species with known (measured) high digestible nitrogen. Through empirical measurement, Marsh and Youngentob (2019) have identified Forest Red Gum, Grey Gum and Tallowwood as reliably having the highest foliar digestible nitrogen and some of the lowest PSMs, with Grey Box also considered a useful species given its relatively high nutritional value and resilience in drier conditions.

The potential benefit of the proposed nutrient enrichment program was modelled by Professor Robert Clark of the Australian National University using a nearest neighbour tree dataset (n=187) and the mean digestible nitrogen values database established for the subject site (Marsh and Youngentob 2019). The model, as shown in **Figure 7.8**, represents the basis for selecting the optimal enrichment model for this mitigation.

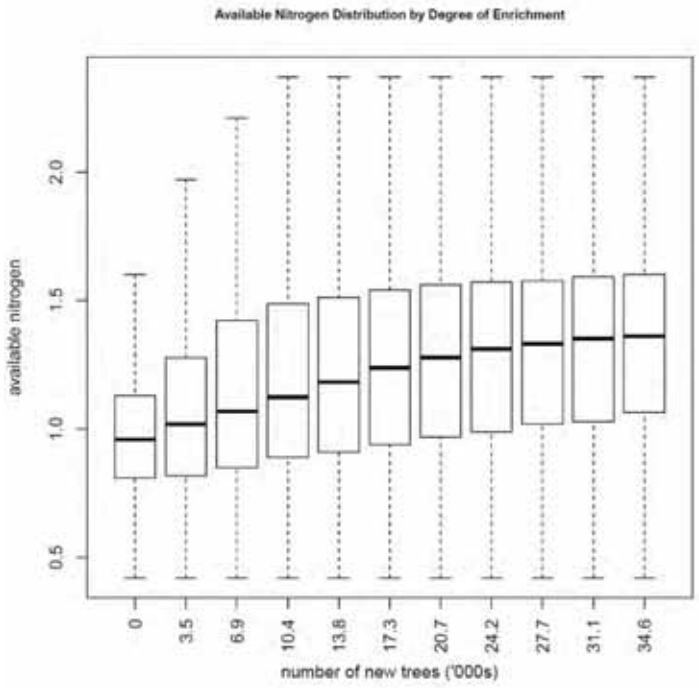


Figure 7.8 Available Nitrogen Distribution by Degree of Enrichment

An enrichment planting program involving the use of 10,400 trees was selected as the optimum mitigation scenario for the area shown in **Figure 7.6**. This scenario was selected following the consideration of the plant community types, the current and natural tree densities associated with these areas and patch/ connectivity values within this area. This enrichment prescription aims to provide a local improvement in Koala habitat and other species proximal to areas of already high value habitat. Further, it is expected that these enrichment works will also improve the foraging value of the forest stand for more common folivores such as the Brush-tailed Possum, thereby providing beneficial outcomes for species such as Large Forest Owls (e.g. Powerful Owl).

7.1.1.2.1 Prescription

Intra-forest enrichment plantings have the purpose of increasing foliar nutrient value across the Conservation Area where required. The application of nutrient enrichment works is proposed for the area shown in **Figure 7.6** and comprises approximately 143 ha.

Conceptualised, it is estimated that a modest enrichment program involving intra-forest plantings of approximately 10,400[33] high nutrient value trees and/ or tending[34] of existing preferred Koala feed trees provides an optimal prescription that balances effect with other factors (i.e. cost and impact on receiving environment). The prescription would use species compatible with the relevant PCTs occurring within the management area (i.e. Tallowwood, Forest Redgum, Grey Box and Grey Gum). **Table 7.7** outlines the proposed treatments, their purpose and expected time to ecological benefit.

Table 7.7 Tree Canopy Nutrient Enrichment: Treatments, Purpose and Time to Ecological Benefit

Enrichment Treatment	Purpose	Time to Ecological Benefit
'Tending' of insitu recruiting preferred Koala feed tree species in areas of low digestible nitrogen using stand thinning (gap creation) and selective removal of recruiting tree species with low digestible nitrogen values	• Enrich habitat suitability for canopy folivores[31] • Locally increase fallen log length from thinned tree species • Minimise disruption to existing ecological function	7+ years (Kavanagh and Stanton 2012)
Direct seeding using propagules with known high digestible nitrogen combined with mosaic fire burns to accelerate natural regeneration	• Enrich habitat suitability for canopy folivores[31] with minimal impact on stem densities • Minimise disruption to existing ecological function	Unknown but estimated to be at least 7+ years (Kavanagh and Stanton 2012)
Intra forest tree plantings using forestry tubes propagated from trees with known high digestible nitrogen and low PSMs in areas with low predicted digestible nitrogen and/ or weed management areas	• Hasten forest structure regeneration following weed management • Enrich habitat suitability for canopy folivores[31] with high value digestible nitrogen propagules	Unknown but estimated to be at least 7+ years (Kavanagh and Stanton 2012)

On average, the proposed enrichment treatments would not alter stem densities by more than a mean of 70 stems per hectare. Compared to mean stem density across the whole site (i.e. 180 stems/ ha ± 150), this would represent an increase to ~250 stems/ ha; a stem density remaining substantially below that reported for comparable forests (i.e. 516 ± 135 stems/ ha; Kerle 2005). These intra-forest plantings for the 143 ha management area are considered to be at the lower end of any such prescription and are not likely to cause detrimental impacts to the broader ecological values of this area (EcoLogical 2020; **Appendix L**). However, to further minimise the likelihood for any detriment impacts, it is proposed to manage enrichment prescriptions involving tree plantings broadly as follows:

- Preferentially apply plantings to primary weed management areas (e.g. lands occupied by medium to high lantana infestation). Such infestations have already suppressed canopy regeneration and, in this respect, supplementary plantings would represent an appropriate co-management activity.
- Cap supplementary plantings to a combined limit of 380 stems/ ha (i.e. sum of existing and planted trees); a level that does not exceed the lower range of observed stem densities for Hunter Macleay dry sclerophyll forests (Kerle 2005).

[33] See Figure 7.11 for effect of 10,400 tree plantings for the proposed planting area shown in Figure 7.9

[34] 'Tending' to mean the selective nurturing or encouraged growth of a naturally occurring recruiting tree involving mechanical interventions such as forest thinning and canopy pruning

7.1.1.2.2 Predicted Benefit

The predicted effect of enrichment plantings is shown in **Figure 7.9** with expected 'nett change' shown in **Figure 7.10**. This mitigation is estimated to provide an average 5-10% increase in available foliage nitrogen across the management area (**Figure 7.6**), with the predicted benefit showing substantial localised benefit in Koala habitat value and connectivity. Assuming early implementation, the realisation of this benefit is expected to occur within 7-20 years of implementation (i.e. during Phase 3) (Kavanagh and Stanton 2012).

In the absence of enrichment plantings, BioLink (2019a) estimate an average koala density of 0.048 ± 0.04 (SE) per hectare, which is well within the Marsh and Youngentob (2019) average carrying capacity estimate of 0.5 to 0.75 animals per hectare. These differences suggest ample capacity for an increase in koala densities within the Conservation Area. Assuming, on average, that the enrichment plantings lift digestible nitrogen by 5-10% for the management area, and this translates into ecological benefit for the koala, then it is likely that the BioLink (2019a) koala density estimate is likely to rise accordingly.

A substantial increase in Koala activity is expected throughout the 143 ha management area, as the targeted plantings specifically aim to raise the importance of the current marginal habitat value to levels that would sustain higher densities. As shown in **Figure 7.6**, the prescriptions proposed vary across the management area, as the objective of this work is to broadly uplift digestible nitrogen levels from existing conditions to levels above 1.0%. Therefore, these prescriptions aim to provide spatially variable outcomes with the sum of all ecological benefit contributing to a broad generation of moderate to high value habitat.

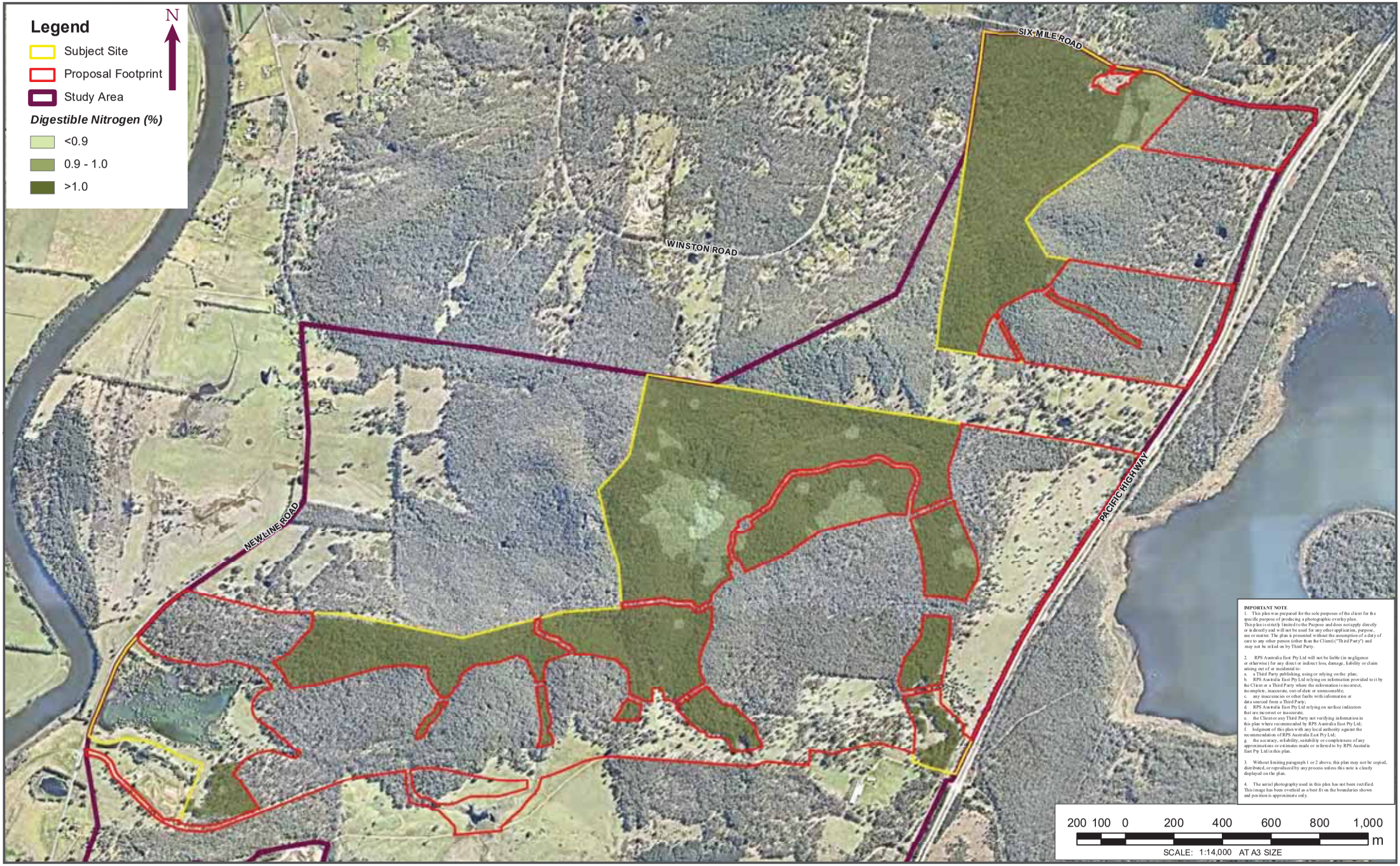
Enrichment plantings are predicted to elevate the Marsh and Youngentob (2019) carrying capacity for this part of the Conservation Area by ~0.1 individuals per hectare. While this ecological benefit is not expected to directly translate into an additional habitat area that may be occupied by 14 koala individuals (i.e. 143 ha management area multiplied by the corresponding increase in carrying capacity), it is reasonable to conclude that the benefit will be substantive (i.e. planting of 10,400 trees is likely to have a measurable effect). The ecological benefit arising from the targeted mitigation works is likely to translate into an enriched habitat zone that may be used by at least an additional five koalas although a higher occupancy rate may eventuate following achievement of maximum effect. Further, at this spatial scale the habitat enrichment works are unlikely to have any unintended impacts that may otherwise arise in higher density koala populations (e.g. negative congener interactions commonly observed in higher density populations).

7.1.1.2.3 Timing

As for habitat enhancement, the initiation of foliar nutrient value enrichment in the Conservation Area is also proposed prior to site preparation works (i.e. Phase 0). The primary aim of these works is to pre-emptively respond to future impacts anticipated in Phases 2 and 3 (i.e. 3 years +). Based on published data a benefit to the Koala population could be expected to be seen in approximately 7 years from commencement of Phase 0 (Kavanagh and Stanton 2012).

7.1.1.2.4 Impacts

The proposed enrichment prescriptions will have the effect of modifying parts of the Conservation Area for the benefit of the Koala. By subtly changing plant species composition t prescriptions may modify the forest and result in unintended impacts on other species. However, as discussed in **Section 5.1.1**, it is considered that these impacts are either neutral or beneficial for affected species and vegetation in general. Therefore, it is considered that this mitigation measure is not likely to have a measurable deleterious impact on the vegetation and habitat of the Conservation Area.



TITLE : FIGURE 7.9: PREDICTED TREE CANOPY NUTRIENT ENRICHMENT OUTCOME

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.09 Predicted Tree Canopy Nutrient Enrichment Outcome D A3 20200720.mxd

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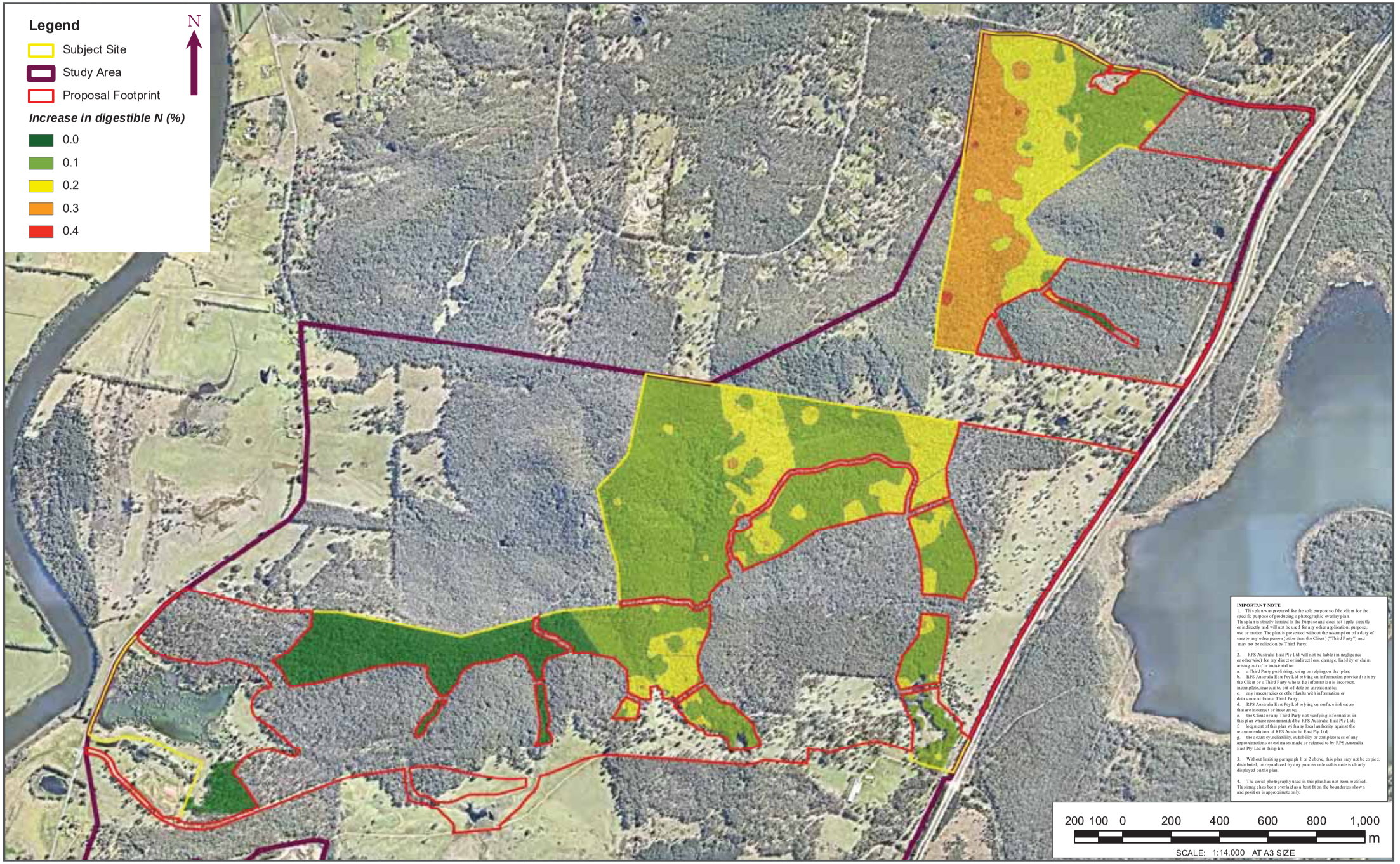

TITLE : FIGURE 7.10: PREDICTED NETT CHANGE IN TREE CANOPY NUTRIENT VALUE

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **20/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): D A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.10 Predicted Nett change in Tree Canopy Nutrient Value D A3 20200720.mxd

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7.1.1.3 Vegetation Clearing Procedure

A clearing procedure that considers the spatial and temporal impacts on affected species is proposed to minimise impact by allowing for readjustments to occur in habitat occupancy. Three steps have been defined in order to deliver a clearing outcome sensitive to the habitat needs of affect species. These are outlined below:

- Step 1: Targeted removal of exotic species where a duty under Section 21 of the *Biosecurity Act* 2015 is required. Species with a biosecurity duty are to be eliminated and/ or minimised to an extent that is consistent with prescribed control measures. Such activities apply to the whole subject site (i.e. both Proposal and Conservation Area) with notable species with a biosecurity duty including:
  - African Olive (*Olea europaea* subsp. *cuspidata**);
  - Lantana (*Lantana camara**);
  - Ground Asparagus (*Asparagus aethiopicus**);
  - Blackberry (*Rubus fruticosus** species *aggregate*);
  - Alligator Weed (*Alternanthera philoxeroides**); and
  - Water Hyacinth (*Eichhornia crassipes**).
- Step 2: Partial vegetation removal where the purpose of this intermediate step is to:
  - Gradually establish areas proposed for future urban purposes (impact areas), to:
    - Provide adequate time for offset vegetation and other impact mitigation measures to be established in (or at the interface with (e.g. fencing)) the Conservation Area; and
    - Minimise impact intensity on native flora and fauna in lieu of a future complete clearing event (i.e. minimise the temporal impacts of habitat loss by providing opportunity for displaced fauna to gradually relocate to improved habitat in adjoining Conservation Area).
  - Provide an opportunity for the recovery of habitat resources for use in mitigation works performed within the Conservation Area (i.e. recover logs, bushrock, and natural hollows); and
  - Provide separation between the bushfire threat and development through the construction of bushfire Asset Protection Zones (APZ) for all staged clearing and development as outlined in Section 3.2.1 “Staged Development” of Planning for Bushfire Protection 2019.

  The prescription for partial vegetation removal is to meet the following specifications:
  - Maintenance of all retained vegetation to an APZ standard to ensure radiant heat exposure < 29kW/m^2 towards residential development and < 10kW/m^2 towards Special Fire Protection Purpose Developments;
  - Retention of Preferred Koala Feed Trees (PKFT) with a diameter at breast height (dbh) of 300 mm or more; and
  - Retention of hollow-bearing trees and/or other tree species deemed suitable by an arborist and bushfire consultant for inclusion in urban landscapes to enhance visual amenity and provide foraging and roosting habitat for species adapted to urban landscapes.

  The partially cleared state is, at all times, required to demonstrate sufficient landform stability (e.g. negligible evidence of erosion) to maintain satisfactory water quality standards at the catchment scale.
- Step 3: Complete native and exotic vegetation removal with the exception of trees deemed suitable by an arborist and bushfire consultant for inclusion in urban landscape, subject to compatibility with engineered structures. Consideration should be given to the integration of suitable tree species into the urban landscape. Soil and erosion management procedures are to be applied in this step to ensure satisfactory water quality standards at the catchment scale, with specific details of these management

specifications to be provided in the approved subdivision works certificate for the corresponding construction activities. Manage harm to fauna through observance of preclearance surveys and clearing supervision.

To avoid doubt, Step 3 in any Phase can only occur to the extent that consent is granted for development within that Phase, thereby preventing indiscriminate clearing. This requires the satisfactory competition of Steps 1 and 2, each having the purpose of minimising impacts over time on affected species. Notwithstanding, Step 1 can occur at any time in any Phase where consistent with regulated biosecurity obligations. To ensure impact minimisation, Step 2 of Phase 2 cannot proceed until Step 3 of Phase 1 is completed for all areas contained within Phase 1 (i.e. a process facilitating the movement of fauna into adjoining vegetation). Similarly, Step 2 of Phase 3 cannot proceed until Step 3 of Phase 2 is completed.

A detailed specification for each of these steps is provided in **Section 3** of the VMP (**Appendix D**). Pre-clearance and clearing supervision to minimise harm on fauna in Step 3 is described in Appendix A of the VMP (**Appendix D**) and BMP (**Appendix C**).

7.1.1.4 Weed Management

7.1.1.4.1 Overview

Weeds generally have life cycles that facilitate their own spread in various ways (i.e. faster germination, crowding out of other species, higher numbers of propagules, more efficient propagule dispersal). Weeds also threaten native plant species through competition for limited resources. Sunlight, nutrient, water and space availability are limited, and an extensive presence of weeds is detrimental to native species. This can change vegetation community composition and lead to ecological issues involving poor soil quality, erosion and sedimentation, decline in fauna foraging and nesting habitats and the extinction of native flora species. KTPs are listed under the TSC Act applicable to the study area are listed below:

- Invasion, establishment and spread of *Lantana camara*; and
- Invasion of native plant communities by exotic perennial grasses and the African Olive; and
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants (e.g. Water Hyacinth).

Presently, these weeds occur within the study area. Distributions patterns indicate an occupancy preference for lands with poor accessibility for non-native herbivores such as feral deer and cattle (i.e. not controlled by herbivory). Conversely, highly accessible lands allow for grazing pressures to suppress weed occurrence.

Other notable noxious weeds that occur within the study area and are classed as WoNS are listed below:

- Blackberry (*Rubus fruticosus**);
- Water Hyacinth (*Eichhornia crassipes**);
- Alligator Weed (*Alternanthera philoxeroides**);
- Asparagus fern (*Asparagus aethiopicus**); and
- Fireweed (*Senecio madagascariensis**).

A comprehensive weed management framework is provided in the BMP for the Conservation Area (**Appendix C**) and VMP for the site preparation area (**Appendix D**).

7.1.1.4.2 Treatment and timing

The removal of all weeds from the Conservation Area is the desired outcome; however, there are limitations regarding the extent to which this can be achieved. A realistic approach involves controlling and suppressing weed species, thus providing a better opportunity for native flora to germinate, grow and establish

dominance. Priority will be given to weed species listed in **Section 7.1.1.3.1**. Specific treatment and timing requirements are provided in the BMP for the Conservation Area.

Herbicide is considered appropriate for larger weed species and areas of large infestation containing few natives. The application of herbicides for weeding purposes should only be applied by qualified personnel, and should be kept to a minimum. Particular caution will be used when applying herbicides around waterways and environmentally sensitive areas, particularly aquatic environments to ensure chemicals do not contaminate waterways or sensitive habitats. Where chemical usage is unavoidable environmentally friendly herbicides will be utilised.

In sensitive environments such as heavily forested areas, threatened ecological communities and in sparse weed infestations manual removal of herbaceous weeds, regrowth and seedlings is the preferred method of weed management. If intensive weeding is required, the soil should be stabilised or planted out with native seedlings by the end of each working day. Fire may also be used to assist in the initial suppression of weeds by removing vegetative cover and improving access to follow-up treatment applications.

Weed removal works will be undertaken outside the seed period of the target weeds, particularly weeds which produce large qualities of seed. Generally, the most effective time for undertaking weed management activates is during spring when majority of weed species are undertaking new growth and flowering. Where weeding must be undertaken within seeding periods, seed will be collected, bagged and destroyed offsite, ensuring that no seed remains on site.

Follow up weed removal must be undertaken at regular intervals to reduce recolonization of weeds from the seed bank.

7.1.1.4.3 Performance target

Ongoing suppression is the most pragmatic framework for managing weeds within the Conservation Area. A performance target of <5% total weed cover is proposed and is to be evaluated at the hectare scale. Measurement would consist of five randomly placed 50 m transects per hectare to measure percent cover using the point intercept method, with intercept measures obtained every 1 m along the transect. A mean percent cover would be calculated and reported. Monitoring and reporting requirements and performance targets are outlined in the BMP.

Table 7.8 Weed Management Performance targets and Response

Performance Target	Measure (% cover)	Management Response
Within target	<5%	• No management response • Continue monitoring activities
Approaching target	5-10%	• Perform targeted secondary weed management practices • Investigate to identify possible causation for weed increases and refine management practices to match need • Monitor effectiveness of suppression activities in addition to normal monitoring works
Outside acceptable weed cover	>10%	• Map weed occurrences and intensity as baseline • Perform targeted primary and widespread secondary weed management practices • Investigate to identify possible causation for weed increases and refine management practices to match need • Monitor effectiveness of suppression activities in addition to normal monitoring works. Consider revisions to monitoring design to reflect any change in weed distributions and/ or density

7.1.1.5 Feral Fauna Management

7.1.1.5.1 Overview

Introduced species pose direct and indirect threats to native fauna either through predation or competition. Pests such as the feral European rabbit (*Oryctolagus cuniculus*) and fallow deer (*Dama dama*) pose severe threats towards native flora through herbivory and fauna habitat (i.e. simplification of vegetation structure). The latter threat is considered particularly important to the management of the Koala within the Conservation Area as reduced/ simplified vegetation structure may increase the risk of predation by wild dogs and Dingo.

Pest species such as the European fox (*Vulpes vulpes*), Wild dog (excluding Dingo) and feral cat (*Felis catus*) pose a predation threat to native fauna species, particularly small mammals and reptiles. Their management is important for maintaining current fauna populations and encouraging recolonisation into rehabilitated areas.

The framework for managing feral fauna within the Conservation Area is detailed below and in **Appendix C**.

7.1.1.5.2 Treatment and timing

To control feral species, several management techniques must be employed over an extended period of time. Typical management actions that will be implemented for pest species within the Conservation Area include, but are not limited to:

- Inspections by a qualified ecologist to detect pest species diversity and abundance on site;
- Sightings of pest species to be notified to the designated land manager;
- Coordinated culling of feral deer in associated with Local Land Services;
- Baiting using canid pest injectors to control European fox and wild dog;
- Destruction of rabbit warrens;
- Trapping and removal program for feral cats;
- Maintaining a clean, rubbish free environment as to not attract feral species scavenging; and
- Restriction of domestic species from the Conservation Area.

Site-specific management measures for feral and pest species control are to be detailed in the Conservation Area BMP (**Appendix C**).

7.1.1.5.3 Performance Targets

The performance targets for high threat feral animals within the Conservation Area are outlined in **Table 7.9.**

Table 7.9 Feral Animal Management

Target Species	Performance Management	Management Objectives
Wild Dog	Zero abundance (excludes Dingo)	Eradication (excludes Dingo) during Phases 0 and 1 and maintained in-perpetuity
Feral Deer	Zero abundance	Eradication during Phase 0 and maintained in-perpetuity (important outcome as this species has the capacity to adversely impact the effectiveness of habitat enrichment works)
Feral Cat	Very low abundance	Continued suppression using contemporary measures

7.1.1.5.4 Inspections and reporting

Ongoing monitoring for each site will include recording the extent and location of pest species occurrence, the type of species found and their approximate density. This information will inform the particular actions required to manage pests and protect threatened flora and ecological communities.

7.1.1.6 Habitat Protection

7.1.1.6.1 Overview

Habitat protection measures are required for a range of threatened species particularly the Koala and threatened flora. The following sections outline the measures proposed for these matters.

7.1.1.6.2 Fauna Fencing

The interface between the Proposal and Conservation Area is to be characterised by a Koala proof fence with 'furniture' specifications for culverts' and Koala bridges and grids, which all have the purpose of:

- Excluding free ranging Koala's from the urban area to prevent mortality from domestic dog attack and vehicle strike;
- Excluding domestic dogs from the Conservation Area to prevent mortality from domestic dog attack and enable wild dog management; and
- Aiding the efficient movement of Koalas within/ through the Conservation Area along designated habitat corridors.

While good arguments exist for enabling the free movement of Koalas through friendly perimeter fencing (i.e. allow unlimited movement into the urban precinct to access remnant foraging resource), it is considered that the threats posed by domesticated dog attack, motor vehicle strike and drowning in swimming pools collectively represent serious unmanageable threats outweighing the small benefit. It is for this reason that such fencing is not proposed in this circumstance and that a hard barrier between the development and known koala habitat is recommended.

The fence is to be readily visible from the perimeter roadside environment (i.e. to minimise the incidence of vandalism and loss of primary function) and constructed in a manner so as to allow access for recreational uses (e.g. bush walking) and biodiversity management (e.g. implementation of ecological burns and management of edge effects). Access for recreation and land management activities such as bush fire management works is to be facilitated by an internal track and regular access points, with the track width enabling the free movement for the efficient implementation of management actions (e.g. fence maintenance and weed management). Fencing will also protect the Conservation Area from undesirable activities (such as illegal dumping, 4wd and motorbike activities, logging) and from existing rural activities (grazing by cattle, horse and goats).

Pictorial details showing Koala bridge and grid designs are provided in **Figures 7.11** and **7.12** respectively. These have the purpose of preventing Koala movements into the urban environment where KTPs may result in harm or mortality. The furniture used in culverts to aid Koala movements is shown in **Figure 7.13**, which has the purposes of facilitating Koala movement beneath roads to and from habitat areas. The proposed Koala fence is shown in **Figure 7.14**.

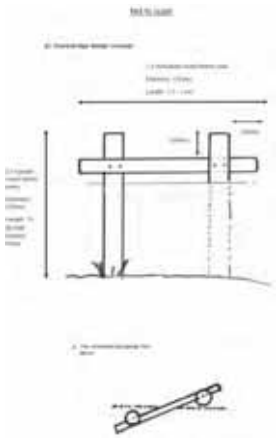


Figure 7.11 Koala bridge

Figure 7.12 Koala grid

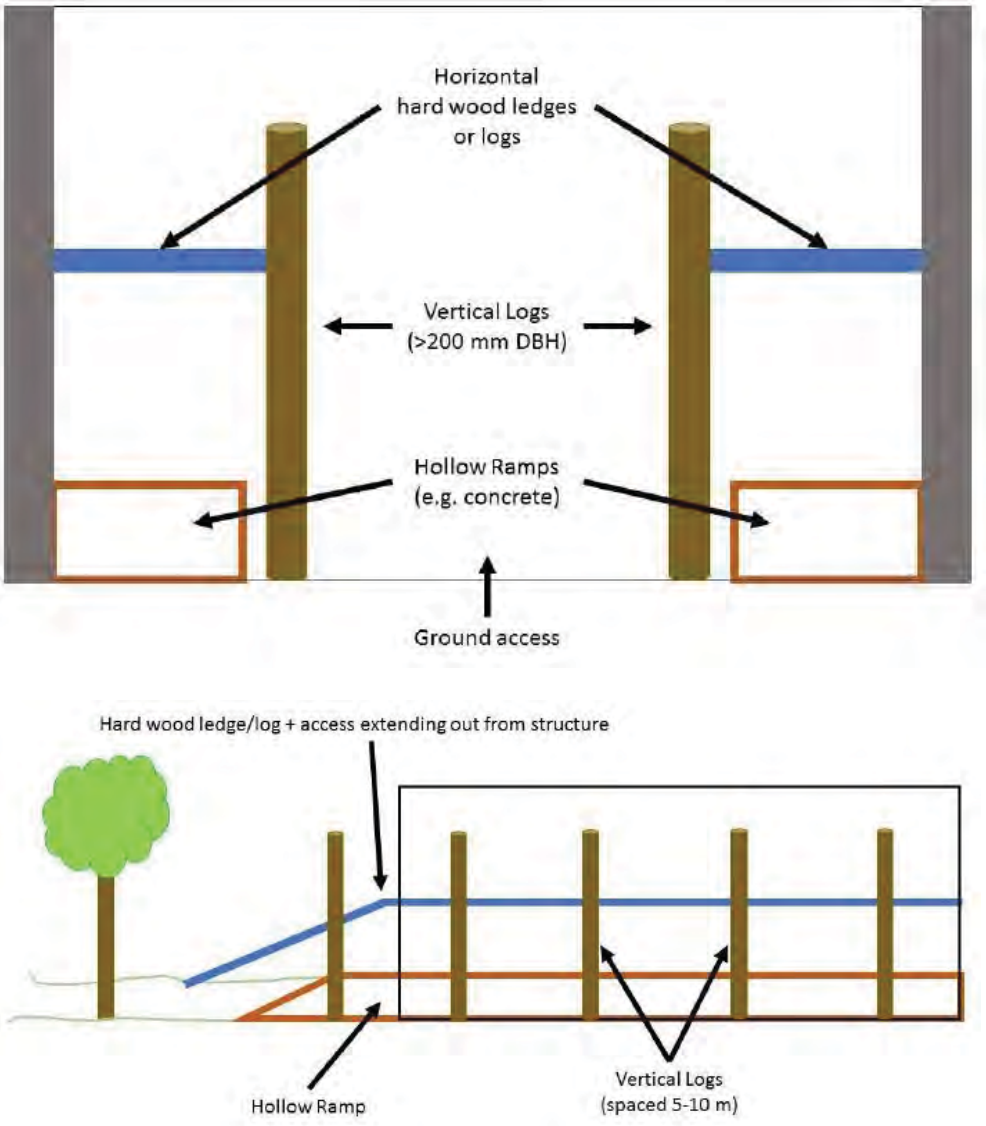
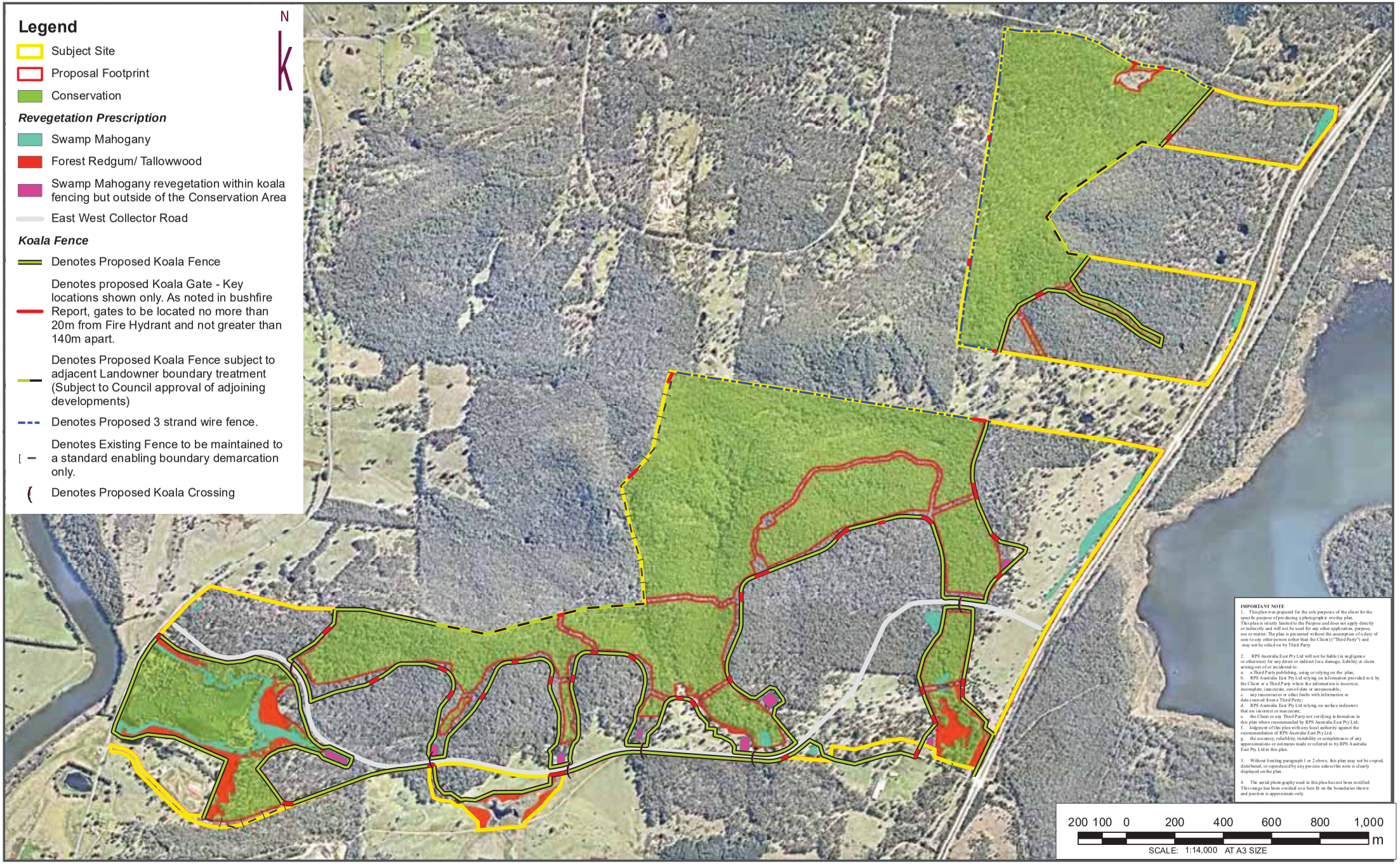


Figure 7.13 Culvert Furniture for Koala Road Underpasses



TITLE : FIGURE 7.14: PROPOSED KOALA FENCE AND CROSSINGS

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (mark.aitkens)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.14 Proposed Koala Fence and Crossings C A3 20200720.mxd

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JOB REF: **PR130430**

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7.1.1.6.3 Threatened Flora

Pterostylis chaetophora

The Proposal would result in the removal of three patches of the threatened orchid *Pterostylis chaetophora* comprising ~ 20 plants and retention of ~470 plants within the Conservation Area. Plants retained in the Conservation Area will be initially managed and monitored in accordance with a BMP for the establishment period following by ongoing in-perpetuity protection and management under an appropriate conservation mechanism.

Aside from the loss of known habitat, *Pterostylis chaetophora* also faces the risk of localised extinction from non-Proposal related (existing) impacts (e.g. herbivory by exotic species such as feral deer). In recognition of the Proposal's impact and the risk from exotic species herbivory, it is proposed to establish exclusion fencing around retained *Pterostylis chaetophora* individuals in addition to pest management (**Section 7.1.1.4**) to minimise the potential for decline of this species within the study area.

The herbivory exclusion fencing is to be established with a minimum 30 m radius from known locations of *Pterostylis chaetophora*, to not only allow protection of known individuals but to also provide protected habitat for future recruitment. Opportunity for integrating the sub-population occurring within the Conservation Area into the Saving Our Species regional monitoring program will be explored.

Corybas × dowlingii

The Proposal would result in the removal of part of a large patch of *Corybas × dowlingii* comprising ~ 118 plants and retention of ~1,467 plants within the Conservation Area. Plants retained in the Conservation Area will be initially managed and monitored in accordance with a BMP for the establishment period following by ongoing in-perpetuity protection and management under an appropriate conservation mechanism. The feasibility of a successful outcome is rated as high as the proposed management and conservation measures for this species at this location are superior to those at the Stoney Ridge Reserve located at Soldiers Point, which comprises a large persisting population.

Maundia triglochinoides

The Koala fence as outlined in **Section 7.1.1.6.2** will preclude access to the Conservation Area where this species occurs. Plants located within their habitat will be protected from unintended impacts.

7.1.1.7 Construction Phase Mitigation Measures

7.1.1.7.1 Direct Impacts on Vegetation

The Proposal describes a vegetation clearing procedure for proposed development areas outside of the Conservation Area, as outlined in **Section 7.1.1.3**, with the mechanics of implementing this procedure described in the VMP (**Appendix D**). It is the purpose of this procedure to minimise the effect of habitat loss on resident fauna through a progressive and sensitive vegetation removal. Vegetation with lower values are to be removed first (i.e. trees and shrubs that are not identified as important for species such as the Koala, nectar dependent species such as the Grey-headed Flying Fox and Squirrel Glider and or hollow dependent species such as the Brush-tailed Phascogale). Progressive clearing over time is designed to allow for the reconfiguration of individual home ranges as conditions change over time.

7.1.1.7.2 Direct Impacts on Resident Fauna

Pre-construction measures such as pre-clearance fauna surveys to check for any nesting or roosting fauna and move them to adjacent habitat will be required due to the presence of habitat features suitable for native fauna within the subject site. This will be performed in accordance with a Council approved Vegetation Management Plan (VMP) prepared in accordance with Council relevant development control plan, as provided in **Appendix D**. The VMP is to have regard for initiatives and requirements specified in the Council approved BMP for the Conservation Area, as provided in **Appendix C**.

7.1.1.7.3 Mitigation of Impacts on Water Quality and Quantity

The BMT WBM Guidelines on water management prepared for the Kings Hill Urban Release Area (BMT WBM Pty Ltd 2014) advocate the use of sensitive stormwater treatment devices including swales, constructed wetlands, infiltration basins, media filters and permeable paving, depending on the treatment scale. These devices were investigated as part of the Proposal design process, however many were not integrated for a number of reasons:

- In general, slopes within the Proposal impact footprint are generally too steep to accommodate road side swales. Further consideration is expected for the feasibility of swales during the more detailed design processes;
- Soil properties do not lend themselves to infiltration, especially concentrated at locations immediately downstream of roadways and other infrastructure; and
- It is the preference of the NSW Department of Industry - Water to have water quality treatment devices offline which reduces the potential for constructed wetlands to be incorporated as part of the development.

Bio-filtration basins in combination with Gross Pollutant Traps (GPTs) are considered the most efficient and economical treatment devices for the Kings Hill development at a precinct scale. Rain water tanks at a lot scale have also been included as the first step in the treatment train. A typical basin is shown in **Plate 7.4** below.

Plate 7.4 Photograph of Water Retention Basin (Waterbydesign)

Bio-filtration has been considered downstream of the GPTs for a number of reasons:

- They can be placed offline therefore satisfying the requirements outlined by DI – Water;
- They have minimal standing water within the basin, typically emptied shortly following precipitation events, therefore reducing environments that are susceptible to pest species such as mosquitoes and algae;
- They are typically used as an end of line treatment device and are therefore ideal for the proposed development due to steep grades in upstream reaches of the development;
- They have a greater treatment efficiency per square metre when compared to wetlands and are therefore highly effective at removing suspended solids, nutrients and gross pollutants from stormwater;

- They have the ability to satisfy both water quality and quantity requirements for the development due to retention capacity within the basins; and
- They can be aesthetically pleasing if properly designed with the potential to be easily integrated into the development masterplan within parks and surrounding residential zones.

Bio-filtration basins are typically designed as an offline treatment option for runoff prior to discharging downstream.

It is expected that flows from the minor events are to enter the basins and flows from the major event will bypass. This will be achieved by a "splitter pit" immediately upstream of the bioretention basin. Flows up to and including the 1 in 2 year event, deemed "low flows" will be diverted to the bioretention basin, while larger flows will be directed to the downstream detention basin, channel or existing creek.

7.1.2 Compensatory Strategies

DGR 7.1.2 Compensatory strategies

The Proposal's impacts on threatened species and ecological communities has considered the loss of habitat through site preparation works and the effect of impact avoidance and amelioration measures.

Assessments of significance provided in **Section 8** conclude that the Proposal is not expected to have an adverse significant impact on affected species. Notwithstanding, compensatory measures are proposed as listed below:

- Research (i.e. tree canopy nutrient enrichment for the Koala); and
- Provision of an in-perpetuity conservation agreement with funded management for the Conservation Area.

The following sections outline the proposed compensatory measures and their purpose. Additional suggested 'off site' improvement measures are outlined in **Section 7.1.2.1.3** for consideration.

7.1.2.1 Compensatory Measures

7.1.2.1.1 Research: Measuring the effectiveness of tree canopy nutrient enrichment for the Koala

Habitat loss is one of the main threats to koala populations. Revegetation is universally recognised as a key management strategy to mitigate impacts of habitat loss by improving areas of potential habitat and creating wildlife corridors that link isolated populations. Unfortunately, the nutritional quality of existing and replanted trees has been largely overlooked in koala conservation efforts. There is a real risk that revegetation projects that do not consider forage quality might not provide the key nutritional elements that support viable populations of eucalypt folivores, and therefore, mitigation goals will go unrealised.

The Nutritional Ecology Lab located at the Australian National University (ANU), has spent over thirty years investigating the chemical determinants of forage quality for leaf eating animals. Their research has shown that relatively small differences in foliar nutrients and toxins can have significant impacts on animal reproductive success and population densities. The quality of forage for the koala is largely determined by inherited genetic traits that differ between individual trees and across species. Thus, seeds or cuttings collected from unpalatable trees could re-establish unpalatable vegetation, even when the tree species are known to be eaten by koalas.

Despite considerable variation across landscapes, forage quality has been largely ignored in considerations of habitat quality and habitat restoration owing to difficulties in landscape-scale assessments. However, there are now proven methods to rapidly assess eucalypt forage quality across wide areas using near-infrared spectrophotometry. As a result, it is possible to undertake assessments of the nutritional quality of trees used as seed sources for revegetation projects and the nutritional quality of the resulting habitats. This

means that we can use our extensive knowledge about how eucalypt nutritional composition influences foraging decisions and population densities to regenerate or enrich landscapes to support viable populations of koalas now and into the future.

The proposed research project will facilitate the development of a best-practice revegetation prescription for koala habitat restoration and enrichment. We anticipate that the results of this ground-breaking work will influence future policy and improve the outcomes for this iconic and nationally important, vulnerable species in areas where habitat loss is occurring. We will use the existing site-level forage quality information collected at Kings Hill to identify high-quality trees to source seed for revegetation to partially offset planned development work on part of the Kings Hill site. Seedlings grown from selected trees will form the foundations for the revegetation and enrichment works proposed in the Conservation Area.

Plant-animal interactions are an area of excellence at the ANU, with the ANU lab being a leader in this field for decades. ANU propose to partner with KHD, RPS and the federal government through an Australian Research Council (ARC) Linkage project that translates prior research into targeted management activities and allows the testing of key assumptions about the importance of forage quality in determining habitat quality and landscape carrying capacity for koalas. ARC Linkage is a federal grant scheme that exists to support long term strategic research alliances between higher education institutions and business, industry, other research agencies and community organizations. Funding from the federal government supplements cash and in-kind contributions from Partner Organizations to apply advanced knowledge to problems as a basis for achieving national economic, commercial, environmental, or social benefits.

In collaboration with professional statistician, Associate Professor Robert Clark, ANU have developed models for Kings Hill that predict changes in forage quality based on several replanting scenarios in the landscape. Using a replicated, landscape-scale experimental design, we will be able to use these models to test hypotheses about how targeted high-quality replanting's will impact forage quality, population densities, and landscape use by koalas. Koala landscape use and population densities will be monitored using detection dogs and a modified mark recapture method based on scat detection combined with DNA analysis to identify individual koalas. Additional koala population threats will be concurrently mitigated through wild-dog baiting and exotic weed removal. The Kings Hill site will form one case-study that will be concurrently replicated at two other sites with different koala population densities and forest types. The support for that work will be provided by local NGOs and conservation trusts as part of the larger ARC linkage project.

7.1.2.1.2 In-perpetuity Conservation Agreement

The Conservation Area currently contains high biodiversity values and habitat suitable for long term use and occupation by affected species. In addition to these habitat values, the Conservation Area is of sufficient size and shape to sustainably retain viable populations of affected threatened species within the local area.

An in-perpetuity conservation agreement for the managed protection of these biodiversity values forms part of the VPA (to be entered into with Council), which is acknowledged in the CERs as an appropriate mechanism for the delivery of lasting conservation outcomes. The in-perpetuity agreement is expressly for the purpose of providing certainty in the delivery of a lasting local conservation outcome for affected species. The implementation of the BMP for the Conservation Area is to support the establishment of the Conservation Area, and is the vehicle for delivering the amelioration measures.

Two ways in which the in-perpetuity conservation agreement can be achieved are as follows:

- Registration of a VPA under Section 7.6 of the EP&A Act to run with the land; or
- Biodiversity Stewardship Site Agreement under Part 5 Division 2 of the *Biodiversity Conservation Act* 2016.

If the in-perpetuity conservation agreement established for the Conservation Area is via a VPA registered under s7.6 of the EP&A Act, then the management regime and costs associated with implementation would be defined by the BMP (**Appendix C**), as revised following completion of establishment works. The revised

BMP would focus on maintenance style management regimes and would dispense with the more intense establishment works associated with the mitigation actions performed during Phases 0 and 1.

Alternatively, an in-perpetuity conservation agreement established under Part 5 Division 2 of the *Biodiversity Conservation Act* 2016 would be subject to outcomes from the formal application process. This agreement would be entered into with the Biodiversity Conservation Trust and would run with the land (i.e. registered to title). The agreement would be established following satisfactory completion of the BMP (**Appendix C**), then managed in accordance with an approved and fully funded Management Action Plan.

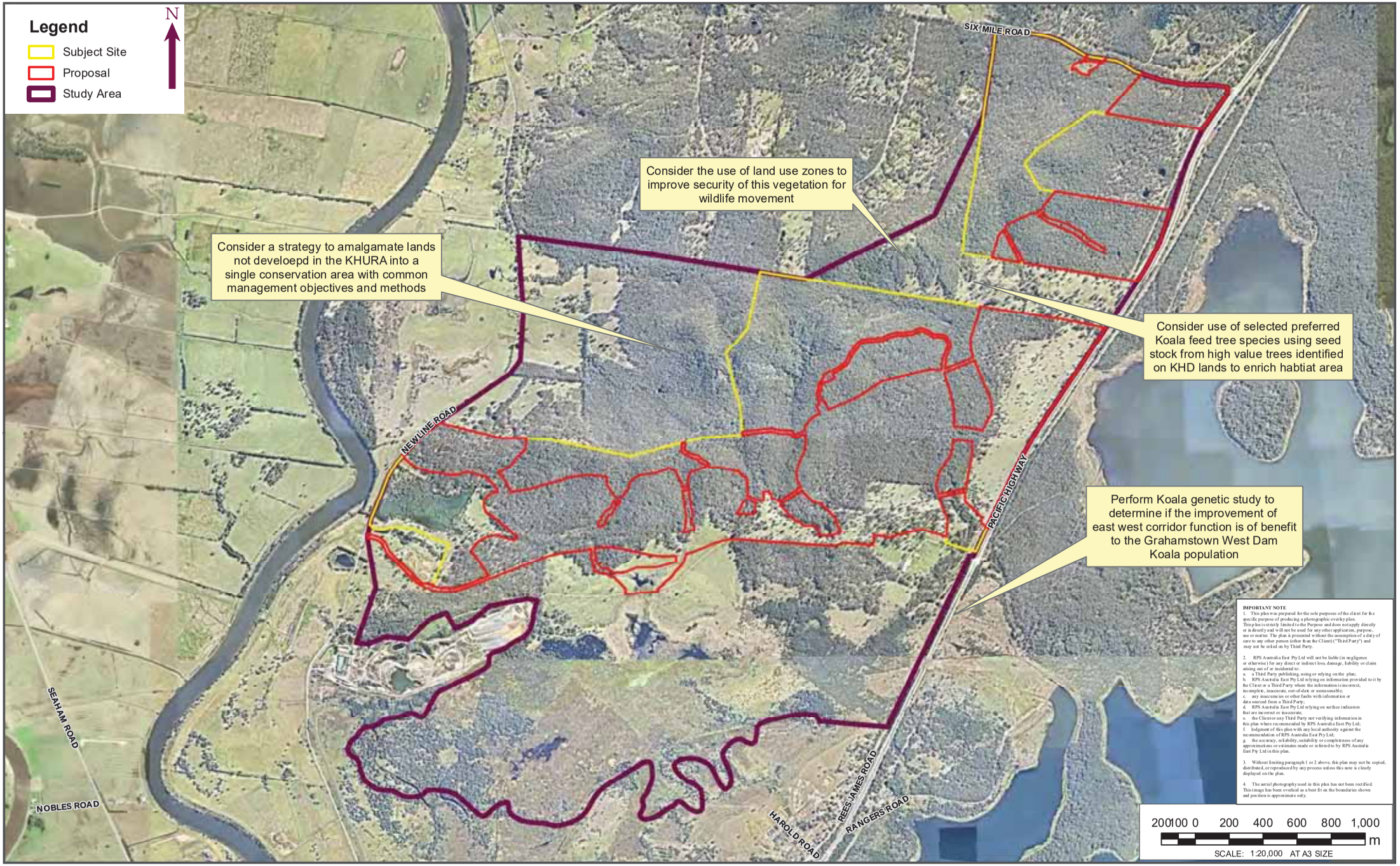
Notwithstanding the in-perpetuity conservation agreement for the Conservation Area, there are areas of the Conservation Area that may afford other land use opportunities of a kind that are compatible with, or separated from, recognised biodiversity values. To this end, these areas will be specified within the conservation agreement and, if needed, subject to further assessment (under a separate development application) to demonstrate that the proposed activities (e.g. eco-tourism, mountain bike trails, horse riding, orienteering, tree climbing, ceremonial areas, cultural heritage, environmental appreciation and education activities) are permissible, appropriate and compatible with the approved conservation agreement.

7.1.2.1.3 Offsite Improvement Measures

Offsite improvement measures additional to those outlined in the preceding sections, as shown on **Figure 7.15**, are recommended for consideration in the broader management of biodiversity for the locality. Benefit achieved through implementation of the mitigation measures specified in **Section 7.1.1** would be further strengthened at the landscape scale by improving/ securing fauna movement pathways for key species such as the Koala. Suggested additional offsite improvement measures are listed below:

- Consolidation of all E2 lands and impact avoided areas, where obtained, within the KHURA precinct into a single Conservation Area with appropriately coordinated and funded in-perpetuity protection and management; and
- Connection of the Kings Hill Koala Hub with the Grahamstown West Koala Hub.

It is important to note that these improvement measures do not part of the amelioration measures proposed in **Section 7.1.1** and are considered additional to what is required. These additional improvement measures are suggested on the basis of the koala genetics study [OWAD 2019b (**Appendix H**); Hogan et al *in prep*.] where a fauna movement underpass beneath the Pacific Highway coincident with the Old Irrawang Spillway would serve to improve genetic flow. The underpass as described by BioLink (2017b) will provide an east-west connection for Koalas that will link the Kings Hill hub with the Grahamstown West Dam hub; an action that will contribute to a safer pathway for genetic flow between these hubs thereby minimising the possibility of genetic drift into the future as arising from the effects of the Pacific Highway (Hogan et al *in prep*.). The location of this link coincides with the most viable least-cost pathway identified by BioLink (2018b) for this part of PSC LGA.



TITLE : FIGURE 7.15: RECOMMENDED 'OFF SITE' IMPROVEMENT MEASURES

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **21/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.15 Recommended 'off site' Improvement D A3 20200721.mxd

CLIENT: **PM NO 1 PTY LIMITED**

JOB REF: **PR130430**

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7.1.2.2 Adequacy of Compensatory Measures

As recommended in the CERs, and only where required, direct offsets are to be used to address circumstance where a significant residual impact is either expected or has eventuated (i.e. failure of amelioration measures). OEH's *Principles for the use of biodiversity offsets in NSW* (OEH 2014) are to be used to evaluate the adequacy of proposed compensatory measures.

The following section outlines how the Proposal is not inconsistent with the OEH (2014) principles despite the Proposal not requiring a formal offset.

7.1.2.2.1 OEH principles for the use of biodiversity offsets in NSW (OEH 2014)

1. Impacts must be avoided first by using prevention and mitigation measures.

The primary objective of the SIS has been to identify opportunity for impact avoidance outcomes in concert with mitigation measures to minimise local impacts on threatened species and ecological communities and to demonstrate no significant residual impact for a threatened species or ecological community.

A spatial and temporal understanding of impacts on threatened species and ecological communities within the study area has provided an evidence based approach to the development of a targeted impact avoidance strategy as outlined in **Section 7.1**, **Figure 7.1** and **Table 7.1**. These measures demonstrate meaningful and quantifiable impact reductions for threatened species by:

- Avoiding high value Koala habitat, this being a key objective identified by BioLink (2019a) for the long term protection of the Koala within the KHURA;
- Avoiding high densities of hollow-bearing tree, a key habitat requirement for hollow dependent fauna such as the Brush-tailed Phascogale;
- Avoiding vegetation patches with high maturity (i.e. vegetation with large diameter trees with hollows), a key requirement for the protection of habitat important to the lifecycle of Large Forest Owls; and
- Implementing maintenance of functional habitat corridors where the specifications for these corridors aim to reduce any negative congener interactions (e.g. average widths greater than 100 m for important connections).

The Proposal boundary was also adjusted throughout the impact assessment process, resulting in a reduced edge to area ratio and improved access for management, thereby minimising the negative impacts of edge effects.

In turn, these impact avoidance measures are to be retained within the Conservation Area for the purposes of maintaining the continued presence of locally occurring threatened species. Proposed mitigation measures are considered adequate for supporting ecological function and process necessary for the sustainable protection of threatened species habitat.

2. All regulatory requirements must be met.

"Offsets cannot be used to satisfy approvals or assessments under other legislation, such as assessment requirements for Aboriginal heritage sites and for pollution or other environmental impacts (unless specifically provided for by legislation or additional approvals)" (OEH 2014).

The Proposal will meet all regulatory requirements in an appropriate manner without duplication.

3. Offsets must never reward ongoing poor performance.

"Offset schemes should not encourage landholders to deliberately degrade or mismanage offset areas in order to increase the value from the offset" (OEH 2014).

The Proposal involves the enhancement/ enrichment of residual habitat contained within the Conservation Area prior to the onset of any impact associated with the Proposal (i.e. Phase 0). Offsite offsets will be

procured through appropriate government endorsed and regulated mechanisms that prevent the degrading or mismanagement of offset areas.

4. Offsets will complement other government programs.

"A range of tools is required to achieve the NSW Government's conservation objectives, including the establishment and management of new national parks, nature reserves, state conservation areas and regional parks, and incentives for private landholders" (OEH 2014).

The Proposal is not inconsistent with NSW Government's conservation objectives and tools available for the securing of conservation outcomes (i.e. use of in-perpetuity conservation agreement to protect the biodiversity values within the Conservation Area).

5. Offsets must be underpinned by sound ecological principles.

Sound ecological principles will govern the identification of suitable offsets (i.e. offsets to comply with offset rules specified in the Biodiversity Offset Scheme). Suitable offsets will be:

- 'Like for like' habitat and biodiversity values (i.e. as established under the TSC Act or BC Act);
- Comprise habitat with high integrity (i.e. equal or greater landscape values such as patch size and connectivity); and
- Suitably located with respect to the impact area (i.e. within the same IBRA subregion and/or adjoining subregion).

Direct offsets procured through the Biodiversity Offset Scheme will:

- Include the conservation of structure, function and compositional elements of biodiversity, including threatened species;
- Enhance biodiversity at a range of scales (i.e. research program for the Koala);
- Consider the conservation status of ecological communities; and
- Ensure the long-term viability and functionality of biodiversity.

The Proposal provides a 'like for like' Conservation Area that is to be managed in-perpetuity for the protection of affected threatened species at the local level. The Conservation Area comprises habitat with high integrity (and improved following implementation of the BMP) and is located adjacent to the area of impact. It is considered that the Proposal is not inconsistent with this principle.

6. Offsets should aim to result in a net improvement in biodiversity over time.

"Enhancement of biodiversity in offset areas should be equal to or greater than the loss in biodiversity from the impact site" (OEH 2014).

The Proposal provides a like for like conservation area adjacent other impact area. The area to be considered in-perpetuity is equal to or greater than loss in biodiversity in the impact site. Integrity is to be improved through implementation of the BMP. It is considered that the proposal is not inconsistent with this principle.

7. Offsets must be enduring – they must offset the impact of the development for the period that the impact occurs.

"As impacts on biodiversity are likely to be permanent, the offset should also be permanent and secured by a conservation agreement or reservation and management for biodiversity. Where land is donated to a public authority or private conservation organisation and managed as a biodiversity offset, it should be accompanied by resources for its management. Offsetting should only proceed if an appropriate legal mechanism or instrument is used to secure the required actions" (OEH 2014).

Mitigation proposed for the Conservation Area includes, among other measures, the use of an appropriate conservation mechanism to protect biodiversity values within the Conservation area. This area is to be

managed in accordance with the BMP (Appendix C) with appropriate funds for management and implementation timeframe. Monitoring is a key part of the BMP (see **Appendix C**) as it has the purposes of measuring the performance of amelioration measures and the Phase by Phase regulation of offset liabilities. Adaptative management practices are to be applied in circumstances where mitigation works are not achieving specified performance targets.

The Conservation Area is to be secured under a permanent in-perpetuity conservation agreement. It is considered that the proposal is not inconsistent with this principle.

8. Offsets should be agreed prior to the impact occurring.

"Offsets should minimise ecological risks from time-lags. The feasibility and in-principle agreements to the necessary offset actions should be demonstrated prior to the approval of the impact. Legal commitments to the offset actions should be entered into prior to the commencement of works under approval" (OEH 2014).

The Conservation Area to be provided as an in-perpetuity conservation outcome is defined in this SIS and is the subject of the VPA. It is considered that the proposal is not inconsistent with this principle.

9. Offsets must be quantifiable – the impacts and benefits must be reliably estimated.

"Offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. The methodology must be based on the best available science, be reliable and used for calculating both the loss from the development and the gain from the offset" (OEH 2014).

The Proposal provides for a conservation area of where the biodiversity values have been quantified using the same methods as those used to quantify the impact area.

10. Offsets must be targeted.

"They must offset impacts on the basis of like-for-like or better conservation outcomes. Offsets should be targeted according to biodiversity priorities in the area, based on the conservation status of the ecological community, the presence of threatened species or their habitat, connectivity and the potential to enhance condition by management actions and the removal of threats" (OEH 2014).

The Conservation Area is adjacent to the impact area. Implementation of the VMP and BMP is targeted and designed to manage impacts at the local scale. It is considered that the proposal is not inconsistent with this principle.

11. Offsets must be located appropriately.

"Wherever possible, offsets should be located in areas that have the same or similar ecological characteristics as the area affected by the development" (OEH 2014).

The Conservation Area is adjacent to the impact area and is within the same biogeographical setting as the impact area. It is considered that the proposal is not inconsistent with this principle.

12. Offsets must be supplementary.

"They must be beyond existing requirements and not already funded under another scheme. Areas that have received incentive funds cannot be used for offsets. Existing protected areas on private land cannot be used for offsets unless additional security or management actions are implemented. Areas already managed by the government, such as national parks, flora reserves and public open space, cannot be used as offsets" (OEH 2014).

The conservation obligations of the proposal are independent of other schemes or arrangements. It is considered that the proposal is not inconsistent with this principle.

13. Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or contracts.

"Offsets must be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes" (OEH 2014).

The VPA is a legally binding agreement that runs with the land. It refers to the implementation of a BMP that comprises performance measures and completion expectations. It is considered that the proposal is not inconsistent with this principle.

7.1.2.2.2 Port Stephens CKPoM

The consideration of the Post Stephens CKPoM performance criteria for development applications is provided in **Section 5.1.4** including cross referencing to parts of the SIS that address each criterion. **Table 5.6** demonstrates that the Proposal, inclusive of the amelioration (**Section 7.1.1**) and research (**Section 7.1.2.1.1**), adequately addresses the Port Stephens CKPoM performance criteria for development applications.

7.1.3 Ongoing Monitoring

DGR 7.1.3 Ongoing monitoring

7.1.3.1 Conservation Area

A commitment to monitoring is part of the BMP (see **Appendix C**) used to establish the Conservation Area. Two objectives define the monitoring program as listed below:

- Quantitatively measure and evaluate the benefit of amelioration measures implemented for threatened species affected by the Proposal; and
- Determine if amelioration measures meet or exceed predefined performance criteria or whether to employ the use of direct offsets is triggered.

Monitoring methods specified in the BMP (**Appendix C**) are listed below:

- Point Intercept Transect for measuring weed cover;
- Vegetation Integrity Plots (BAM plots) to track vegetation and habitat health;
- Photograph points to visually appreciate change over time;
- Camera trapping to monitoring the activity of feral fauna and threatened species;
- Nest box inspections to measure the occupancy hence value of this habitat feature;
- Counts of planted trees to track revegetation success; and
- Bird surveys to evaluate ongoing habitat occupancy of the wetland 803 precinct including Grey-crowned Babbler.
- Threatened flora counts to demonstrate ongoing protection and timely identification of unexpected threats; and
- Routine surveys to determine if the Koala remains in the Conservation Area and is breeding.

Monitoring methods, timing, frequency and analysis are detailed in the corresponding section of the BMP (**Appendix C**). The following sections outline the design principles of the monitoring program and the adaptive management.

7.1.3.1.1 Design Principles

Framework

The monitoring program within the BMP is conceptualised on the BACI (Before, After, Control, Impact) design principles (Underwood 1991) where practical and feasible. This monitoring design is preferred over a

simple Before-After monitoring model as it has capacity to assign causation to observed change (e.g. distinguish between the 'treatment' effects and other unrelated environmental factors) rather than simply detect change.

A BACI design involves data collection from monitoring sites located within:

- An area where change is expected following the application of a 'treatment' (e.g. amelioration); and
- Corresponding control/ reference sites that are independent of the treatment.

The complete BACI dataset also involves the collection of temporal data (i.e. data from all monitoring sites obtained before and after the application of the treatment).

Baseline (before) data will be collected prior to the start of site preparation works, with data collection reflective of expected temporal and biological variation (i.e. the main purpose of the baseline data is to try to understand pre-treatment natural variation in all monitoring sites). Repeated sampling of BACI monitoring sites would be performed over time for the purposes of detecting and quantifying change. This process will evaluate the effectiveness of management activities and, where relevant, provide insight into how the management regime may be adapted to achieve the objectives of the BMP.

Measures

The monitoring program measures are quantitative and suitable for evaluating against performance measures.

Stratification

A systematic grid that avoids sampling bias is to be used to guide monitoring activities as shown in **Figure 7.16**. Numbers within the grid cells reflect the numbering system used in the OWAD (2019a) study.

Sample Replication and Independence

Sample replication is to have regard for the analytical methods used to performance test the monitoring results.

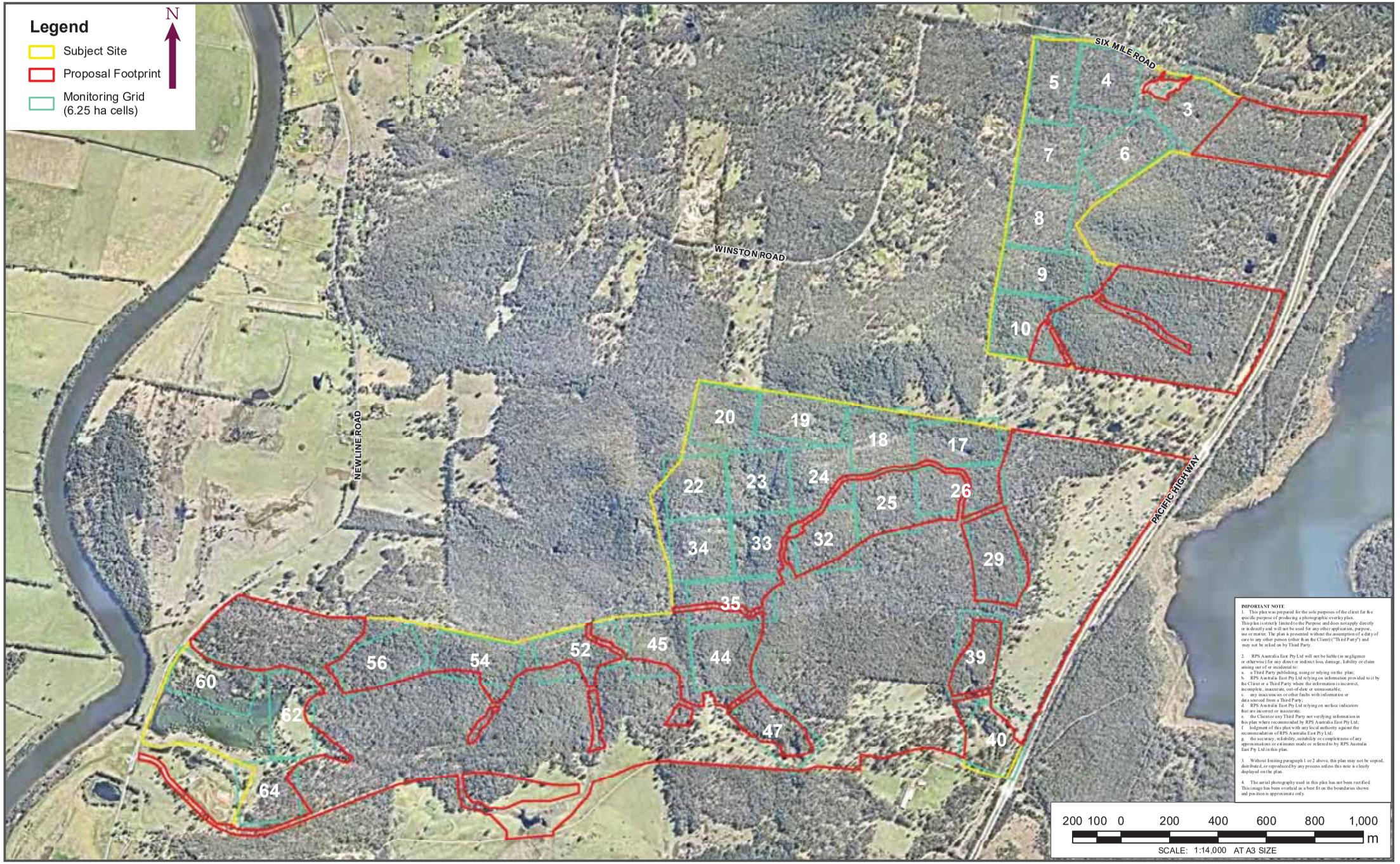
Baseline data

The purpose of baseline data is to benchmark the variation in measured values for treatment and control areas prior to the implementation of the treatment. Therefore, the longer the baseline period, the better the understanding of natural variance.

7.1.3.1.2 Adaptive Management

Adaptive management provides a flexible decision making framework that enables the management and monitoring framework to be adjusted over time in response to monitoring outcomes as they are understood. Through feedback to the management process, the management procedures are changed in steps until monitoring shows that the desired outcome is obtained. Accordingly, the monitoring program is to be suitably designed to provide statistical confidence in management outcomes and any decisions made in altering management specifications.

In adaptive management the goal to be achieved is set, so there is no uncertainty as to the outcome, and conditions requiring adaptive management do not lack certainty, but rather they establish a regime which would permit changes, within defined parameters, to the way the outcome is achieved.



TITLE : FIGURE 7.16: MONITORING LOCATIONS WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **21/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.16 Monitoring Locations within the Conservation Area C A3 20200720.mxd

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JOB REF: **PR130430**

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The Adaptive Management Framework proposed is a process of ongoing testing, learning, monitoring and managing and relies on:

- Description of the environmental value and its role in the landscape, including aspects of the Proposal that may result in a significant impact to the environmental value (this document);
- A model of the environmental response to certain management actions/ decisions, supported by the description of the environment;
- Identification of clear management objectives for each environmental value;
- Mechanisms to test the model;
- Engagement with relevant stakeholders in the evaluation of management actions/ decisions;
- Monitoring the system using best available technologies and multiple lines of evidence to:
  - Evaluate progress against objectives;
  - Determine the status of the system;
  - Increase our understanding of the system; and
  - Refine the modelling where applicable.

An adaptive management response would be initiated through the annual monitoring report and prepared as a response to management issues as part of the next Annual Works Program. Revised management specifications would be developed and supplied to Council for review. Revised management specifications would be discussed with Council and, where altered, be incorporated into the BMP as an update.

Specific performance criteria may be specified for these matters to reflect altered management specifications and revised efficacy timeframes. These 'specific performance criteria' are designed to evaluate the effectiveness of remedy management actions, are designed to be temporary and are supplementary to the performance criteria.

7.1.3.2 Wetland Monitoring

7.1.3.2.1 Background

The development of the KHURA has the potential to impact on coastal wetland 804 (Irrawang Swamp) as identified in the Irrawang Swamp Plan of Management (HWC 2012). KHD acknowledge the management plan, notably its objectives, these being:

- To restore the wetland to a desired state and eliminate, or least manage, existing threats.
- To manage the restored wetland for the long-term to address any potential degradation of the system in the future.

HWC (2012) outlines a monitoring program to evaluate the performance of management regimes that aim to remedy impacts from past land uses and existing threats. Past land uses and their impacts include:

- Construction and operation of floodgates on Pennington Drain to exclude tidal and flood inundation, resulting in a loss of estuarine communities and aquatic species diversity;
- Construction and maintenance of drainage channels to increase outflows from the swamp, resulting in alteration of natural hydrological regime thereby promoting the dominance by dry Phase vegetation, particularly weeds and introduced grasses;
- Vegetation clearing that has reduced tree and shrub stratum and forested wetland communities, resulting in a change from riparian / swamp forest and shrubland to treeless communities with loss of biodiversity and capacity for filtration of sediment and other pollutants;

- Planting of pasture grasses that has increased competition with native species thereby reducing the abundance of native dry Phase species; and
- Construction of Newline Road bund having the effect of altering hydrological regimes in western section of swamp, which appears to have promoted reduction in exotic pasture with transition to freshwater wetland vegetation through increased inundation (Eco Logical 2011).

Existing threats identified by HWC (2012) operating within wetland 804 are listed below:

- Weed species incidence, spread and abundance including notable Weeds of National Environmental Significance such as Lantana (*Lantana camara*), Water Hyacinth (*Eichornia crassipes*), Blackberry (*Rubus fruticosus* aggregate species), Fireweed (*Senecio madagascariensis*) and Alligator Weed (*Alternanthera philoxeroides*);
- Grazing by managed livestock and feral deer. HWC has removed managed livestock grazing from Irrawang Swamp leaving feral deer and the only remaining source of exotic grazing activity. Herbivory and land degradation caused by feral deer is listed as a Key Threatening Process (KTP) listed under the *Biodiversity Conservation Act* 2016;
- Acid sulphate soils should excavation unearth deep sulphide rich soil horizons;
- New Line road bund (see past land use for outline of impacts);
- Surrounding catchment wide land uses such as waste management facility (i.e. encroachment on the northern boundary of the wetland (part of the SEPP 14 wetland appears to have been cleared) and leachate or contaminated water) and residential development in the catchment (i.e. changes to surface water flow and nutrient);
- Access where uncontrolled entry points result in trail bike riders and cattle entering the swamp; and
- Fire management where vegetation management is required for the protection of external land uses.

A three yearly monitoring program has been implemented as part of the Irrawang Swamp Plan of Management with the most recent monitoring event performed in 2018 (Kleinfelder 2018). Prior monitoring of wetland vegetation cover (HWR 2003; Umwelt 2012; Kleinfelder 2018) indicates fluctuation and contraction in some native vegetation types over a 15 year period, notably Paperbark/ Melaleuca, with a reduced spatial extent of 3.02 ha observed between the two more recent monitoring events (i.e. 11.62 ha to 8.60 ha). Kleinfelder (2018) suggest the reason for this change is “Likely to be due to small differences in the linework, and classification of one patch of *Melaleuca ericifolia*”.

Other notable changes within the central northern Paperbark/ Melaleuca observed in a recent site inspection (16 October 2019), which is likely to be having a pronounced impact on the integrity on this patch, includes the invasion of high threat weeds such as Alligator Weed (*Alternanthera philoxeroides*). Kleinfelder (2018) do not note the occurrence of this high threat weed in this patch, with recent observations indicating a widespread occurrence in this area. It is not clear as to why this has occurred; however, it may be related to the removal of cattle grazing and its effect on regulating the growth/ expansion of this species in the absence of sufficient weed suppression activity to compensate for this change.

Kleinfelder (2018) provide statistical comparison of flora transect data obtained from repeated measures sampling locations comprising ‘test’ (n=7) and ‘reference sites’ (n=3). Two separate analysis were performed, with the first being solely on the 2018 dataset and the second on the combined 2002, 2011 and 2018 monitoring dataset. The results indicate no significant different between test and reference sites in 2018; however, statistically significant differences were identified between monitoring events (i.e. 2002, 2011 and 2018). Kleinfelder (2018) discussed the potential contributing factors for these statistical differences indicating that observer bias (e.g. plant identification) and changes in weed presence and abundance may be driving this change. Also noted by Kleinfelder (2018) was the substantial change in one of the reference sites (Transect 8) where considerable Swamp Oak (*Casuarina glauca*) regeneration has been noted.

7.1.3.2.2 Need for Monitoring

KHD recognise the purpose of the Irrawang Swamp Plan of Management (HWC 2012) including its objectives (i.e. restore the environmental quality of the wetland following the implementation of the Grahamstown Dam augmentation project) and the monitoring can be used to test the efficacy of management performed to minimise the impacts of the Grahamstown Dam augmentation project.

While impacts arising from the development of the KHD component of the KHURA on wetland 804 are predicted to be minor and negligible (Alluvium 2019; **Appendix D**), an increased frequency and quantity of water flows into the Irrawang Swamp represents a similar kind of impact to those associated with the Grahamstown Dam augmentation project. Parts of the swamp identified as sensitive to hydraulic change relative to the Proposal include vegetation dependent on wetting and drying cycles, as shown in **Figure 7.17**.

The monitoring component of the Irrawang Swamp Plan of Management focuses on the measurement of biological systems, with monitoring to cease following the completion of two 'post impact' monitoring events. The second 'post impact' monitoring event was completed in 2018 (Kleinfelder 2018), although the monitoring report recommended the continuation of the monitoring program. It is currently unclear as to whether or not HWC intends to act on this recommendation.

7.1.3.2.3 Focus

The Proposal's impact on wetland 804 is likely associated with change in water inflow quantity and frequency. These impacts were modelled using annual water volume and frequency to predict these changes [Alluvium 2019 (**Appendix D**)] with the conclusion being a minimal impact on sensitive matters (i.e. areas of wetting and drying).

Therefore, the monitoring of wetland 804 is to focus on the measurement of actual change in water regimes. Variation in water depth and extent of cover is to be monitored within sensitive areas to test the conclusion that the Proposal is not likely to have any substantive impact over existing conditions. This monitoring is in addition to the program implemented by HWC, which KHD supports its ongoing role in the management of wetland 804.

7.1.3.2.4 Method and Design

Water depth is to be measured in the deepest part of the sensitive area identified in wetland 804 (**Figure 7.16**). The distance from the inundated edge of the associated waterbody to the water depth gauge is to be measured at three separate predefined locations to measure the corresponding variation in water inundation. A weather station measuring rainfall and evaporation is to be similarly established to measure local conditions. The proposed water monitoring and weather station locations is provided in **Figure 7.18**.

7.1.3.2.5 Frequency and Duration

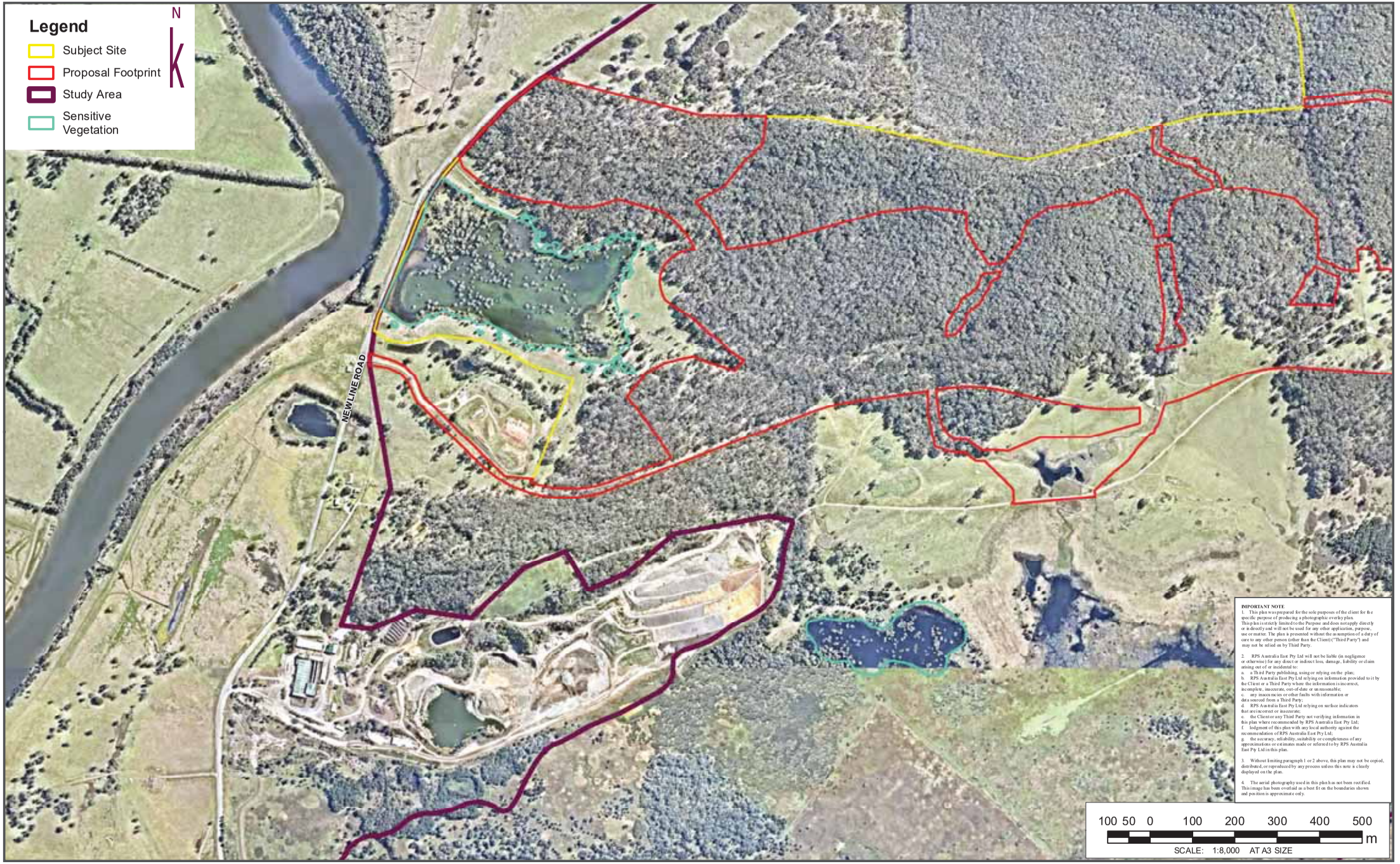
A monthly frequency for the water monitoring program is recommended to obtain sufficient data to analyse biological datasets obtained through implementation of the HWC (2012) monitoring program. Measures should be obtained at the start of each monitoring month. This program would cease at the same time as the HWC (2012) monitoring program.

7.1.3.2.6 Baseline Data

A two year baseline dataset is to be obtained prior to the initiation of Phase 1 works. This data is to be used to characterise the pre-development hydraulic conditions of the sensitive parts of wetland 804 for comparison with post impact environment.

7.1.3.2.7 Reporting

A monitoring report comprising the methods, results, discussion, conclusions and recommendations is to be prepared annually and provided to PSC for review and dispersal to HWC for their comment.



TITLE : FIGURE 7.17: SENSITIVE VEGETATION IN WETLAND 804

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (mark.aitkens)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\3. SIS\20200719 SIS Final Version\130430 Figure 7.17 Proposed Monitoring Wetland 803_804 C A3 20200721.mxd

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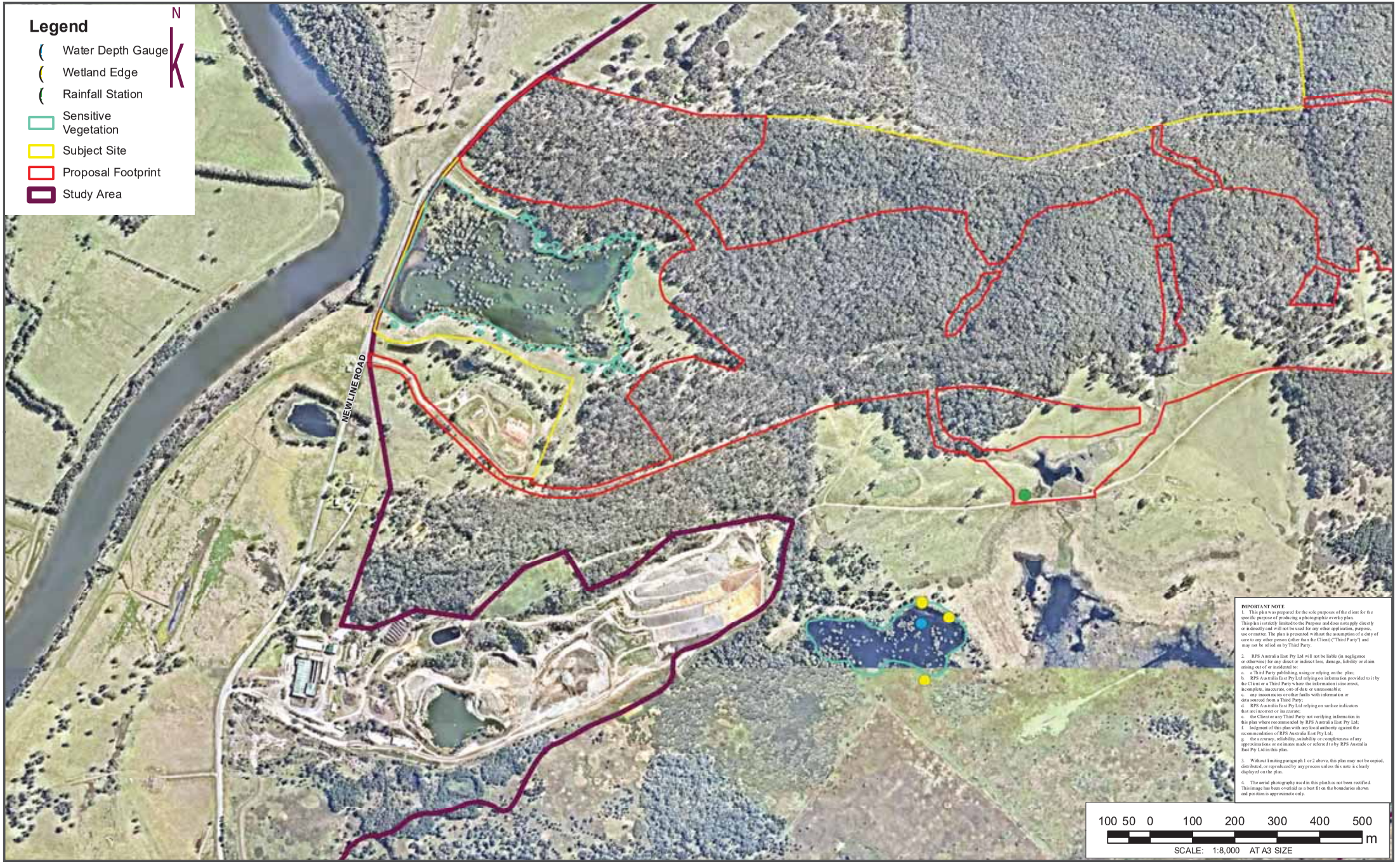

TITLE : FIGURE 7.18: PROPOSED WATER MONITORING LOCATIONS FOR WETLAND 804

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **27/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): C A3 (mark.aitkens)

PATH: J:\JOBS\144K\144701 Sydney (MR)\10 - Drafting\Arcgis Map Documents\Eco\03 Holsworthy\Report Figures\130430 Figure 7.18 Proposed Monitoring Wetland 803_804 C A3 20200721.mxd

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8 ASSESSMENT OF SIGNIFICANCE OF LIKELY EFFECT OF PROPOSED ACTION

This chapter covers the following Director General's Requirements:

DGR 8. ASSESSMENT OF SIGNIFICANCE OF LIKELY EFFECT OF PROPOSED ACTION

An 'Assessment of Significance' (s. 5A EP&A Act) is to be provided for each of the affected species (threatened species, populations or ecological communities) identified in the SIS, incorporating relevant information from **Sections 5.1** to **7** of the SIS. On the basis of these assessments a conclusion is to be provided concerning whether, based on more detailed assessment through the SIS process and consideration of alternatives and ameliorative measures proposed in the SIS, the proposal is still considered likely to have a significant effect on threatened species, populations or ecological communities or their habitats.

This SIS provides an evidence-based approach to inform revisions of the land zones boundaries (see **Figure 1.1**) with the aim being a targeted and meaningful reduction in impacts on threatened species and ecological communities. This process has produced a revised Proposal boundary embodying impact avoidance, as shown in **Figure 2.2**, to reduce direct impacts as discussed in **Section 5.1.1**. The SIS assessment has simultaneously considered indirect impacts (**Section 5.1.2**) and broader cumulative impacts (**Section 5.1.3**). **Section 7** describes the impact avoidance measures (see **Table 7.3** of **Section 7.1**) and amelioration measures proposed to minimise the need for an '*extensive offset and mitigation strategy*' recommended by EcoBiological (2009) for option 2 (**Section 5.1.3**). In so doing, the impact of the Proposal as defined by the progressive implementation through Phases 0 to 3 (see **Figures 5.2** to **5.4**) has sought to minimise the broader cumulative impacts of the KHURA as mitigation implemented prior to and during early Phases of the Proposal is designed to minimise the direct impacts.

The following sections provide Assessments of Significance for affected species. The preparation of these assessments has reference to **Sections 5.1** to **7** of this SIS as required by the CERs.

8.1 Flora species

8.1.1 *Corybas dowlingii*

8.1.1.1 Preface

Wagner et al (2020) (see **Appendix K**) shows that *Corybas dowlingii* is no longer recognised as a species, rather a hybrid between *C. aconitiflorus* and *C. barbarae*. Accordingly, *Corybas X dowlingii* is not classed as an endangered species under the TSC Act. Notwithstanding, an impact assessment has been provided to determine the likely impact of the Proposal on the species.

8.1.1.2 Habitat

The habitat of *Corybas dowlingii* is described in the NSW Scientific Committee (2007) final determination as "typically grows in gullies in tall open forest on well-drained gravelly soil at elevations of 10-200m". Occupied habitat within the subject site is generally consistent with this habitat description.

8.1.1.3 Ecology

Corybas dowlingii forms clonal colonies, an aspect of its ecology that has allowed for the successful translocation of this species at Bulahdelah in response to an impact from the construction of the Pacific Highway bypass at that location (Dr Mark Clements pers comms).

Corybas dowlingii is reliant on a mycorrhizal relationship (i.e. *Tulasnella* sp.) for growth and reproduction (Lyon 2014). Without the interaction, the orchid is neither likely to survive germination or undergo lifecycle processes.

The species is pollinated by small winged insects typically microdipterans of the family Mycetophilidae. Commonly known as fungus gnats, the adult flies are active in humid weather, usually running or flying close to the ground and often prominent in organically rich soils. These insects have very small ranges thus limiting the movement of pollen across the landscape.

8.1.1.4 Presence within the Subject Site

Corybas × *dowlingii* has been identified within the subject site with representation in both the area to be cleared and the Conservation Area. Surveys performed are considered adequate for this species (**Section 4**) with the results being representative of occurrence. A count of 1,585 individual plants was recorded within the subject site with 118 individuals occurring within the impact area with the remaining 1,467 individuals occurring within the Conservation Area.

8.1.1.5 Assessment of Significance

Assessment of Significance: Red Helmet Orchid

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The lifecycle of *Corybas x dowlingii* requires the presence of moist eucalypt forest capable of reliably supporting the symbiont fungus and pollinator gnat flies.

In response to this habitat requirement, the Proposal has segregated a large patch of occupied habitat from site preparation works (~8.62 ha) (i.e. impact avoidance). This habitat is to be retained and integrated into the Conservation Area for in-perpetuity conservation and management, thereby providing long term security. Management regimes will include the control of feral fauna and exotic flora (e.g. Lantana), which otherwise reduce habitat integrity for this species. It is anticipated that establishment and management of the Conservation area may increase the area and quality of occupied habitat for this species, and thus may increase the size of the conserved population over time.

Indirect impacts such as soil desiccation and light are primarily managed by the proximity of retained habitat to the site preparation works. Limited natural light penetration is expected due to the sun angle (i.e. habitat edge has a south facing orientation with the sun angle being in the northern part of the sky for most of the year). The planting of *Melaleuca nodosa* along the edge of the Conservation Area is proposed to further minimise the encroachment of additional light on habitat. Fire regimes are to be managed using small mosaic burning with appropriate fire frequency, timing and intensity.

The Proposal will retain a patch of occupied habitat for inclusion within a Conservation Area managed in-perpetuity in accordance with a conservation agreement. This habitat area is of sufficient size and value to allow for sustained occupancy and recruitment irrespective of impacts associated with the KHURA.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts, including loss of individuals and gain from in-perpetuity management, and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Red Helmet Orchid

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~5.00 ha of occupied habitat) and restoration of diminished habitat areas, a habitat area of 4.66 ha comprising a low density of plants (i.e. 1 plant per 0.04 ha) is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 3.14 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of occupied habitat for this species.

Retained (modified)

The Conservation Area comprises occupied habitat with a greater density than the impact area (i.e. 1 plant per 0.06 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of propagules, related biodiversity and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Assessment of Significance: Red Helmet Orchid

Corybas dowlingii has a widespread yet fragmented known occurrence. Occurrences within the subject site are consistent with prescribed habitat conditions (i.e. wet sclerophyll forest) and is not at the extremity of its known range. The total number observed does not exceed the size of other populations such as Stoney Ridge Reserve (NSW Scientific Committee 2007) and Awaba-Fassifern (RPS 2019). The recent bushfires of the 2019-20 summer season have not had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 537,881 ha of wet sclerophyll forest; BCD 2020). In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Proposal has taken into consideration the KTPs of relevance to the species listed below together with counter measures used to manage their effects.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native

Assessment of Significance: Red Helmet Orchid	
	Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.

Assessment of Significance: Red Helmet Orchid	
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	

8.1.1.6 Conclusion

The Proposal is expected to result in the loss of ~118 plants from a total of 1,585 plants (i.e. 7.5% reduction), with residual occupied 'like for like' habitat retained in the adjoining Conservation Area (i.e. 1,467 plants within 8.62 ha or 92.5% of the local population). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation

arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.1.2 Small Water-ribbons

8.1.2.1 Habitat

Harden (1993) describes *Maundia triglochinoides* as a wetland species that "grows in swamps or shallow freshwater in heavy clay; north from southern Sydney". According to the Threatened Species Profile Database (BCD 2019), the habitat of *Maundia triglochinoides* is described as swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients and is associated with wetland species such as *Triglochin procerum*.

8.1.2.2 Ecology

Maundia triglochinoides is described as a wetland species flowering in the warmer months (i.e. November to January) (BCD 2019). It is most likely wind pollinated and dispersed by water via diaspore (i.e. seed) and root tubers. In relation to the latter, the species spreads vegetatively, with tufts of leaves arising along rhizome. Populations expand following flood events and contract to more permanent wetlands in times of low rainfall.

Locally, it appears that the growth of Alligator Weed (*Alternanthera philoxeroides*) in combination with livestock grazing (i.e. highly palatable species and loss of water habitat area during the spring summer period) has substantially impacted the number of individuals observed within the subject site.

8.1.2.3 Presence within the Subject Site

Maundia triglochinoides has been identified within the subject site with representation in both the area to be cleared and the Conservation Area. Surveys performed are considered adequate for this species (**Section 4**) with the results being representative of occurrence. The species was observed in an unmanaged and constructed inline dam near the mid reach of an ephemeral creek outside the floodplain, which is the natural geomorphological feature characteristic of this species habitat. The other two recorded locations include separate inline dams located within the Conservation Area within/ adjacent to the floodplain.

8.1.2.4 Assessment of Significance

Assessment of Significance: Small Water-ribbons

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition.

The Proposal will have the effect of reducing the habitat area currently occupied by the species within the subject site by approximately 40%. The habitat area to be removed is located within an anthropogenically made structure (i.e. turkey nest dam) outside the typical geomorphological setting associated with natural habitat for this species (i.e.

Assessment of Significance: Small Water-ribbons

floodplain). There is no evidence of species dispersal into habitat located below the turkey nest dam with the ongoing presence of the species within this structure being uncertain without active management (i.e. removal of sediment that would otherwise fill the dam and displace the water depth required).

Conversely, the remaining habitat retained in two separate water bodies are located within the Conservation Area within/ adjacent to the floodplain and represent a more natural occurrence of the species. As part of the Proposal the retained habitat will be actively managed to minimise the effect of existing threats such as livestock grazing and Alligator Weed, which both cause dysfunction in recruitment processes either by loss of vegetative material (i.e. grazing and trampling) or germination (i.e. Alligator Weed smothers habitat area). Further, the habitat will be protected in-perpetuity for the purposes of biodiversity conservation. With management, it is anticipated that the establishment and management of the Conservation Area will allow the species to successfully recruit over multiple generations and may also functionally increase the area by this species. This habitat area is considered to be of sufficient size and value to allow for sustained occupancy and recruitment irrespective of impacts associated with the KHURA.

Indirect impacts such as water quality and quantity are to be managed a sensitive stormwater design that aims to minimise hydraulic change in the receiving environment. More specifically, it is likely that removal of livestock grazing will further minimise the risk of failed life cycle processes as the water consumed by this livestock will remain available for the species particularly during its reproductive Phase.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts, including loss of individuals and gain from in-perpetuity management, and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Assessment of Significance: Small Water-ribbons

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~0.8 ha of occupied habitat) and restoration of diminished habitat areas, a habitat area of 0.08 ha is to be removed in Phase 1 representing the largest and only impact on this species. The impact assessed is conservative as the micro-siting of detention basins and design thereof are proposed to minimise impacts, however the nature of this impact is not known until detail designs are prepare This impact is to occur during the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of occupied habitat for this species.

Retained (modified)

The Conservation Area comprises occupied habitat (i.e. 0.15 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of propagules, related biodiversity and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

The Proposal provides enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**) that significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**). The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of propagules, related biodiversity and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Assessment of Significance: Small Water-ribbons

Occupied habitat removed by the Proposal is located within a man made turkey nest dam upslope and outside the floodplain, the latter being an important geomorphological component that defines the extent of naturally occurring habitat. The long term certainty of this habitat remaining viable for *Maundia triglochinoides* is questionable as, without management, it is expected that the man made structure will eventually infill and no longer support this species. The recent bushfires of the 2019-20 summer season have not had an adverse impact on occupied habitat within the region (BCD 2020). In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and the uncertainty of habitat persistence in the man made turkey nest dam, it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this

Assessment of Significance: Small Water-ribbons	
	respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.

Assessment of Significance: Small Water-ribbons	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	The subject site currently has limited examples of escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by escaped garden plants. It is considered that this KTP are not likely to result in any detrimental impacts to threatened species and ecological communities.

8.1.2.5 Conclusion

The Proposal may result in the removal of 0.08 ha of habitat comprising this species in Phase 1, however detailed design processes and application of the sensitive vegetation clearing procedure (VMP; **Appendix D**) may yet result in an avoidance outcome for the *Maundia triglochinoides*. The Proposal will retain 0.15 ha of occupied habitat within the Conservation Area. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.1.3 Taree Rustyhood Orchid

8.1.3.1 Habitat

The Taree Rustyhood Orchid belongs to a clade of greenhoods commonly referred to as Rustyhoods or *Oligochaetochilus*. According to the Threatened Species Profile Database (BCD 2019), the ecology and habitat of *Pterostylis chaetophora* is as follows:

- Prefers seasonally moist, dry sclerophyll forest with a grass and shrub understorey.
- Flowers from September to November. Vegetative reproduction is not common in this group of Greenhoods, but some species may form more than one dropper annually. Fails to flower in dry seasons.
- Plants are deciduous and die back to the large, underground tubers after seed release. New rosettes are produced following soaking autumn and winter rains.

The species occurs in two conservation reserves being Columbey National Park and Wingen Maid Nature Reserve. Observations from local occurrences at Columbey National Park, Wallaroo State Forest, Grahamstown West and the Conservation Area provide additional context for defining the habitat preferences for this species, these being:

- A species rich mix of tree species with open forest structure and canopy gaps. Species include Grey Box (*Eucalyptus moluccana*), Ironbarks [mostly Broad-leaved Ironbark (*Eucalyptus fibrosa*)], Forest Redgum (*Eucalyptus tereticornis*) and Spotted Gum (*Corymbia maculata*) with the latter species never being dominant.
- The proximal incidence of *Melaleuca nodosa*. The presence of this species, which is likely linked to imperfectly drained soils, could represent favourable soil conditions reflective of locally retaining elevated soil moisture levels after sufficient autumn – winter rainfall events. This habitat preference may be important in the perennial survival of orchid tubers and also serve to activate flowering events.

8.1.3.2 Ecology

The Taree Rustyhood Orchid (*Pterostylis chaetophora*) belongs to a greenhood group comprising members adapted to semi-arid to arid conditions, with continental distributions reflective of these characteristics (i.e. largely inland distribution). Key adaptations of this group include:

- Multiple flowers per raceme for increased seed production (i.e. ~ 3,500 seeds per fertilised flower);
- Flower height (i.e. elevated position to maximise dispersal potential);
- Flowering time (i.e. typically in spring where the production of dehisced seed coincides with increased windiness to aid dispersal potential); and
- Longer lived seed to survive the drier hotter summer months (~ 1 year versus ~ 0.5 years for non rustyhoods).

The germination and later survival of *Pterostylis chaetophora* is solely dependent on its relationship with the symbiotic fungus *Ceratobasidium cornigerum* (Dr Mark Clements pers. coms. 2019); this being consistent with findings from earlier mycorrhizal – *Pterostylis* studies (Warcup 1981). Without this fungus, *Pterostylis chaetophora* is unable to germinate then reproduce.

8.1.3.3 Presence within the Subject Site

Pterostylis chaetophora has been identified within the subject site with representation in both the area to be cleared and the Conservation Area. Surveys performed are considered adequate for this species (**Section 4**) with the results being representative of occurrence. The species was observed in small low number clusters within the area to be cleared, with the individual count numbering approximately 20 individuals. A large sub-population numbering ~460 individuals was observed within the Conservation area.

8.1.3.4 Assessment of Significance

Assessment of Significance: Taree Rustyhood Orchid

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition.

The Proposal will have the effect of reducing the habitat area by approximately 35% of occupied habitat within the subject site (i.e. habitat area calculated by a 30 m buffer around each plant), although this impact area only contains 20 plants, whereas the retained habitat in the Conservation Area comprises ~460 plants. As part of the Proposal the retained habitat will be actively managed to minimise the effect of existing threats such as grazing by feral deer and rubbish dumping, which both have the potential to cause dysfunction in recruitment processes either by loss of vegetative material (i.e. grazing and trampling) or habitat area (i.e. displaced by rubbish). Further, the habitat will be protected in-perpetuity for the purposes of biodiversity conservation. With management, it is anticipated that the establishment and management of the Conservation Area will allow the species to continue successful recruitment over multiple generations, which may also lead to an increase the area occupied by this species. This habitat area is considered to be of sufficient size and value to allow for sustained occupancy and recruitment irrespective of impacts associated with the KHURA.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and

Assessment of Significance: Taree Rustyhood Orchid

- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts, including loss of individuals and gain from in-perpetuity management, and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

<u>Removal</u>

After accounting for the beneficial outcome generated from restoration of diminished habitat areas, a habitat area of 1.41 ha comprising ~20 individual plants is to be removed over three Phases of the Proposal, with Phase 1 representing the largest proportional impact (i.e. 0.85 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of occupied habitat for this species.

<u>Retained (modified)</u>

The Conservation Area comprises occupied habitat (i.e. 4.36 ha and ~460 individuals), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Assessment of Significance: Taree Rustyhood Orchid

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of propagules, related biodiversity and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

The Proposal provides enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**) that significantly increases the wildlife connectivity outcomes indicated by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**). The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of propagules, related biodiversity and genetic flow to other areas of habitat. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Proposal is removing habitat associated with small aggregations of *Pterostylis chaetophora,* which are presumably satellite occurrences of the much larger source sub-population found in the Conservation Area (~460 plants). The recent bushfires of the 2019-20 summer season have not had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020). In light of the in-perpetuity protection and management of a larger occupied patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification.

Assessment of Significance: Taree Rustyhood Orchid	
	Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within

Assessment of Significance: Taree Rustyhood Orchid	
	the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	

8.1.3.5 Conclusion

The Proposal is expected to result in the loss of ~20 plants from a total of ~480 plants (i.e. 4.2% reduction), with residual occupied 'like for like' habitat retained in the adjoining Conservation Area (i.e. 460 plants within 4.36 ha or 95.8% of the local population). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large

and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2 Fauna Species

8.2.1 Glossy-Black Cockatoo

8.2.1.1 Habitat

The Glossy-black Cockatoo occurs in many vegetation types, from woodland and open sclerophyll to tall open wet forest and rainforest. This species can survive in fragmented landscapes, however it requires large tracts of native vegetation for breeding (OEH 2019b). However, the key limiting resource that constrain its foraging extent are Allocasuarina spp. This bird feeds almost exclusively on seeds of several species of Casuarina and Allocasuarina (collectively known as Sheoak).

8.2.1.2 Ecology

The Glossy-black Cockatoo feeds primarily on seeds from Black Sheoak (*Allocasuarina littoralis*) and Forest Sheoak (*A. torulosa*) in areas near the coast. PCTs that offer these resources may constitute suitable habitat, provided these feed trees are in high enough abundance (typically dense stands of Sheoak are required). However, optimal habitat that satisfies both feeding and breeding requirements, is a combination of forests and woodlands with large hollows within which it nests in close proximity to large expanses of foraging habitat. Specifically, Glossy-black Cockatoo prefers to nest in large old hollows within living or dead eucalypts, located >5m above the ground (DEC 2006; OEH 2019b).

The Glossy Black-Cockatoo mates for life, with pairs maintaining their bond all year round. The female prepares the nest hollow and incubates the eggs, only leaving the nest to feed herself after the newly hatched nestling is a week old. Males feed the female and nestling throughout the incubation and brooding period. Once fledged, the young bird is fed by both parents for up to four months and remains with them until the next breeding season.

8.2.1.3 Presence within the Subject Site

The Glossy-black Cockatoo has been identified within the subject site with observed habitat use limited (i.e. foraging only) to the area to be cleared. HWR (2004) describe similar results for this species where its is said "*Glossy-black Cockatoo usage of the study area is minor*" and limited to the northern part of the study area. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**) and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019) with the paucity and restricted observation being a function of the limited amount of habitat within the subject site. The species is highly mobile and wide ranging, with breeding pairs often utilising habitat more broadly throughout the locality (i.e. habitat within 5 km of the subject site).

8.2.1.4 Assessment of Significance

Assessment of Significance: Glossy-black Cockatoo

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Glossy-black Cockatoo, which is based on the utilisation of the subject site and study area for foraging purposes, has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of reducing the foraging habitat area currently utilised by the species within the subject site by approximately 29.83 ha. The habitat area to be removed is currently limited to foraging habitat as there is no evidence of this species breeding within the subject site. Isolated unmapped foraging values will remain within the Conservation Area, which will be retained and actively managed. Threats to the natural recruitment of *Allocasuarina* spp. will be managed (i.e. control of feral deer), which has the potential to precent the recruitment of this important foraging resource. Further, habitat trees (i.e. hollow-bearing trees) will be protected in-perpetuity and would be available for nesting and breeding opportunities if foraging resources increase under management. It is anticipated that the establishment and management of the Conservation Area will allow the species to at least utilise existing scattered habitat for foraging purposes, as is currently the case, but may also lead to an increase in the area occupied by this species should an increase in foraging resources occur. To this end, it is considered that the Conservation Area is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time and dispersal to and from the Conservation Area (i.e. genetic flow).

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;

Assessment of Significance: Glossy-black Cockatoo

- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the restoration of diminished habitat areas, a habitat area of 29.83 ha is to be removed over three Phases of the Proposal, with Phase 2 representing the largest proportional impact (i.e. 19.08 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of habitat for this species.

Retained (modified)

The Conservation Area comprises scattered foraging habitat for this species (i.e. scattered *Allocasuarina torulosa*), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

Assessment of Significance: Glossy-black Cockatoo

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Glossy-black Cockatoo relies on large areas of native vegetation with sufficient densities of *Allocasuarina* spp. and hollow-bearing trees for foraging and breeding. The area of habitat to be removed is insufficiently large to satisfy a breeding pair of Glossy-black Cockatoos without reliance on additional resources in the locality. Utilisation of this habitat is most likely during the non-breeding period; a period where Glossy-black Cockatoos are highly mobile and less dependent on breeding habitat. The habitat is not likely to be important in natal dispersal; although it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020). Despite the impact of the recent fire event, the infrequent observation of this species within the subject site, the limited area of foraging habitat and more frequent observations of this species elsewhere in the locality it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of native vegetation cover occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through sensitive clearing procedures with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this

Assessment of Significance: Glossy-black Cockatoo	
	respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Local Land Services would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these

Assessment of Significance: Glossy-black Cockatoo	
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels.

Assessment of Significance: Glossy-black Cockatoo	
	Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.1.5 Conclusion

The Proposal will result in the progressive removal of 29.83 ha of foraging habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**) that may be used as foraging habitat by the Glossy-black Cockatoo. No significant habitat for this species will be removed within the study area (i.e. breeding habitat). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.2 Brown Treecreeper

8.2.2.1 Habitat

Brown Treecreeper eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species. It requires hollows in standing dead or live trees and tree stumps to nest. It uses a diverse range of woodland areas to forage for insects amongst leaf litter, tussocks and fallen timber, and along trunks and lateral branches.

8.2.2.2 Ecology

The Brown Treecreeper is a sedentary species, considered to be resident in many locations throughout its range; present in all seasons or year-round at many sites; territorial year-round, though some birds may disperse locally after breeding. It is a gregarious species and usually observed in pairs or small groups of 8 to 12 birds; terrestrial and arboreal in about equal proportions; active, noisy and conspicuous while foraging on trunks and branches of trees and amongst fallen timber; spend much more time foraging on the ground and fallen logs than other treecreepers. The species breeds in pairs or co-operatively in territories which range in size from 1.1 to 10.7 ha (mean = 4.4 ha). Each group is composed of a breeding pair with retained male offspring and, rarely, retained female offspring. Often in pairs or cooperatively breeding groups of two to five birds (BCD 2019b).

8.2.2.3 Presence within the Subject Site

The Brown Treecreeper has been identified very infrequently within the subject site with observation mostly in the Conservation Area. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**) with the infrequent observation consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019; Birdata 2020). The species is highly mobile and wide ranging, with breeding pairs often utilising habitat more broadly throughout the locality (i.e. habitat within 5 km of the subject site).

8.2.2.4 Assessment of Significance

Assessment of Significance: Brown Treecreeper

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Brown Treecreeper, which is based on known utilisation of the subject site and study area for foraging purposes (and possibly breeding – unconfirmed), has considered the effect of:

Assessment of Significance: Brown Treecreeper

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of reducing the habitat area currently utilised by the species within the subject site by approximately 209.64 ha, which is countered by the restoration and retention of 214.07 ha of habitat within the Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

Assessment of Significance: Brown Treecreeper

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 206.64 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 214.07 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and

Assessment of Significance: Brown Treecreeper

Figure 1.2), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Brown Treecreeper relies on large areas of native vegetation with sufficient densities of hollow-bearing trees for breeding. The area of habitat to be removed is sufficiently large to satisfy a breeding pair of Brown Treecreepers as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, the paucity of observations within the subject site (i.e. habitat possibly not relied on for important lifecycle processes such as breeding) and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this

Assessment of Significance: Brown Treecreeper	
	respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	The subject site currently has relatively low abundance of Noisy Miner (*Manorina melanocephala*) with greatest abundance associated with vegetation along cleared edges and a grazed understory. These areas are largely restricted to the Proposal impact footprint where vegetation clearing works are proposed. The increased abundance of Noisy Miners in this part of the subject site is likely due to the increased productivity of these lands and the modified/ absent understory (Lindenmayer et al 2018). The Proposal will shift the boundary between forested and treeless/ modified grazing lands upslope to a new interface demarcated by the boundary of the Conservation Area. A corresponding shift in Noisy Miner activity may also occur as a consequence resulting in increased Noisy Miner activity within the Conservation area. Patch size and understory condition are important factors in the effect of Noisy Miner aggression on woodland bird species (Lindenmayer et al 2018). In this respect the Proposal does not include any provisions for the establishment of bush fire asset protection zones within the Conservation Area. The exclusion of this management regime means that the generally shrubby

Assessment of Significance: Brown Treecreeper	
	understory of the native vegetation within the Conservation Area will remain intact and will therefore limit the propensity for Noisy Miner activity. Proposed enhancement works include the early removal of exotic flora such as African Olive and Lantana and use of mosaic fire to stimulate understorey growth and plant species diversity. In places, the exotic flora species are in high densities and currently suppress the natural regeneration of shrub and overstorey native species. Early removal of these species will allow the understorey within the Conservation Area to naturally regenerate, which is likely to be to the detriment of the Noisy Miner. The patchy use of fire is also likely to stimulate the regeneration of shrub species in places where exotic flora densities are high. The large patch area represented by the Conservation Area and adjoining E2 lands occur on unproductive relatively infertile soils. The Noisy Miner shows preference for productive sites (Oldland et al 2009), within decreased abundance associated with infertile unproductive sites (Montague Drake et al 2011). The Conservation Area predominantly occurs on infertile soils and as such is unlikely to be preferentially colonised by the Noisy Miner. It is concluded that the Phased removal of native vegetation may increase the potential for Noisy Miner occupation within the Conservation Area as habitat is progressively cleared and restricted to the Conservation Area. Exotic flora management and the use of fire to manage the understorey is expected to increase the understorey vegetation structure to a more natural state and accordingly limit the aggression of Noisy Miners. The low productivity associated with soils in the Conservation Area is also likely to limit the abundance and aggression of Noisy Miners. The large residual patch size is likely to maintain Noisy Miner free areas thus allowing for occupancy by sensitive woodland bird species. Therefore, it is considered that the Proposal is not likely to enhance the operation of this KTPs to an extent that would result in the decline or exclusion of sensitive woodland bird species.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove

Assessment of Significance: Brown Treecreeper	
	these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime. Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed

Assessment of Significance: Brown Treecreeper	
	within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow. The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs "Cat Trap Loan Agreement" as described on Councils website (https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.2.5 Conclusion

The Proposal will result in the progressive removal of 206.64 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 214.07 ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation

arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.3 Varied Sittella

8.2.3.1 Habitat

The Varied Sittella inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. Foraging habitat for Varied Sittella constitutes crevices in rough or decorticating bark, dead branches, standing dead trees and small branches and twigs in the tree canopy.

8.2.3.2 Ecology

This Varied Sittella builds nests in upright tree forks high in the living tree canopy. They can often re-use the same fork or tree in successive years. This species is sedentary, so exhibits a restricted foraging range. This species usually breeds cooperatively, with the breeding pair having several helpers. They will sometimes also breed in single pairs. Only the breeding female incubates the eggs and broods the young. All help to feed the young and remove faecal sacs.

8.2.3.3 Presence within the Subject Site

The Varied Sittella has been identified on occasion within the subject site with observation mostly in the Conservation Area. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**) with the observations indicating greater activity within areas of elevated habitat integrity, which is generally associated with the Conservation Area.

8.2.3.4 Assessment of Significance

Assessment of Significance: Varied Sittella

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Varied Sittella, which is based on known utilisation of the subject site and study area for foraging purposes (and possibly breeding – unconfirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and

Assessment of Significance: Varied Sittella

  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 209.64 ha over an 8+ year timeframe, which will be countered by the immediate retention of 214.07 ha habitat within the Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Varied Sittella

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 206.64 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 214.07 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Assessment of Significance: Varied Sittella

The Varied Sittella relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed is sufficiently large to satisfy a breeding pair of Varied Sittellas as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity

Assessment of Significance: Varied Sittella	
	development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	The subject site currently has relatively low abundance of Noisy Miner (*Manorina melanocephala*) with greatest abundance associated with vegetation along cleared edges and a grazed understory. These areas are largely restricted to the Proposal impact footprint where vegetation clearing works are proposed. The increased abundance of Noisy Miners in this part of the subject site is likely due to the increased productivity of these lands and the modified/ absent understory (Lindenmayer et al 2018). The Proposal will shift the boundary between forested and treeless/ modified grazing lands upslope to a new interface demarcated by the boundary of the Conservation Area. A corresponding shift in Noisy Miner activity may also occur as a consequence resulting in increased Noisy Miner activity within the Conservation area. Patch size and understory condition are important factors in the effect of Noisy Miner aggression on woodland bird species (Lindenmayer et al 2018). In this respect the Proposal does not include any provisions for the establishment of bush fire asset protection zones within the Conservation Area. The exclusion of this management regime means that the generally shrubby understory of the native vegetation within the Conservation Area will remain intact and will therefore limit the propensity for Noisy Miner activity. Proposed enhancement works include the early removal of exotic flora such as African Olive and Lantana and use of mosaic fire to stimulate understorey growth and plant species diversity. In places, the exotic flora species are in high densities and currently suppress the natural regeneration of shrub and overstorey native species. Early removal of these species will allow the understorey within the Conservation Area to naturally regenerate, which is likely to be to the detriment of the Noisy Miner. The patchy use of fire is also likely to stimulate the regeneration of shrub species in places where exotic flora densities are high.

Assessment of Significance: Varied Sittella	
	The large patch area represented by the Conservation Area and adjoining E2 lands occur on unproductive relatively infertile soils. The Noisy Miner shows preference for productive sites (Oldland et al 2009), within decreased abundance associated with infertile unproductive sites (Montague Drake et al 2011). The Conservation Area predominantly occurs on infertile soils and as such is unlikely to be preferentially colonised by the Noisy Miner. It is concluded that the Phased removal of native vegetation may increase the potential for Noisy Miner occupation within the Conservation Area as habitat is progressively cleared and restricted to the Conservation Area. Exotic flora management and the use of fire to manage the understorey is expected to increase the understorey vegetation structure to a more natural state and accordingly limit the aggression of Noisy Miners. The low productivity associated with soils in the Conservation Area is also likely to limit the abundance and aggression of Noisy Miners. The large residual patch size is likely to maintain Noisy Miner free areas thus allowing for occupancy by sensitive woodland bird species. Therefore, it is considered that the Proposal is not likely to enhance the operation of this KTPs to an extent that would result in the decline or exclusion of sensitive woodland bird species.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

Assessment of Significance: Varied Sittella	
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime. Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow. The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs "Cat Trap Loan Agreement" as described on Councils website (https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.3.5 Conclusion

The Proposal will result in the progressive removal of 212.14 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). Countering this impact, the Proposal will retain a 'like for like' habitat area of 214.07 ha (i.e. the Conservation Area) for in-perpetuity protection and management. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.4 Little Lorikeet

8.2.4.1 Habitat

The Little Lorikeet roosts in treetops, preferably in close proximity to feeding areas. Feeds mostly on nectar and pollen, occasionally on native fruits such as mistletoe. It typically nests in hollows in the limb or trunk of smooth-barked Eucalypt. Forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in Angophora, Melaleuca and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity. Isolated flowering trees in open country (e.g. paddocks, roadside remnants and urban trees) also help sustain viable populations of the species.

8.2.4.2 Ecology

The Little Lorikeet preferentially nests in proximity to feeding areas, most typically selecting hollows in the limb or trunk of smooth-barked Eucalypts. Entrance is small (3 cm) and usually high above the ground (2–15 m). These nest sites are often used repeatedly for decades, suggesting that preferred sites are limited. Riparian trees often chosen, including species like Allocasuarina. Nesting season extends from May to September. In years when flowering is prolific, Little Lorikeet pairs can breed twice, producing 3-4 young per attempt. However, the survival rate of fledglings is unknown (BCD 2019b).

8.2.4.3 Presence within the Subject Site

The Little Lorikeet has been identified infrequently within the subject site with observation in the area to be cleared and the Conservation Area. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**) with the infrequent observation consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019; Birdata 2020). The species is highly mobile and wide ranging, with breeding pairs often utilising habitat more broadly throughout the locality (i.e. habitat within 5 km of the subject site).

8.2.4.4 Assessment of Significance

Assessment of Significance: Little Lorikeet

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Little Lorikeet, which is based on known utilisation of the subject site and study area for foraging purposes (and possibly breeding – unconfirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],

Assessment of Significance: Little Lorikeet

- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 212.14 ha over an 8+ year timeframe, which will be countered by the immediate retention of 214.07 ha habitat within the Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

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In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 212.14 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 214.07 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and

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Figure 1.2), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Little Lorikeet relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed is sufficiently large to satisfy a breeding pair of Little Lorikeets as is the area of habitat to be retained in the Conservation Area. The species is sedentary during breeding and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this

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	respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	The subject site currently has relatively low abundance of Noisy Miner (*Manorina melanocephala*) with greatest abundance associated with vegetation along cleared edges and a grazed understory. These areas are largely restricted to the Proposal impact footprint where vegetation clearing works are proposed. The increased abundance of Noisy Miners in this part of the subject site is likely due to the increased productivity of these lands and the modified/ absent understory (Lindenmayer et al 2018). The Proposal will shift the boundary between forested and treeless/ modified grazing lands upslope to a new interface demarcated by the boundary of the Conservation Area. A corresponding shift in Noisy Miner activity may also occur as a consequence resulting in increased Noisy Miner activity within the Conservation area. Patch size and understory condition are important factors in the effect of Noisy Miner aggression on woodland bird species (Lindenmayer et al 2018). In this respect the Proposal does not include any provisions for the establishment of bush fire asset protection zones within the Conservation Area. The exclusion of this management regime means that the generally shrubby

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	understory of the native vegetation within the Conservation Area will remain intact and will therefore limit the propensity for Noisy Miner activity. Proposed enhancement works include the early removal of exotic flora such as African Olive and Lantana and use of mosaic fire to stimulate understorey growth and plant species diversity. In places, the exotic flora species are in high densities and currently suppress the natural regeneration of shrub and overstorey native species. Early removal of these species will allow the understorey within the Conservation Area to naturally regenerate, which is likely to be to the detriment of the Noisy Miner. The patchy use of fire is also likely to stimulate the regeneration of shrub species in places where exotic flora densities are high. The large patch area represented by the Conservation Area and adjoining E2 lands occur on unproductive relatively infertile soils. The Noisy Miner shows preference for productive sites (Oldland et al 2009), within decreased abundance associated with infertile unproductive sites (Montague Drake et al 2011). The Conservation Area predominantly occurs on infertile soils and as such is unlikely to be preferentially colonised by the Noisy Miner. It is concluded that the Phased removal of native vegetation may increase the potential for Noisy Miner occupation within the Conservation Area as habitat is progressively cleared and restricted to the Conservation Area. Exotic flora management and the use of fire to manage the understorey is expected to increase the understorey vegetation structure to a more natural state and accordingly limit the aggression of Noisy Miners. The low productivity associated with soils in the Conservation Area is also likely to limit the abundance and aggression of Noisy Miners. The large residual patch size is likely to maintain Noisy Miner free areas thus allowing for occupancy by sensitive woodland bird species. Therefore, it is considered that the Proposal is not likely to enhance the operation of this KTPs to an extent that would result in the decline or exclusion of sensitive woodland bird species.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove

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	these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime. Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed

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	within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow. The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs "Cat Trap Loan Agreement" as described on Councils website (https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.4.5 Conclusion

The Proposal will result in the progressive removal of 212.14 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). Countering this impact, the Proposal will retain a 'like for like' habitat area of 214.07 ha (i.e. the Conservation Area) for in-perpetuity protection and management. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.5 White-bellied Sea-Eagle

8.2.5.1 Habitat

The White-bellied Sea Eagle is found in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands (DoE 2017a). It occupies habitat characterised by the presence of large areas of open water (larger rivers, swamps, lakes, the sea) and have been recorded in (or flying over) a variety of terrestrial habitats (DoE 2017a). This species has been recorded at or in the vicinity of freshwater swamps, lakes, reservoirs, billabongs, saltmarsh and sewage ponds. Within the locality, there are 71 recorded locations of the White-bellied Sea Eagle, scattered throughout and predominantly in association with Grahamstown Dam in the east and along larger riparian areas and wetlands.

8.2.5.2 Ecology

The White-bellied Sea-eagle nests are primarily built in tall emergent eucalypt trees and they may be built in a variety of sites including; bushes, mangroves, cliffs, rocky outcrops, caves, crevices, on the ground or even on artificial structures (Marchant & Higgins 1993; DoE 20117a). Nest trees often have emergent dead branches which are used as 'guard roosts' (Dennis et al. 2011b; Debus et al. 2014 ; as cited by, NSW Scientific Committee 2016).

8.2.5.3 Presence within the Subject Site

The White-bellied Sea-eagle been consistently observed within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes vegetation within and surrounding wetland 803, with nesting occurring in a tree adjacent toe this wetland and within the Conservation Area.

8.2.5.4 Assessment of Significance

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a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the White-bellied Sea-eagle, which is based on known utilisation of the subject site and study area for breeding and possibly foraging purposes (unconfirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;

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- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 9.68 ha over an 8+ year timeframe, which will be countered by the immediate retention of 9.99 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. An important contribution to habitat improvement is the revegetation of treeless lands surrounding wetland 803, which will have the purpose of improving patch integrity hence minimise (buffer) the effect of indirect impacts originating from the future developed landscape. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will minimise the impact intensity on resident fauna at the margins of the Conservation Area.

Additional mitigation focusing on the minimisation of light pollution on nesting/ roosting birds is also proposed. Directional (shielded) street lighting designed to shed light directly onto the road surface. Sensitive directional residential lighting is also proposed to minimise any disruption to nesting/ roosting animals during the night.

The retained habitat comprises suitable 'like for like' values for breeding including the retention of the nest tree, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

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In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~3.12 ha) and restoration of diminished habitat areas, a habitat area of 9.68 ha is to be removed over three Phases of the Proposal, with Phase 2 representing the largest proportional impact (i.e. 3.48 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of breeding habitat for this species.

Retained (modified)

The Conservation Area comprises breeding habitat (i.e. 9.99 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as

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habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The White-bellied Sea-eagle utilises a large home range for foraging with nest sites peripheral to these foraging areas being important to the species. A nest of the White-bellied Sea-eagle, which is to be retained within the Conservation Area, is known to produce successful breeding events. Buffer habitat that is to be removed is peripheral to the nest site. Buffer habitat within typical movement pathways to and from the nest site over wetland 803 will remain unchanged. Treeless lands adjacent to wetland 803 within the Conservation area will be revegetated to a forest. Buffer habitat east of the nest tree is likely to be used for movement, although less frequently than pathways over wetland 803 which leads into the Williams River floodplain. Notwithstanding, nest fidelity is shown to be adversely impacted by development within buffer habitat, thus indicating that the habitat associated with the nest tree is likely to be important for the nesting pair.

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing

Assessment of Significance: White-bellied Sea Eagle	
	the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.

Assessment of Significance: White-bellied Sea Eagle	
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.5.5 Conclusion

The Proposal will result in the progressive removal of 9.68 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). Countering this impact, the Proposal will retain a 'like for like' habitat area of 9.99 ha inclusive of the known nest tree (i.e. the Conservation Area) for in-perpetuity protection and management. In addition, cleared lands located within close proximity to the nest tree will also be revegetated and will further improve the conditions surrounding the nest tree. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.6 Square-tailed Kite

8.2.6.1 Habitat

The Square-tailed Kite is found in a variety of timbered habitats including dry woodlands and open forests and shows a particular preference for timbered watercourses. Appears to occupy large hunting ranges of more than 100km^2 (BCD 2019).

8.2.6.2 Ecology

The Square-tailed Kite usually hunts by flying low over the treetops, occasionally plunging down through the foliage to snatch a bird or insect from among the leaves or twigs. The species often eats the nestlings of birds, and sometimes it will remove the entire nest to get at the young birds, and at other times may remove the tiny birds, one clutched tightly by the talons of each foot. They also catch adult birds by surprising them in the canopy of the forest. It breeds from July to February, with nest sites generally located along or near watercourses, in a fork or on large horizontal limbs (BCD 2019).

8.2.6.3 Presence within the Subject Site

The Square-tailed Kite has been observed once within the subject site flying over the tree canopy in the Conservation Area. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes forested vegetation cover, which the species may periodically use for foraging when conditions are suitable. Frequent observations within the Williams and Hunter River floodplain (BCD 2019a) and wetland 804 are consistent with the wide ranging and highly mobile character of this species.

8.2.6.4 Assessment of Significance

Assessment of Significance: Square-tailed Kite

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Square-tailed Kite, which is based on known utilisation of the subject site and study area for foraging purposes with no confirmed breeding activity (although possible), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;

Assessment of Significance: Square-tailed Kite

- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 212.14 ha over an 8+ year timeframe, which will be countered by the immediate retention of 214.07 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Square-tailed Kite

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 206.64 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 214.07 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

Assessment of Significance: Square-tailed Kite

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Square-tailed Kite relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed is insufficiently large to satisfy a breeding pair of Square-tailed Kite and is likely to form part of a much larger home range. The species is largely sedentary and as such would likely use the habitat for breeding and non-breeding purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, the likely ongoing utilisation of habitat by this species in the locality (e.g. wetland 804 and Hunter – Williams River floodplain) and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool'

Assessment of Significance: Square-tailed Kite	
	(https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before

Assessment of Significance: Square-tailed Kite	
	moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.6.5 Conclusion

The Proposal will result in the progressive removal of 212.14 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 214.07 ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.7 Osprey

8.2.7.1 Habitat

The Osprey is a fish dependent species and consequently favours coastal areas, especially the mouths of large rivers, lagoons and lakes that are capable of sustaining fish species of typical weight range 150-300g. The Osprey nests in live and dead trees near large tracts of suitable foraging habitat (e.g. large riverine corridors) and is also able to use artificial structures.

8.2.7.2 Ecology

The Osprey breeds from July to September in NSW. Nests are made high up in dead trees or in dead crowns of live trees, usually within one kilometre of the sea. The incubation of 2-3 eggs, usually by the female, is about 40 days. Female remains with young almost until they fly, usually after about nine weeks in the nest.

8.2.7.3 Presence within the Subject Site

The Osprtey has been identified once within the subject site (i.e. a fly over). Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes native vegetation nearby major riverine corridors and wetlands, which the species might use for nesting and/ or perching during foraging forays.

8.2.7.4 Assessment of Significance

Assessment of Significance: Osprey

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Osprey, which is based on known utilisation of the subject site and study area for movement (i.e. fly over) with no confirmed breeding activity (although possible), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:

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  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will not reduce the availability of habitat currently utilised by the species. Conversely, the Proposal will retain habitat surrounding wetland 803 that may be used for breeding purposes. Mitigation works involving the management of stormwater, as specified in **Section 7** and assessed in **Section 5.1.2**, will be completed to minimise the effect of altered hydraulic functioning in the catchments of wetlands 803 and 803. The stormwater design principles that are to be incorporated into the Proposal are likely to have a minor and inconsequential impact on wetlands 803 and 804 such that there is no expected change in vegetation types or condition within these wetlands. Wetting and drying cycles are expected to remain relatively consistent with pre-development conditions.

The retained habitat comprises suitable 'like for like' habitat, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle. Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. minor and inconsequential changes in hydraulic conditions) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

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Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Removal

The Proposal is not expected to result in the loss of habitat for this species (i.e. wetland, swamp sclerophyll and adjacent vegetation to be retained). Indirect impacts on these areas of retained potential habitat are minimal and unlikely to result in any loss.

Retained (modified)

The Conservation Area comprises potential habitat (i.e. ~14.85 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works). Changes in vegetation and habitat values as a consequence of altered hydrological regimes are expected to be minor and inconsequential (Alluvium 2019).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Habitat for the Osprey comprises estuarine and coastal waters for foraging with adjacent lands for nesting and breeding. Habitat within the subject site may be used for breeding purposes only; although there is no current evidence of this type of usage. Nesting habitat is largely restricted to the periphery of wetland 803, which is to be retained in the Conservation Area and will not be removed. The recent bushfires of the 2019-20 summer season have little impact on occupied habitat along the NSW east coast that may provide habitat for this species (BCD 2020).

In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be affected by the Proposal is not regarded as important to the long-term survival of the species in the locality.

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e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).	
Critical habitat has not been declared or mapped for this species. Not applicable.	
f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.	
No approved NSW recovery or threat abatement plans relate to this species. Not applicable.	
g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events.

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	The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.7.5 Conclusion

The Proposal will not result in the removal of habitat for this species. Conversely, potential breeding sites in wetland and peripheral lands are to be retained. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition

with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.8 Magpie Goose

8.2.8.1 Habitat

The Magpie Goose is found in a variety of open wetland areas such as floodplains and swamps although mainly found in shallow wetlands (less than 1 m deep) with dense growth of rushes or sedges. Often seen in trios or flocks on shallow wetlands, dry ephemeral swamps, wet grasslands and floodplains; roosts in tall vegetation.

8.2.8.2 Ecology

Activities are centred on wetlands, mainly those on floodplains of rivers and large shallow wetlands formed by run-off where it is fairly sedentary apart from some movement during the dry season. The species can breed in both summer and winter dominated rainfall areas and is strongly influenced by water level; most breeding now occurs in monsoonal areas; nests are formed in trees over deep water; breeding is unlikely in south-eastern NSW. They are colonial breeders and are gregarious outside of the breeding season when they can form large and noisy flocks of up to a few thousand individuals.

8.2.8.3 Presence within the Subject Site

The Magpie Goose has not been identified within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes vegetation within wetland 803, which the species may periodically use for foraging when conditions are suitable.

8.2.8.4 Assessment of Significance

Assessment of Significance: Magpie Goose

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Magpie Goose, which is based on possible habitat utilisation (i.e. not recorded) of the subject site and study area for foraging purposes (i.e. no breeding expected but may be possible), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;

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- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will not reduce the availability of habitat currently utilised by the species. Conversely, the Proposal will retain habitat within and surrounding wetland 803 that may be used for foraging breeding purposes. Mitigation works involving the management of stormwater, as specified in **Section 7** and assessed in **Section 5.1.2**, will be completed to minimise the effect of altered hydraulic functioning in the catchments of wetlands 803 and 803. The stormwater design principles that are to be incorporated into the Proposal are likely to have a minor and inconsequential impact on wetlands 803 and 804 such that there is no expected change in vegetation types or condition within these wetlands. Wetting and drying cycles are expected to remain relatively consistent with pre-development conditions.

The retained habitat will be actively managed and protected in-perpetuity for the benefit of the species. The removal of livestock and management of feral deer may improve habitat conditions within wetland 803 where macrophyte growth is allowed to occur. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle should it utilise wetland 803 either periodically for foraging or for breeding. Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. minor and inconsequential changes in hydraulic conditions) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

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Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Removal

The Proposal is not expected to result in the loss of habitat for this species (i.e. wetland, swamp sclerophyll and adjacent vegetation to be retained). Indirect impacts on these areas of retained potential habitat are minimal and unlikely to result in any loss.

Retained (modified)

The Conservation Area comprises potential habitat (i.e. ~14.85 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works). Changes in vegetation and habitat values as a consequence of altered hydrological regimes are expected to be minor and inconsequential (Alluvium 2019).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Habitat for the Magpie Goose comprises coastal wetlands for foraging and breeding. Habitat within the subject site may be used for infrequent foraging purposes with breeding events considered unlikely (i.e. wetland vegetation generally unsuitable for nesting). Foraging habitat is largely restricted to the periphery of wetland 803, which is to be

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retained in the Conservation Area and will not be removed. The recent bushfires of the 2019-20 summer season have little impact on occupied habitat along the NSW east coast that may provide habitat for this species (BCD 2020).

In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be affected by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this

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	respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of

Assessment of Significance: Magpie Goose	
	native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	The subject site currently has limited examples of escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as escaped garden plants. It is considered that this KTP are not likely to result in any detrimental impacts to threatened species and ecological communities.

8.2.8.5 Conclusion

The Proposal will not result in the loss of habitat for this species. Indirect impacts through changes in hydraulic conditions are considered minor and inconsequential. Removal of livestock grazing and herbivory by feral deer is likely to result in isolated improvement in wetland vegetation habitat, with suitable habitat retained in the Conservation area that is subject to in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect habitat of value for this species. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.9 Australasian Bittern

8.2.9.1 Habitat

The Australasian Bittern is a cryptic and partly nocturnal species that inhabits densely vegetated wetlands. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Eleocharis* spp.).

8.2.9.2 Ecology

The Australasian Bittern hides during the day amongst dense reeds or rushes and feed mainly at night on frogs, fish, yabbies, spiders, insects and snails. It typically constructs feeding platforms over deeper water from reeds trampled by the bird; platforms are often littered with prey remains. Breeding occurs in summer from October to January; nests are built in secluded places in densely-vegetated wetlands on a platform of reeds; there are usually six olive-brown eggs to a clutch.

8.2.9.3 Presence within the Subject Site

The Australasian Bittern has not been identified within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes vegetation within wetland 803, which the species may periodically use for foraging when conditions are suitable.

8.2.9.4 Assessment of Significance

Assessment of Significance: Australasian Bittern

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Australasian Bittern, which is based on possible habitat utilisation (i.e. not recorded) of the subject site and study area for foraging purposes (i.e. no breeding expected but may be possible), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will not reduce the availability of habitat currently utilised by the species. Conversely, the Proposal will retain habitat within and surrounding wetland 803 that may be used for foraging and breeding purposes. Mitigation works involving the management of stormwater, as specified in **Section 7** and assessed in **Section 5.1.2**, will be completed to minimise the effect of altered hydraulic functioning in the catchments of wetlands 803 and 804. The stormwater design principles that are to be incorporated into the Proposal are likely to have a minor and inconsequential impact on wetlands 803 and 804 such that there is no expected change in vegetation types or condition within these wetlands. Wetting and drying cycles are expected to remain relatively consistent with pre-development conditions.

The retained habitat will be actively managed and protected in-perpetuity for the benefit of the species. The removal of livestock and management of feral deer may improve habitat conditions within wetland 803 where macrophyte growth is allowed to occur. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle should it utilise wetland 803 either periodically for foraging or for breeding. Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;

Assessment of Significance: Australasian Bittern

- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. minor and inconsequential changes in hydraulic conditions) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

<u>Removal</u>

The Proposal is not expected to result in the loss of habitat for this species (i.e. wetland, swamp sclerophyll and adjacent vegetation to be retained). Indirect impacts on these areas of retained potential habitat are minimal and unlikely to result in any loss.

<u>Retained (modified)</u>

The Conservation Area comprises potential habitat (i.e. ~14.85 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works). Changes in vegetation and habitat values as a consequence of altered hydrological regimes are expected to be minor and inconsequential (Alluvium 2019).

i) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Assessment of Significance: Australasian Bittern

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

ii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Habitat for the Australasian Bittern comprises coastal wetlands for foraging and breeding. Habitat within the subject site may be used for infrequent foraging purposes with breeding events considered unlikely (i.e. wetland vegetation generally unsuitable for nesting). Foraging habitat is largely restricted to the periphery of wetland 803, which is to be retained in the Conservation Area and will not be removed. The recent bushfires of the 2019-20 summer season have little impact on occupied habitat along the NSW east coast that may provide habitat for this species (BCD 2020).

In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be affected by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to

Assessment of Significance: Australasian Bittern	
	provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.

Assessment of Significance: Australasian Bittern	
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	The subject site currently has limited examples of escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as escaped garden plants. It is considered that this KTP are not likely to result in any detrimental impacts to threatened species and ecological communities.

8.2.9.5 Conclusion

The Proposal will not result in the loss of habitat for this species. Indirect impacts through changes in hydraulic conditions are considered minor and inconsequential. Removal of livestock grazing and herbivory by feral deer is likely to result in isolated improvement in wetland vegetation habitat, with suitable

habitat retained in the Conservation area that is subject to in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect habitat of value for this species. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.10 Black Bittern

8.2.10.1 Habitat

The Black Bittern is mainly found in freshwater wetlands, where they inhabit dense emergent vegetation of reeds and sedges, and inundated shrub thickets. They are also occasionally found in brackish and saline wetlands such as mangrove swamps, Juncus-dominated salt marsh and the wooded margins of coastal lagoons (Marchant and Higgin 1991). When disturbed, freezes in a characteristic bittern posture (stretched tall, bill pointing up, so that shape and streaked pattern blend with upright stems of reeds), or will fly up to a branch or flush for cover where it will freeze again.

8.2.10.2 Ecology

The Black Bittern is generally solitary, but occurs in pairs during the breeding season, from December to March. During the day, it roosts in trees or on the ground amongst dense reeds. Feeds on frogs, reptiles, fish and invertebrates, including snails, dragonflies, shrimps and crayfish, with most feeding done at dusk and at night. Like other bitterns, but unlike most herons, nesting is solitary. Nests, built in spring are located on a branch overhanging water and consist of a bed of sticks and reeds on a base of larger sticks. Between three and five eggs are laid and both parents incubate and rear the young.

8.2.10.3 Presence within the Subject Site

The Black Bittern has not been identified within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes vegetation within wetland 803, which the species may periodically use for foraging when conditions are suitable.

8.2.10.4 Assessment of Significance

Assessment of Significance: Black Bittern

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Black Bittern, which is based on possible habitat utilisation (i.e. not recorded) of the subject site and study area for foraging purposes (i.e. no breeding expected but may be possible), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;

Assessment of Significance: Black Bittern

- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will not reduce the availability of habitat currently utilised by the species. Conversely, the Proposal will retain habitat within and surrounding wetland 803 that may be used for foraging breeding purposes. Mitigation works involving the management of stormwater, as specified in **Section 7** and assessed in **Section 5.1.2**, will be completed to minimise the effect of altered hydraulic functioning in the catchments of wetlands 803 and 803. The stormwater design principles that are to be incorporated into the Proposal are likely to have a minor and inconsequential impact on wetlands 803 and 804 such that there is no expected change in vegetation types or condition within these wetlands. Wetting and drying cycles are expected to remain relatively consistent with pre-development conditions.

The retained habitat will be actively managed and protected in-perpetuity for the benefit of the species. The removal of livestock and management of feral deer may improve habitat conditions within wetland 803 where macrophyte growth is allowed to occur. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle should it utilise wetland 803 either periodically for foraging or for breeding. Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. minor and inconsequential changes in hydraulic conditions) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Black Bittern

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Removal

The Proposal is not expected to result in the loss of habitat for this species (i.e. wetland, swamp sclerophyll and adjacent vegetation to be retained). Indirect impacts on these areas of retained potential habitat are minimal and unlikely to result in any loss.

Retained (modified)

The Conservation Area comprises potential habitat (i.e. ~14.85 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works). Changes in vegetation and habitat values as a consequence of altered hydrological regimes are expected to be minor and inconsequential (Alluvium 2019).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Habitat for the Black Bittern comprises coastal wetlands for foraging and breeding. Habitat within the subject site may be used for infrequent foraging purposes with breeding events considered unlikely (i.e. wetland vegetation generally unsuitable for nesting). Foraging habitat is largely restricted to the periphery of wetland 803, which is to be

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retained in the Conservation Area and will not be removed. The recent bushfires of the 2019-20 summer season have little impact on occupied habitat along the NSW east coast that may provide habitat for this species (BCD 2020).

In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be affected by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this

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	respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of

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	native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	The subject site currently has limited examples of escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as escaped garden plants. It is considered that this KTP are not likely to result in any detrimental impacts to threatened species and ecological communities.

8.2.10.5 Conclusion

The Proposal will not result in the loss of habitat for this species. Indirect impacts through changes in hydraulic conditions are considered minor and inconsequential. Removal of livestock grazing and herbivory by feral deer is likely to result in isolated improvement in wetland vegetation habitat, with suitable habitat retained in the Conservation area that is subject to in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect habitat of value for this species. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.11 Dusky Woodswallow

8.2.11.1 Habitat

The Dusky Woodswallow is often reported in woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including regenerating forests; very occasionally in moist forests or rainforests (Higgins and Peter 2002). At sites where Dusky Woodswallows are recorded the understorey is typically open with sparse eucalypt saplings, acacias and other shrubs, including heath (Higgins and Peter 2002). The ground cover may consist of grasses, sedges or open ground, often with coarse woody debris (Higgins and Peter 2002). Birds are also often observed in farm land, usually at the edges of forest or woodland or in roadside remnants or wind breaks with dead timber (Higgins and Peter 2002; M. Schulz in litt. November 2014). In western New South Wales this species is primarily associated with River Red Gum/Black Box/Coolibah open forest/woodland associated with larger river/creek systems and is less common and far more patchily distributed in other communities such as mallee and cypress-pine woodland (M. Schulz in litt. November 2014).

8.2.11.2 Ecology

Primarily eats invertebrates, mainly insects, which are captured whilst hovering or sallying above the canopy or over water. Also frequently hovers, sallies and pounces under the canopy, primarily over leaf litter and dead timber. Also occasionally take nectar, fruit and seed.

Depending on location and local climatic conditions (primarily temperature and rainfall), the dusky woodswallow can be resident year round or migratory. In NSW, after breeding, birds migrate to the north of the state and to southeastern Queensland, while Tasmanian birds migrate to southeastern NSW after breeding. Migrants generally depart between March and May, heading south to breed again in spring. There is some evidence of site fidelity for breeding.

Although dusky woodswallows generally breed as solitary pairs or occasionally in small flocks, large flocks may form around abundant food sources in winter. Large flocks may also form before migration, which is often undertaken with other species.

The nest is an open, cup-shape, made of twigs, grass, fibrous rootlets and occasionally casuarina needles, and may be lined with grass, rootlets or infrequently horsehair, occasionally unlined. Nest sites vary greatly, but generally occur in shrubs or low trees, living or dead, horizontal or upright forks in branches, spouts, hollow stumps or logs, behind loose bark or in a hollow in the top of a wooden fence post. Nest sites may be exposed or well concealed by foliage.

8.2.11.3 Presence within the Subject Site

The Dusky Woodswallow has been observed on occasion within the subject site flying over wetland 803 in the Conservation Area. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes the wetland and forested vegetation cover, which the species may periodically use for foraging and breeding. Observations in spring indicate the species was a breeding migrant, with activity limited to the Conservation Area (i.e. wetland 803).

8.2.11.4 Assessment of Significance

Assessment of Significance: Dusk Woodswallow

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Dusk Woodswallow, which is based on known habitat utilisation of the subject site and study area for foraging purposes and possible breeding activity (although not confirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

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The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 212.14 ha over an 8+ year timeframe, which will be countered by the immediate retention of 219.56 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable foraging values and areas for breeding and will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

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ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 212.14 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 219.56 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Dusky Woodswallow relies on large areas of native vegetation for breeding and foraging. While migratory, the species can over winter in breeding habitat, which does not appear to be the case within the subject site. The area of habitat to be removed is sufficiently large to satisfy a breeding pair of Dusky Woodswallows as is the area of habitat to be retained in the Conservation Area. Given the observation of this species in spring it is considered that the species may use this habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020).

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In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, the paucity of observations within the subject site (i.e. migratory and does not over winter) and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing

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	native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	The subject site currently has relatively low abundance of Noisy Miner (*Manorina melanocephala*) with greatest abundance associated with vegetation along cleared edges and a grazed understory. These areas are largely restricted to the Proposal impact footprint where vegetation clearing works are proposed. The increased abundance of Noisy Miners in this part of the subject site is likely due to the increased productivity of these lands and the modified/ absent understory (Lindenmayer et al 2018). The Proposal will shift the boundary between forested and treeless/ modified grazing lands upslope to a new interface demarcated by the boundary of the Conservation Area. A corresponding shift in Noisy Miner activity may also occur as a consequence resulting in increased Noisy Miner activity within the Conservation area. Patch size and understory condition are important factors in the effect of Noisy Miner aggression on woodland bird species (Lindenmayer et al 2018). In this respect the Proposal does not include any provisions for the establishment of bush fire asset protection zones within the Conservation Area. The exclusion of this management regime means that the generally shrubby understory of the native vegetation within the Conservation Area will remain intact and will therefore limit the propensity for Noisy Miner activity. Proposed enhancement works include the early removal of exotic flora such as African Olive and Lantana and use of mosaic fire to stimulate understorey growth and plant species diversity. In places, the exotic flora species are in high densities and currently suppress the natural regeneration of shrub and overstorey native species. Early removal of these species will allow the understorey within the Conservation Area to naturally regenerate, which is likely to be to the detriment of the Noisy Miner. The patchy use of fire is also likely to stimulate the regeneration of shrub species in places where exotic flora densities are high. The large patch area represented by the Conservation Area and adjoining E2 lands occur on unproductive relatively infertile soils. The Noisy Miner shows preference for productive sites (Oldland et al 2009), within decreased abundance associated with infertile unproductive sites (Montague Drake et al 2011). The Conservation Area predominantly occurs on infertile soils and as such is unlikely to be preferentially colonised by the Noisy Miner. It is concluded that the Phased removal of native vegetation may increase the potential for Noisy Miner occupation within the Conservation Area as habitat is progressively cleared and restricted to the Conservation Area. Exotic flora management and the

Assessment of Significance: Dusk Woodswallow	
	use of fire to manage the understorey is expected to increase the understorey vegetation structure to a more natural state and accordingly limit the aggression of Noisy Miners. The low productivity associated with soils in the Conservation Area is also likely to limit the abundance and aggression of Noisy Miners. The large residual patch size is likely to maintain Noisy Miner free areas thus allowing for occupancy by sensitive woodland bird species. Therefore, it is considered that the Proposal is not likely to enhance the operation of this KTPs to an extent that would result in the decline or exclusion of sensitive woodland bird species.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before

Assessment of Significance: Dusk Woodswallow	
	moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime. Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow. The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs "Cat Trap Loan Agreement" as described on Councils website (https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.11.5 Conclusion

The Proposal will result in the progressive removal of 212.14 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 219.56 ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key

threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.12 Black-necked Stork

8.2.12.1 Habitat

This species inhabits tropical and warm-temperate terrestrial wetlands, estuarine and littoral habitats and occasionally grassland and wooded areas (Marchant and Higgins 1990). Foraging occurs in fresh or saline waters up to 0.5m deep, preferring extensive sheets of shallow freshwater over grassland or sedgeland; shallow swamps with short emergent vegetation and abundant aquatic flora and permanent billabongs and pools on floodplains (Marchant and Higgins 1990). Less common in intertidal waters, littoral and estuarine mudflats or areas of fringing mangroves (Marchant and Higgins 1990).

8.2.12.2 Ecology

Black-necked Storks build large nests high in tall trees close to water. Trees usually provide clear observation of the surroundings and are at low elevation (reflecting the floodplain habitat). In NSW, breeding activity occurs May - January; incubation May - October; nestlings July - January; fledging from September. Parents share nest duties and in one study about 1.3-1.7 birds were fledged per nest. The NSW breeding population has been estimated at about 75 pairs. Territories are large and variable in size. They have been estimated to average about 9,000 ha, ranging from 3,000-6,000 ha in high quality habitat and 10,000-15,000 ha in areas where habitat is poor or dispersed (BCD 2019b).

8.2.12.3 Presence within the Subject Site

The Black-necked Stork is rarely observed within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes vegetation within wetland 803, which the species may periodically use for foraging when conditions are suitable.

8.2.12.4 Assessment of Significance

Assessment of Significance: Black-necked Stork

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Black-necked Stork, which is based on infrequent habitat utilisation (i.e. not recently recorded) of the subject site and study area for foraging purposes (i.e. no breeding expected but may be possible), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;

Assessment of Significance: Black-necked Stork

- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will not reduce the availability of habitat currently utilised by the species. Conversely, the Proposal will retain habitat within and surrounding wetland 803 that may be used for foraging and breeding purposes. Mitigation works involving the management of stormwater, as specified in **Section 7** and assessed in **Section 5.1.2**, will be completed to minimise the effect of altered hydraulic functioning in the catchments of wetlands 803 and 804. The stormwater design principles that are to be incorporated into the Proposal are likely to have a minor and inconsequential impact on wetlands 803 and 804 such that there is no expected change in vegetation types or condition within these wetlands. Wetting and drying cycles are expected to remain relatively consistent with pre-development conditions allowing for periodic (infrequent) foraging forays, which appears to be the limit of activity demonstrated by this species within the wetland 803.

The retained habitat will be actively managed and protected in-perpetuity for the benefit of the species. The removal of livestock and management of feral deer may improve habitat conditions within wetland 803 where macrophyte growth is allowed to occur. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle should it utilise wetland 803 either periodically for foraging or for breeding. Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. minor and inconsequential changes in hydraulic conditions) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Black-necked Stork

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Removal

The Proposal is not expected to result in the loss of habitat for this species (i.e. wetland, swamp sclerophyll and adjacent vegetation to be retained). Indirect impacts on these areas of retained potential habitat are minimal and unlikely to result in any loss.

Retained (modified)

The Conservation Area comprises potential habitat (i.e. ~14.85 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works). Changes in vegetation and habitat values as a consequence of altered hydrological regimes are expected to be minor and inconsequential (Alluvium 2019).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Habitat for the Black-necked Stork comprises coastal wetlands for foraging and breeding. Habitat within the subject site may be used for infrequent foraging purposes with breeding events considered unlikely (i.e. the only recorded breeding activity by this species is in a wetland near Tomago). Foraging habitat is largely restricted to infrequent

Assessment of Significance: Black-necked Stork

forays in wetland 803, which is to be retained in the Conservation Area and will not be removed or adversely impacted. The recent bushfires of the 2019-20 summer season have little impact on occupied habitat along the NSW east coast that may provide habitat for this species (BCD 2020).

In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be affected by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this

Assessment of Significance: Black-necked Stork	
	respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of

Assessment of Significance: Black-necked Stork	
	native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	The subject site currently has limited examples of escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as escaped garden plants. It is considered that this KTP are not likely to result in any detrimental impacts to threatened species and ecological communities.

8.2.12.5 Conclusion

The Proposal will not result in the loss of habitat for this species. Indirect impacts through changes in hydraulic conditions are considered minor and inconsequential. Removal of livestock grazing and herbivory by feral deer is likely to result in isolated improvement in wetland vegetation habitat, with suitable habitat retained in the Conservation area that is subject to in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect habitat of value for this species. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.13 Grey-crowned Babbler

8.2.13.1 Habitat

The Grey-crowned Babbler can be found in open Box-Gum Woodlands on the slopes, Box-Cypress pine and open Box Woodlands on alluvial plains and in woodlands on fertile soils in coastal regions (OEH 2019b). Woodlands typically have regenerating trees, tall shrubs and an intact ground cover of grass and forbs (NSW Scientific Committee, 2011c). Nests for this species are dome-shaped and built from sticks and are usually located in shrubs or saplings, and may also be built on the outermost leaves of low branches of larger eucalypts (OEH 2019b).

8.2.13.2 Ecology

The Grey-crowned Babbler is primarily an insectivore that occasionally eats seed. It is terrestrial and arboreal species favouring the latter behaviour when compared to other babbler species. Foraging forays are commonly seen on the ground where it turns leaf litter, bark and small stones to uncover prey and also low shrubs and trees in feeding flocks of 2-15 birds. Feeding flocks maintain a tight association and rarely separated by more than 30 m at any one time for social and predator evasion reasons (Higgins and Peter 2002).

Co-operatively breeding groups comprise a breeding pair and several non-breeding birds who are helpers of auxiliaries. Helpers or auxiliaries aid in the building/ maintenance of dome shaped brood and roost nests in addition to feeding young. Nests often build in tall shrubs and small trees (saplings), with *Casuarina glauca* and *Melaleuca styphelioides* favoured on site. Groups often roost in one nest for warmth and predator evasion reasons (Higgins and Peter 2002).

Groups typically comprise 4-12 birds with declining populations often identified by small groups of 1-3 birds and linked to fragmentation (i.e. >300m separation between habitat patches), predation and habitat simplification (i.e. burning for fuel reduction, tree dieback, removal of fallen timber/ logs, cattle grazing and invasion of pasture grasses/ exotic plants). Habitat simplification is often denoted by the loss of important resources for feeding and nest building through depletion of an accumulated leaf litter layer, increase in groundcover plant species and loss of shrub layer (Higgins and Peter 2002).

Groups live in permanent territories, often adjoining others, which are aggressively defended throughout the year. Home ranges or territories vary in area (e.g. 1.5 to 50 ha) with territory size dependant on resource availability and quality and not necessarily the number of birds. Offspring often stay with the breeding pair for up to two years, with dispersal occurring into neighbouring unoccupied habitat thereafter and form new breeding groups once sexually mature (i.e. 2-4 years) (Higgins and Peter 2002).

8.2.13.3 Presence within the Subject Site

The Grey-crowned Babbler has been observed regularly within the subject site around wetland 803 in the Conservation Area and in vegetation dominated by Forest Redgum north of wetland 803 and in the western part of the area to be cleared. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004,

EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). However, it is noteworthy to mention that Grey-crowned Babbler in the central parts of the subject site, as indicated by HWR (2004), is no longer apparent (i.e. no birds or nests observed in this area), which is likely to be a function of changing habitat conditions (e.g. dominated by weeds such as Lantana and African Olive) . Habitat within the subject site includes the wetland and adjoining forested vegetation cover, which the species uses for foraging and breeding. Recent observations indicate that breeding activity is occurring within *Casuarina glauca* trees located within the Conservation Area (i.e. wetland 803).

HWC (2004) report an indicative population estimate of 1,259 ± 296 Grey-crowned Babblers within the local area proximal to Kings Hill with a total habitat area of 5,843 ha. Negative habitat indicators identified by HWC (2004) include the presence of invasive exotics such as *Lantana camara* and inappropriate disturbance regimes such as fire and livestock grazing, which are matters that are being managed in the Conservation area for the benefit of the species (i.e. managing vegetation to improve understorey floristics and structure).

8.2.13.4 Assessment of Significance

Assessment of Significance: Grey-crowned Babbler

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Grey-crowned Babbler, which is based on known utilisation of the subject site and study area for foraging and breeding purposes, has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 32.21 ha over an 8+ year timeframe, which will be countered by the immediate retention of 12.44 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. An important contribution to habitat improvement is the removal of livestock grazing and herbivory by feral deer (i.e. allows for the establishment of a shrubby understory and improved leaf litter layer) and the revegetation of treeless lands surrounding wetland 803 (i.e. 9.40 ha), which will have the purpose of improving/ establishing

Assessment of Significance: Grey-crowned Babbler

foraging and breeding habitat for the species and improving patch integrity for the scattered treed vegetation surrounding wetland 803. These actions will increase habitat area, access and quality for the species.

Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will minimise the impact intensity on resident fauna at the margins of the Conservation Area.

Additional mitigation focusing on the minimisation of light pollution on nesting/ roosting birds is also proposed. Directional (shielded) street lighting designed to shed light directly onto the road surface. Sensitive directional residential lighting is also proposed to minimise any disruption to nesting/ roosting animals during the night.

The retained habitat comprises suitable 'like for like' values for breeding including the retention of currently utilised nests, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

Assessment of Significance: Grey-crowned Babbler

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~1.01 ha of occupied habitat), restoration of diminished habitat areas and revegetation works (i.e. 9.40 ha around wetland 803), a habitat area of 32.21 ha comprising 3-7 individuals on average is to be removed over three Phases of the Proposal, with Phase 2 representing the largest proportional impact (i.e. 13.17 ha). The Proposal's impact ceases in Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of occupied habitat for this species.

Retained (modified)

The Conservation Area comprises occupied habitat (i.e. 12.44 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works). This includes the revegetation of treeless lands around wetland 803, which are proximal to existing nesting and foraging areas, thereby providing habitat for the species into the future.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Grey-crowned Babbler relies on small to medium areas of native vegetation with suitable vegetation structure for nesting (i.e. shrub understory) and groundcover stratum for foraging. The area of habitat to be removed is sufficiently large to satisfy a family group of Grey-crowned Babblers as is the area of habitat to be retained/ established and improved in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement (e.g. movement between habitat surrounding wetland 803 and 804 will be retained and managed). The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020).

Assessment of Significance: Grey-crowned Babbler	
In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, the paucity of observations within the subject site (i.e. habitat possibly not relied on for important lifecycle processes such as breeding) and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.	
e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).	
Critical habitat has not been declared or mapped for this species. Not applicable.	
f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.	
No approved NSW recovery or threat abatement plans relate to this species. Not applicable.	
g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native

Assessment of Significance: Grey-crowned Babbler	
	vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	The subject site currently has relatively low abundance of Noisy Miner (*Manorina melanocephala*) with greatest abundance associated with vegetation along cleared edges and a grazed understory. These areas are largely restricted to the Proposal impact footprint where vegetation clearing works are proposed. The increased abundance of Noisy Miners in this part of the subject site is likely due to the increased productivity of these lands and the modified/ absent understory (Lindenmayer et al 2018). The Proposal will shift the boundary between forested and treeless/ modified grazing lands upslope to a new interface demarcated by the boundary of the Conservation Area. A corresponding shift in Noisy Miner activity may also occur as a consequence resulting in increased Noisy Miner activity within the Conservation area. Patch size and understory condition are important factors in the effect of Noisy Miner aggression on woodland bird species (Lindenmayer et al 2018). In this respect the Proposal does not include any provisions for the establishment of bush fire asset protection zones within the Conservation Area. The exclusion of this management regime means that the generally shrubby understory of the native vegetation within the Conservation Area will remain intact and will therefore limit the propensity for Noisy Miner activity. Proposed enhancement works include the early removal of exotic flora such as African Olive and Lantana and use of mosaic fire to stimulate understorey growth and plant species diversity. In places, the exotic flora species are in high densities and currently suppress the natural regeneration of shrub and overstorey native species. Early removal of these species will allow the understorey within the Conservation Area to naturally regenerate, which is likely to be to the detriment of the Noisy Miner. The patchy use of fire is also likely to stimulate the regeneration of shrub species in places where exotic flora densities are high. The large patch area represented by the Conservation Area and adjoining E2 lands occur on unproductive relatively infertile soils. The Noisy Miner shows preference for productive sites (Oldland et al 2009), within decreased abundance associated with infertile unproductive sites (Montague Drake et al 2011). The Conservation Area predominantly occurs on infertile soils and as such is unlikely to be preferentially colonised by the Noisy Miner.

Assessment of Significance: Grey-crowned Babbler	
	It is concluded that the Phased removal of native vegetation may increase the potential for Noisy Miner occupation within the Conservation Area as habitat is progressively cleared and restricted to the Conservation Area. Exotic flora management and the use of fire to manage the understorey is expected to increase the understorey vegetation structure to a more natural state and accordingly limit the aggression of Noisy Miners. The low productivity associated with soils in the Conservation Area is also likely to limit the abundance and aggression of Noisy Miners. The large residual patch size is likely to maintain Noisy Miner free areas thus allowing for occupancy by sensitive woodland bird species. Therefore, it is considered that the Proposal is not likely to enhance the operation of this KTPs to an extent that would result in the decline or exclusion of sensitive woodland bird species.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the
Invasion and establishment of exotic vines and scramblers	

Assessment of Significance: Grey-crowned Babbler	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime. Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow. The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs "Cat Trap Loan Agreement" as described on Councils website (https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the

Assessment of Significance: Grey-crowned Babbler	
	Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.13.5 Conclusion

The Proposal will result in the progressive removal of 32.21 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 12.44 ha (i.e. the Conservation Area) and revegetation of 9.40 ha adjacent to this 'like for like' habitat for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect sufficient 'like for like' habitat supportive of the species and its life cycle needs. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.14 Powerful Owl

8.2.14.1 Habitat

The Powerful Owl inhabits a range of vegetation types from woodland and open sclerophyll forest to tall open wet forest and rainforest (OEH 2019b). It typically utilises large areas of connected woodland or forest habitat, however, it can also occur in fragmented habitats.

The recovery plan described optimum habitat as “Habitat for this species is widespread and primarily tall, moist productive eucalypt forests of the eastern tableland edge and the mosaic of wet and dry sclerophyll forests occurring on undulating, gentle terrain nearer the coast. Optimal habitat includes a tall shrub layer and abundant hollows supporting high densities of arboreal marsupials” (DEC 2006). Roosting habitat is characterised by DEC (2006) as “groves of dense mid-canopy trees or tall shrubs in sheltered gullies, typically on wide creek flats and at the heads of minor drainage lines, but also adjacent to cliff faces and below dry waterfalls. Species commonly used for roosting include the She-oaks Allocasuarina spp., rainforest species such as Coachwood Ceratopetalum apetalum, Lilly Pilly Acmena smithii and Sassafras Doryphora sassafras, Black Wattle Acacia melanoxylon, Turpentine Syncarpia glomulifera and eucalypts. Roosting sites are commonly among small groves of up to 2 ha of similar-sized trees with dense foliage in the height range 3-15 m.

8.2.14.2 Ecology

DEC (2006) describes optimum nesting habitat as “old hollow eucalypts in unlogged, unburnt gullies and lower slopes within 100 m of streams or minor drainage lines, with hollows greater than 45 cm diameter and greater than 100 cm deep; surrounded by canopy trees and subcanopy or understorey trees or tall shrubs. Hollow entrances are greater than 6 m above ground, commonly more than 20 m where the forest permits, in trees of at least 80 cm diameter at breast height. A pair is generally faithful to a traditional nesting hollow, but also sometimes uses alternative hollows in the nesting gully”.

DEC (2006) state that habitat clearing and fragmentation resulting in small (less than 200 ha) forest fragments that are more than 1 km from large areas of forest are not used by Powerful Owls, but may provide marginal habitat for non-breeding Masked Owls. The likely ability of the owls to disperse over tens of kilometres through a mosaic of forested and cleared land suggests that there are unlikely to be any barriers to gene flow within NSW. Owl populations are unlikely to have declined or been fragmented to the point where their genetic integrity is threatened.

The LMCC (2014) identify specific conservation priorities for Large Forest Owls with reference to nest and/or breeding roost tree habitat. Habitats for conservation priority include:

- Confirmed nest sites (including a 100m buffer), breeding roost trees (including a 50m buffer) and sustainable home range extant habitat around such sites;
- Riparian habitat;
- Corridor connectivity along riparian corridors and between major habitat fragments; and
- Old growth forest.

8.2.14.3 Presence within the Subject Site

The Powerful Owl has been observed on occasion within the subject site with observations being in both the Conservation Area and area to be cleared. HWR (2004) note the following for this species:

"White no Powerful Owls responded to call playback, feather and whitewash found in the rainforest gully were definitely attributed to Powerful Owl. This species evidently roosts in this gully (*sic* Conservation Area) although it was not observed there during our survey."

Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). It is noteworthy to mention that targeted stag watch surveys of candidate hollow-bearing trees (i.e. testing for nesting/ breeding activity during the breeding period) showed that the Powerful Owl was not using habitat within the area to be cleared for breeding purposes. Habitat within the subject site includes widespread foraging values with high value candidate nest trees located within the Conservation Area in close proximity to prior diurnal roosting activity observed by HWR (2004).

8.2.14.4 Assessment of Significance

Assessment of Significance: Powerful Owl

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Powerful Owl, which is based on known utilisation of the subject site and study area for foraging and possibly breeding purposes (although unconfirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 206.64 ha over an 8+ year timeframe, which will be countered by the immediate retention of 216.49 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in

Assessment of Significance: Powerful Owl

Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

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Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 206.64 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 216.49 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Powerful Owl relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed would form part of the home range of a breeding pair of Powerful Owls as does the area of habitat to be retained in the Conservation Area. The species is largely sedentary with high site fidelity and as such would likely use the habitat for breeding and foraging purposes. Targeted survey of potential nest trees within the area of habitat to be removed identified no breeding activity. High value potential nest trees occur within the Conservation Area, which are to be retained. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW eastern seaboard that may provide habitat for this species (i.e. 4,013,452 ha of dry/ wet sclerophyll forests and rainforest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington

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Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The Large Forest Owl Recovery Plan (2006) lists two objectives that are relevant to the Proposal. These are listed and addressed as follows.

- Ensure the impacts on large forest owls and their habitats are adequately assessed during planning and environmental assessment processes

The purpose of this SIS is to provide a clear, comprehensive and transparent assessment of threatened species impacted by the Proposal including the Powerful Owl. Surveys targeting this species have infrequently resulted in the observation of this species within the subject site. A roosting location was historically observed in the centre of the Conservation Area (HWR 2004), which is an area that supports numerous large hollow-bearing trees that may be used as nest sites by the Powerful Owl. Targeted stag watch surveys of possible nest hollows in the area of habitat removal failed to identify any nesting/ breeding Powerful Owls. One Powerful Owl was observed foraging in the impact area during this survey; however, it showed no preference for any of the possible nest trees subject to the targeted stag watch.

Proposal design incorporated areas of impact avoidance containing possible nest/ roost trees and sites in addition to high value mammalian prey areas denoted by high densities of hollow-bearing trees. The impact avoidance area is to be incorporated into a Conservation Area that is to be managed and protected in-perpetuity via a conservation agreement for the benefit of threatened species including the Powerful Owl.

In conclusion it is considered that the Proposal has taken meaningful and important steps in avoiding, minimising and ameliorating adverse impacts on owls.

- Minimise further loss and fragmentation of habitat by protection and more informed management of significant owl habitat (including protection of individual nest sites)

Detailed field surveys and targeted stag watching failed to identify any individual nest sites for the Powerful Owl. Habitat important to the Powerful Owl including large trees with large hollows occur within the Conservation Area, and while not confirmed as being utilised, it is possible that hollow-bearing trees located within the Conservation Area may be used by Powerful Owls. High densities of hollow-bearing trees are to be retained in the Conservation Area, thereby providing habitat for mammalian prey. Habitat connectivity will be maintained to allow for free movement of Powerful Owls throughout the Conservation Area and locality. While habitat loss is expected, it is considered that the design process has allowed for considerable impact minimisation including the loss and fragmentation of habitat. Not withstanding this loss, it is considered that the retained habitat area within the locality will be sufficient to allow for the persistence of Powerful Owls with in-perpetuity conservation and management of habitat within the Conservation area likely to make an important contribution to this outcome.

In conclusion, it is considered that the Proposal has taken meaningful and important steps in protecting and restoring owl habitat outside conservation reserves.

In addition, OEH have identified the following actions to support the recovery of these species:

- Protect tree hollows suitably sized for prey nesting. Where high priority owl populations occur install nest boxes to increase mammalian prey densities.

The Proposal will result in the removal of hollow-bearing trees that support mammalian prey. The Proposal design incorporated impact avoidance measures to minimise the impact of this habitat clearing. Targeted surveys of potential nest trees identified none of these trees to be utilised by the Powerful Owl for roosting/ breeding activity. Potential breeding/ roost trees are present within the Conservation Area. The BMP (**Appendix C**) provides for establishment works involving the installation of artificial and natural hollows to support mammalian prey with the objective being the establishment of sufficient hollows to equal or better benchmark conditions.

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Progressive clearing over an 8+ year timeframe aims to minimise the impact intensity. Pre-emptive hollow installation ahead of impacts together with sensitive and progressive vegetation and habitat clearing methods have the purpose of minimising any disruption to mammalian prey distribution and abundance. While habitat loss is expected, it is considered that the Proposal incorporates actions consistent with the conservation principles of the Recovery Plan.	
g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes;

Assessment of Significance: Powerful Owl	
	• No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl.

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	Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.14.5 Conclusion

The Proposal will result in the progressive removal of 206.64 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 216.49 ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large

and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.15 Masked Owl

8.2.15.1 Habitat

The Masked Owl (*Tyto novaehollandiae*) is a large forest owl that occupies dry eucalypt forests and woodlands from sea level to 1,100 m. Pairs have a large home-range of 500 to 1,000 hectares and is not a species exhibiting seasonal variation in its distribution. It roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting with a preference for vertical hollows in large trees.

The recovery plan described optimum habitat as “dry eucalypt forests of the tablelands, western slopes and the undulating wet-dry forests of the coast. Optimal habitat includes an open understorey and a mosaic of sparse (grassy) and dense (shrubby) ground cover on gentle terrain” (DEC 2006).

8.2.15.2 Ecology

Roosting habitat is characterised by DEC (2006) as “hollows in live or occasionally dead eucalypts; dense foliage in gullies; and caves or recesses in cliffs. Hollow sites can be in a variety of topographic positions, from gully to upper slope, and are also used as nest sites or have similar characteristics to those used for nesting. Roost sites in trees are greater than 5 m above the ground”.

DEC (2006) describes optimum nesting habitat as “old hollow eucalypts, live or dead but commonly live, in a variety of topographic positions from gully to upper slope, with hollows greater than 40 cm wide and greater than 100 cm deep; there is no relationship with distance to streams. Nest sites may be subject to a variety of disturbance regimes, which make nest trees susceptible to loss (wind throw and burning). Hollow entrances are at least 3 m above ground, in trees of at least 90 cm diameter at breast height. The pair is faithful to a traditional nesting hollow, but may also use alternative hollows in the breeding territory in different years”.

8.2.15.3 Presence within the Subject Site

The Masked Owl has been observed once within the subject site with the only observation being in the Conservation Area. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). It is noteworthy to mention that numerous targeted owl calling and stag watch surveys of candidate hollow-bearing trees (i.e. testing for nesting/ breeding activity during the breeding period) indicates that the Masked Owl was not using habitat within the area to be cleared for breeding purposes. This appears broadly consistent with HWC (2004) findings which note the following for this species:

“*habitat on and in the vidinity of the study area are suitable habtiat for the Masked Owl. The recent record of a roadkill on the Pacific Highway adjacent to the study area (J. King pers obs.) suggests the species utilises the study area and is possibly resident there*”.

Habitat within the subject site includes widespread foraging values with high value candidate nest trees located within the Conservation Area.

8.2.15.4 Assessment of Significance

Assessment of Significance: Masked Owl

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Masked Owl, which is based on known utilisation of the subject site and study area for foraging and possibly breeding purposes (although unconfirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 206.64 ha over an 8+ year timeframe, which will be countered by the immediate retention of 216.49 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool

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(https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;

- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 206.64 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

Assessment of Significance: Masked Owl

The Conservation Area comprises foraging and possible breeding habitat (i.e. 216.49 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Masked Owl relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed would form part of the home range of a breeding pair of Masked Owls as does the area of habitat to be retained in the Conservation Area. The species is largely sedentary with high site fidelity and as such would likely use the habitat for breeding and foraging purposes. Targeted survey of potential nest trees within the area of habitat to be removed identified no breeding activity. High value potential nest trees occur within the Conservation Area, which are to be retained. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW eastern seaboard that may provide habitat for this species (i.e. 4,013,452 ha of dry/ wet sclerophyll forests and rainforest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The Large Forest Owl Recovery Plan (2006) lists two objectives that are relevant to the Proposal. These are listed and addressed as follows.

- Ensure the impacts on large forest owls and their habitats are adequately assessed during planning and environmental assessment processes

The purpose of this SIS is to provide a clear, comprehensive and transparent assessment of threatened species impacted by the Proposal including the Masked Owl. Surveys targeting this species have rarely observation of this species within the locality with only one recent observation confirming presence within Conservation Area. Targeted stag

Assessment of Significance: Masked Owl

watch surveys of possible nest hollows in the area of habitat removal failed to identify any nesting/ breeding Masked Owls. One Masked Owl was observed foraging in the Conservation Area during this survey; however, it showed no preference for any of the possible nest trees subject to the targeted stag watch.

Proposal design incorporated areas of impact avoidance containing possible nest/ roost trees and sites in addition to high value mammalian prey areas denoted by high densities of hollow-bearing trees. The impact avoidance area is to be incorporated into a Conservation Area that is to be managed and protected in-perpetuity via a conservation agreement for the benefit of threatened species including the MaskedOwl.

In conclusion it is considered that the Proposal has taken meaningful and important steps in avoiding, minimising and ameliorating adverse impacts on owls.

- Minimise further loss and fragmentation of habitat by protection and more informed management of significant owl habitat (including protection of individual nest sites)

Detailed field surveys and targeted stag watching failed to identify any individual nest sites for the Masked Owl. Habitat important to the Masked Owl including large trees with large hollows occur within the Conservation Area, and while not confirmed as being utilised, it is possible that hollow-bearing trees located within the Conservation Area may be used by Masked Owls. High densities of hollow-bearing trees are to be retained in the Conservation Area, thereby providing habitat for mammalian prey. Habitat connectivity will be maintained to allow for free movement of Masked Owls throughout the Conservation Area and locality. While habitat loss is expected, it is considered that the design process has allowed for considerable impact minimisation including the loss and fragmentation of habitat. Not withstanding this loss, it is considered that the retained habitat area within the locality will be sufficient to allow for the persistence of Masked Owls with in-perpetuity conservation and management of habitat within the Conservation area likely to make an important contribution to this outcome.

In conclusion, it is considered that the Proposal has taken meaningful and important steps in protecting and restoring owl habitat outside conservation reserves.

In addition, OEH have identified the following actions to support the recovery of these species:

- Protect tree hollows suitably sized for prey nesting. Where high priority owl populations occur install nest boxes to increase mammalian prey densities.

The Proposal will result in the removal of hollow-bearing trees that support mammalian prey. The Proposal design incorporated impact avoidance measures to minimise the impact of this habitat clearing. Targeted surveys of potential nest trees identified none of these trees to be utilised by the Masked Owl for roosting/ breeding activity. Potential breeding/ roost trees are present within the Conservation Area as was the only observation of the Masked Owl (foraging). The BMP (**Appendix C**) provides for establishment works involving the installation of artificial and natural hollows to support mammalian prey with the objective being the establishment of sufficient hollows to equal or better benchmark conditions.

Progressive clearing over an 8+ year timeframe aims to minimise the impact intensity. Pre-emptive hollow installation ahead of impacts together with sensitive and progressive vegetation and habitat clearing methods have the purpose of minimising any disruption to mammalian prey distribution and abundance. While habitat loss is expected, it is considered that the Proposal incorporates actions consistent with the conservation principles of the Recovery Plan.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared

Assessment of Significance: Masked Owl	
	classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.

Assessment of Significance: Masked Owl	
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement.

Assessment of Significance: Masked Owl	
	In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.15.5 Conclusion

The Proposal will result in the progressive removal of 206.64 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 216.49 ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.16 Regent Honeyeater

8.2.16.1 Habitat

Regent Honeyeaters are typically associated with box-ironbark eucalypt associations, where the species seems to prefer more fertile sites with higher soil water content, including creek flats, broad river valleys and lower slopes. Other forest types regularly utilised by Regent Honeyeaters include wet lowland coastal forest dominated by Swamp Mahogany (*Eucalyptus robusta*), Spotted Gum Ironbark associations and riverine woodlands (where it is known to feed on nectar from *Amyema cambagei*) (DoE 2016a).

8.2.16.2 Ecology

The Regent Honeyeater is a generalist forager, although it feeds mainly on the nectar from a relatively small number of eucalypts that produce high volumes of nectar. Key eucalypt species include Mugga Ironbark, Yellow Box, White Box and Swamp Mahogany. Other tree species may be regionally important. For example the Lower Hunter Spotted Gum forests have recently been demonstrated to support regular breeding events. Flowering of associated species such as Thin-leaved Stringybark Eucalyptus eugenioides and other Stringybark species, and Broad-leaved Ironbark E. fibrosa can also contribute important nectar flows at times. Nectar and fruit from the mistletoes Amyema miquelii, A. pendula and A. cambagei are also utilised. When nectar is scarce lerp and honeydew can comprise a large proportion of the diet. Insects make up about 15% of the total diet and are important components of the diet of nestlings (BCD 2019b).

Colour-banding of Regent Honeyeater has shown that the species can undertake large-scale nomadic movements in the order of hundreds of kilometres. However, the exact nature of these movements is still poorly understood. It is likely that movements are dependent on spatial and temporal flowering and other resource patterns. To successfully manage the recovery of this species a full understanding of the habitats used in the non-breeding season is critical (BCD 2019b).

There are three known key breeding areas, two of them in NSW - Capertee Valley and Bundarra-Barraba regions. The species breeds between July and January in Box-Ironbark and other temperate woodlands and riparian gallery forest dominated by River Sheoak. Regent Honeyeaters usually nest in horizontal branches or forks in tall mature eucalypts and Sheoaks (BCD 2019). Breeding is also frequently observed in the lower Hunter Valley at various sites near Cessnock and in the upper Hunter Valley at Munghorn Gap and Widden Valley.

8.2.16.3 Presence within the Subject Site

The Regent Honeyeater has not been identified within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes winter flowering eucalyptus, which the species may use during regional migrations.

8.2.16.4 Assessment of Significance

Assessment of Significance: Regent Honeyeater

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Regent Honeyeater, which is based on possible utilisation (i.e. not recorded) of the subject site and study area for foraging purposes (breeding very unlikely but may occur), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat that may be used by the species by approximately 212.14 ha over an 8+ year timeframe, which will be countered by the immediate retention of 214.07 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values, which will be actively managed and protected in-perpetuity for the benefit of the species. Revegetation works incorporating Swamp Mahogany on fertile soils around wetland 803 is likely to produce high value foraging habitat for this species during the winter period where the Regent Honeyeater is known to frequent coastal districts.

It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the

Assessment of Significance: Regent Honeyeater

subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;

- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat that may be used by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging habitat) and restoration of diminished habitat areas, a habitat area of 212.14 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging habitat for this species.

Retained (modified)

Assessment of Significance: Regent Honeyeater

The Conservation Area comprises foraging habitat (i.e. 214.07 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Regent Honeyeater in the lower Hunter Valley primarily relies on native vegetation in the winter – early spring period that comprises high value nectar resources primarily for foraging. Habitat in the locality is generally not used for breeding purposes. The area of habitat to be removed is sufficiently large to satisfy foraging activity by the Regent Honeyeater as is the area of habitat to be retained/ established and improved in the Conservation Area. The species is highly nomadic and as such would likely use the habitat foraging purposes on an infrequent and unpredictable basis. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, the paucity of observations within the subject site (i.e. habitat possibly not relied on for important lifecycle processes such as breeding) and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing

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	the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.

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Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	The subject site currently has relatively low abundance of Noisy Miner (*Manorina melanocephala*) with greatest abundance associated with vegetation along cleared edges and a grazed understory. These areas are largely restricted to the Proposal impact footprint where vegetation clearing works are proposed. The increased abundance of Noisy Miners in this part of the subject site is likely due to the increased productivity of these lands and the modified/ absent understory (Lindenmayer et al 2018). The Proposal will shift the boundary between forested and treeless/ modified grazing lands upslope to a new interface demarcated by the boundary of the Conservation Area. A corresponding shift in Noisy Miner activity may also occur as a consequence resulting in increased Noisy Miner activity within the Conservation area. Patch size and understory condition are important factors in the effect of Noisy Miner aggression on woodland bird species (Lindenmayer et al 2018). In this respect the Proposal does not include any provisions for the establishment of bush fire asset protection zones within the Conservation Area. The exclusion of this management regime means that the generally shrubby understory of the native vegetation within the Conservation Area will remain intact and will therefore limit the propensity for Noisy Miner activity. Proposed enhancement works include the early removal of exotic flora such as African Olive and Lantana and use of mosaic fire to stimulate understorey growth and plant species diversity. In places, the exotic flora species are in high densities and currently suppress the natural regeneration of shrub and overstorey native species. Early removal of these species will allow the understorey within the Conservation Area to naturally regenerate, which is likely to be to the detriment of the Noisy Miner. The patchy use of fire is also likely to stimulate the regeneration of shrub species in places where exotic flora densities are high. The large patch area represented by the Conservation Area and adjoining E2 lands occur on unproductive relatively infertile soils. The Noisy Miner shows preference for productive sites (Oldland et al 2009), within decreased abundance associated with infertile unproductive sites (Montague Drake et al 2011). The Conservation Area predominantly occurs on infertile soils and as such is unlikely to be preferentially colonised by the Noisy Miner. It is concluded that the Phased removal of native vegetation may increase the potential for Noisy Miner occupation within the Conservation Area as habitat is progressively cleared and restricted to the Conservation Area. Exotic flora management and the use of fire to manage the understorey is expected to increase the understorey vegetation structure to a more natural state and accordingly limit the aggression of Noisy Miners. The low productivity associated with soils in the Conservation Area is also likely to limit the abundance and aggression of Noisy Miners. The large residual patch size is likely to maintain Noisy Miner free areas thus allowing for occupancy by sensitive woodland bird species. Therefore, it is considered that the Proposal is not likely to enhance the operation of this KTPs to an extent that would result in the decline or exclusion of sensitive woodland bird species.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments.

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	Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime. Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow. The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs “Cat Trap Loan Agreement” as described on Councils website

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	(https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.16.5 Conclusion

The Proposal will result in the progressive removal of 212.14 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 214.07 ha (i.e. the Conservation Area) and revegetation of 9.40 ha adjacent to this 'like for like' habitat for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.17 Swift Parrot

8.2.17.1 Habitat

The Swift Parrot is a nectivore that favours feed trees that flower in winter such as Swamp Mahogany (*E. robusta*), Spotted Gum, Red Bloodwood, Forest Red Gum, Mugga Ironbark (*E. sideroxylon*) and White Box (*E. albens*). Commonly used lerp infested trees include Inland Grey Box (*E. microcarpa*), Grey Box (*E. moluccana*), Blackbutt (*E. pilularis*), and Yellow Box (E*. melliodora*) (OEH 2019b).

8.2.17.2 Ecology

The Swift Parrot migrates to the Australian south-east mainland between February and October, where it forages in areas where eucalypts are flowering profusely or where there is abundant lerp (from sap-sucking bugs) infestations (OEH 2019b). On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. The species often return to some foraging sites on a cyclic basis depending on food availability. Following winter they return to Tasmania where they breed from September to January, nesting in old trees with hollows and feeding in forests dominated by Tasmanian Blue Gum *Eucalyptus globulus*.

8.2.17.3 Presence within the Subject Site

The Swift Parrot has not been identified within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Habitat within the subject site includes winter flowering eucalypts, which the species may use during regional migrations.

8.2.17.4 Assessment of Significance

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a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Swift Parrot, which is based on possible utilisation (i.e. not recorded) of the subject site and study area for foraging purposes (no breeding), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;

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- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of foraging habitat that may be used by the species by approximately 212.14 ha over an 8+ year timeframe, which will be countered by the immediate retention of 214.07 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values, which will be actively managed and protected in-perpetuity for the benefit of the species. Revegetation works incorporating Swamp Mahogany on fertile soils around wetland 803 is likely to produce high value foraging habitat for this species during the winter period where the Swift Parrot is known to frequent coastal districts. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue part of its life cycle (i.e. foraging), as the area retained is sufficiently dimensioned and configured to allow for multiple animals to visit and utilise habitat over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid movement thus maintain genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

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b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat that may be used by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging habitat) and restoration of diminished habitat areas, a habitat area of 212.14 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging habitat for this species.

Retained (modified)

The Conservation Area comprises foraging habitat (i.e. 214.07 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

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iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.	
The Swift Parrot is a winter migratory visitor to the lower Hunter Valley where it primarily relies on native vegetation comprising high value nectar resources for foraging purposes only. Habitat in the locality is not used for breeding purposes. The area of habitat to be removed is sufficiently large to satisfy foraging activity by the Swift Parrot as is the area of habitat to be retained/ established and improved in the Conservation Area. The species is migratory and as such would likely use the habitat on an infrequent and unpredictable basis. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020). In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, the paucity of observations within the subject site (i.e. habitat possibly not relied on for important lifecycle processes such as breeding) and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.	
e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).	
Critical habitat has not been declared or mapped for this species. Not applicable.	
f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.	
No approved NSW recovery or threat abatement plans relate to this species. Not applicable.	
g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the

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	subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	The subject site currently has relatively low abundance of Noisy Miner (*Manorina melanocephala*) with greatest abundance associated with vegetation along cleared edges and a grazed understory. These areas are largely restricted to the Proposal impact footprint where vegetation clearing works are proposed. The increased abundance of Noisy Miners in this part of the subject site is likely due to the increased productivity of these lands and the modified/ absent understory (Lindenmayer et al 2018). The Proposal will shift the boundary between forested and treeless/ modified grazing lands upslope to a new interface demarcated by the boundary of the Conservation Area. A corresponding shift in Noisy Miner activity may also occur as a consequence resulting in increased Noisy Miner activity within the Conservation area. Patch size and understory condition are important factors in the effect of Noisy Miner aggression on woodland bird species (Lindenmayer et al 2018). In this respect the Proposal does not include any provisions for the establishment of bush fire asset protection zones within the Conservation Area. The exclusion of this management regime means that the generally shrubby understory of the native vegetation within the Conservation Area will remain intact and will therefore limit the propensity for Noisy Miner activity. Proposed enhancement works include the early removal of exotic flora such as African Olive and Lantana and use of mosaic fire to stimulate understorey growth and plant species diversity. In places, the exotic flora species are in high densities and currently

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	suppress the natural regeneration of shrub and overstorey native species. Early removal of these species will allow the understorey within the Conservation Area to naturally regenerate, which is likely to be to the detriment of the Noisy Miner. The patchy use of fire is also likely to stimulate the regeneration of shrub species in places where exotic flora densities are high. The large patch area represented by the Conservation Area and adjoining E2 lands occur on unproductive relatively infertile soils. The Noisy Miner shows preference for productive sites (Oldland et al 2009), within decreased abundance associated with infertile unproductive sites (Montague Drake et al 2011). The Conservation Area predominantly occurs on infertile soils and as such is unlikely to be preferentially colonised by the Noisy Miner. It is concluded that the Phased removal of native vegetation may increase the potential for Noisy Miner occupation within the Conservation Area as habitat is progressively cleared and restricted to the Conservation Area. Exotic flora management and the use of fire to manage the understorey is expected to increase the understorey vegetation structure to a more natural state and accordingly limit the aggression of Noisy Miners. The low productivity associated with soils in the Conservation Area is also likely to limit the abundance and aggression of Noisy Miners. The large residual patch size is likely to maintain Noisy Miner free areas thus allowing for occupancy by sensitive woodland bird species. Therefore, it is considered that the Proposal is not likely to enhance the operation of this KTPs to an extent that would result in the decline or exclusion of sensitive woodland bird species.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	

Assessment of Significance: Swift Parrot	
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime. Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow. The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs "Cat Trap Loan Agreement" as described on Councils website (https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.17.5 Conclusion

The Proposal will result in the progressive removal of 212.14 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 214.07 ha (i.e. the Conservation Area) and revegetation of 9.40 ha adjacent to this 'like for like' habitat for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.18 Scarlet Robin

8.2.18.1 Habitat

The Scarlet Robin lives in dry eucalypt forests and woodlands; it is known to associate with 663 PCTs across NSW. The understorey is usually open and grassy with few scattered shrubs. This species lives in both mature and regrowth vegetation. It occasionally occurs in mallee or wet forest communities, or in wetlands and tea-tree swamps. Scarlet Robin habitat usually contains abundant logs and fallen timber: these are important components of its habitat. The Scarlet Robin breeds on ridges, hills and foothills of the western slopes, the Great Dividing Range and eastern coastal regions; this species is occasionally found up to 1000 m in altitude. The Scarlet Robin is primarily a resident in forests and woodlands, but some adults and young birds disperse to more open habitats after breeding. In autumn and winter many Scarlet Robins live in open grassy woodlands, and grasslands or grazed paddocks with scattered trees.

8.2.18.2 Ecology

The Scarlet Robin is a nest breeding species in an open cup made of plant fibres and cobwebs and is built in the fork of tree usually more than 2 m above the ground; nests are often found in a dead branch in a live tree, or in a dead tree or shrub. They form permanent monogamous pairs that maintain territories year round. The male advertises and defends the territory by singing from high, prominent perches. During the breeding season, the female selects a suitable, well-hidden nest site in a tree fork and builds a compact open cup nest (individuals of this species have also been reported making a nest on part of a building, such as a gutter). The female incubates the eggs while the male feeds her. Both sexes feed the nestlings, and will continue to feed the young for some time once fledged.

8.2.18.3 Presence within the Subject Site

The Scarlet Robin has been rarely identified within the subject site with observation mostly in the Conservation Area. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). The highly infrequent observations may be indicative of dispersal rather than usage of the site for breeding.

8.2.18.4 Assessment of Significance

Assessment of Significance: Scarlet Robin
a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in

Assessment of Significance: Scarlet Robin

habitat condition/ configuration or area and competition. The assessment provided for the Scarlet Robin, which is based on known habitat utilisation of the subject site and study area for foraging purposes and possible breeding activity (although not confirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 206.64 ha over an 8+ year timeframe, which will be countered by the immediate retention of 213.92 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

Assessment of Significance: Scarlet Robin

In light of the Proposal impacts, including the in-perpetuity protection and loss habitat and progressive gain in habitat value over time from Conservation Area establishment and management, and evaluation of possible future cumulative impacts, it is considered that the Proposal is not likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of occupied habitat) and restoration of diminished habitat areas, a habitat area of 212.14 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of occupied habitat for this species.

Retained (modified)

The Conservation Area comprises occupied habitat (i.e. 213.92 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and

Assessment of Significance: Scarlet Robin

Figure 1.2), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Scarlet Robin relies on large areas of native vegetation with appropriate vegetation structure to support foraging and breeding. The area of habitat to be removed is sufficiently large to satisfy a breeding pair of Scarlet Robins as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, the paucity of observations within the subject site (i.e. habitat possibly not relied on for important lifecycle processes such as breeding) and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this

Assessment of Significance: Scarlet Robin	
	respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	The subject site currently has relatively low abundance of Noisy Miner (*Manorina melanocephala*) with greatest abundance associated with vegetation along cleared edges and a grazed understory. These areas are largely restricted to the Proposal impact footprint where vegetation clearing works are proposed. The increased abundance of Noisy Miners in this part of the subject site is likely due to the increased productivity of these lands and the modified/ absent understory (Lindenmayer et al 2018). The Proposal will shift the boundary between forested and treeless/ modified grazing lands upslope to a new interface demarcated by the boundary of the Conservation Area. A corresponding shift in Noisy Miner activity may also occur as a consequence resulting in increased Noisy Miner activity within the Conservation area. Patch size and understory condition are important factors in the effect of Noisy Miner aggression on woodland bird species (Lindenmayer et al 2018). In this respect the Proposal does not include any provisions for the establishment of bush fire asset protection zones within the Conservation Area. The exclusion of this management regime means that the generally shrubby

Assessment of Significance: Scarlet Robin	
	understory of the native vegetation within the Conservation Area will remain intact and will therefore limit the propensity for Noisy Miner activity. Proposed enhancement works include the early removal of exotic flora such as African Olive and Lantana and use of mosaic fire to stimulate understorey growth and plant species diversity. In places, the exotic flora species are in high densities and currently suppress the natural regeneration of shrub and overstorey native species. Early removal of these species will allow the understorey within the Conservation Area to naturally regenerate, which is likely to be to the detriment of the Noisy Miner. The patchy use of fire is also likely to stimulate the regeneration of shrub species in places where exotic flora densities are high. The large patch area represented by the Conservation Area and adjoining E2 lands occur on unproductive relatively infertile soils. The Noisy Miner shows preference for productive sites (Oldland et al 2009), within decreased abundance associated with infertile unproductive sites (Montague Drake et al 2011). The Conservation Area predominantly occurs on infertile soils and as such is unlikely to be preferentially colonised by the Noisy Miner. It is concluded that the Phased removal of native vegetation may increase the potential for Noisy Miner occupation within the Conservation Area as habitat is progressively cleared and restricted to the Conservation Area. Exotic flora management and the use of fire to manage the understorey is expected to increase the understorey vegetation structure to a more natural state and accordingly limit the aggression of Noisy Miners. The low productivity associated with soils in the Conservation Area is also likely to limit the abundance and aggression of Noisy Miners. The large residual patch size is likely to maintain Noisy Miner free areas thus allowing for occupancy by sensitive woodland bird species. Therefore, it is considered that the Proposal is not likely to enhance the operation of this KTPs to an extent that would result in the decline or exclusion of sensitive woodland bird species.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these

Assessment of Significance: Scarlet Robin	
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime. Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow.

Assessment of Significance: Scarlet Robin	
	The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs "Cat Trap Loan Agreement" as described on Councils website (https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.18.5 Conclusion

The Proposal will result in the progressive removal of 206.64 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 214.07 ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.19 Squirrel Glider

8.2.19.1 Habitat

This species prefers a range of dry and moist sclerophyll forest, swamp forest, and woodland vegetation communities typically including Blackbutt-Bloodwood forest with heath understorey in coastal areas (BCD 2019). LMCC (2014) indicate the minimum habitat patch size that will be occupied by squirrel gliders is strongly influenced by habitat quality. Squirrel gliders occupy very small patches if habitat quality is high, and much larger habitat patch sizes in lower quality habitat. However, the probability of a patch being occupied by squirrel gliders decreases with remnant size. Modelling predicts that density and occurrence begins to decline when patch size falls below 100 ha depending on time since isolation, remnant shape, and distance to nearby habitat. In Wyong, the largest known remnant of suitable habitat without squirrel gliders is 30 ha. Habitat patches of less than 4 ha are considered unsuitable for permanent occupancy. Small habitat patches of 4 ha to 30ha, are considered at high risk of local extinction. Minor habitat patches of 30 ha to 100 ha, are considered at moderate to low risk in the short-term, and high risk in the long-term; and major habitat patches, 100 ha to 1,000 ha are considered at no risk in the short-term, (50 yrs to 100 yrs), and low to moderate risk in the long term (Smith 2002 as cited in LMC 2014).

8.2.19.2 Ecology

Squirrel gliders eat nectar from flowers, pollen and sugary plant and insect exudates (LMCC 2015). In addition to pollen and nectar, arthropods are an important food source (Sharpe & Goldingay 1998; Dobson, Goldingay & Sharpe 2005; Ball et al. 2009). Winter flowering eucalypts or flowering banksias are important (Quin et al. 2004; Sharpe 2004; Sharpe & Goldingay 2010, HWR Ecological 2003), or summer flowering eucalypts with an understorey of acacia species that provide edible gum exudates in winter (e.g. *A. irrorata*, *A. parramattensis* and *A. longifolia*) (Smith and Murray, 2003). They live in family groups of a single adult male one or more adult females and offspring and require abundant tree hollows for refuge and nest sites.

8.2.19.3 Presence within the Subject Site

The Squirrel Glider has been historically observed within the subject site with the only observation being in the Conservation Area (i.e. central gully; WHWC 2004). Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). HWC (2004) indicate that habitat suitable for this species is suspected to associated with the more densely forested hills and gullies, a habitat description that aligns mostly with conditions present within the Conservation Area. HWR (2004) identify positive benefits of managing *Lantana camara* infestations to improve habitat conditions for this species within the subject site.

8.2.19.4 Assessment of Significance

Assessment of Significance: Squirrel Glider

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Squirrel Glider, which is based on possible habitat utilisation of the subject site and study area for foraging breeding purposes (although presence within the subject site has not been recently confirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 206.64 ha over an 8+ year timeframe, which will be countered by the immediate retention of 214.07 ha habitat within the adjoining Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool

Assessment of Significance: Squirrel Glider

(https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;

- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts, including the in-perpetuity protection and loss habitat and progressive gain in habitat value over time from Conservation Area establishment and management, and evaluation of possible future cumulative impacts, it is considered that the Proposal is not likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 206.64 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

Assessment of Significance: Squirrel Glider

The Conservation Area comprises foraging/ breeding habitat (i.e. 214.07 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Squirrel Glider relies on medium areas of native vegetation for breeding and foraging. The area of habitat to be removed is sufficiently large to satisfy a family of Squirrel Gliders as is the area of habitat to be retained in the Conservation Area. No confirmed observations have been made of this species within the subject site since 2003 (HWR 2004), indicating that if present the species is in low densities. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of 'like for like' habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, the paucity of observations within the subject site (i.e. not observed since 2003) and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled

Assessment of Significance: Squirrel Glider	
	threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.

Assessment of Significance: Squirrel Glider	
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 and native vegetation is directly leading to the degradation of these environments (e.g. altering understorey structure and plant composition such as Acacia regrowth). Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising

Assessment of Significance: Squirrel Glider	
	relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime.

Assessment of Significance: Squirrel Glider	
	Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow. The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs "Cat Trap Loan Agreement" as described on Councils website (https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.19.5 Conclusion

The Proposal will result in the progressive removal of 206.64 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 214.07ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number

of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.20 Koala

8.2.20.1 Habitat

The Koala is predominantly found in eucalypt woodlands and forests and feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species (OEH 2019b), but will select preferred food trees based on foliage nutrient value (OEH 2018; Marsh and Youngentob 2019).

8.2.20.2 Ecology

Koalas live for between 10 and 20 years, and generally breed between September and February. Female koalas can breed from about 2 years of age, and have a gestation period of about two month, producing one koala a year.

The nutritional quality of eucalypt leaves for Koalas, hence palatability and habitat suitability, is determined by a combination of foliar nutrients and plant secondary metabolites (PSMs). Protein is one of the most important nutritional aspects of forage quality because it is considered a limiting nutrient for many herbivores (Mattson 1980) and is required in adequate amounts to support animal growth and reproduction, which is in relatively low concentrations in eucalypts (Wallis et al. 2010). However, even eucalypts that contain adequate protein may not always be good food for koalas. This is because PSMs can limit the ability of animals to access protein, either because some PSMs (e.g. tannins) bind to proteins and make them indigestible (Marsh et al. 2003, DeGabriel et al. 2008, Wallis et al. 2010), or because others (e.g. formylated phloroglucinol compounds and unsubstituted B-ring flavanones) have toxic properties that limit the amount of leaves that animals can eat (Marsh et al. 2007, Marsh et al. 2015, Marsh et al. 2019).

Koalas also require suitable areas for thermoregulation especially during the hotter months of the year. Trees suitable for foraging may not be adequate for thermoregulatory purposes. Denser forests with higher leaf area values and tree types such as smooth barks are often favoured as diurnal rest sites especially during the hotter months.

8.2.20.3 Presence within the Subject Site

The Koala has been observed throughout the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019).

8.2.20.4 Assessment of Significance

Assessment of Significance: Koala

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Koala, which is based on known habitat utilisation of the subject site and study area for foraging and breeding activity, has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

An understanding habitat area requirement for this species is provided in BioLink (2018), which identifies a minimum habitat area of 900 ha of secondary habitat to sustain an effective koala 'hub' comprising 50 individuals (i.e. local viable population). The 'Kings Hill' hub, as described by BioLink (2019a), is estimated to have an availability of at least 1,000 ha of secondary koala habitat, a habitat area calculated from unadjusted vegetation mapping for the locality (NPWS 2003). However, in validating this vegetation mapping for the Kings Hill locality, BioLink (2019c) identified inaccuracies in this vegetation mapping and subsequently inferred a greater quantum of habitat availability for the Koala within the Kings Hill hub. The mapping inaccuracy in the Kings Hill hub area is primarily centred on the erroneous classification of MU 30 Coastal Plains Smooth-barked Apple Woodland (i.e. MU 30 is not classed as secondary koala habitat). BioLink (2019c) recommend the reclassification of MU 30 to MU 16, which is classed as secondary koala habitat. The application of recommended adjustments in vegetation classification results in an increase in the total secondary koala habitat area available within the Kings Hill hub from ~1,300 ha to 1,657 ha. After discounting 280 ha of secondary koala habitat, which coincides within the imbedded rural-residential subdivision where there is a high probability of domestic dog attack in this area (BioLink 2019a), the revised available secondary koala habitat within the Kings Hill hub is 1,377 ha.

The hub assessment prepared by BioLink (2019a) is considered a conservative appraisal of the local Koala population. A genetic study including genetic material sourced from koalas located north and east of the Kings Hill hub show genetic similarity between Kings Hill koalas and other individuals outside the area referred to as the Kings Hill hub (OWAD 2019). Genetic material obtained from individuals located at Booral, Clarence Town, Grahamstown Dam and Karuah indicate a cohort of individuals that are part of the same population indicating genetic flow between individuals located within the Kings Hill hub and further afield. While the size of this population is not known, the genetic samples included in the analysis indicates that the spatial extent of this population is well beyond the Kings Hill hub habitat area as delineated by BioLink (2019a). The findings of the genetic study area appear consistent with ARKS mapping, which assigns the individuals within the Kings Hill hub and other individuals nearby to the Wang Wauk State Forest ARKS (DPIE 2019). The Wang Wauk State Forest ARKS is classed as having moderate resilience and security and has a total area of 174,864 ha (DPIE 2019).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 152.00 ha over an 8+ year timeframe, which will be countered by the immediate retention of 189.46 ha habitat within the adjoining Conservation Area. The habitat loss will reduce the available secondary koala habitat occurring within the Kings Hill hub from 1,377 ha to 1,225 ha, which represents a habitat area that is 36% greater than the minimum required for sustaining a

Assessment of Significance: Koala

koala 'hub' comprising 50 animals (i.e. local viable population). On this metric alone, it is considered that the Proposal will not result in a loss of habitat that would imperil the local population. When compared to the Wang Wauk State Forest ARKS habitat area, it is considered that the habitat loss proposed is negligible.

Notwithstanding, mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), are to be performed prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. These mitigation measures include:

- Installation of a Koala fence to isolate individuals located within the Conservation Area from the site preparation works area (i.e. minimise the likelihood for mortality through dog attack, vehicle strike and pool drownings).
- Installation of Koala bridges along the fence to convey animals from the site preparation area into the Conservation Area;
- Revegetation of treeless lands that surround wetland 803 with Swamp Mahogany, Forest Redgum and Tallowwood to produce 'Primary Koala Habitat', which is known to support a greater density of Koala (BioLink 2019b);
- Enrichment plantings within the Conservation Area to address habitat loss within the site preparation area and improve browse quantity for additional individuals accommodated in the Conservation Area; and
- Use of koala grids to prevent Koala movement from the Conservation Area onto roads.

Habitat loss will be managed in a sensitive manner in accordance with a vegetation clearing procedure. The Procedure aims to retain preferred Koala feed trees for as long as is practicable within the site preparation area to minimise impact intensity. Phase 1 works minimises impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

Assessment of Significance: Koala

In light of the Proposal impacts, including the in-perpetuity protection and loss habitat and progressive gain in habitat value over time from Conservation Area establishment and management, and evaluation of possible future cumulative impacts, it is considered that the Proposal is not likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 152.00 ha is to be removed over three Phases of the Proposal, with Phase 1 representing the largest proportional impact (i.e. 59.79 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 189.46 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and

Assessment of Significance: Koala

Figure 1.2), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

BCD (2020) present the following appraisal of the 2019-20 bush fire impacts on Koala habitat in eastern NSW, "As of 6 January 2020, more than 24% of all koala habitat in eastern NSW was within fire-affected areas. The total area of high or very high suitability koala habitat affected by fire in eastern NSW was more than 19%".

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of aiding in the maintenance of a local viable population of this species, the moderate resilience/ security of the Wang Wauk State Forest ARKS and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is potentially regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The Recovery Plan for the Koala (DECC 2008) identifies a number of relevant objectives and actions for the species, specifically:

- Conserve koalas in their existing habitat: The Proposal includes the in-perpetuity conservation of 189.46 ha of habitat for the species with allowances for movement corridors into adjoining habitat to maintain genetic flow.
- Assess the impact of habitat loss and fragmentation on koala populations: The SIS has considered the effect of habitat loss and fragmentation on the Koala. Key mitigation measures are proposed to manage these impacts including the provision of a managed in-perpetuity Conservation Area, revegetation and enrichment works to locally improve the quality, availability and quantity of preferred browse species, the provision of functional wildlife links to allow free movement through the Conservation Area to adjacent habitat areas.
- Develop appropriate road risk management in koala habitat: The Proposal includes the construction of a koala fence, bridges and road grids to exclude koalas from environments where vehicle strike may occur.
- Implement strategies which minimise the impacts of dogs on koala populations: The Proposal includes mitigation to prevent dog attach such as the construction of a Koala fence and feral dog control within the Conservation Area.
- Develop and implement strategies to reduce the impact of fires on koala populations: The Proposal includes the operation of a BMP and subsequent in-perpetuity management regimes that incorporate the proper management of bush fire risk to avoid impacts on resident koalas.
- Rehabilitate and restore koala habitat and populations: The Proposal includes the revegetation of treeless lands using high value feed tree species (i.e. Forest Redgum, Swamp Mahogany and Tallowwood) and enrichment of existing forests to restore these vegetated areas.

It is considered that the Proposal is not inconsistent with the objectives or actions of the Recovery Plan.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Assessment of Significance: Koala	
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and

Assessment of Significance: Koala	
	• No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	

Assessment of Significance: Koala	
Predation and Hybridisation by Feral Dog (*Canis lupis familiaris*)	DPIE (2019) identifies the Kings Hill area, as part of the Wang Wauk State Forest ARKS, as an area of high risk of dog attack. The Proposal has included the following mitigation measures to address this risk: • Koala fence to prevent Koalas from entering the development area and prevent domestic dogs from entering the Conservation Area; and • Feral dog control within the Conservation Area to minimise the likelihood of dog attack on Koalas. The mitigation actions included in the Proposal, as outlined in the BMP, are to be implemented in-perpetuity. Locally it is considered that these actions will reduce the risk of dog attack on the Koala.

8.2.20.5 Conclusion

The Proposal will result in the progressive removal of 152.00 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 189.46 ha (i.e. the Conservation Area) and revegetation of 9.40 ha adjacent to this 'like for like' habitat for in-perpetuity protection and management. Further mitigation measures including the construction of a Koala fence, road grids and bridges are included in the Proposal to prevent movement of Koalas into the developed landscape where risk of mortality from dog attack, vehicle strike and drowning is significantly higher. Feral dog management within the Conservation Area is provided to minimise the effect of dog attack. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.21 Brush-tailed Phascogale

8.2.21.1 Habitat

The Brush-tailed Phascogale broadly prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter; although is also known in rainforest and wet sclerophyll forest (OEH 2019b). This species preferentially uses a habitat complex comprising groundcover layer features (e.g. fallen logs) and arboreal features such as hollow-bearing trees for denning and “rough barked trees of 25 cm DBH or greater” for foraging (OEH 2019b).

8.2.21.2 Ecology

The Brush-tailed Phascogale feeds mostly on arthropods but will also eat other invertebrates, nectar and sometimes small vertebrates. Females have exclusive territories of approximately 20 - 40 ha, while males have overlapping territories often greater than 100 ha. Nest and shelter in tree hollows with entrances 2.5 - 4 cm wide and use many different hollows over a short time span. Mating occurs May - July; males die soon after the mating season whereas females can live for up to three years but generally only produce one litter (BCD 2019b).

8.2.21.3 Presence within the Subject Site

The Brush-tailed Phascogale has been observed within the subject site since 2004 (HWC 2004; Firebird ecoSultants Pty Ltd 2013 and current investigations). Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). The Brush-tailed Phascogale is considered to occur throughout the entire subject site in low densities, with higher activity levels likely in areas of dense hollow-bearing tree occurrence and mature forest with rough-barked trees; habitat features that are widespread throughout the subject site and locality (Firebird ecoSultants Pty Ltd 2013). HWR (2004) identify positive benefits of managing Lantana camara infestations to improve habitat conditions for this species within the subject site.

8.2.21.4 Assessment of Significance

Assessment of Significance: Brush-tailed Phascogale

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Brush-tailed Phascogale, which is based on known habitat utilisation of the subject site and study area for foraging purposes and inferred breeding activity (i.e. persisting presence within the study area), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],

Assessment of Significance: Brush-tailed Phascogale

- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 203.60 ha (estimated to comprise 60.49 ha foraging only and 143.11 foraging and breeding) over an 8+ year timeframe, which will be countered by the immediate retention of 216.49 ha habitat (estimated to comprise 55.38 ha foraging only and 161.11 foraging and breeding) within the adjoining Conservation Area. Assuming a home range of 40 ha for a breeding female, and no overlap, it is considered that the Conservation Area has capacity to accommodate at least four breeding females and 1-2 males within a broader connected post development 'like for like' habitat area of minimum ~1,500 ha. Given the mobility of this species and the allowances made for movement throughout the locality (i.e. provision of corridors within the subject site that allows for movement in adjoining habitat areas), it is considered that the species will persist within the locality.

Mitigation works supporting the retention of a local viable population, as specified in the BMP for the Conservation Area (**Appendix C**), are to initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding females to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

Assessment of Significance: Brush-tailed Phascogale

In light of the Proposal impacts, including the in-perpetuity protection and loss of habitat and progressive gain in habitat value over time from Conservation Area establishment and management, and evaluation of possible future cumulative impacts, it is considered that the Proposal is not likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 203.60 ha, comprising 60.49 ha of foraging and 143.11 ha of foraging and breeding habitat, is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.12 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises and estimated 216.49 ha of foraging/ breeding habitat (i.e. 55.38 ha of foraging and 161.11 ha of foraging/ breeding habitat), which is to be conserved and secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Assessment of Significance: Brush-tailed Phascogale

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Brush-tailed Phascogale relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed is sufficiently large to satisfy a breeding Brush-tailed Phascogale female and male as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared).

Assessment of Significance: Brush-tailed Phascogale	
	Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within

Assessment of Significance: Brush-tailed Phascogale	
	the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate

Assessment of Significance: Brush-tailed Phascogale	
	the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.
Predation by the Feral Cat *Felis catus*	The KTP relates only to the Feral Cat (*Felis catus*) and does not include domestic or stray cats; although, the KTP listing recognises that domestic or stray cats may become feral in a lifetime. Surveys for the subject site did not detect any Feral Cat activity, although it is recognised that the detection of this species is often difficult with surveys yielding no result often representing a false negative. While it is assumed that Feral Cats are present and/ or operating within the subject site, it is considered that their presence and impact is likely associated with low densities. Feral Cats show a preference for mammals weighing less than 220g and birds less than 200g. Reptiles, amphibians and invertebrates are also eaten. These preferences would place predation pressure on a number of threatened species observed within the subject site such as the Brush-tailed Phascogale, Squirrel Glider, Grey-crowned Babbler, Little Lorikeet, Brown Treecreeper, Varied Sittella, Scarlet Robin and Duck Woodswallow. The progressive clearing of native vegetation over an 8+ year period may result in a concentration of Feral Cat activity within the Conservation Area. Further, it is possible that the future development of the subject site may act as a source for Feral Cats, initially being domestic. Therefore, it is proposed to manage this potential threat as part of the BMP (**Appendix C**) and management arrangements that form part of the in-perpetuity conservation agreement. This process would be broadly consistent with conditions specified in PSCs "Cat Trap Loan Agreement" as described on Councils website (https://www.portstephens.nsw.gov.au/live/resident-services/animals-and-pets accessed January 2019). Cats caught within the conservation area will be managed in accordance with Council Rangers directions and/ or any other arrangements specifically entered into for the Conservation Area. It is concluded that the risk of predation by Feral Cat is likely to be low in light of the current low activity and feral animal control measures proposed in the BMP and in-perpetuity management requirements for the Conservation Area. It is considered that the Proposal will not enhance the effect of Feral Cat predation to an extent that would result in an irreversible decline in biodiversity values within the locality.

8.2.21.5 Conclusion

The Proposal will result in the progressive removal of 203.60 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 216.49 ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large

and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.22 Spotted-tailed Quoll

8.2.22.1 Habitat

The Spotted-tail Quoll inhabits a variety of habitats, including dry to moist open forests or closed forests containing rock caves, hollow logs or trees for denning and foraging. Viable populations of the Spotted-tail Quoll occupy complex overlapping individual home ranges comprising numerous individuals. Females occupy smaller ranges (mean 500 hectares) comprising an abundance of resources with males occupying larger home ranges (Belcher, 2008). Ideal habitat for this species is generally represented by large undisturbed connected tracts of intact native vegetation, which are under threat through the range of this species. Recorded occurrences have high coincidence with old growth forests; a class of vegetation known to contain high habitat values for this species (DEC 2004).

8.2.22.2 Ecology

The Spotted-tailed Quoll occupies home ranges of several hundred to several thousand hectares in size. Spotted-tailed Quolls use multiple dens (possibly in excess of 20) and usually move between them every 1–4 days (DoE 2016b). Recorded den sites include rock crevices, hollow logs, hollow tree buttresses, tree hollows, windrows, clumps of vegetation, caves and boulder tumbles, under buildings and underground burrows, including those of rabbits and wombats (DoE 2016). Maternal den sites include rock crevices, caves, boulder tumbles, hollow logs, hollow tree roots and burrows (DoE 2016b).

Habitat that is critical to the survival of the Spotted-tailed Quoll includes large patches of forest with adequate denning resources and relatively high densities of medium-sized mammalian prey (DoE 2016b). However, the threshold densities of these critical components required to support quoll populations are unknown.

8.2.22.3 Presence within the Subject Site

The Spotted-tailed Quoll has not been observed within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). It is noteworthy to mention that targeted dog detection work for this species across the whole subject site failed to detect signs of traces of this species, this being consistent with the findings of HWR (2004) which state "*No hairs of Spotted-tailed Quoll were among the hair-tube samples*". It is considered that the Spotted-tailed Quoll is not currently using habitat within the subject site with no historical evidence of the species being an occupant of this area.

8.2.22.4 Assessment of Significance

Assessment of Significance: Spotted-tailed Quoll

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Spotted-tailed Quoll, which is based on possible (i.e. not observed) habitat utilisation of the subject site and study area for foraging purposes (breeding possible but unlikely), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat that may be utilised in part by the species by approximately 206.64 ha over an 8+ year timeframe, which will be countered by the immediate retention of 214.07 ha habitat within the adjoining Conservation Area. However, the species has not been observed within the subject site despite the use of detection dogs, camera traps and cage trapping to try and locate evidence of this species. Notwithstanding, assuming a home range of 500 ha for a breeding female, and no overlap, it is considered that the Conservation Area has capacity to accommodate half a home range within a broader connected post development 'like for like' habitat area of minimum ~1,500 ha, which would allowing for up to three female home ranges. Given the mobility of this species and the allowances made for movement throughout the locality (i.e. provision of corridors within the subject site that allows for movement in adjoining habitat areas), it is considered that the species will persist within the locality.

Mitigation works supporting the retention of a local viable population, as specified in the BMP for the Conservation Area (**Appendix C**), are to initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding females to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

Assessment of Significance: Spotted-tailed Quoll

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts, including the in-perpetuity protection and loss of habitat and progressive gain in habitat value over time from Conservation Area establishment and management, and evaluation of possible future cumulative impacts, it is considered that the Proposal is not likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 206.64 ha of possible foraging habitat is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e.

Assessment of Significance: Spotted-tailed Quoll

87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises possible foraging habitat (i.e. 216.49 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Spotted-tailed Quoll relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed is sufficiently large to satisfy nearly half the home range of a single female Spotted-tailed Quoll as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive

Assessment of Significance: Spotted-tailed Quoll	
	clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function.

Assessment of Significance: Spotted-tailed Quoll	
	While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/

Assessment of Significance: Spotted-tailed Quoll	
	natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.22.5 Conclusion

The Proposal will result in the progressive removal of 206.64 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 216.49 ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.23 Grey-headed Flying-fox

8.2.23.1 Habitat

The Grey-headed Flying-fox regularly occurs along the eastern coastal plain of NSW extending into Queensland and Victoria. It roosts in camps, usually in dense riparian habitats. At dusk this species disperses in search of the preferred food source, mainly eucalypt blossom and rainforest fruits. Long distances are covered for up to 50 km radius from camp sites in search of food.

8.2.23.2 Ecology

Two periods of the year are identified as particularly important for the Grey-headed Flying-fox. The breeding period, which occurs during October to January, involves lifecycle process including final weeks of gestation, and during the weeks of birth, lactation and conception. The 'food bottle neck', which occurs during the May to August period, is a time where foraging resources are limited. Resource demands during these periods are important to the Grey-headed Flying-fox.

Two types of camps are established by the Grey-headed Flying-fox these being temporary and permanent camps. Temporary camps are not occupied throughout the year and typically established during the summer period to access habitat resources as they become available. These camps may coincide with breeding activity. Permanent camps are occupied throughout the year and are generally central to all necessary foraging resources, particularly those that occur during the winter food bottle necks.

8.2.23.3 Presence within the Subject Site

The Grey-headed Flying Fox has been periodically observed within the subject site with recent surveys performed in August – September 2019 indicating habitat preferences north of and outside the subject site (i.e. large overflying contingent of Grey-headed Flying Foxs without any activity within the subject site being noted during this important time of the year – food bottleneck). Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). HWC (2004) indicate that habitat suitable for this species is suspected to associated with figs.

8.2.23.4 Assessment of Significance

Assessment of Significance: Grey-headed Flying Fox

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Grey-headed Flying Fox, which is based on known utilisation of the subject site and study area for foraging purposes (no known roosting or camp sites) in close proximity to the Raymond Terrace camp, has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat over an 8+ year timeframe, with the total habitat loss estimated to be 212.14 ha. Habitat loss and protection by seasonality (bi-monthly phenology) is as follows:

Bi-monthly phenology (feed tree modelling)	Phase 1	Phase 2	Phase 3	Total	**Conservation Area**
• Foraging habitat in December – January	46.46	38.54	77.65	162.65	**166.81**
• Foraging habitat in February – March	32.77	20.83	36.55	90.76	**72.30**
• Foraging habitat in April – May	58.61	28.62	68.85	156.08	**178.39**
• Foraging habitat in June – July	58.61	28.62	68.85	156.08	**178.39**
• Foraging habitat in August – September	63.40	32.85	71.48	167.73	**187.95**
• Foraging habitat in October – November	51.69	39.93	73.38	165.00	**176.76**

This habitat removal, as indicated above, will be pronounced during the bottleneck period. However, in the locality, this habitat loss would represent less than 3.5% of similar habitat types. This loss would be countered by the immediate retention of 216.49 ha habitat within the adjoining Conservation Area, with corresponding seasonality of these resources also indicated above in bold.

Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

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The retained habitat comprises suitable 'like for like' foraging values, which will be actively managed and protected in-perpetuity for the benefit of the species. Revegetation works incorporating Swamp Mahogany and Forest Redgum on fertile soils around wetland 803 is likely to produce high value foraging habitat for this species during the winter spring period, which is an important part of the Grey-headed Flying Fox life cycle (i.e. gestation and early lactation). The value and reliability of nectar made available during this period would be of local significance for the Grey-headed Flying Fox.

It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

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d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging habitat) and restoration of diminished habitat areas, a habitat area of 212.14 ha of variable seasonal value is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging habitat for this species.

Retained (modified)

The Conservation Area comprises 'like for like' foraging habitat (i.e. 216.49), which is to be conserved and secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, including 19.40 ha of revegetation works involving high value winter – spring nectar producing eucalyptus (i.e. Swamp Mahogany and Forest Redgum), with the delivery of this benefit expected within 20 years (i.e. when flowering occurs).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Grey-headed Flying Fox relies on large areas of native vegetation for foraging. The area of habitat to be removed is sufficiently large to accommodate regular foraging activity during the winter – spring food bottleneck as is the area of habitat to be retained in the Conservation Area. The species is sedentary around annual camps (e.g. Raymond Terrace Camp) and is also regional migrator depending on foraging resources. This species is likely to rely, in part, on foraging resources in the subject site over the course of the year. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020). Movement by Grey-headed Flying Fox to areas of less impact such as the lower Hunter Valley may occur in the short to medium term as burnt habitat recovers and once again provides habitat for the species.

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of aiding in the maintenance of a local viable population of this species, and the provision of plantings using high value nectar feed trees that coincide with the winter – spring food bottle-neck, it is considered that

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the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality. However, in the short term (~ 5 years), it is considered that the absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha) is likely to have temporarily increased in the importance of habitat within the locality (i.e. habitat for Grey-headed Flying Fox that migrate away from fire effected areas). IN this respect, it is important to not the temporal nature of impacts associated with the Proposal, with impacts during this period limited to Phase 1 habitat loss, with the balance of habitat contained in Phase 2 and 3 remaining available for the species for this period.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The draft National Recovery Plan for the Grey-headed Flying Fox (DoEE 2017) identifies a number of relevant objectives and actions for the species, specifically:

- Identify, protect and enhance native foraging habitat critical to the survival of the Grey-headed Flying-fox: The Proposal will manage and protect foraging habitat within an in-perpetuity conservation area in close proximity to a known camp at Raymond Terrace. The Proposal will enhance the availability of nectar resources during the winter – spring food bottle neck (19.40 ha) through plantings of high value nectar producing trees (Swamp Mahogany and Forest Redgum). Enrichment plantings for an approximately 140 ha will enhance spring nectar supplies (i.e. plantings of Forest Redgum). Cumulative impacts on residual habitat resources indicate a low likelihood for ongoing substantive impacts on foraging habitat.

It is considered that the Proposal is not inconsistent with the objectives or actions of the draft National Recovery Plan.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any

Assessment of Significance: Grey-headed Flying Fox	
	native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined,

Assessment of Significance: Grey-headed Flying Fox	
	this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	

8.2.23.5 Conclusion

The Proposal will result in the progressive removal of 212.14 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 216.49 ha (i.e. the Conservation Area) and revegetation of 19.40 ha with high value winter – spring nectar producing eucalypts (i.e. Swamp Mahogany and Forest Redgum) adjacent to this 'like for like' habitat for in-perpetuity protection and management. The habitat loss within the locality is likely to have an influence on the availability of nectar resources during the bottle feeding

period for the Raymond Terrace camp, although the loss is expected to be less than 3.5% of available foraging resources and further loss of this magnitude is not expected into the future (i.e. cumulative impacts are likely to be low due to tenure, land zoning and regulatory controls on vegetation clearing). The proposed revegetation works will provide a source of high value food during the bottleneck feeding period, with the location of most of this planting (i.e. floodplain) indicating that the amount and reliability of nectar flows produced will be highly prized by foraging Grey-headed Flying Foxes (i.e. vegetation on the floodplain is generally highly overcleared and is a valuable resource that is rare in the locality).

The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.24 Eastern Freetail-bat

8.2.24.1 Habitat

The Eastern Freetail-bat occurs in dry sclerophyll forest and woodland. It roosts in tree hollows and sometimes under bark or in man-made structures (OEH 2019b). No information is available on the diet and foraging of this species except that it hunts insects above the forest canopy or in clearings at the edge of the forest (Strahan, 1995).

8.2.24.2 Ecology

Within the subject site the Eastern Free-tail Bat is likely to use hollow-bearing trees for roosting sites within the subject site including Grey Box, Spotted Gum and Forest Redgum (McConville and Law 2013), particularly in areas with the densest aggregations of hollow-bearing trees (McConville et al 2013a). Foraging is most likely to occur in the low-lying riparian habitats (McConville et al 2013b) including freshwater and saline wetlands.

8.2.24.3 Presence within the Subject Site

The Eastern Freetail-bat has been recorded within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Foraging and roosting habitat is widespread throughout the subject site and locality for this highly mobile and wide ranging species. HWC (2004) notes that this species may roost within the subject site given the presence of hollow-bearing trees, with preferential potential roosting sites likely located within the Conservation area (i.e. periphery of wetland 803 and denser riparian vegetation).

8.2.24.4 Assessment of Significance

Assessment of Significance: Eastern Freetail-bat

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Eastern Freetail-bat, which is based on known habitat utilisation of the subject site and study area for foraging purposes (and possible breeding but unconfirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:

Assessment of Significance: Eastern Freetail-bat

  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 47.94 ha over an 8+ year timeframe, which will be countered by the immediate retention of 101.66 ha habitat within the Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

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Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 47.94 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 19.76 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 101.66 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

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The Eastern Free-tail Bat relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed is sufficiently large to satisfy the life cycle of the Eastern Free-tail Bat as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity

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	development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising

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	relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.24.5 Conclusion

The Proposal will result in the progressive removal of 47.94 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). Countering this impact, the Proposal will retain a 'like for like' habitat area of 101.66 ha (i.e. the Conservation Area) for in-perpetuity protection and management. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.25 Greater Broad-nosed Bat

8.2.25.1 Habitat

The Greater Broad-nosed Bat roosts in tree hollows, but has also been found in buildings (OEH, 2019b). This species occurs in a range of habitats including dry sclerophyll forest, moist eucalypt forest, rainforest, woodland and swamp woodland, however is most commonly found in tall wet forest (OEH, 2019b). Foraging occurs at night searching for insects, predominantly along creek and river corridors (OEH 2019b). Roosting habitat within the subject site that provides preferred habitat for this species includes the moist forests (PCT 1584) with drier vegetation providing foraging habitat and potential roosting habitat. Numerous hollow-bearing trees are scattered across the study area, as well as trees with decorticating bark, also used as habitat for this species.

8.2.25.2 Ecology

Among its habitat preferences, the Greater Broad-nosed Bat is known to forages after sunset, flying slowly and directly along creek and river corridors at an altitude of 3 - 6 m. Little is known of the Greater Broad-nosed Bats reproductive cycle, however a single young is born in January. Prior to birth, females congregate at maternity sites located in suitable trees, where they appear to exclude males during the birth and raising of the single young (BCD 2019b).

8.2.25.3 Presence within the Subject Site

The Greater Broad-nosed Bat has been recorded within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Foraging and roosting habitat is widespread throughout the subject site and locality for this highly mobile and wide ranging species. HWC (2004) notes that this species may roost within the subject site given the presence of hollow-bearing trees, with preferential potential roosting sites likely located within the Conservation area (i.e. periphery of wetland 803 and denser riparian vegetation).

8.2.25.4 Assessment of Significance

Assessment of Significance: Greater Broad-nosed Bat

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Greater Broad-nosed Bat, which is based on known habitat utilisation of the subject site and study area for foraging purposes (and possible breeding but unconfirmed), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;

Assessment of Significance: Greater Broad-nosed Bat

- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 47.94 ha over an 8+ year timeframe, which will be countered by the immediate retention of 101.66 ha habitat within the Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Greater Broad-nosed Bat

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 47.94 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 19.76 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 101.66 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

Assessment of Significance: Greater Broad-nosed Bat

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Greater Broad-nosed Bat relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed is sufficiently large to satisfy the life cycle of the Greater Broad-nosed Bat as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool'

Assessment of Significance: Greater Broad-nosed Bat	
	(https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the

Assessment of Significance: Greater Broad-nosed Bat	
	loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.25.5 Conclusion

The Proposal will result in the progressive removal of 47.94 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). Countering this impact, the Proposal will retain a 'like for like' habitat area of 101.66 ha (i.e. the Conservation Area) for in-perpetuity protection and management. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.26 Southern Myotis

8.2.26.1 Habitat

This species roosts close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage, generally in groups of 10-15 (OEH 2019b). It forages over streams and pools, using its large feet to catch insects and small fish (Law, 2000; OEH 2019b).

8.2.26.2 Ecology

The Southern Myotis forages over streams and pools catching insects and small fish by raking their feet across the water surface. In NSW females have one young each year usually in November or December, with breeding requiring tree-hollows in close proximity to foraging resources.

8.2.26.3 Presence within the Subject Site

The Southern Myotis has not been observed or recorded within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Foraging and roosting habitat is strongly associated with wetland 803. HWC (2004) notes that this species is known to roost in the nearby Balickera Canal tunnel.

8.2.26.4 Assessment of Significance

Assessment of Significance: Southern Myotis

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Southern Myotis, which is based on possible habitat utilisation (i.e. not recorded) of the subject site and study area for foraging purposes and possibly breeding activity (i.e. hollow-bearing trees nearby water resources), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;

Assessment of Significance: Southern Myotis

- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of potential breeding habitat that may be used by the species by approximately 11.58 ha over an 8+ year timeframe, which will be countered by the immediate retention of 21.65 ha habitat (comprising 9.21 ha foraging only and 12.44 breeding only) within the adjoining Conservation Area (i.e. possible foraging and breeding habitat located adjacent to each other within the wetland 803 precinct). Given the mobility of this species and the allowances made for movement throughout the locality (i.e. provision of corridors within the subject site that allows for movement in adjoining habitat areas), it is considered that the species will persist within the locality.

Mitigation works supporting the retention of a local viable population, as specified in the BMP for the Conservation Area (**Appendix C**), are to initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding females to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts, including the in-perpetuity protection and loss of habitat and progressive gain in habitat value over time from Conservation Area establishment and management, and evaluation of possible future cumulative impacts, it is considered that the Proposal is not likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Southern Myotis

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance and restoration of diminished habitat areas, a potential habitat area of 11.58 ha (breeding habitat) is to be removed over three Phases of the Proposal, with Phase 2 representing the largest proportional impact (i.e. 5.45 ha), which is after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of roosting/ foraging habitat for this species.

Retained (modified)

The Conservation Area comprises possible roosting/ foraging habitat (i.e. 9.21 ha foraging and 12.44 breeding), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Assessment of Significance: Southern Myotis

Habitat for the Southern Myotis comprises coastal wetlands for foraging and adjacent terrestrial vegetation for breeding (i.e. roosting hollows). Habitat within the subject site may be used for infrequent foraging purposes while wetland 803 contains water and breeding events if foraging habitat remains available during the breeding period (noting wetland 803 has a wetting drying cycle). Possible foraging and breeding habitat is largely restricted to wetland 803 and its periphery, which is mostly retained in the Conservation Area and will not be removed or adversely impacted. The recent bushfires of the 2019-20 summer season have little impact on occupied habitat along the NSW east coast that may provide habitat for this species (BCD 2020).

In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be affected by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native

Assessment of Significance: Southern Myotis	
	Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/

Assessment of Significance: Southern Myotis	
	natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.26.5 Conclusion

The Proposal will result in the progressive removal of 11.58 ha of possible breeding habitat (not observed) over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures). Countering this impact, the Proposal will retain a 'like for like' habitat area of 21.65 ha (i.e. the Conservation Area) for in-perpetuity protection and management. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5 km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.27 Yellow-bellied Sheath-tail Bat

8.2.27.1 Habitat

The Yellow-bellied Sheath-tail bat uses hollows and buildings where it roosts singly or in groups of up to six, in tree hollows and buildings. In treeless areas they are known to utilise mammal burrows. When foraging for insects, flies high and fast over the forest canopy, but lower in more open country. Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory.

8.2.27.2 Ecology

Breeding has been recorded from December to mid-March, when a single young is born. Seasonal movements are unknown; there is speculation about a migration to southern Australia in late summer and autumn.

8.2.27.3 Assessment of Significance

Assessment of Significance: Yellow-bellied Sheath-tail Bat

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Yellow-bellied Sheath-tail Bat, which is based on possible habitat utilisation (i.e. not recorded) of the subject site and study area for foraging purposes (and possible breeding), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 164.20 ha over an 8+ year timeframe, which will be countered by the immediate retention of 112.41 ha habitat within the Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values

Assessment of Significance: Yellow-bellied Sheath-tail Bat

typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Assessment of Significance: Yellow-bellied Sheath-tail Bat

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat that may be used by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 164.20 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 67.79 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 112.41 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Yellow-bellied Sheath-tail Bat relies on large areas of native vegetation with sufficient densities of hollow-bearing trees for breeding. The area of habitat to be removed is sufficiently large to satisfy the life cycle of the Yellow-bellied Sheath-tail Bat as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,177,500 ha of dry sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, the paucity of observations within the subject site (i.e. habitat possibly not relied on for important lifecycle processes such as breeding) and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River

Assessment of Significance: Yellow-bellied Sheath-tail Bat

representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events.

Assessment of Significance: Yellow-bellied Sheath-tail Bat	
	The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees

Assessment of Significance: Yellow-bellied Sheath-tail Bat	
	per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.27.4 Conclusion

The Proposal will result in the progressive removal of 164.20 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). Countering this impact, the Proposal will retain a 'like for like' habitat area of 112.41 ha (i.e. the Conservation Area) for in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.28 Eastern False Pipistrelle

8.2.28.1 Habitat

The Eastern False Pipistrelle prefers moist habitats, with trees taller than 20 m and the understorey is dense (Churchill, 2009; OEH 2019b). This species generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings (OEH 2019b). Foraging occurs within gaps and spaces within the forest, avoiding areas with a dense understorey, and along tracks, creeks and rivers (Churchill, 2009). Their diet is mainly comprised of beetles and moths, with occasional bugs, ants and flies (Churchill, 2009).

8.2.28.2 Ecology

Little is known about the ecology of the Eastern False Pipistrelle. It is known to hibernate in winter. Females are pregnant in late spring to early summer. As indicated by habitat notes, the species prefers mature mesic habitats such as riparian zones and wet sclerophyll forest.

8.2.28.3 Presence within the Subject Site

The Eastern False Pipistrelle has been recorded within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Foraging and roosting habitat is widespread throughout the subject site and locality for this highly mobile and wide ranging species. HWC (2004) notes that this species may roost within the subject site given the presence of hollow-bearing trees, with preferential potential roosting sites likely located within the Conservation area (i.e. periphery of wetland 803 and denser riparian vegetation).

8.2.28.4 Assessment of Significance

Assessment of Significance: Eastern False Pipistrelle

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Yellow-bellied Sheath-tail Bat, which is based on possible habitat utilisation (i.e. not recorded) of the subject site and study area for foraging purposes (and possible breeding), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:

Assessment of Significance: Eastern False Pipistrelle

  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of locally and progressively reducing the availability of habitat currently utilised by the species by approximately 47.94 ha over an 8+ year timeframe, which will be countered by the immediate retention of 103.93 ha habitat within the Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Eastern False Pipistrelle

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging/ breeding habitat) and restoration of diminished habitat areas, a habitat area of 47.94 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 19.76 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging/ breeding habitat (i.e. 103.93ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Assessment of Significance: Eastern False Pipistrelle

The Eastern False Pipistrelle relies on large areas of native vegetation for foraging and breeding. The area of habitat to be removed is sufficiently large to satisfy the life cycle of the Eastern False Pipistrelle as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity

Assessment of Significance: Eastern False Pipistrelle	
	development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising

Assessment of Significance: Eastern False Pipistrelle	
	relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.28.5 Conclusion

The Proposal will result in the progressive removal of 47.94 ha of habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). Countering this impact, the Proposal will retain a 'like for like' habitat area of 103.93 ha (i.e. the Conservation Area) for in-perpetuity protection and management. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.29 Little Bentwing-bat

8.2.29.1 Habitat

The Little Bentwing-bat can be found in moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub and forage at night for small insects beneath the canopy of densely vegetated habitat (OEH 2019b). It roosts in caves, tree hollows, tunnels, abandoned mines, stormwater drains, culverts, bridges and buildings and forages at night for small insects beneath the canopy of dense vegetation (OEH 2019b).

8.2.29.2 Ecology

Little Bentwing-bats often share roosting sites with the Eastern Bentwing-bat and, in winter, the two species may form mixed clusters. In NSW the largest maternity colony is in close association with a large maternity colony of Eastern Bentwing-bats and appears to depend on the large colony to provide the high temperatures needed to rear its young. Maternity colonies form in spring and birthing occurs in early summer. Males and juveniles disperse in summer (BCD 2019b).

8.2.29.3 Presence within the Subject Site

The Little Bentwing-bat has been observed or recorded within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Foraging habitat is widespread throughout the subject site and locality for this highly mobile and wide ranging species. Breeding habitat is absent. HWC (2004) notes that this species is known to roost in the nearby Balickera Canal tunnel.

8.2.29.4 Assessment of Significance

Assessment of Significance: Little Bentwing-bat

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Little Bentwing-bat, which is based on known utilisation of the subject site and study area for foraging purposes (no breeding habitat), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;

Assessment of Significance: Little Bentwing-bat

- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of reducing the habitat area currently utilised by the species within the subject site by approximately 212.14 ha, which is countered by the restoration and retention of 216.49 ha of habitat within the Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Little Bentwing-bat

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging habitat) and restoration of diminished habitat areas, a foraging habitat area of 212.14 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging habitat (i.e. 216.49 ha), which is to be conserved and secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

Assessment of Significance: Little Bentwing-bat
iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.
The Little Bentwing-bat relies on large areas of native vegetation for foraging, with caves and/or similar structures required for roosting/ breeding which is absent from the subject site. The area of habitat to be removed is sufficiently large to satisfy foraging by the Little Bentwing-bat as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020). In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.
e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
Critical habitat has not been declared or mapped for this species. Not applicable.
f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
No approved NSW recovery or threat abatement plans relate to this species. Not applicable.
g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool'

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	(https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Loss of Hollow-bearing Trees	The Proposal will result in both the removal and in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna.

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	Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.29.5 Conclusion

The Proposal will result in the progressive removal of 212.14 ha of foraging habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures). Countering this impact, the Proposal will retain a 'like for like' habitat area of 216.49 ha (i.e. the Conservation Area) for in-perpetuity protection and management. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the

subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.30 Eastern Bentwing-bat

8.2.30.1 Habitat

The Eastern Bentwing-bat is a highly mobile species that forages in a broad range of vegetation types over large areas, with reliance on caves or similar structures for diurnal roosts, hibernation and breeding.

8.2.30.2 Ecology

Eastern Bentwing-bats primarily roost in caves, but also use derelict mines, storm-water tunnels, buildings and other man-made structures (OEH 2019b). Populations usually centre on a maternity cave that is used annually in spring and summer and have very specific temperature and humidity requirements (OEH 2019b). At other times of the year, this species can travel up to 300km of maternity caves and use cold caves for hibernation in southern Australia. It hunts in forested areas, catching insects flying above the canopy, and in open areas where it flies a few metres off the ground (Churchill, 2009).

8.2.30.3 Presence within the Subject Site

The Eastern Bentwing-bat has been observed or recorded within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Foraging habitat is widespread throughout the subject site and locality for this highly mobile and wide ranging species. Breeding habitat is absent. HWC (2004) notes that this species is known to roost in the nearby Balickera Canal tunnel.

8.2.30.4 Assessment of Significance

Assessment of Significance: Eastern Bentwing-bat

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Eastern Bentwing-bat, which is based on known utilisation of the subject site and study area for foraging purposes (no breeding habitat), has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:

Assessment of Significance: Eastern Bentwing-bat

  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will have the effect of reducing the habitat area currently utilised by the species within the subject site by approximately 212.14 ha, which is countered by the restoration and retention of 216.49 ha of habitat within the Conservation Area. Mitigation works, as specified in the BMP for the Conservation Area (**Appendix C**), will be initiated prior to habitat clearing with the objective of generating early ecological benefit in advance of habitat loss, particularly in Phases 2 and 3. Habitat loss during Phase 1 aims to minimise impact intensity by initially focusing on peripheral vegetation and habitat where lower biodiversity values typically occur (i.e. existing edge effected habitat and vegetation with lower densities of hollow-bearing trees and fallen logs). In combination with the vegetation clearing procedure, as specified in the VMP (**Appendix D**), it is expected that the sensitive clearing methods will greatly improve the likelihood of an orderly displacement of wildlife from the impact area into the Conservation Area.

The retained habitat comprises suitable 'like for like' foraging values and areas for breeding, which will be actively managed and protected in-perpetuity for the benefit of the species. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle, as the area retained is sufficiently dimensioned and configured to allow for multiple breeding animals to persist over time. This conclusion is supported by favourable landscape scale factors used to assess habitat value (OEH 2014) such as patch size (i.e. very large patch > 1,000 ha) and connectivity width (i.e. >100 m). Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. progressive and careful removal of habitat, in-perpetuity habitat protection and progressive condition gain over time following Conservation Area establishment and management) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Assessment of Significance: Eastern Bentwing-bat

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging habitat) and restoration of diminished habitat areas, a foraging habitat area of 212.14 ha is to be removed over three Phases of the Proposal, with Phase 3 representing the largest proportional impact (i.e. 87.55 ha). The bulk of the Proposal's impact is deferred to Phase 3 (i.e. 8+ years) and after the establishment of the Conservation Area and in-perpetuity conservation agreement inclusive of foraging/ breeding habitat for this species.

Retained (modified)

The Conservation Area comprises foraging habitat (i.e. 216.49 ha), which is to be conserved and secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Assessment of Significance: Eastern Bentwing-bat

The Eastern Bentwing-bat relies on large areas of native vegetation for foraging, with caves and/or similar structures required for roosting/ breeding which is absent from the subject site. The area of habitat to be removed is sufficiently large to satisfy foraging by the Eastern Bentwing-bat as is the area of habitat to be retained in the Conservation Area. The species is largely sedentary and as such would likely use the habitat for breeding and foraging purposes. The habitat to be removed is not likely to be important in natal dispersal as it should be noted that the Proposal has accommodated sufficient connected vegetation to maintain local and regional movement. The recent bushfires of the 2019-20 summer season have had an adverse impact on occupied habitat along the NSW east coast that may provide habitat for this species (i.e. 2,715,381 ha of dry and wet sclerophyll forest; BCD 2020).

In light of the in-perpetuity protection and management of a larger patch of habitat within the Conservation Area, which has the purpose of maintaining a local viable population of this species, and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any

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	native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	African Olive and Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of African Olive and Lantana.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/

Assessment of Significance: Eastern Bentwing-bat	
Invasion and establishment of exotic vines and scramblers	or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.2.30.5 Conclusion

The Proposal will result in the progressive removal of 212.14 ha of foraging habitat over 8+ years in accordance with a sensitive vegetation clearing procedure (VMP; **Appendix D**). The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures). Countering this impact, the Proposal will retain a 'like for like' habitat area of 216.49 ha (i.e. the Conservation Area) for in-perpetuity protection and management. More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species are likely to be minor and inconsequential.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect an equal or greater amount of 'like for like' habitat. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the continued utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.31 Green and Golden Bell Frog

8.2.31.1 Habitat

The Green and Golden Bell Frog inhabits marshes, dams and stream-sides, particularly those containing bullrushes (*Typha* spp.) or spikerushes (*Eleocharis* spp.). Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow (*Gambusia holbrooki*), have a grassy area nearby and diurnal sheltering sites available (BCD 2019b).

8.2.31.2 Ecology

The Green and Golden Bell Frog has exhibited the ability to occur highly disturbed areas, particularly in the Greater Sydney region such as Kooragang Island. The species is active by day and usually breeds in summer when conditions are warm and wet. Males call while floating in water and females produce a raft of eggs that initially float before settling to the bottom, often amongst vegetation. Tadpoles feed on algae and other plant-matter; adults eat mainly insects, but also other frogs (BCD 2019b).

8.2.31.3 Presence within the Subject Site

The Green and Golden Bell Frog has not been observed or recorded within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Foraging habitat may occur within wetland 804 and, to a lesser extent, wetland 803; although never observed.

8.2.31.4 Assessment of Significance

Assessment of Significance: Green and Golden Bell Frog

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Green and Golden Bell Frog, which is based on possible habitat utilisation (i.e. not recorded) of the subject site and study area for foraging purposes with maybe breeding although unlikely, has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:

Assessment of Significance: Green and Golden Bell Frog

  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will not reduce the availability of habitat currently utilised by the species. Conversely, the Proposal will retain habitat within and surrounding wetland 803 that may be used for foraging and breeding purposes. Mitigation works involving the management of stormwater, as specified in **Section 7** and assessed in **Section 5.1.2**, will be completed to minimise the effect of altered hydraulic functioning in the catchments of wetlands 803 and 804. The stormwater design principles that are to be incorporated into the Proposal are likely to have a minor and inconsequential impact on wetlands 803 and 804 such that there is no expected change in vegetation types or condition within these wetlands. Wetting and drying cycles are expected to remain relatively consistent with pre-development conditions.

The retained habitat will be actively managed and protected in-perpetuity for the benefit of the species. The removal of livestock and management of feral deer may improve habitat conditions within wetland 803 where macrophyte growth is allowed to occur. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle should it utilise wetland 803 either periodically for foraging or for breeding. Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;
- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. minor and inconsequential changes in hydraulic conditions) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

Assessment of Significance: Green and Golden Bell Frog
i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
Species not listed as an endangered or critically endangered ecological community. Not applicable.
ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
Species not listed as an endangered or critically endangered ecological community. Not applicable.
d. In relation to the habitat of a threatened species, population or ecological community:
i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
Removal The Proposal is not expected to result in the loss of habitat for this species (i.e. wetland, swamp sclerophyll and adjacent vegetation to be retained). Indirect impacts on these areas of retained potential habitat are minimal and unlikely to result in any loss. Retained (modified) The Conservation Area comprises potential habitat (i.e. ~14.85 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works). Changes in vegetation and habitat values as a consequence of altered hydrological regimes are expected to be minor and inconsequential (Alluvium 2019).
ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.
iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.
Habitat for the Green and Golden Bell Frog comprises coastal wetlands for foraging and breeding with adjacent terrestrial vegetation used for movement and shelter. Habitat within the subject site may be used for foraging and breeding while wetland 803 contains water (noting wetland 803 has a wetting drying cycle and is marginally suitable due to the lack of macrophytic vegetation). This habitat will retained in the Conservation Area and will not be removed or adversely impacted. The recent bushfires of the 2019-20 summer season have little impact on occupied habitat along the NSW east coast that may provide habitat for this species (BCD 2020).

Assessment of Significance: Green and Golden Bell Frog

In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be affected by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within

Assessment of Significance: Green and Golden Bell Frog	
	the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	The subject site currently has limited examples of escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.

8.2.31.5 Conclusion

The Proposal will not result in the loss of habitat for this species. Indirect impacts through changes in hydraulic conditions are considered minor and inconsequential. Removal of livestock grazing and herbivory by feral deer is likely to result in isolated improvement in wetland vegetation habitat, with suitable habitat retained in the Conservation area that is subject to in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna). More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect habitat of value for this species. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality.

Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.2.32 Wallum Froglet

8.2.32.1 Habitat

Wallum Froglets are found in a wide range of habitats, usually associated with acidic swamps on coastal sand plains. They typically occur in sedgelands and wet heathlands. They can also be found along drainage lines within other vegetation communities and disturbed areas, and occasionally in swamp sclerophyll forests (BCD 2019b).

8.2.32.2 Ecology

The species breeds in swamps with permanent water as well as shallow ephemeral pools and drainage ditches. Breeding is thought to peak in the colder months, but can occur throughout the year following rain. Eggs of 1.1-1.2 mm are deposited in water with a pH of <6 and tadpoles take 2-6 months to develop into frogs. Wallum Froglets shelter under leaf litter, vegetation, other debris or in burrows of other species. Shelter sites are wet or very damp and often located near the water's edge. Males may call throughout the year and at any time of day, peaking following rain (BCD 2019b).

8.2.32.3 Presence within the Subject Site

The Wallum Frog has not been observed or recorded within the subject site. Surveys performed as part of this investigation are considered adequate for this species (**Section 4**), and appear consistent with the results of surveys performed over the past 15-20 years for this area (HWR 2004, EcoBiological 2009, PEA Consulting 2010, Firebird ecoSultants Pty Ltd 2013; Arcadis 2019). Foraging habitat may occur within wetland 804 and, to a lesser extent, wetland 803; although never observed.

8.2.32.4 Assessment of Significance

Assessment of Significance: Wallum Froglet

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

A viable local population requires repeated successful recruitment events (i.e. life cycle completion) by multiple sequential generations within an area of suitable habitat. Some of the challenges faced by viable local populations include interrupted breeding events, loss of individuals (e.g. impacts from fire, weather, predation, disease), changes in habitat condition/ configuration or area and competition. The assessment provided for the Wallum Froglet, which is based on possible habitat utilisation (i.e. not recorded) of the subject site and study area for foraging and breeding purposes, has considered the effect of:

- Habitat loss, both direct and indirect impacts as discussed in **Section 5**, including the manner in how this occurs [i.e. progressive clearing using a procedure designed to minimise harm and provide opportunity for adjustment, as outlined in the Proposal description (**Section 2.1.1**) and VMP (**Appendix D**)],
- Impact avoidance measures (i.e. benefit), as outlined in **Section 2.1.1.1** and **Section 7.1**;
- Mitigation measures (i.e. benefit), as detailed in **Section 7** and BMP (**Appendix C**) to minimise impact intensity, to provide adequate habitat and connectivity, and to manage threats and improve conditions conducive to successful recruitment events. As outlined in **Section 7**, this is achieved under the BMP by:
  - the enhancement/ enrichment of habitat values in the Conservation Area to sustainably improve ecological integrity prior to progressive clearing events; and
  - improving habitat in the Conservation Area to a level that will enable the progressive transition of species out of impact areas into a long term sustainable Conservation Area that will be managed, funded, and protected in-perpetuity;
- Cumulative impacts (i.e. confidence in the understanding of broader impacts), as detailed in **Section 2.1.2.8** and **Section 5.1.1**); and
- In-perpetuity conservation and management of 'like for like' biodiversity values proximal to the impact for the benefit of the species (i.e. VPA).

The Proposal will not reduce the availability of habitat currently utilised by the species. Conversely, the Proposal will retain habitat within and surrounding wetland 803 that may be used for foraging and breeding purposes. Mitigation works involving the management of stormwater, as specified in **Section 7** and assessed in **Section 5.1.2**, will be completed to minimise the effect of altered hydraulic functioning in the catchments of wetlands 803 and 804. The stormwater design principles that are to be incorporated into the Proposal are likely to have a minor and inconsequential impact on wetlands 803 and 804 such that there is no expected change in vegetation types or condition within these wetlands. Wetting and drying cycles are expected to remain relatively consistent with pre-development conditions.

The retained habitat will be actively managed and protected in-perpetuity for the benefit of the species. The removal of livestock and management of feral deer may improve habitat conditions within wetland 803 where macrophyte growth is allowed to occur. It is anticipated that the establishment and management of this Conservation Area under an in-perpetuity conservation agreement will allow the species to continue its life cycle should it utilise wetland 803 either periodically for foraging or for breeding. Wildlife corridors protected in the Conservation Area will aid dispersal to and from habitat thus maintaining genetic flow.

Cumulative impacts arising from development unrelated to the Proposal are expected to be controlled within the locality and have minor inconsequential influence on the viability of a local population as:

- R1/ B2 and B4 land zonings are absent from lands surrounding the KHURA (i.e. no future urban development pressure is planned for the locality);
- Private land holdings are predominantly RU2 where coincident with native vegetation. Where impact thresholds are exceeded (i.e. s7.2 and 7.3 of the BC Act), the clearing of vegetation and habitat on these lands is regulated by formal assessment processes administered by PSC. Here, it is noted that most of the RU2 lands within 5 km of the subject site are mapped as having biodiversity value on the Biodiversity Values Map and Threshold Tool (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap accessed January 2020) meaning that any land clearing within this area will require the application of the BAM and participation in the Biodiversity Offsets Scheme;

Assessment of Significance: Wallum Froglet

- E1/ E2 and E3 land zonings within and nearby the KHURA will not be adversely impacted by the Proposal nor is there a likelihood for these lands to be adversely impacted by other unrelated anthropogenic land uses; and
- Vegetation and habitat within the area classified as SP1 land zoning, which is owned and managed by Hunter Water Corporation and largely associated with the periphery of Grahamstown Dam, is not likely to be cleared as these natural areas form an essential part of protecting the integrity of the lower Hunter Valley drinking water catchment.

In light of the Proposal impacts (i.e. minor and inconsequential changes in hydraulic conditions) and evaluation of possible future cumulative impacts, it is considered that the Proposal is **not likely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Species is not listed as an endangered population. Not applicable.

c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Species not listed as an endangered or critically endangered ecological community. Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Species not listed as an endangered or critically endangered ecological community. Not applicable.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

<u>Removal</u>

The Proposal is not expected to result in the loss of habitat for this species (i.e. wetland, swamp sclerophyll and adjacent vegetation to be retained). Indirect impacts on these areas of retained potential habitat are minimal and unlikely to result in any loss as a result of the action proposed.

<u>Retained (modified)</u>

The Conservation Area comprises potential habitat (i.e. ~14.85 ha), which is to be conserved secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works). Changes in vegetation and habitat values as a consequence of altered hydrological regimes are expected to be minor and inconsequential (Alluvium 2019).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Assessment of Significance: Wallum Froglet

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of individuals, biodiversity related to its life cycle and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Habitat for the Wallum Froglet comprises coastal wetlands for foraging and breeding with adjacent terrestrial vegetation used for movement and shelter. Habitat within the subject site may be used for foraging and breeding while wetland 803 contains water (noting wetland 803 has a wetting drying cycle and is marginally suitable due to the lack of macrophytic vegetation). This habitat will be retained in the Conservation Area and will not be removed or adversely impacted. The recent bushfires of the 2019-20 summer season have little impact on occupied habitat along the NSW east coast that may provide habitat for this species (BCD 2020).

In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be affected by the Proposal is not regarded as important to the long-term survival of the species in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this species. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this species. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with

Assessment of Significance: Wallum Froglet	
	revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	The subject site currently has limited examples of escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.

8.2.32.5 Conclusion

The Proposal will not result in the loss of habitat for this species. Indirect impacts through changes in hydraulic conditions are considered minor and inconsequential. Removal of livestock grazing and herbivory by feral deer is likely to result in isolated improvement in wetland vegetation habitat, with habitat that may be suitable for this species retained in the Conservation area that is subject to in-perpetuity protection and management. The establishment of the Conservation Area through implementation of the BMP (**Appendix C**) will address relevant existing key threatening processes acting on this land for the benefit of the species (e.g. improve vegetation structure, plant species diversity, habitat condition, predation pressures and competition with exotic fauna).

More broadly, land zoning, tenure and effect of regulatory controls (e.g. operation of the BC Act) within the locality (i.e. ~ 5km radius of the subject site) will collectively minimise the propensity and effect of cumulative impacts such that ongoing adverse impacts on the habitat of this species in the locality are likely to be minor, inconsequential and not of sufficient scale or nature to impact the life cycle or movement of the species.

The Conservation Area, established through implementation of a BMP (**Appendix C**) that forms part of the Proposal, is to be maintained under an in-perpetuity conservation agreement to protect habitat of value for this species. The habitat area protected is considered sufficiently large and of appropriate dimensions to allow for sustained use over time, thereby allowing the utilisation/ occupation of this habitat by the threatened species as part of its lifecycle.

The Proposal is not expected to result in the loss of or contribute to the loss of a local viable population of this species through interruption of the species lifecycle. The species and its habitat will not become fragmented or isolated, which would otherwise impact genetic flow and population viability. The number of individuals impacted will not adversely affect the total number of individuals known nor would it alter the known distribution of the species within the locality. Relevant KTPs have been identified and are to be managed within the Conservation Area in accordance with the BMP and in-perpetuity conservation arrangements. It is considered that the residual impacts of the Proposal have been appropriately managed such that the Proposal is not likely to have a significant impact on this species.

On this basis, it is considered that impact avoidance and amelioration measures proposed (see **Section 7**) have adequately addressed the residual impacts of the Proposal on this species. Accordingly, additional compensatory measures such as the provision of a biodiversity offset is not required to address the impacts of the Proposal.

8.3 Endangered Ecological Communities

8.3.1 Lower Hunter Spotted Gum Ironbark Forest

8.3.1.1 Description

Lower Hunter Spotted Gum Ironbark Forest (LHSGIF) is currently known to occur in the Lower Hunter Valley centred on the Cessnock-Beresfield area and approximately bounded by the towns of Paxton, Branxton, Clarence Town, Beresfield, Mt Vincent and the northern boundary of Watagans National Park. The northern and southern parts of its distribution are separated by the floodplain of the Hunter River. It is important to note that the subject site is located on the outer edge of the distribution as indicated by a line between Clarence Town and Beresfield, with average annual rainfall withi nteh subject site being greater than the prescribed range indicated for this ecological community, which is 750-1,000 mm.

LHSGIR is usually dominated by *Corymbia maculata* (Spotted Gum) and *Eucalyptus fibrosa* (Broad-leaved Ironbark), with *E. punctata* (Grey Gum) occurring less frequently. Other tree species have been recorded infrequently, including *E. crebra*, *E. moluccana*, *E. agglomerata*, *E. umbra*, *C. gummifera*, *Syncarpia glomulifera*, *E. globoidea*, *E. paniculata* subsp. *paniculata*, *E. sparsifolia*, *Angophora costata*, *E. acmenoides*, *E. fergusonii* subsp. *fergusonii, E. nubila* and *C. eximia* (NPWS 2000). None of these species are characteristic of Lower Hunter Spotted Gum Ironbark Forest. LHSGIF is characterised by an assemblage of flora species as listed below:

Acacia parvipinnula, Aristida vagans, Billardiera scandens, Bursaria spinosa, Callistemon linearifolius, Cheilanthes sieberi subsp. sieberi, Correa reflexa, Corymbia maculata, Daviesia ulicifolia, Denhamia silvestris, Dianella revoluta var. revoluta, Dichelachne micrantha, Entolasia stricta, Eragrostis brownii, Eucalyptus fibrosa, Eucalyptus punctata, Glycine clandestina, Goodenia rotundifolia, Grevillea montana Grevillea parviflora subsp. parviflora, Hardenbergia violacea, Lepidosperma laterale, Leptospermum parvifolium, Lissanthe strigosa, Lomandra filiformis, Lomandra multiflora, Macrozamia flexuosa, Melaleuca decora, Melaleuca nodosa, Microlaena stipoides, Opercularia diphylla, Ozothamnus diosmifolius, Panicum simile, Paspalidium distans, Persoonia linearis, Phyllanthus hirtellus, Platysace ericoides, Podolobium ilicifolium, Pomax umbellata, Pratia purpurascens, Pultenaea spinosa, Rytidosperma pallidum, Themeda triandra and Vernonia cinerea var. cinerea.

Lower Hunter Spotted Gum Ironbark Forest is known to occur principally on Permian and Carboniferous geology in the central to lower Hunter Valley. The Permian substrates most commonly supporting the community belong to the Dalwood Group, the Maitland Group and the Greta and Tomago Coal Measures (NSW Department of Mines 1966, 1969). In the area of Paterson, Seaham and Clarence Town, the community occurs on Carboniferous sediments including the Wallaringa, Mt Johnstone and Seaham formations. The community is strongly associated with, although not restricted to, the yellow podsolic and solodic soils of the Lower Hunter soil landscapes of Aberdare, Branxton and Neath (Kovac and Lawrie 1991). These substrates are considered to produce 'moderately fertile' soils (Kovac and Lawrie 1991).

Lower Hunter Spotted Gum Ironbark Forest grades into Spotted Gum/Broad-leaved Mahogany/Red Ironbark moist shrubby open forest (MU 65 of Somerville 2009b) in areas with similar edaphic properties but receiving a higher average annual rainfall. This community includes vegetation described as Coastal

Foothills Spotted Gum Ironbark Forest, Seaham Spotted Gum Ironbark Forest (MU 15 and MU 16 of NPWS 2000) and Hinterland Spotted Gum Ironbark Forest (Bell 2013). The subject site is characterised by a higher annual rainfall than that prescribed for LHSGIF, with much of the vegetation observed within the subject site being classed as Spotted Gum/Broad-leaved Mahogany/Red Ironbark moist shrubby open forest and not part of the EEC.

8.3.1.2 Presence within the Subject Site

Lower Hunter Spotted Gum Ironbark Forest is mapped in the south-eastern corner of the subject site. Surveys and analysis performed as part of this investigation are considered adequate for this ecological community (**Section 4**). The mapping of this ecological community within the subject site is first recognition of its occurrence and reflects the recent listing definition, which has expanded the geographical range to include the NSW North Coast Bioregion (previously limited to the Sydney Basin Bioregion). The mapping of this community within the subject site is also conservative and precautionary, as discussed in detail in **Section 6.1.1**, with the degree of precaution weighted in favour of this ecological community rather than recognition of a highly disturbed patch of PCT 1590 (Seaham Spotted Gum Ironbark Forest – which is assessed as not being consistent with the final determination for this ecological community). The occurrence of this ecological community within the subject site is limited to an isolated patch of weathered basaltic soils (soils of high fertility), which is atypical for this community.

8.3.1.3 Assessment of Significance

Assessment of Significance: Lower Hunter Spotted Gum Ironbark Forest
a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
Community not listed as a threatened species. Not applicable.
b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Community not listed as an endangered population. Not applicable.
c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
The NSW Scientific Committee (2019) identify the extent of occurrence for this ecological community to be 1,773 km^2. Sivertsen et al.'s (2011) estimate of tree cover, between 17,456 ha (open forest structure, 27% of pre-1750 distribution) and 26,298 ha (all structural forms, 41% of pre-1750 distribution). Nearby mapped occurrences of this ecological community indicate the reserved occurrence of 419 ha in Columbey National Park and 87 ha in Columbey State Conservation Area (Bell 2016). The Proposal will result in the removal of 5.05 ha of this ecological community representing 0.03% of its total extent and 0.99% relative to local reserved patches in Columbey National Park Columbey State Conservation Area. Given the highly disturbed nature of the patch and its isolation, and the retention of ~1 ha of this vegetation within the Conservation Area, it is considered that the Proposal will not have an adverse effect on the extent of this ecological community such that its local occurrence is likely to be placed at rick of extinction.

Assessment of Significance: Lower Hunter Spotted Gum Ironbark Forest

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

The Proposal will modify the retained patch of LHSGIF by improving the floristic and structural character of vegetation retained within the Conservation Area. These actions will aid in the managed retention of this ecological community within the locality.

d. In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Proposal will remove and retain habitat occupied by this species. Retained habitat is to be modified through implementation of a BMP for the purposes of improving habitat conditions for the species (e.g. removal of weed species such as Lantana), with retained habitat subject to an in-perpetuity conservation outcome.

Removal

After accounting for the beneficial outcome generated from impact avoidance (i.e. avoided ~38.47 ha of foraging habitat) and restoration of diminished habitat areas, a foraging habitat area of 5.07 ha is to be removed over three Phases of the Proposal, with Phase 1 representing the largest proportional impact.

Retained (modified)

The Conservation Area comprises foraging habitat (i.e. 1.07 ha), which is to be conserved and secured in accordance with a VPA involving conservation establishment works (i.e. BMP) and an in-perpetuity conservation agreement. The BMP has the purpose of reducing/ managing existing unmanaged threats on the species and its habitat (e.g. fire events, herbivory by feral herbivores, existing weed invasions). Habitat modification resulting from the proposed action aims to improve habitat conditions for the benefit of the species, with the delivery of this benefit expected within five years (i.e. by the end of Phase 1 works).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of components of the ecological community and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The patch of LHSGIF to be removed is small, highly disturbed and isolated from larger more intact patches of this ecological community. The integrity of the vegetation and habitat is compromised by a long history of vegetation clearing and livestock grazing, as indicated by the modified groundcover layer including simplified floristics and presence of exotics. It is considered that the habitat to be removed is not important to the long term survival of the ecological community in the locally (i.e. representation in Columbrey National Park and Columbrey State Conservation Area).

The recent bushfires of the 2019-20 summer season have little impact on the habitat of this EEC within the region (BCD 2020). In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the ecological community in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Assessment of Significance: Lower Hunter Spotted Gum Ironbark Forest

Critical habitat has not been declared or mapped for this community. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this community. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification. Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be:

Assessment of Significance: Lower Hunter Spotted Gum Ironbark Forest	
	• No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	
Loss of Hollow-bearing Trees	The Proposal will result in the removal and retention/ in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to

Assessment of Significance: Lower Hunter Spotted Gum Ironbark Forest	
	minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brown Treecreeper, Little Lorikeet, Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.3.1.4 Conclusion

The local occurrence of Lower Hunter Spotted Gum-Ironbark Forest EEC in the subject site is comprised of a total of 6.25 ha in a disturbed condition with 5.07 ha to be removed by the Proposal. The community occurs in a degraded condition in the study area and has been moderately impacted by previous land uses. An area of 419 ha of Lower Hunter Spotted Gum-Ironbark Forest EEC is protected in Columbey National Park located about 13 km to the north. Further protections of this community exist in Werakata National Park and Sate Conservation Area. The total loss of this community is approximately 0.03% of the area formally reserved in the mentioned conservation reserves. Retention of 1.08 ha within the Conservation Area and retained presence of other local occurrences in the study area indicates that this community is not likely to be placed at risk of local extinction. While not relied on in this assessment, the provision of an in-perpetuity managed patch of this EEC in the Conservation Area will retain the local occurrence of this EEC. It is considered that the Proposal is not likely to have a significant impact on Lower Hunter Spotted Gum-Ironbark Forest EEC.

8.3.2 Swamp Oak Forest

8.3.2.1 Description

SOFF EEC is found on the coastal floodplains of NSW. It has a dense to sparse tree layer in which *Casuarina glauca* (swamp oak) is the dominant species northwards from Bermagui.

Other trees including *Acmena smithii* (lilly pilly), *Glochidion* spp. (cheese trees) and *Melaleuca* spp. (paperbarks) may be present as subordinate species, and are found most frequently in stands of the community northwards from Gosford. Tree diversity decreases with latitude, and *Melaleuca ericifolia* is the only abundant tree in this community south of Bermagui.

The understorey is characterised by frequent occurrences of vines, *Parsonsia straminea*, *Geitonoplesium cymosum* and *Stephania japonica* var. *discolor*, a sparse cover of shrubs, and a continuous groundcover of forbs, sedges, grasses and leaf litter.

The composition of the ground stratum varies depending on levels of salinity in the groundwater. Under less saline conditions prominent ground layer plants include forbs such *Centella asiatica*, *Commelina cyanea*, *Persicaria decipiens* and *Viola banksii*; graminoids such as *Carex appressa*, *Gahnia clarkei*, *Lomandra longifolia*, *Oplismenus imbecillis*; and the fern *Hypolepis muelleri*.

On the fringes of coastal estuaries, where soils are more saline, the ground layer may include the threatened grass species, *Alexfloydia repens*, as well as *Baumea juncea*, *Juncus kraussii*, *Phragmites australis*, *Selliera radicans* and other saltmarsh species.

8.3.2.2 Assessment of Significance

Assessment of Significance: Swamp Oak Forest
a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
Community not listed as a threatened species. Not applicable.
b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Community not listed as an endangered population. Not applicable.
c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
The Proposal will not reduce or adversely affect the extent of SOFF EEC. The Proposal will not place this EEC at risk of extinction

Assessment of Significance: Swamp Oak Forest
ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
The Proposal will restore and improve extent of SOFF EEC within the subject site through revegetation works around wetland 803. The Proposal will not substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
d. In relation to the habitat of a threatened species, population or ecological community:
i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
The Proposal will not remove SOFF EEC.
ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of components of the ecological community and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.
iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.
The Proposal will not remove, modify, fragmented or isolated SOFF EEC. SOFF EEC is to be retained within the Conservation Area and is subject to restoration works to improve its current integrity. The recent bushfires of the 2019-20 summer season have little impact on the habitat of this EEC within the region (BCD 2020). In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the ecological community in the locality.
e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
Critical habitat has not been declared or mapped for this community. Not applicable.
f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
No approved NSW recovery or threat abatement plans relate to this community. Not applicable.
g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat.

Assessment of Significance: Swamp Oak Forest	
	For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification: • PCT 1584: Currently 42% cleared in NSW – 47.56 ha reduction caused by the Proposal will not result in an overcleared state • PCT 1590: Currently 48% cleared in NSW – 159.05 ha reduction caused by the Proposal will not result in an overcleared state • PCT 1600: Currently 66% cleared in NSW – 5.15 ha reduction caused by the Proposal will not result in an overcleared state Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events.

Assessment of Significance: Swamp Oak Forest	
	The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the

Assessment of Significance: Swamp Oak Forest	
	duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of Lantana.
Invasion of native plant communities by exotic perennial grasses Invasion and establishment of exotic vines and scramblers Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Loss of Hollow-bearing Trees	The Proposal will result in the removal and retention/ in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brown Treecreeper, Little Lorikeet, Brush-tailed Phascogale, Squirrel Glider and medium

Assessment of Significance: Swamp Oak Forest	
	sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures. It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.3.2.3 Conclusion

The local occurrence of SOFF EEC in the subject site is wholly located within the Conservation Area and will not be removed by the Proposal. The community occurs in a degraded condition in the study area and has been moderately impacted by previous land uses. Restoration works are expected to improve the habitat integrity of SOFF EEC. Indirect impacts from stormwater inflows are minor and inconsequential. It is considered that the Proposal is not likely to have a significant impact on SOFF EEC.

8.3.3 Swamp Sclerophyll Forest

8.3.3.1 Description

SSFCF EEC has an open to dense tree layer of eucalypts and paperbarks although some remnants now only have scattered trees as a result of partial clearing. The trees may exceed 25 m in height, but can be considerably shorter in regrowth stands or under conditions of lower site quality where the tree stratum is low and dense. For example, stands dominated by *Melaleuca ericifolia* typically do not exceed 8 m in height. The community also includes some areas of fernland and tall reedland or sedgeland, where trees are very sparse or absent.

The most widespread and abundant dominant trees include *Eucalyptus robusta* (swamp mahogany), *Melaleuca quinquenervia* (paperbark) and, south from Sydney, *Eucalyptus botryoides* (bangalay) and Eucalyptus longifolia (woollybutt). Other trees may be scattered throughout at low abundance or may be locally common at few sites, including *Callistemon salignus* (sweet willow bottlebrush), *Casuarina glauca* (swamp oak) and *Eucalyptus resinifera* subsp. *hemilampra* (red mahogany), *Livistona australis* (cabbage palm) and *Lophostemon suaveolens* (swamp turpentine).

8.3.3.2 Assessment of Significance

Assessment of Significance: Swamp Sclerophyll Forest
a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
Community not listed as a threatened species. Not applicable.
b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Community not listed as an endangered population. Not applicable.
c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
The Proposal will not reduce or adversely affect the extent of SSFCF EEC. The Proposal will not place this EEC at risk of extinction.
ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
The Proposal will restore and improve extent of SSFCF EEC within the subject site through revegetation works around wetland 803. The Proposal will not substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
d. In relation to the habitat of a threatened species, population or ecological community:
i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Assessment of Significance: Swamp Sclerophyll Forest

The Proposal will not remove SSFCF EEC.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of components of the ecological community and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Proposal will not remove, modify, fragmented or isolated SSFCF EEC. SSFCF EEC is to be retained within the Conservation Area and is subject to restoration works to improve its current integrity. The recent bushfires of the 2019-20 summer season have little impact on the habitat of this EEC within the region (BCD 2020). In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the ecological community in the locality.

e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared or mapped for this community. Not applicable.

f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No approved NSW recovery or threat abatement plans relate to this community. Not applicable.

g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive

Assessment of Significance: Swamp Sclerophyll Forest	
	clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification: • PCT 1584: Currently 42% cleared in NSW – 47.56 ha reduction caused by the Proposal will not result in an overcleared state • PCT 1590: Currently 48% cleared in NSW – 159.05 ha reduction caused by the Proposal will not result in an overcleared state • PCT 1600: Currently 66% cleared in NSW – 5.15 ha reduction caused by the Proposal will not result in an overcleared state Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution; • No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones;

Assessment of Significance: Swamp Sclerophyll Forest	
	• No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Ecological consequences of high frequency fires	Current fire management in the local landscape operates within a framework that generally excludes the prescription of management works within the subject site. The Proposal, through the BMP and VMP, will provide a clear framework for the management of fire within the Conservation Area, which is to be managed in-perpetuity for the biodiversity protection. Combined, this management framework will provide reasonable opportunity for reducing the risk of high frequency fires within the Conservation Area for the benefit of native species that occupy this area.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.

Assessment of Significance: Swamp Sclerophyll Forest	
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	Lantana have existing (pre-Proposal) infestation across the study area. The Proposal aims to permanently remove these species from the site preparation area through implementation of the VMP (**Appendix D**). These species are to be intensely managed in the Conservation Area through implementation of the BMP (**Appendix C**), with the aim of these management regimes being the reduction in occurrence to less than 5% cover. These suppression/ elimination works are consistent with regional management strategy for these species. Vegetation and habitat are expected to benefit from these management works by allowing for greater natural recruitment opportunities and improvements in groundcover plant diversity. It is considered that actions arising from the Proposal will not aid in the invasion, establishment or spread of Lantana.
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.
Invasion and establishment of exotic vines and scramblers	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	
Loss of Hollow-bearing Trees	The Proposal will result in the removal and retention/ in-perpetuity conservation of hollow-bearing trees within the subject site. Initially, the principles of impact avoidance, as outlined in **Section 2.1.1.1**, were used during the Proposal design Phase to minimise the loss of hollow-bearing trees (i.e. avoidance of 38.47 ha native vegetation with parts of this impact avoidance area comprising relatively high densities of hollow-bearing trees). Avoided areas have been integrated into the Conservation Area for in-perpetuity management/ protection. Hollow-bearing trees located within the site preparation area are to be removed in accordance with the vegetation clearing procedure (**Section 2.1.1.4**) as detailed in the VMP (**Appendix D**). The purpose of this procedure is to progressively remove these habitat features in a sensitive manner so as to encourage fauna movement into the Conservation Area. Careful clearing practices are to be implemented for each hollow-bearing tree clearance to minimise harm to occupant fauna. Habitat enhancement works within the Conservation Area form part of the Proposal as mitigation for the loss of hollow-bearing trees. These works, which are specified in the BMP (**Appendix C**), have the purpose of enhancing parts of the Conservation Area where hollow-bearing tree densities are below the published benchmark state (i.e. benchmark = 10 or more hollow-bearing trees per hectare). The Proposal, as specified in the BMP (**Appendix C**), has made allowance for the installation of ~1,750 artificial/ natural hollows within the Conservation Area prior to and during Phase 1 works. Various hollow sizes will be used with a particular focus on the provision of hollows for the Brown Treecreeper, Little Lorikeet, Brush-tailed Phascogale, Squirrel Glider and medium sized arboreal mammals (e.g. Brush-tailed Possum), which would form an important food source for Large Forest Owls such as the Powerful Owl. Following completion of Phase 1 works, it is anticipated that the Conservation Area will have a density of hollow-bearing trees equal to or greater than benchmark state. Installed hollows will be monitored for occupancy and function for 3-5 years after installation. Longer term, it is expected that the vegetation within the Conservation Area will continue to develop natural hollows as the stand matures.

Assessment of Significance: Swamp Sclerophyll Forest	
	It is concluded that the sequenced removal of hollow-bearing trees combined with pre-emptive artificial and natural hollow installations in the Conservation Area to a benchmark or greater standard will adequately mitigate the loss of hollow-bearing trees in the short to medium term. Longer term, it is considered that the in-perpetuity protection and management of native vegetation and habitat within the Conservation Area will allow for the natural development of hollow-bearing trees. On this basis, it is considered that species reliant on habitat contained within hollow-bearing trees will persist in the local area.
Removal of dead wood and dead trees	The Proposal will result in the removal of dead wood and trees imbedded within areas of native vegetation cleared during site preparation works. These clearing works are sequential and will focus on areas of lower biodiversity value in Phase 1 before moving into higher value habitat in subsequent Phases. Conversely, dead wood and trees imbedded within the Conservation Area will be retained in-situ and will be protected by an in-perpetuity conservation agreement. In addition, the Proposal also includes provisioning for the collection and installation of 'fallen logs' within the Conservation Area as mitigation for the loss of this habitat type within the Proposal impact footprint. Trees cleared from the Proposal impact footprint will be harvested, processed and installed in parts of the Conservation Area where fallen log lengths are below benchmark levels. Specifications for this mitigation is provided in the BMP (**Appendix C**) with the identification and harvesting processes outlined in the VMP (**Appendix D**). It is concluded that the sequenced removal of dead wood and trees matched with the in-perpetuity protection of this habitat within the Conservation Area, as supplemented by fallen log installations to a benchmark or greater standard, will adequately mitigate the loss of this habitat in the long term. On this basis, it is considered that species reliant on this habitat type will persist in the local area.

8.3.3.3 Conclusion

The local occurrence of SSFCF EEC in the subject site is wholly located within the Conservation Area and will not be removed by the Proposal. The community occurs in a degraded condition in the study area and has been moderately impacted by previous land uses. Restoration works are expected to improve the habitat integrity of SSFCF EEC. Indirect impacts from stormwater inflows are minor and inconsequential. It is considered that the Proposal is not likely to have a significant impact on SSFCF EEC.

8.3.4 Freshwater Wetlands

8.3.4.1 Description

FWCF EEC occur in coastal areas subject to periodic flooding and in which standing fresh water persists for at least part of the year in most years. Typically occurs on silts, muds or humic loams in low-lying parts of floodplains, alluvial flats, depressions, drainage lines, backswamps, lagoons and lakes but may also occur in backbarrier landforms where floodplains adjoin coastal sandplains. Generally occur below 20 m elevation on level areas. They are dominated by herbaceous plants and have very few woody species. The structure and composition of the community varies both spatially and temporally depending on the water regime: Those that lack standing water most of the time are usually dominated by dense grassland or sedgeland vegetation, often forming a turf less than 0.5 metre tall and dominated by amphibious plants including *Paspalum distichum* (water couch), *Leersia hexandra* (swamp rice-grass), *Pseudoraphis spinescens* (mud grass) and *Carex appressa* (tussock sedge). Where they are subject to regular inundation and drying the vegetation may include large emergent sedges over 1 metre tall, such as *Baumea articulata*, *Eleocharis equisetina* and *Lepironia articulata*, as well as emergent or floating herbs such as *Hydrocharis dubia* (frogbit), *Philydrum lanuginosum* (frogsmouth), *Ludwigia peploides* subsp. *montevidensis* (water primrose), *Marsilea mutica* (nardoo) and *Myriophyllum* spp. (milfoils). As standing water becomes deeper or more permanent, amphibious and emergent plants become less abundant, while floating and submerged aquatic herbs become more abundant. These latter species include *Azolla filiculoides* var. rubra, *Ceratophyllum demersum* (hornwort), *Hydrilla verticillata* (water thyme), *Lemna* spp. (duckweeds), Nymphaea gigantea (giant waterlily), *Nymphoides indica* (water snowflake), *Ottelia ovalifolia* (swamp lily) and *Potamageton* spp. (pondweeds). The threatened aquatic plants, *Aldrovanda vesiculosa* and *Najas marina*, also occur within this community. For a comprehensive list of species that characterize the community open the Scientific Determination link in the top right box.

8.3.4.2 Assessment of Significance

Assessment of Significance: Freshwater Wetlands
a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
Community not listed as a threatened species. Not applicable.
b. In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Community not listed as an endangered population. Not applicable.
c. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
The Proposal will not have an adverse effect on the extent of FWCF EEC such that its local occurrence is likely to be placed at risk of extinction.

Assessment of Significance: Freshwater Wetlands
ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
The Proposal will not substantially and adversely modify the composition of FWCF EEC such that its local occurrence is likely to be placed at risk of extinction.
d. In relation to the habitat of a threatened species, population or ecological community:
i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
The Proposal will not remove FWCF EEC.
ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
The Proposal incorporates enhanced wildlife movement corridors as recommended by EcoBiological (2009) (see **Section 5.1.2.1** and **Figure 5.5**), a study commissioned by Port Stephens Council, which significantly increases the wildlife connectivity outcomes as intended by the Government approved zone boundaries (see **Section 1.2** and **Figure 1.2**), which was gazetted in 2010 as informed by the EcoBiological (2009) assessment. The enhanced corridor connections are of sufficient dimensions to act as habitat in its own right while allowing for the dispersal of components of the ecological community and genetic flow to other areas of habitat. These corridors will be protected and managed in-perpetuity within the Conservation Area. Therefore, it is considered that the Proposal will not fragment or isolate the habitat of this species from other areas of habitat.
iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.
The Proposal will not remove, modify, fragmented or isolated SSFCF EEC. The recent bushfires of the 2019-20 summer season have little impact on the habitat of this EEC within the region (BCD 2020). In light of the in-perpetuity protection and management of habitat within the Conservation Area and absence of widespread and damaging wildfires in the lower NSW North Coast bioregion (i.e. lands south of a line between Smiths Lake and Barrington Tops to the Hunter River representing a land area of ~550,000 ha), it is considered that the habitat to be removed by the Proposal is not regarded as important to the long-term survival of the ecological community in the locality.
e. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
Critical habitat has not been declared or mapped for this community. Not applicable.
f. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
No approved NSW recovery or threat abatement plans relate to this community. Not applicable.
g. Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands	The Proposal will lead to an increase in the impermeable area for catchments draining into wetlands 803 and 804. Potential exists for a greater influx of water entering both these wetlands over shorter timeframes together with increased nutrient loads. Without careful stormwater management, the alteration in flow regimes has the potential to impact wetting/ drying cycles, floristic assemblages and habitat. For this reason the Proposal incorporates WSUD principles for development above natural wetlands (**Sections 2.1.1.5** and **7.1.1.7.3**) with assessment of these principles in **Section 5.1.2.3**. The assessment showed that hydraulic change as a consequence of the Proposal is likely to be short term and not likely to have any measurable impact on wetland floristics and/ or

Assessment of Significance: Freshwater Wetlands	
	habitat (Alluvium 2019). While hydraulic alteration is expected, it is predicted that these changes will not have any substantive effect on the receiving wetlands such that wetting/ drying cycles, floristic assemblages and habitat would be adversely altered.
Clearing of native vegetation	Over an 8+ year timeframe the Proposal will progressively clear ~3.5% of the native vegetation occurring within 5 km of the subject site (i.e. 212.14 ha of 5,997.42 ha; NPWS 2003). Impact intensity will be minimised through progressive and sensitive clearing procedures (VMP; **Appendix D**) with mitigation performed pre-emptively within the Conservation Area designed to provide alternative habitat options for displaced fauna. The Proposal initially counters this by restoring, enhancing and managing the 243.86 ha Conservation Area in accordance with a BMP (**Appendix C**) (e.g. removal of weeds, feral deer and uncontrolled threats) followed by the protection and management of this 'like for like' vegetation and habitat in accordance with an in-perpetuity conservation agreement. The Proposal would result in a reduction to the estimated pre-European extent of each PCT impacted. In its own right, this clearing will make a small contribution to the loss of these PCT without resulting in a reclassification from its current cleared classification into an overcleared (i.e. >70-90% of pre-European vegetation being cleared) or highly overcleared (i.e. >90% of pre-European vegetation being cleared) classification: • PCT 1584: Currently 42% cleared in NSW – 47.56 ha reduction caused by the Proposal will not result in an overcleared state • PCT 1590: Currently 48% cleared in NSW – 159.05 ha reduction caused by the Proposal will not result in an overcleared state • PCT 1600: Currently 66% cleared in NSW – 5.15 ha reduction caused by the Proposal will not result in an overcleared state Residual vegetation within 5 km of the subject site is in private (i.e. rural and residential lands) and public ownership (i.e. Wallaroo State Forest, Medowie State Conservation Area and Hunter Water Corporation lands surrounding Grahamstown Dam). In this respect is expected that existing regulatory controls and land zoning applicable to these lands will limit the extent of native vegetation clearing (i.e. *Biodiversity Conservation Act* 2016). Vegetation clearing on privately owned lands, as regulated by the *Biodiversity Conservation Act* 2016, mandates a formal assessment process where exceeding prescribed thresholds. Greater than 50% of the native vegetation cover within 5 km of the subject site is included in the 'Biodiversity Values Map and Threshold Tool' (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap; accessed January 2020), meaning that the clearing of any native vegetation within these lands would automatically trigger the formal assessment process (i.e. requirement for a biodiversity development assessment report in accordance with the Biodiversity Assessment Method). Port Stephens Council and/ or Native Vegetation Panel would be responsible for assessing and determining these applications, with associated approvals requiring biodiversity offsets. It is considered that the threat posed by this KTP has been appropriately mitigated and managed at the local scale through the protection of 'like for like' native vegetation and habitat with the Conservation Area. Cumulative impacts arising from native vegetation clearing unrelated to the Proposal will be controlled/ managed by mandatory formal approvals processes for clearing native vegetation on privately owned lands (i.e. *Biodiversity Conservation Act* 2016), which is administered by independent regulatory authorities. This regulatory process will appropriately control future vegetation clearing events. The proposed in-perpetuity conservation and management of a similar quantum of 'like for like' native vegetation and habitat for the benefit of affected threatened species in the local area is likely to result in no net biodiversity loss, as it is considered that there will be: • No extinctions for species of restricted distribution;

Assessment of Significance: Freshwater Wetlands	
	• No loss of local genotypes; • No fragmentation effects leading to limited gene flow; • No increase in dryland salinity; • No degradation of riparian zones; • No increased habitat for invasive species; and • No loss or disruption of ecological function. While there will be a progressive loss of leaf litter layer and changes to soil biota within the area cleared of native vegetation, this loss is countered by the in-perpetuity retention of like for like values within the adjoining Conservation Area.
Human-caused Climate Change	The Proposal is estimated to result in the progressive loss of 212.14 ha of native vegetation over an 8+ year timeframe. Assuming 200-400 carbon tonnes per hectare (Ximenes et al 2017; Lucas et al 2017), it is estimated that the above-ground biomass cleared by the Proposal is between 42.43 – 84.86 Kt of carbon. Conversely, the Proposal will avoid the removal of 38.47 ha and, with revegetation works aiming to establish 19.30 ha of native vegetation, will partially mitigate this loss by an estimated 11.67 – 23.23 Kt of carbon. Further mitigation includes the harvesting and placement of sawn logs in the Conservation Area as fallen logs (i.e. habitat enhancement works) amounting to the storage of ~0.27 Kt of carbon within the Conservation Area. A net loss of ~30.49 – 61.36 Kt of carbon stored in above-ground biomass is estimated over the term of the Proposal. Annualised, this equates to ~0.0002% of Australia's 2018-19 CO_2e emissions (Commonwealth of Australia 2019). While the Proposal will contribute to a net loss of above-ground biomass and associated carbon storage, the in-perpetuity protection of 231.19 ha of native vegetation within the Conservation Area with an estimated above-ground biomass of 46.24 – 92.48 Kt of carbon, will compensate for this loss (i.e. use of measures to prevent the clearing of this land in-perpetuity). Accordingly, it is considered that the loss of stored carbon associated with native vegetation cleared by the Proposal is minor and is likely to make negligible contribution to Human-caused Climate Change over the term of the Proposal and into the future.
Herbivory and environmental degradation caused by feral deer	Independent of the Proposal, feral deer currently occupy the study area and actively graze throughout the native vegetation. Evidence of browsing, trampling, ring-barking, antler rubbing, dispersal of weeds and creation of trails has been observed within the subject site. This is minor evidence of exposing soils to erosion/ accelerating erosion and it is likely that feral deer activity within wetlands 803 and 804 is directly leading to the degradation of these environments. Through implementing the BMP (**Appendix C**), the Proposal includes direct action on the control of feral deer to minimise its impact on the biodiversity values contained within the Conservation Area. The BMP proposes an ongoing cull of feral deer for the duration of its operation with the objective being no observable evidence of feral deer activity within the Conservation Area. Ongoing management is proposed in-perpetuity to limit the effect of feral deer on local biodiversity. It is considered that the Proposal includes actions consistent with the management of this KTP such that impacts from herbivory by feral deer will be reduced within the local area.
Invasion of native plant communities by exotic perennial grasses	The subject site currently has limited examples of exotic perennial grass, vines and scramblers and escaped garden plants including aquatic species. However, the Proposal may lead to an increased risk of exotic flora species introductions over time and/ or allow existing exotic flora occurrences to proliferate. As such, the Proposal incorporates strong exotic flora management procedures through the operation of a VMP for the site preparation area and BMP for the Conservation Area. These both have the
Invasion and establishment of exotic vines and scramblers	

Assessment of Significance: Freshwater Wetlands	
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	aim to identifying and suppressing exotic flora species. In-perpetuity management actions to be applied within the Conservation Area will also have the aim of preventing/ suppressing exotic species invasions. On this basis it is considered that provisions for the management of exotic flora through the VMP and BMP will prevent the invasion, establishment, loss and degradation of native plant and animal habitat by exotic flora such as invasive perennial grasses, exotic vines and scramblers and escaped garden plants. It is considered that these KTPs are not likely to result in any detrimental impacts to threatened species and ecological communities.

8.3.4.3 Conclusion

The local occurrence of FWCF EEC in the subject site is wholly located within the Conservation Area and will not be removed by the Proposal. The community occurs in a degraded condition in the study area and has been moderately impacted by previous land uses. Restoration works are expected to improve the habitat integrity of FWCF EEC. Indirect impacts from stormwater inflows are minor and inconsequential. It is considered that the Proposal is not likely to have a significant impact on FWCF EEC.

9 ADDITIONAL INFORMATION

This chapter covers the following Director General's Requirements:

DGR 9 ADDITIONAL INFORMATION

9.1 Qualifications and Experience

DGR 9.1 Qualifications and experience

A species impact statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement (Section 110(4)).

The SIS project team included key personnel listed in **Table 9.1**. Experience and qualifications of each team member are provided in **Appendix R**.

Table 9.1 Project Team

Personnel	Company	Role	Contact Details
Mark Aitkens BSc	RPS	Principal Ecologist	(02) 4940 4200
Joe May BSc	RPS	Ecologist	(02) 4940 4200
Janene Devereux BSc	RPS	Senior Ecologist	(02) 4940 4200
Kieran Marshall BSc (hons)	RPS	Ecologist	(02) 4940 4200
Shelomi Doyle BSc	RPS	Ecologist	(02) 4940 4200
Shawn Ryan BSc	RPS	Ecologist	(02) 4940 4200
Hayden Beck BSc PhD	RPS	Senior Ecologist	(02) 4940 4200
Dan Creevey	RPS		
Rhys Corrigan BSc	RPS	Field Ecologist	(02) 4940 4200
Giorginna Xu	RPS	Field Ecologist	(02) 4940 4200
Sam Des Forges	RPS	Field Ecologist	(02) 4940 4200
Zach Cotter	RPS	Field Ecologist	(02) 4940 4200
Daniel Watts BSc (hons)	RPS (now EcoLogical)	Ecologist	
Duncan Scott-Lawson	RPS	Ecologist	(02) 4940 4200
Simon Danielsen BSc	Astrebla Ecological Services	Principal Ecologist/Botanist	0423 706 440

9.2 Other Approvals

DGR 9.2 Other approvals required for the development or activity

A list of any approvals that must be obtained under any other Act or law before the action may 'be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population or ecological community (Section 110(2)(j) and Section 110(3)(g)).

Consent is required under Part 4 of the EP&A Act. The consent authority is Port Stephens Council.

A referral to the Department of Agriculture, Water and Environment (DAWE) will be prepared to assess the Proposal under the EPBC Act, due to potential impacts to threatened species listed under the EPBC Act. These species include the Koala, which is a Matter of National Environmental Significance.

9.3 Licensing Matters Relating to Conducting Surveys

DGR 9.3 Licensing matters relating to the survey

- NSW National Parks and Wildlife Service Scientific Investigation Licence S100536 (Valid 31 December 2019);
- Animal Research Authority (Trim File No: 16/361) issued by NSW Department of Primary Industries (Valid 21 March 2020);
- Animal Care and Ethics Committee Certificate of Approval (Trim File No: 16/361) issued by NSW Department of Primary Industries (Valid 21 March 2020); and
- Certificate of Accreditation of a Corporation as an Animal Research Establishment (Trim File No: 01/1522 & Ref No: AW2001/014) issued by NSW Agriculture (Valid 22 May 2020).

9.4 Section 110(5) Reports

DGR 9.4 Section 110(5) Reports

Information contained in the profiles of the affected species was used in the preparation of this SIS. The documentation listed in the References Section was also considered.

10 CONCLUSION

The purpose of this SIS is to identify threatened species issues and inform the proposal of appropriate amelioration for potential adverse impacts resulting from the proposal. Amelioration proposed includes, but is not limited to impact avoidance, minimisation and mitigation. Compensatory measures are provided where necessary.

The proposed Concept DA has principally been revised as a result of investigations, findings and recommendations of this SIS. In particular, and in addition to conventional methodologies required under the CERs, the SIS is informed by innovative and comprehensive Koala assessment involving dog detection of scats, genetic analysis of the population, and foliage nutrient analysis. Taking the Koala as the species having the greatest potential to be impacted by the proposal, this work resulted in habitat mapping of a resolution, and with a reliability, that is significantly greater than is ordinarily provided in an SIS. This mapping has generated multiple outcomes with the most important being:

- The identification of high value habitat where impact avoidance outcomes could be identified and realised by curtailing the proposed development footprint; and/or
- The devising of an impact minimisation strategy to enable the potential for impacts to be mitigated by pre-empting impact areas and in advance of potential impact, implementing a program of enrichment in strategic areas of retained habitat with sufficient time to attain ecological benefit.

Data obtained has also provided an increased understanding of the Proposals impact on other relevant threatened species such as the Brush-tailed Phascogale

A total of 212.14 ha of native vegetation and threatened species habitat will be removed by the Proposal over three separate Phases lasting 8+ years. Corresponding with this will be the establishment of a Conservation Area comprising high value habitat for locally occurring threatened species including those affected by the Proposal. A comprehensive impact mitigation package forms part of the Proposal and has the purpose of minimising impacts on threatened species at the local level. An in-perpetuity and managed conservation agreement for the Conservation Area forms part of the Proposal.

The Conservation Area will be managed in accordance with a Biodiversity Management Plan, which details the suite of mitigation measures designed to ameliorate impact on affected threatened species. The mitigation included as part of the Proposal is listed below:

- Habitat enrichment works for the Koala;
- Habitat enhancement (i.e. installation of hollows, fauna fencing and emplacement of fallen logs);
- Weed management (e.g. removal of Lantana and African Olive);
- Feral animal control (e.g. wild dogs, feral cats and deer);
- Fencing of Conservation Areas which will:
  - curb and deter illegal and uncontrolled activities (e.g. illegal dumping, timber getting, hunting)
  - manage existing rural activities that impact on native plants and weed dispersal (e.g. grazing by cattle, horses, goats)
- Habitat protection for threatened species; and
- Use of a conservation mechanism to locally protect threatened species and their habitat from future development.

In light of the impacts from development and the ecological benefit delivered through the mitigation package, it has been concluded in this SIS that the Proposal is not likely result in a significant impact on affected species assessed in the SIS.

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Appendix A

Office of Environment and Heritage Chief Executive Requirements

NSW GOVERNMENT | Office of Environment & Heritage

DOC18/654859-1

Mr David Robertson
Director
Cumberland Ecology
david.robertson@cumberlandecology.com.au

Dear Mr. Robertson

Chief Executive's Requirements for a Species Impact Statement for a Proposed Residential and Roadway Development at Kings Hill, Raymond Terrace

I refer to your letter dated 27 July 2018 to the Chief Executive of the Office of Environment and Heritage (OEH) seeking Chief Executive's Requirements (CERs) for a Species Impact Statement (SIS) for a proposed residential subdivision development. OEH previously issued CERs for this proposal on the 16 June 2017. Given that the CERs have lapsed and that you are adding an extra parcel of land for consideration, OEH has decided to re-issue the CERs in this instance. OEH notes that you now request that the CERs be expanded to encompass a Concept Masterplan for the residential development on Lot 41 in DP1037411, and that it also covers an additional 108.2 ha parcel to the north Lot 41 described as Lot 4821 in DP852073. You further state that the intent of the SIS to provide for the 1st stage of the Concept Plan to be carried out, that being the proposed east west collector road that forms the spine of masterplan within Lot 41 DP1037411, however, in total the SIS will cover entire 516.2 ha spread over two parcels of land. Although OEH has indicated that this is permissible (as per OEH meeting with proponent on 2 August 2018), OEH has clearly stated that the consent authority (Port Stephens Council) must support the proposed staging of the development and the additional parcel of land, as well as the SIS must clearly assess the entire cumulative impact within the study area including development of adjoining lands not subject to the SIS.

OEH notes that the proposal is located within the Port Stephens local government area, which is an 'interim designated area' under the *Biodiversity Conservation (Savings and Transitional) Amendment Regulation 2018*. As such this means that Part 4 matters under the *Environmental Planning and Assessment Act 1979* (EP&A Act) are assessed in accordance with the repealed *Threatened Species Conservation Act 1995* (TSC Act) until 24 November 2018.

The SIS is to be prepared in accordance with Section 111 of the repealed TSC Act. OEH understands the proposal is for a residential subdivision development under the Part 4 provisions of the EP&A Act which is located within Lot 41 in DP1037411 and Lot 4821 in DP852073, located at Kings Hill in Raymond Terrace, within the Port Stephens local government area (LGA).

In response to your request, please find attached CERs for a SIS (**Attachment A**) to address all known and potential threatened species, populations and ecological communities (including their habitat). I note that in your earlier correspondence (dated 19 December 2014) you stated that the proposal will significantly impact at least two species listed under the TSC Act: the Brush-tailed Phascogale and the Koala. Apart from these two species, OEH believes the SIS must address all

likely species, populations, ecological communities and their habitats that may be directly or indirectly impacted by the proposal. A list of potential species, populations and ecological communities has been provided in **Attachment A**.

Survey and assessment work already completed can contribute to the SIS so long as it meets OEH survey requirements (including referenced guidelines and currency and that the CERs are met by the total survey effort. The proponent will need to ensure that all surveys (both flora and fauna, and targeted surveys) are current (i.e. not greater than five years old), including any BioBanking plots undertaken to inform offsetting strategies, and they are undertaken in accordance with current OEH guidelines or currently accepted methodologies. Any BioBanking assessments will need to use the 2014 methodology and all appropriate calculator files must be submitted via the OEH portal. Credit variations permitted under the Framework for Biodiversity for Major Projects do not apply to Part 4 matters.

Following completion of the SIS, it is to be submitted to the Port Stephens Council as the consent authority. If the consent authority determines that the proposal is likely to have a significant effect on threatened species, populations or ecological communities (including their habitat), then the concurrence of the Chief Executive of OEH is required before consent may be granted. A concurrence application is not required should Council decide to reject the application or if Council determines that the proposal is unlikely to have a significant effect on threatened species, populations or ecological communities. The consent authority must ensure that the SIS is compliant with the CERs.

The SIS must be submitted to Port Stephens Council before the 24 November 2018. If not, then the proposal may be subject to the *Biodiversity Conservation Act 2016* and would likely trigger the application of the Biodiversity Offset Scheme and the application of the Biodiversity Assessment Method.

Please note that the issuing of CERs is a statutory requirement for OEH and should not be considered as support or endorsement of the proposed development.

If seeking concurrence, OEH requests that Council or the proponent provide: one (1) printed copy and a searchable electronic copy (i.e. *.pdf format) of the SIS (including copies of survey data sheets and GIS mapping files), the original development application, any social and economic appraisal of the development and any supporting or background reports (including previous surveys). Any BioBanking calculations undertaken for offsetting purposes must include the submission of the credit calculator files and associated field data sheets and GIS mapping files. A checklist for determining if the SIS has met the requirements of the Minister administering the TSC Act is provided in **Attachment B**.

If you require any further information regarding this matter please contact Steve Lewer, Regional Biodiversity Conservation Officer, on 4927 3158.

Yours sincerely

ND

NICOLE DAVIS
ACTING SENIOR TEAM LEADER - PLANNING
HUNTER CENTRAL COAST BRANCH
REGIONAL OPERATIONS DIVISION

9 September 2018

Enclosures: Attachments A & B

ATTACHMENT A:

CHIEF EXECUTIVE'S REQUIREMENTS FOR A SPECIES IMPACT STATEMENT FOR A PROPOSED RESIDENTIAL AND ROADWAY DEVELOPMENT AT KINGS HILL, RAYMOND TERRACE, NSW

The purpose of a Species Impact Statement (SIS) is to:

- allow the applicant or proponent to identify threatened species issues and provide appropriate amelioration for adverse impacts resulting from the proposal
- assist consent and determining authorities in the assessment of a development application under Part 4 or request for Part 5 approval under the EP&A Act
- assist the Chief Executive of OEH in deciding whether or not concurrence should be granted for the purposes of Parts 4 or 5 of the EP&A Act
- assist the Chief Executive of OEH or the Minister for the Environment when consulted for the purposes of Parts 4 or 5 of the EP&A Act
- assist the Chief Executive of OEH in the assessment of Section 91 License applications lodged under the TSC Act.

DEFINITIONS

The definitions given below are relevant to these requirements:

- ***abundance*** means a quantification of the population of the species or community
- ***activity*** has the same meaning as in the EP&A Act
- ***affected species*** means subject species likely to be affected by the proposal
- ***conservation status*** is regarded as the degree of representation of a species or community in formal conservation reserves
- ***DA*** number means Development Application number
- ***development*** has the same meaning as in the EP&A Act
- ***Chief Executive*** means the Chief Executive of the Office of Environment and Heritage
- ***DP*** means *Deposited Plan* which is the **plan** number given to a subdivision that is registered by the Land Property Information
- ***LGA*** means local government area
- ***locality*** means the area within a five (5) kilometre radius of the study area.
- ***region*** has the same meaning as that contained in the TSC Act
- ***significant species*** means species not listed in the TSC Act but considered to be of regional or local significance
- ***study area*** is the subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly.
- ***subject site*** means the area which is proposed for development/activity
- ***subject species*** means those threatened and significant species, populations and ecological communities which are known or considered likely to occur in the study area
- ***threatening process*** has the same meaning as that contained in the TSC Act; the definition is not limited to key threatening processes.

All other definitions are the same as those contained in the TSC Act.

MATTERS WHICH HAVE BEEN LIMITED OR MODIFIED

The following Section 110 matters in the TSC Act need only be addressed where relevant:

- all reference to threat abatement plans; and
- all reference to critical habitat. At the time of printing, the areas of declared critical habitat are not relevant to this proposal.

The proponent should be aware that recovery plans may be approved, critical habitat may be declared and key threatening processes may be listed between the issue of these requirements and the granting of consent. If this occurs, these additional matters will need to be addressed in the SIS and considered by the consent, determining or concurrence authority.

MATTERS TO BE ADDRESSED

The TSC Act provides that the SIS must meet all the matters specified in Sections 109 and 110 of the TSC Act with the exception of those matters limited above. The requirements outlined in Sections 109 and 110 (excluding the matters limited above) have been repeated below (italics) along with the specific CERs for your proposal. Previous surveys and assessments that are relevant to the locality may be used to assist in addressing these requirements.

Section 111 (1) of the TSC Act states that an applicant must comply with the CERs concerning the form and content of the SIS. Failure to fully comply with the CERs is therefore a potential breach of the legislation, and may result in OEH being unable to grant concurrence to a request by the consent authority to carry out the activity. Accordingly, the SIS must be formatted to follow the sections and subsections provided in the CERs.

1 FORM OF THE SPECIES IMPACT STATEMENT

1.1 A species impact statement must be in writing (Section 109 (1));

1.2 A species impact statement must be signed by the principal author of the statement and by:

(a) the applicant for the licence, or

(b) if the species impact statement is prepared for the purposes of the Environmental Planning and Assessment Act 1979, the applicant for development consent or the proponent of the activity proposed to be carried out (as the case requires) Section 109(2)).

The applicant or proponent must sign the following declaration:

"I... [insert name], of ...[address], being the applicant for the development consent...[insert DA number, Lot & DP numbers, street, suburb and LGA names] have read and understood this species impact statement. I understand the implications of the recommendations made in the statement and accept that they may be placed as conditions of consent or concurrence for the proposal".

2. CONTEXTUAL INFORMATION

2.1 Description of proposal, subject site and study area

A species impact statement must include a full description of the action proposed, including its nature, extent, location, timing and layout (Section 110 (1))

2.1.1 Description of the proposal

A full description of the action includes a description of all associated actions, including, but not restricted to: - location of all lots / building envelopes, installation and maintenance of any proposed buildings / dwellings and associated structures, the proposed number and size of such lots, buildings / dwellings and associated structures, location of any associated facilities (including roads, amenities and other services), fire protection zones, access and egress routes, changes in surface water flows, impacts of noise disturbance and pollution, and any increases in people and road traffic. Actions that occur both on and off the subject land as a result of the proposal must be assessed; including actions conducted during any construction phase and any proposed action post-construction (e.g. proposed actions within a management plan).

2.1.2 Definition of SIS study area

The SIS study area must be defined. The study area will generally be larger than the development site as it includes any adjacent areas that will be directly or indirectly affected by the proposal. In defining the study area consideration shall be given to possible indirect effects of the proposed action on the area surrounding the subject site, for example habitat fragmentation, vegetation corridors, altered hydrology regimes, soil erosion, pollution, and increased human presence or associated impacts. These may include adjacent parcels of land containing suitable habitat for threatened species. It is therefore important to recognise that these parcels may need to be investigated along with the development site. The location, size and dimensions of the study area shall be provided. In describing the study area, the SIS must consider cumulative impacts, such as additional known or proposed development adjacent to the works subject to this proposal.

The study area should be established before the list of likely impacted threatened species, populations, ecological communities (including their habitat) is determined so species etc. that are less obviously affected are also included. The study area must be clearly defined, marked on a geo-referenced map / aerial photograph (or equivalent), clearly showing the development site boundary and any additional areas facing indirect impact, and included in the final report.

Direct impacts are those that directly affect individuals or their habitat. Examples of direct impacts include:

- poisoning or removal of the organism itself
- removal of habitat
- clearing of native vegetation / habitat

If the proposal involves the clearing of vegetation and removal / damage to habitat the environmental assessment must clearly articulate the size of this impact, and where applicable delineate this based on vegetation / habitat type.

Indirect impacts occur when project-related activities affect species, populations or ecological communities in a manner other than direct loss. Examples of indirect impacts include (but not limited to):

- sediment, pollutant or nutrient runoff into adjacent vegetation
- habitat fragmentation or isolation
- implementation of asset protection zones (*though these may also represent direct impact)
- loss of genetic diversity of threatened species, populations or communities
- altered pollination syndromes that may adversely affect seed set
- soil erosion
- altered hydrology regimes (including downstream impacts)
- changes to the saline / freshwater balance in marine environments
- exposure to heat or predators, or loss of shade
- inhibition of nitrogen fixation
- weed invasion and feral animal incursion
- introduction and spread of pathogens, such as Dieback fungus (*Phytophthora*) and Myrtle Rust (*Uredo rangelii*)
- noise
- dust
- light pollution (i.e. increasing skyglow from uncontrolled urban uplight)
- fire (such as changes to intensity and frequency)
- fertilizer drift
- increased human activity (including litter) within or directly adjacent to sensitive habitat areas.

Indirect impacts should not be just limited to the terrestrial habitats. In stances where a development site adjoins marine, estuarine and riparian / riverine environs / habitat, impacts on these must be considered.

Note: Indirect impacts may lead to direct loss, and as such must be adequately quantified and assessed. Both impacts within the proposed development footprint and on adjacent / surrounding lands must be considered, and where appropriate adequately considered and addressed.

2.1.3 Description of SIS study area

The description of the study area must include (but not limited to):

- The vegetation communities (Plant Community Types [PCTs]) and habitat types, including identification of the classification system used in the SIS. Details of the methodology adopted to delineate vegetation communities on site (e.g. random stratified sampling). Full floristic description of all vegetation communities present (including disturbed and undisturbed). A listing of the amount (in hectares) of each vegetation community in the study area. A geo-referenced map / aerial photograph (or equivalent) showing the location of the vegetation communities. A full floristic list in tabular format of all taxa (both native and exotic) recorded on the subject site, indicating which communities they occur in, their cover / abundance and frequency, conservation (including taxa of conservation significance) and comparisons to previous vegetation studies / mapping (if applicable);
- An examination of previous land uses and events, and the effect of these land uses and events on the study area. Examples of such land uses and events are clearing, timber felling, draining, recreational use and agricultural activities (including grazing);
- An examination of the fire history, or at least the time since the last fire, for the subject site is to be provided. Ideally, information on the frequency, season and intensity of fire events on the subject site will be provided. To adequately address this requirement, it may be necessary to consider fire events in the surrounding landscape;
- The local government land zoning and any proposed rezoning, and an examination of the degree of protection that current zoning and any proposed rezoning provides or will provide to native vegetation and threatened species, populations and ecological communities on the subject site and in the study area and the locality;
- The land tenure and any proposed changes (e.g. acquisition by OEH as a nature reserve, national park, regional park etc.), and an examination of the degree of protection that current land tenures and any proposed land tenures provides or will provide to native vegetation and threatened species in the study area;
- Cumulative impacts of surrounding development, both known and proposed.
- State Environmental Planning Policies (e.g. SEPP 14 Coastal Wetlands, SEPP 44 Koala Habitat Protection, SEPP 71 Coastal Protection) and an examination of the degree of protection these policies provide to native vegetation and threatened species on the subject site and in the study area; and
- Relevant Local Government planning instruments, including Local Environmental Plans and Development Control Plans.

2.2 Provision of relevant plans and maps

A plan of the subject area, including the scale of the plan should be provided. An aerial photograph (preferably colour) of the locality (or reproduction of such a photograph) shall be provided, if possible. This aerial photograph should clearly show the subject site and the scale of the photograph. It should be geo-referenced and show the date of the photograph.

A geo-referenced topographic map or equivalent of the subject site and immediate surrounds at an appropriate scale should be provided. This map should detail the location of the proposal and location of works on site (including areas of indirect impact). Additionally, to provide an overview of the natural landscape in the general locality, the map should show or be overlain with details of vegetated (i.e. woody [e.g. forests, woodland, shrubland and heath] and non-woody native vegetation [e.g. grassland, sedgeland and saltmarsh]) vs. cleared areas, as well as indicating the current activities/usage of this land, such as rural, agricultural, industrial and residential. OEH expects a separate map will be provided to indicate what specific vegetation communities are on subject site (as detailed above in Section 2.1.3).

A map of the locality, showing any locally significant areas for threatened species such as parks and reserves, and areas of high human activity such as townships, regional centres and major roads will also be provided. The location, size and dimensions of study area shall be provided.

Where any biodiversity offsets are proposed, the proponent must provide OEH with a proper survey plan, prepared by a registered surveyor that clearly shows the location and boundaries of any offset land. A printed copy of each survey plan must be provided to OEH at A1 or A0 scale. The survey plan must be of a form that is acceptable to OEH. Electronic copies should also be provided.

2.3 Land tenure information

Information about the land tenure across the study area. Any limitations to sampling across the study area (e.g. denied access to private land) shall be noted.

3 INITIAL ASSESSMENT

A general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area, that is likely to be affected by the action (Section 110 (2)(a)).

3.1 Identifying subject species

3.1.1 Assessment of available information

In determining these species ('the subject species'), consideration shall be given to the habitat types present within the study area, recent and historic records of threatened species or populations in the locality and the known distribution of threatened species.

Databases such as OEH's *Atlas of NSW Wildlife* (www.bionet.nsw.gov.au), *BioBanking Credit Calculator* (www.environment.nsw.gov.au/biobanking/calculator.htm), *Atlas of Living Australia* (www.ala.org.au), *Australian Museum* (http://ozcam.org.au), *Birdlife Australia* (http://birdsaustralia.ala.org.au/BDRS/home.htm), and the *Royal Botanic Gardens* (http://plantnet.rbgsyd.nsw.gov.au) should be consulted to assist in compiling the list. It should be noted that if the OEH Wildlife Atlas is the only database that is referred to, due to data exchange agreements, the data provided by OEH will only include that for which OEH is a custodian. In many cases, this may only be a small subset of the data available. Other databases must also be consulted to create a comprehensive list of subject species.

The following species shall be considered for inclusion in the list of subject species, as they have either been recorded in the general area (approx. 10km radius), are within the species' known geographic limits or their broad habitat preferences may be present on site:

Threatened Species
(* indicates species that are listed on the *Environment Protection and Biodiversity Conservation Act 1999*).

Flora (27 taxa):

For targeted surveys please note the following known flowering / fruiting times for each species to time surveys appropriately. Surveying at these times is required for species that are not readily detectable (or are cryptic), where flowers or fruits are necessary for their positive identification. If targeted flora surveys for these species are conducted outside a species known phenology then justification must be provided as to why; if this is not provided or considered inappropriate, then all such species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided. For species which do not require flowers / fruits for positive identification (e.g. large trees / shrubs), then survey as appropriate (though appropriate justification on methods used is still required). It is recommended to utilise known reference sites to help delineate flowering patterns and sampling timeframes. OEH can provide advice on this for some species.

Targeted flora surveys must also adequately sample / cover all suitable habitat on the study area, and utilise suitable detection techniques (as per OEH 2016) such as belt transects (at appropriate widths to spot cryptic species) or random meanders (that sufficiently cover all known / potential habitat areas [i.e. not just the tracks or readily accessible areas]). If targeted flora surveys are poorly conducted or surveyed out of season (incl. > 5 year currency) then appropriate justification must be provided as to why; if this is not provided or considered inappropriate, then all such affected species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided.
Subject threatened flora to be considered:

- **Charmhaven Apple (*Angophora inopina*)*** – flowers principally between mid-December and mid-January, and also sporadically at other times outside of this period (Bell 2001a); *Angophora inopina* has been confused and probably wrongly determined in many cases as *Angophora floribunda*, principally due to both species possessing rough, fibrous bark, and appearing superficially similar in flower and fruit morphology (Bell 2001a), vegetatively it may be distinguished by its broad, coriaceous leaves with short, broad petioles, whilst its fruit tend to be larger and cup-shaped to pyriform and not as prominently ribbed (Bell 2001a).
- **Trailing Woodruff (*Asperula asthenes*)** – flowers and fruits in spring (Thompson 2009); fruits are required to separate genera *Asperula* and *Galium* (Harden 1992).
- **Netted Bottle Brush (*Callistemon linearifolius*)** – flowers spring to summer (Harden 2002), with Benson & McDougall (1998) specifically noting October to November in the Greater Sydney Region.
- **Red Helmet Orchid (*Corybas dowlingii*)** – flowers June to (early) August (Jones 2004); *Corybas dowlingii* and *C. barbarae* (a more common related taxon) occur sympatrically, with the former species typically flowering as *C. barbarae* is finishing (Jones 2004); in Stoney Ridge Reserve (Soldiers Point) the species is known to flower from mid to late-July (Okada 2006); the largest population which is in the Port Stephens LGA at 'Stoney Ridge Reserve (and adjacent lands) has its peak flowering in early to mid-June (in 2017/18 species started flowering around 5 June(S. Lewer pers. com. 2018).
- **Leafless Tongue Orchid (*Cryptostylis hunteriana*)*** – in NSW flowering occurs from December to February (Nicholls 1938, Jones 1993, Harden 1993) though Bell (2001b) states that the Central Coast populations (i.e. Freeman's Waterhole, Vales Point and Wyee) flower in November.
- **White-flowered Wax Plant (*Cynanchum elegans*)*** – flowers August to February (-May), with a peak period in November; mature fruits appear between December and May (Benson & McDougall 1993).
- **Spider Orchid (*Dendrobium melaleucaphilum*)** – flowers July to October (Harden 1994, Bishop 2000); frequently on *Melaleuca styphelioides*, less commonly on rainforest trees or on rocks in coastal (Harden 1994); previously known as the 'large-flowered paperbark form' of *D. tetragonum* (Harden 1994).
- **Sand Doubletail (*Diuris arenaria*)** –flowers in August to September (Espallargas 2005).
- **Small Snake Orchid (*Diuris pedunculata*)*** - flowers August to September (Bishop 2000); historically recorded from the Lower Hunter (e.g. Maitland), appears now confined to north east NSW on the New England Tablelands, around Armidale, Uralla, Guyra and Ebor; typically grows on grassy slopes or flats (OEH – Threatened species profile database, accessed December 2014).
- **Rough Doubletail (*Diuris praecox*)*** – has a short flowering season, restricted to August to September, and usually no more than 2 weeks (Benson & McDougall 2005), but Espallargas (2005) has recorded 3-4 weeks on Tomaree Peninsula; in the Newcastle area tend to flower from last week in July to early August (first two weeks) (S. Lewer pers. comm. 2013).
- **Camfield's Stringybark (*Eucalyptus camfieldii*)** – flowering period November to December (Brooker & Kleinig 1999).
- **Parramatta Red Gum (*Eucalyptus parramattensis* subsp. *decadens*)*** – flowering typically occurs between November to January (Bell 2006).
- **Tangled Bedstraw (*Galium australe*)** – poorly recorded in NSW; most flowering collections have been made in late spring to early autumn, potentially overlooked due to its small size and cryptic

nature, fruits required to separate genera *Asperula* and *Galium* (Harden 1992); flowers spring – summer (Thompson 2009).

- **Bauer's Midge Orchid (*Genoplesium baueri*)** – flowers December to May (Harden 1993, Bishop 2000, Benson & McDougall 2005); previously known from Port Stephens area.
- **Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*)*** – flowers from July to December (Benson & McDougall 2000, Makinson 2000, Harden 2002, Fairley 2004); in the Lower Hunter, Lake Macquarie / Newcastle area flowering normally occurs annually between late September and early December (Falding 2013).
- **Small Water-ribbons (*Maundia triglochinoides*)** – flowers November to January, in the warmer months (Harden 1993, Benson & McDougall 2002); without flowering material it may be confused with the more common genus *Triglochin* (i.e. 'individual fruit dehiscing but carpels remaining fused along their central axis for most of their length, ovule pendulous, attached at the apex of ovary in *Maundia*' cf. 'individual fruit separating into carpels, ovule erect, attached at the base of the ovary in *Triglochin*' [Aston 1971, Harden 1993]), though *Maundia* tends to have spongy inflated leaves compared to linear, flattened or terete and strap-like in *Triglochin* (Aston 1971, Harden 1993).
- **Biconvex Paperbark (*Melaleuca biconvexa*)*** - flowering occurs over just 3 to 4 weeks in September and October (OEH – Threatened species profile database, accessed October 2010), though Harden (2002) notes generally summer.
- **Grove's Paperbark (*Melaleuca groveana*)*** – flowers spring (Harden 2002).
- **Tall Knot-weed (*Persicaria elatior*)*** – flowers January to February (February - April for fruiting) (Benson & McDougall 1999); inflorescence required to separate species in genus (i.e. small clusters / individual flowers cf. dense spikes, elongated [as in *P. elatior*] or sub-globose spike-like racemes [Harden 2001]).
- **Scant Pomaderris (*Pomaderris queenslandica*):** - flowers in spring – summer (Stanley & Ross 1986), with buds apparent for many months before flowers open; NPWS (2002) note flowering occurs specifically between October to November.
- **A Greenhood Orchid (*Pterostylis chaetophora*)** – flowers from September to November (Bishop 2000); currently known to occur between Kurri Kurri and Taree, including from the Grahamstown Dam catchment area, Seaham-Clarence Town district and Columbey National Park (Bell 2009) which are near the subject site. The Grahamstown Dam population is just north-east (<5km) from the proposal, and as such OEH would recommend using this location as a reference site with respect to flowering and informing appropriate sampling time. The Grahamstown Dam site, along with the Seaham populations have both been recorded in the depauperate *Melaleuca* understory of Ironbark-Spotted Gum communities; to which OEH notes that this habitat is likely present on the proposal and needs to be adequately sampled (i.e. in accordance with OEH 2016).
- **Dwarf Kerrawang (*Rulingia prostrata*)** – this species flowers between October and December (Benson & McDougall 2001).
- **Heath Wrinklewort (*Rutidosis heterogama*)*** - Harden (1993) notes that it flowers chiefly in autumn, though Bell & Driscoll (2004) note flowering can occur earlier from November to December (in the Lower Hunter and Central Coast); while DECC (2009b) recorded it flowering in late march on coastal headlands in the Newcastle area.
- **Rainforest Senna (*Senna acclinis*)** – flowers spring and summer (Harden 2002).
- **Magenta Lilly Pilly (*Syzygium paniculatum*)*** - flowers December to January / March (Harden 2002, Benson & McDougall 1998), though mature fruits are required to positively identify this species, which mature in May (Payne 1997).
- **Black-eyed Susan (*Tetratheca juncea*)*** – flowers predominantly November to February, though known to flower early from June onwards (Harden 1992, Driscoll 2003); noted infrequently all year under suitable conditions, recorded in late autumn to winter in some sub-coastal populations (e.g. Awabakal NR – S. Lewer pers. comm. 2013).
- **Horned Pondweed (*Zannichellia palustris*)** – flowers during the warmer months, namely summer (Harden 1993); species acts as an annual in NSW, and typically dies off at the end of summer, hence unlikely detectable during cooler months.

Fauna (65 species):

For Fauna species please be aware of: (i) habitat preferences and known distribution for each of the species as an indication as to whether they may occur in the study area, and (ii) the best times of year these species may be detected if subject to surveys. If animals are captured with an uncertain taxonomy, species should be forwarded to the Australian Museum by a suitably qualified scientific licence holder.

Subject threatened fauna to be considered:

Amphibians (2 species):
Wallum Froglet (*Crinia tinnula*)
Green and Golden Bell Frog (*Litoria aurea*)*

Reptiles (2 species):
Pale-headed Snake (*Hoplocephalus bitorquatus*)
Stephen's Banded Snake (*Hoplocephalus stephensii*)

Birds (38 species):
Magpie Goose (*Anseranas semipalmata*)
Dusky Woodswallow (*Artamus cyanopterus cyanopterus*)
Australasian Bittern (*Botaurus poiciloptilus*)
Bush Stone-curlew (*Burhinus grallarius*)
Gang-gang Cockatoo (*Callocephalon fimbriatum*)
Glossy Black Cockatoo (*Calyptorhynchus lathami*)
Spotted Harrier (*Circus assimilis*)
Brown Treecreeper (*Climacteris picumnus* subsp. *victoriae*)
Barred Cuckoo-shrike (*Coracina lineata*)
Varied Sittella (*Daphoenositta chrysoptera*)
White-fronted Chat (*Epthianura albifrons*)
Black-necked Stork (*Ephipporhynchus asiaticus*)
Black Falcon (*Falco subniger*)
Little Lorikeet (*Glossopsitta pusilla*)
Painted Honeyeater (*Grantiella picta*)
White-bellied Sea-eagle (*Haliaeetus leucogaster*)*
Little Eagle (*Hieraaetus morphnoides*)
Swift Parrot (*Lathamus discolor*)*
Square-tailed Kite (*Lophoictinia isura*)
Black-chinned Honeyeater (eastern subspecies) (*Melithreptus gularis* subsp. *gularis*)
Hooded Robin (south-eastern form) (*Melanodryas cucullata* subsp. *cucullata*)
Turquoise Parrot (*Neophema pulchella*)
Barking Owl (*Ninox connivens*)
Powerful Owl (*Ninox strenua*)
Osprey (previously *Pandion haliaetus* now *Pandion cristatus*)
Scarlet Robin (*Petroica boodang*)
Flame Robin (*Petroica phoenicea*)
Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis* subsp. *temporalis*)
Wompoo Fruit-dove (*Ptilinopus magnificus*)
Rose-crowned Fruit-dove (*Ptilinopus regina*)
Superb Fruit-dove (*Ptilinopus superbus*)
Speckled Warbler (*Pyrrholaemus sagittatus*)
Diamond Firetail (*Stagonopleura guttata*)
Red-backed Button-quail (*Turnix maculosa*)
Grass Owl (*Tyto capensis*)
Masked Owl (*Tyto novaehollandiae*)
Sooty Owl (*Tyto tenebricosa*)
Regent Honeyeater (*Xanthomyza phrygia*)*

Mammals (23 species):

Rufous Bettong (*Aepyprymnus rufescens*)
Eastern Pygmy-possum (*Cercartetus nanus*)
Large-eared Pied Bat (*Chalinolobus dwyeri*)
Spotted-tailed Quoll (*Dasyurus maculatus*) *
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
Golden-tipped Bat (*Kerivoula papuensis*)
Parma Wallaby (*Macropus parma*)
Little Bent-wing Bat (*Miniopterus australis*)
Eastern Bent-wing Bat (*Miniopterus schreibersii* subsp. *oceanensis*)
Eastern Freetail bat (*Mormopterus norfolkensis*)
Large-footed Myotis (*Myotis adversus*)
Yellow-bellied Glider (*Petaurus australis*)
Squirrel Glider (*Petaurus norfolcensis*)
Brush-tailed Phascogale (*Phascogale tapoatafa*)
Koala (*Phascolarctos cinereus*)* only combined populations of Qld, NSW and the ACT are listed on EPBC Act.
Common Planigale (*Planigale maculata*)
Long-nosed Potoroo (*Potorous tridactylus*)* only subspecies *tridactylus* (SE Mainland) is listed on EPBC Act.
Eastern Chestnut Mouse (*Pseudomys gracilicaudatus*)
Grey-headed Flying-fox (*Pteropus poliocephalus*)*
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)
Greater Broad-nosed Bat (*Scoteanax rueppellii*)
Common Blossom-bat (*Syconycteris australis*)
Eastern Cave Bat (*Vespadelus troughtoni*)

Endangered Populations

- *Cymbidium canaliculatum* population in the Hunter Catchment (*Note: *Cymbidium canaliculatum* flowers from September to October (Bishop 2000), typically it is most commonly found in *Eucalyptus albens* (White Box) dominated woodlands (including those dominated by the intergrade *E. albens-moluccana*) of the Upper Hunter, though it has been found, less commonly, to grow on *E. dawsonii* (Slaty Box), *E. crebra* (Narrow-leaved Ironbark), *E. moluccana* (Grey Box), Angophora floribunda (Rough-barked Apple), Acacia salicina (Cooba) and on some other species; also in dead stags).
- Emu population in the NSW North Coast Bioregion and Port Stephens LGA.
- *Leionema lamprophyllum* subsp. *obovatum* population in the Hunter Catchment.

Endangered ecological communities

- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.
- Lowland rainforest of the NSW North Coast and Sydney Basin Bioregions.
- Lowland rainforest on floodplain of the NSW North Coast Bioregion.
- Hunter Valley Vine Thicket in the NSW North Coast and Sydney Basin Bioregions.
- River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.
- Subtropical coastal floodplain forest of the NSW North Coast Bioregion.
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.
- Swamp Oak Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.

Vulnerable ecological communities

- Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions.

The above lists are not necessarily exhaustive. The applicant must carry out their own process of determining the subject species. This process should incorporate consideration of:

- the vegetation communities present within the study area
- the presence, quantity, quality and degree of fragmentation of likely habitat for individual threatened species
- recent (within the last ten years) records of threatened species, populations and ecological communities in the locality
- the known distribution of threatened species, populations and ecological communities
- the known and predicted use of habitat for all potential species.

OEH's *Atlas of NSW Wildlife*, *Australian Museum* and *Royal Botanic Gardens* databases, the *Birds Australia* and *NSW Bird Atlas* databases (for birds) and other relevant databases should be used to assist in compiling or assessing the list. The Data Licensing Officer at OEH's Head Office should be contacted on 9585 6684 to obtain information on the Atlas database.

Threatened species, populations and ecological communities on the above list may be excluded from further consideration as subject species only if a fully documented justification, robust to external examination, is provided. This documentation must address, as a minimum, the criteria for determining subject species that are listed above. In particular, threatened species that are cryptic, mobile or little surveyed (or possess combinations of these parameters (e.g. bats)), and for which the study area provides suitable habitat and falls within the species' range, must not be excluded solely on the basis of a lack of records in the locality. Furthermore, threatened species that occur in a range of habitats must not be excluded on the basis that their core habitat is not present in the study area or locality.

The proponent should be aware that additional species, populations, and ecological communities could be added to the schedules of the TSC Act between the issue of these requirements and the granting of consent. If this occurs, these additional matters will need to be addressed in the SIS and considered by the consent, determining, or concurrence authority.

Records recorded in preliminary surveys (as per Applicant's correspondence dated 19 December 2014) and on OEH's 'Atlas of NSW Wildlife' database

OEH notes that in your correspondence (dated 19 December 2014) you have indicated that the proposal will significantly impact at least two species listed under the NSW *Threatened Species Conservation Act 1995*: - the Brush-tailed Phascogale and the Koala. This correspondence states that the proposal will significantly impact these species through the physical loss of habitat (i.e. vegetation clearing), removal of feed and roosts trees for the Koala, loss of suitable nesting (i.e. den sites) and foraging habitat for the Brush-tailed Phascogale, and the fragmentation of habitat for both species. OEH would expect either avoidance of this habitat or the provision of suitable compensatory habitat utilizing recognized biodiversity offset mechanisms (as discussed below).

OEH notes that under SEPP 44 Koala Habitat Protection, Port Stephens Council have produced the *Port Stephens Comprehensive Koala Plan of Management* (June 2002) which applies to the Port Stephens LGA. As such OEH expects that this document and associated maps be consulted in the production of the SIS. Copies of the plan and maps can be obtained from council or their website:

www.portstephens.nsw.gov.au/index.php?option=com_content&view=article&id=1132921:comprehensive-koala-plan-of-management-c&catid=2822&Itemid=4033

Apart from these two species, OEH is of the view that the SIS must address all likely species, populations, ecological communities and their habitats that may be directly or indirectly impacted by the proposal, as listed above.

Based on a search of the 'Atlas of NSW Wildlife' database and the vegetation map provided in the above correspondence OEH notes the following species and ecological communities which have

been recorded on either the subject site or on the adjacent land within the study area. These species and communities will need to be considered in the SIS:

- Threatened Flora: *Asperula asthenes* (Trailing Woodruff) and *Maundia triglochinoides* (Small Water-ribbons).
- Threatened Fauna: Black-necked Stork, Brush-tailed Phascogale, Eastern Bent-wing Bat, Eastern False Pipistrelle, Eastern Freetail-bat, Greater Broad-nosed Bat, Grey-crowned Babbler (eastern subspecies), Grey-headed Flying-fox, Koala, Large-footed Myotis and Little Bent-wing Bat.
- Ecological Communities: (i) Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions, Hunter Valley Vine Thicket in the NSW North Coast and Sydney Basin Bioregions, and Swamp Oak Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.

Preliminary Listed Species

OEH draws your attention to species that may have preliminary listing under the TSC Act. They may be found on the website of the NSW Scientific Committee at www.environment.nsw.gov.au/committee/ListOfScientificCommitteeDeterminations.htm. Any preliminary-listed may receive final determination under the Act during your SIS process and hence you would need to consider them.

Any 'final determination' to list a species, population or ecological community as 'critically endangered' or 'endangered' made after lodgement of a development application or activity proposal needs to be included in the consideration of impacts and the application of the assessment of significance. Vulnerable species listed after lodgement are not subject to impact assessment as long as the application is determined within 12 months of lodgement.

Given that the proposal will significantly impact on threatened species, the known presence of a variety of threatened species and ecological communities and the apparent high conservation values identifiable with this proposal and adjacent to the subject site, it is reasonable to expect that OEH concurrence will be required. In this instance, council will assess whether or not the proposal will significantly impact on threatened species, populations, ecological communities and their habitat, and as such request OEH concurrence. If significant impact is determined, the proponent will need to satisfy OEH 'offset principles' (OEH 2011). To achieve this, the SIS will need to clearly demonstrate how the impacts can be avoided first by using prevention and mitigation measures. This may include modifying the proposal to avoid an area of biodiversity value or putting in place measures to prevent impacts. In instances where this cannot be attained and impacts cannot be avoided then offsets will need to be provided that address the remaining impacts or the impacts in general. Offsets or provision of compensatory habitat must lead to the overall maintenance or improvement of biodiversity values on site (i.e. 'improve or maintain' principle), and as such must be in accordance with 'offset provision' principles, as outlined OEH website (2014), or via a biodiversity assessment under the 'BioBanking Assessment Methodology' (OEH 2014b).

4 SURVEY

4.1 Requirement to survey

A fauna and flora survey must be conducted in the study area. Targeted surveys should be conducted for all subject species determined in accordance with Section 3.1. Recent (less than 5 years old) surveys and assessments may be used to assist in addressing this requirement. However, previous surveys (5 years or less) will not be considered to have addressed this requirement if they have:

- been undertaken in seasons, weather conditions or following extensive disturbance events when the target subject species are unlikely to be detected or present (e.g. outside known flowering / fruiting periods, adverse drought conditions, flooding, bushfire [though some species are 'fire obligates' requiring fire to germinate], slashing and overgrazing etc.); or

- utilised methodologies, survey sampling intensities, timeframes or baits that are not the most appropriate ones for detecting the target subject species unless these differences can be clearly demonstrated to be likely to have had an insignificant impact upon the outcomes of the surveys.

Surveys must be undertaken by appropriately experienced and qualified persons (including appropriately accredited people under 142B(1)(c) of the *Threatened Species Conservation Act 1995* with respect to the use of the BioBanking Assessment Methodology). A recognised expert, from institutions such as the Australian Museum (Sydney), the National Herbarium of NSW at the Royal Botanic Gardens (Sydney) or the Queensland Herbarium (Brisbane), or who is otherwise considered acceptable by OEH, must be used to determine or confirm the identification of species that are unknown or which have been only provisionally identified.

Survey methods adopted must be those considered by experienced wildlife surveyors to be those most likely to detect the targeted subject species (more than one survey method must be utilized for those subject species for which complementary methods have the potential to result in a significant increase in detection). Survey effort (including intensity, repetition and coverage) must be at a level that can be reasonably expected to detect the subject species if present in the study area. Surveys must be undertaken at the time of year when the subject species are most likely to be detected (e.g. targeted threatened flora should be carried out when a species is flowering or fruiting, as these features are typically required to positively identify species) and, where possible, in appropriate weather conditions. OEH expects the weather conditions (e.g. minimum ambient air temperature, maximum ambient air temperature, amount of precipitation that occurs each 24 hour period, details about wind speed and direction and the amount of cloud cover) and the phase of the moon to be recorded for each day of survey (including dates) to be documented and included in the report.

Survey procedures and assessment of results should be consistent with those procedures and assessment approaches contained within the following OEH publications:

- *'Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities' (DEC – November 2004)'*. (*Note: Section 6.1 *Assessment of Significance* has been amended by DECC 2007b)
- *'Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians* (DECC – April 2009a)'
- *'Threatened Species Assessment Guidelines: The Assessment of Significance'* (DECC – August 2007b).
- 'NSW Guide to Surveying Threatened Plants'. (OEH, 2016)

*Note that OEH has produced separate survey guidelines to cover Amphibians (frogs) and plants, which replace those sections in the DEC (2004) guidelines. However, the survey requirements for all other species of fauna are still found in the DEC (2004) guidelines.

The above documents can be located on OEH's website under the 'Threatened species survey and assessment guidelines' at:

- http://www.environment.nsw.gov.au/surveys/GuidelinesForCarryingOutASurvey.htm

If a proposed survey methodology is likely to vary significantly from widely accepted methods, the proponent should discuss the proposed methodology with OEH prior to undertaking the SIS, to determine whether OEH considers that it is appropriate.

In addition to the above guidelines, OEH has recently posted new information on OEH website to ensure appropriate surveys are completed, with particular reference to fauna surveying.

False absences and imperfect detection

While the presence of a target species can often be confirmed at a site relatively easily, it is generally impossible to confirm a species is absent. Unless a species has a 100% chance of being detected on a single visit (i.e. it has a probability detection of 1) non-detection does not necessarily mean the

species is absent (MacKenzie *et al.* 2002). Very few species are so conspicuous that they are always detected in each survey (MacKenzie *et al.* 2002).

A species' detectability is influenced by several factors (Tyre *et al.* 2003). Such factors include:

- the species in question – fauna species with large home ranges are especially likely to go undetected in an area, as at any given time they may be in another part of their range
- climatic conditions (e.g. temperature, rainfall)
- experience of the surveyor/s
- the survey methodology used.

An observed absence may be due to an observer failing to detect a species that is actually resident at the site, for example, a bird that was elsewhere in its home range at the time of the survey or failed to call during a point count (MacKenzie 2005). False absences have serious consequences for habitat modelling and monitoring studies as well as impact assessments. When fauna surveys are conducted for the purpose of impact assessment, false absences may result in inadequate conservation measures and an increased risk of local extinction (Wintle *et al.* 2005).

Hence, the SIS should be conservative when determining whether a species, population or community (including their habitat) are potentially present (i.e. precautionary approach).

Stratifying the site

When designing a field survey, firstly stratify the study area (i.e. divide the area into relatively homogenous units – often referred to as 'environmental sampling units' or 'stratification units'). Stratified sampling provides a logical, objective and efficient method of undertaking surveys and ensures that the full range of potential habitats and vegetation types will be systematically sampled and mapped. For the mapping of vegetation and delineation of habitat types, the study area / subject site should be initially stratified on biophysical attributes (e.g. landform, geology, elevation, slope, soil type, aspect, climate, rainfall etc.) that best delineate likely vegetation changes across the landscape. Vegetation structure or type (as per the OEH Plant Community Type or other acknowledged vegetation mapping / classification), condition and disturbance history may be used to better define the boundaries of stratification units.

Once the stratification units have been identified, they should be recorded on a survey map. Remote sensing such as aerial or satellite photograph interpretation coupled with ground truthing will help better refine and determine the spatial vegetation patterns and habitat types across a study area.

For further information on stratification and the use of Biometric tool (BioBanking Credit Calculator) in this process (particularly for fauna) refer to the new information posted on OEH website, as detailed above.

Visiting the site

Conduct a preliminary site visit to refine the initial stratification units, determine the broad vegetation types (e.g. if using OEH BioNet Vegetation Classification database to determine Plant Community Types [PCTs]) present at the site, assess the vegetation condition and conduct a broad habitat assessment to help delineate specific features suitable for sampling.

Taking a copy of OEH's BioNet Vegetation Classification database (for PCTs) (http://www.environment.nsw.gov.au/research/Visclassification.htm) for the relevant former Catchment Management Authority (CMA), local government areas or equivalent (e.g. existing vegetation mapping) into the field during the preliminary site visit, may be useful in determining the likely vegetation types present. However, for some CMAs this should only be used as a guide as some vegetation types / communities have not been captured or delineated in the database.

Survey Design

Once the site has been stratified, an adequate survey design (e.g. stratified random sampling for vegetation / flora) should be developed which adequately samples all stratification units and habitat types. Vegetation survey sites should be selected randomly and be based on the variation inherent in the stratification, while fauna sites are likely to be selected on the basis of vegetation change and specific habitat types present (e.g. hollow bearing trees, feed trees, rock outcrop, presence of water etc.). Additional targeted surveying will be required for threatened species that are dependent on specific vegetation types or habitats or require specific sampling because of seasonality (e.g. flowering season for some plants, warmer months for fauna etc.).

To sample vegetation, for example, a standard plot should be adopted to ensure the structural and floristic character of all vegetation types on site is adequately captured (e.g. 0.04 ha [20m × 20m] quadrat).

Targeted Surveys - Flora

For targeted flora surveys please note the known flowering / fruiting times for each species to time surveys appropriately (as listed above for potential 'subject species'). Surveying at known flowering times is required for all potential species that are not readily detectable (or are cryptic), where flowers or fruits are necessary for their positive identification. If targeted flora surveys for potential species are conducted outside a species known phenology then justification must be provided as to why; if this is not provided or considered inappropriate, then all such species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided. For species which do not require flowers / fruits for positive identification (e.g. large trees / shrubs), then survey as appropriate (though appropriate justification on methods used is still required). It is recommended to utilise known reference sites to help delineate flowering patterns and sampling timeframes. OEH can provide advice on this for some species.

Targeted flora surveys must also adequately sample / cover all suitable habitat on the study area, and utilise suitable detection techniques such as belt transects (at appropriate widths to spot cryptic species) or random meanders (that sufficiently cover all known / potential habitat areas [i.e. not just the tracks or readily accessible areas]). OEH has produced a new survey guideline which outlines preferred survey methodologies and techniques - 'NSW Guide to Surveying Threatened Plants'. (OEH, 2016). If targeted flora surveys are poorly conducted or surveyed then appropriate justification must be provided as to why; if this is not provided or considered inappropriate, then all such affected species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided.

Targeted Surveys – Fauna

When undertaking targeted fauna surveys, you must be aware of: (i) habitat preferences and known distribution for each of the species as an indication as to whether they may occur in the study area, (ii) the best times of year these species may be detected if subject to surveys, and (iii) suitable survey techniques to adequately detect a potential species. If targeted fauna surveys are poorly conducted, inappropriately surveyed or undertaken outside known detection periods, then appropriate justification must be provided as to why; if this is not provided or considered inappropriate, then all such affected species will be considered to be present on all available habitat and in viable numbers, and as such will require suitable biodiversity offsets or their habitat avoided.

If animals are captured with an uncertain taxonomy, species should be forwarded to the Australian Museum by a suitably qualified scientific licence holder.

Habitat assessment

Habitat assessment is recommended for all sites and should be used to supplement surveying and survey design. In instances where intensive or species-specific surveys have not been carried out

due to either timing or seasonality constraints, habitat assessment may be used as a surrogate for intensive surveys. However, in this instance threatened species should be assumed present if their habitat requirements are met. Ensure all impact assessments include a thorough habitat assessment.

Undertaking a habitat assessment of the study area will assist with predicting the occurrence of threatened species in the study area and will guide the location of targeted surveys. A comprehensive habitat assessment should be conducted across the whole site, identifying key habitat features for both flora and fauna.

You should be familiar with the habitat requirements of each threatened species identified as possibly occurring in the study area. This information can be obtained from OEH's recovery plans website (http://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/programs-legislation-and-framework/recovery-plans), threatened species profiles and scientific literature. Threatened species profiles are available on OEH website:

- www.environment.nsw.gov.au/threatenedspecies/

The habitat assessment should include information on:

- landscape features in the study area (e.g. river banks, rocky outcrops, dry slopes, wetlands, undulating terrain)
- any other features that could provide habitat such as hollow-bearing trees or culverts
- the vegetation types present (such as OEH's BioNet Vegetation Classification database (for PCTs - http://www.environment.nsw.gov.au/research/Visclassification.htm) or appropriate vegetation mapping).

It is important to record all areas of native and introduced vegetation, as even weeds can potentially provide habitat for threatened fauna. As part of the habitat assessment, you should look for:

- hollow-bearing trees, including dead stags;
- bush rock and rocky outcrops;
- natural burrows, such as those of the Hastings River Mouse;
- large trees with basal cavities;
- logs;
- wetlands, streams, rivers, dams and other water bodies;
- nests and roosts;
- wombat burrows;
- dens used by yellow-bellied gliders, squirrel gliders and brush-tailed phascogales;
- yellow-bellied glider and squirrel glider sap feed trees;
- distinctive scats (e.g. those of the spotted-tailed quoll or koala);
- latrine and den sites of the spotted-tailed quoll;
- *Allocasuarina* spp.;
- flying-fox camps;
- Microchiropteran bat tree roosts;
- Microchiropteran bat subterranean roosts (caves, culverts, tunnels and disused mineshafts);
- swift parrot and regent honeyeater feed or nest trees;
- winter-flowering eucalypts;
- mistletoes;
- permanent soaks and seepages; and
- areas that can act as corridors for plant or animal species.

Another important factor to consider is the connectivity value of the site. If the proposal site forms an important corridor in the area, the development is likely to have an effect on threatened species in the region.

A geo-referenced map / aerial photograph (or equivalent), of the study area detailing key habitat features, including the vegetation types, must be included in the report.

Flora / Vegetation Survey and Mapping

Typically, a floristic quadrat / transect will be used for vegetation based surveying. This should record the vegetation structure and cover of all structural layers, all species present, including their cover and abundance, and general location (e.g. Global Positioning System (GPS) co-ordinates etc.) and physiographic details (e.g. condition, position in landscape, soils etc.). These techniques are described in the OEH guidelines and are generally the accepted national (NVIS – National Vegetation Inventory System) standard (www.environment.gov.au/topics/science-and-research/databases-and-maps/national-vegetation-information-system). Each stratification unit must be adequately sampled.

All quadrats / transects should be adequately assessed to determine a suitable vegetation classification which accurately reflects the site. This may be done manually, or through the aid of appropriate statistical software / numerical analysis, such as cluster analysis and ordination analysis computer packages (e.g. PATN (Belbin 1989)). The latter will be dependent on how detailed the survey was, the size of the area sampled, the inherent diversity / complexity of vegetation on site and the amount of plot data collected. Details of the classification and how it was determined must be supplied in the report.

To complement and better refine the vegetation classification, ground truthing and aerial photograph or satellite imagery interpretation should be used. This will be used to generate the vegetation map and enable greater definition / delineation of vegetation communities present, and ensure a more accurate map. Ground-truthing and Aerial Photograph Interpretation (API) should be conducted at a level which captures all the obvious vegetation changes / communities on the subject site (particularly those that are noticeable at the ground-level) and ensure that all vegetation communities are adequately delineated on a geo-referenced map (the 'vegetation map'). Floristic quadrats / transects and any associated analysis will help define and describe the communities shown on the vegetation map. Recognition and delineation of native vegetation patterns on aerial photography may be based on combinations of:

- texture (crown size and shape)
- vegetation height and density
- vegetation and background tone and colour
- landuse pattern (non-woody areas).

Determining Biometric vegetation types / Plant Community Types

The classification of native vegetation in NSW follows the system described by Dr David Keith in '*Ocean Shores to Desert Dunes: The Native Vegetation of New South Wales and the ACT*' (Keith 2004). This classification scheme divides native vegetation into 17 broad vegetation formations. Each formation consists of a number of vegetation classes. There are 99 vegetation classes.

OEH has developed a 'NSW Vegetation Types Database' for use with the BioMetric tool, which is designed to assist in assessing biodiversity values when preparing property vegetation plans under the *Native Vegetation Act 2003* and BioBanking agreements under the TSC Act. This database (known as VIS) provides detailed information on the Plant Community Types (PCT) of NSW, such structure, floristics, key characteristics species, distribution and conservation value (but not limited to this). Access to the information on PCTs and the VIS database is located at:

- www.environment.nsw.gov.au/biobanking/tools.htm

If you are proposing to conduct a biodiversity assessment using BioBanking Assessment Methodology under Biodiversity Banking and Offsets Scheme, as outlined in the 'BioBanking Assessment Methodology 2014' (OEH 2014b), to determine the offset requirements of the proposal, then it is advisable and advantageous that during the survey component of the SIS that you collect the relevant data in the appropriate format for the Biometric tool (i.e. BioBanking Credit Calculator) (*Note: this may reduce duplication or further surveying at a later date). This process can provide details of the required ecosystem and species (threatened) credits that need to be retired to offset the

impacts of the development. Under this scenario all vegetation types in the study area should be identified and matched to an OEH BioMetric vegetation type.

For details on the use of Biometric, the 'BioBanking Assessment Methodology 2014' (OEH 2014b) and BioBanking in general refer to the following OEH website (Note: - the new information posted on the OEH website, as detailed above, includes details on site selection, survey intensity and methodology, and vegetation condition measurements):

- www.environment.nsw.gov.au/biobanking/

If a BioBanking assessment is conducted using the Credit Calculator then OEH requests that the proponent provide an explanation of how the local vegetation communities were assigned to Biometric vegetation types, copies of BioBanking Credit Reports, copies of all field data sheets, an explanation of the underlying assumptions used at every step of the BioBanking Credit Calculator (see Section 4.5 below), and the submission of the credit calculator files via the OEH portal (as described in **Appendix 2**).

4.2 Documentation of survey effort and technique

4.2.1 Description of survey techniques and survey sites

Survey technique(s) must be described and a reference given, where available, outlining the survey technique employed. Specific subject species targeted by each survey technique should be listed.

Survey site(s) and stratification units must be identified on a geo-referenced map / aerial photograph (or equivalent), with a clear legend, at the same scale as previous maps where possible. The size, orientation and dimensions of a quadrat or a length of transect should be clearly noted for each type of survey technique undertaken. Full Australian Map Grid (AMG) grid (Geocentric Datum of Australia (GDA) compliant) references for the survey site(s) should be noted.

4.2.2 Documenting survey effort

The time invested in each survey technique applied must be summarised (preferably in tabular format) in the SIS (e.g. - number of person hours per transect / quadrat, duration of call playback, number of nights traps set etc.). It is not sufficient to aggregate all time spent on all survey techniques. Effort must be expressed for each separate survey technique and each separate vegetation community. Survey, quadrat and transect sites must be schematically shown on a geo-referenced map or photograph. Targeted surveys also need to specify method adopted (e.g. belt transects, random meander [Cropper 1993]), habitats searched (e.g. type / features), duration, effort, prevailing weather conditions and location. Environmental conditions during the survey should be noted at the commencement of each survey technique.

Personnel details including name of all surveyor(s) and contact phone number should be provided. The person who identified records (e.g. Anabat, hair tubes, motion-sensor camera, and scat analysis) should also be identified.

4.3 Survey results

4.3.1 Subject species survey results

The report should provide a full list of all flora and fauna recorded in the study area / subject site.

Subject species recorded in the study area shall be identified, and the vegetation community in which they were recorded noted. Information concerning all records of threatened species made during the survey is to be provided in an appendix to the SIS. This information is to be in a form consistent with *Atlas of NSW Wildlife* data recording cards and include information for all fields listed on these cards.

The limitations of survey techniques employed (including survey intensity, detectability of species, seasonality, weather conditions and adverse disturbance conditions) must be considered and

discussed with respect to the results of the survey, and additional subject species considered to potentially occur in the study area identified. This assessment must be robust to external evaluation.

4.3.2 General species survey results

The SIS must provide details of all the vegetation communities (including disturbed and undisturbed / modified), habitat types, and all fauna and flora recorded on the subject site and study area in general.

A full list of the protected fauna and native plant species (as defined by the *National Parks and Wildlife Act 1974*) found during the course of surveys must be included. Such information is indicative of the habitat quality of the site. This list must indicate the significance of each species, whether the species is introduced, and the habitat in which each species was recorded.

4.4 Subject species habitat mapping

Areas identified as known or potential habitat in the study area are to be mapped on a geo-referenced map / aerial photograph (or equivalent) separately for each of the subject species. These maps should be at the same scale as previous maps where feasible, and are to include any point locality records of the relevant subject species recorded from the SIS survey in the study area. Note: Records obtained from the 'Atlas of NSW Wildlife' database can be used in determining likely habitat, but they are not to be schematically mapped in the SIS, as this is considered a breach of licence conditions for such records.

While in some circumstances the task of identifying potential habitat can be problematic, the SIS should provide the best expert estimate of the habitat of each threatened species, populations and ecological communities known or considered likely to occur in the study area. This is necessary in order to clearly support conclusions concerning the quantitative significance of habitat loss associated with the proposal. Information which can be used in preparing these maps includes records of threatened species in the local area, maps of vegetation communities and broad habitat types in the study area, information on the habitat requirements of threatened species and site-specific knowledge gained through field survey and inspection during preparation of the SIS.

4.5 General report structure

In summary, the report must include details on the following (but not be limited to):

- a description of the subject site, study area and its regional context; including a geo-referenced map / aerial photograph (or equivalent) indicating their location;
- details of the survey methodology and design adopted, including:
    - the number and location of traps (e.g. cage, Elliott, hair sampling tubes etc.), call playback sites, diurnal searches, random meanders, quadrats and transects,
    - the number of repetitions (Note: – you will need to provide a justification if this differs from the recommendations in these guidelines),
    - details of all floristic plots and transects,
    - details of the stratification,
    - identification of the classification system used (e.g. Specht *et. al.* (1974), Walker & Hopkins (1998) [Note: the classification must have regard to both structural and floristic composition elements]),
    - timing of surveying, climatic (weather) conditions and phases of the moon during survey,
    - details of how the vegetation classification for the site was developed, including details and associated products (e.g. dendrograms / two-way tables) of any analyses used, if applicable,
    - copies of any analyses used (e.g. PATN or other statistical files) and all field data sheets, and
    - geo-referenced maps / aerial photographs (or equivalent) showing the location of all survey points, quadrats and transects, and stratification units.

- detailed description of all vegetation communities / types (both undisturbed and disturbed) on the site and study area (it is preferable to link them to, OEH's Plant Community Types / Biometric vegetation types – in which case a step by step summary of how the site vegetation was matched with available Biometric vegetation types should also be included), including a geo-referenced map / aerial photograph (or equivalent) showing their location. The descriptions should include: - a general description, characteristic features (e.g. lacks a mid-storey, restricted to a particular geomorphic / edaphic feature etc.), their distribution and size (e.g. hectares), their vegetation structure (including cover), their condition, key diagnostic species, relationship to other communities, species richness and any significant species present (e.g. threatened species, Rare or Threatened Australian Plants (ROTAP: Briggs & Leigh 1996), regionally significant taxa);
- details of all habitat features / types should be included and mapped (where appropriate), such as frequency and location of stags, hollow bearing trees (including size), mature / old growth trees, culverts, rock shelters, rock outcrops, presence of feed tree / shrub / groundcover species (e.g. winter-flowering eucalypts, *Acacia* and *Banksia* trees, *Casuarina / Allocasuarina* and areas of native grasses], crevices, caves, drainage lines, soaks etc.;
- if a BioBanking assessment is conducted for the development site and any offset sites then the proponent must provide:
    - copies of any BioBanking Credit Reports and BioBanking Agreement Credit Reports generated,
    - copies of all field data sheets,
    - copies of a checklist that includes the data and underlying assumptions used at every step of the BioBanking Credit Calculator, and
    - submission of the credit calculator files via the OEH portal (as outlined in **Appendix 2**).
- a list of all flora and fauna detected on the study area / subject site during the surveys, including threatened species. All threatened species, populations and ecological communities must be clearly marked on geo-referenced map / aerial photograph (or equivalent);
- details of how the proposal will impact (both direct and indirect) and affect known and potential threatened species, populations and ecological communities (including their habitat). This is likely to include a revised 5A assessment of significance;
- details of the habitat assessment;
- detail the cumulative impacts of this proposal and any other developments within the locality that impact on threatened species, populations, ecological communities and their habitats; including an appraisal of how any adverse impacts will be avoided, mitigated against or offset;
- details of how the proposal may impact on corridors, connective links and fragmentation;
- details of how the proposal will impact (both directly and indirectly) on adjacent or nearby OEH conservation estate or if applicable, other internationally / nationally important areas, (e.g. Ramsar wetlands, wetlands listed in the Directory of Important Wetlands, SEPP14 mapped wetlands and Forestry flora reserves);
- details of any impacts on or relevance of other environmental policies or guidelines (as outlined in Section 2.1.3);
- details of mitigation and offset / compensatory habitat measures;
- details of any other approvals required under any other State or Federal legislation;
- names, qualifications and experience of all personnel involved in the field surveys, analysis of results and report writing;
- paper copies of any maps of proposed biodiversity offset areas at A0 or A1 scale that clearly show the location and boundaries of any proposed offset area. These maps must be prepared by a registered surveyor and be proper survey plans that are acceptable to local Councils;
- an assessment of how the project meets the principles of Ecologically Sustainable Development, as defined in section 6(2) of the *Protection of the Environment Administration Act 1991*;
- a discussion of the likely social and economic consequences of granting or of not granting concurrence; and
- any other information outlined elsewhere in these guidelines, such as background and comparisons to previous studies (e.g. vegetation mapping reports), mitigation and offset measures etc. that should be included in the report.

5 ASSESSMENT OF LIKELY IMPACTS ON THREATENED SPECIES AND POPULATIONS

Section 5 need only be addressed if threatened species or endangered populations are likely to be affected.

Assessment of impacts must include the assessment of indirect impacts and those of associated activities, including, but not restricted to: installation and maintenance of utilities, access and egress routes; and changes in surface water flows. These actions or impacts may occur on or off the subject land.

Assessment of impacts must also include an assessment of impacts from the provision of fire protection zones. If, as part of the development, there will be a requirement to provide fuel free or fuel reduced zones in retained bushland, the impacts of this on any threatened species or populations must be addressed as part of the impacts of the overall proposal. Proponents should also consider recommendations in '*Planning for Bushfire Protection*' (NSW Rural Fire Service 2006) and consider the use of perimeter roads as an option in providing fuel free zones and reducing impacts on retained bushland.

5.1 Assessment of species likely to be affected

An assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action (*Section* 110(2)(b)).

This requirement is asking you to refine your list of subject species and populations (given the outcome of survey and analysis of likely impacts) in order to identify which threatened species or endangered populations may be affected and the nature of the impact.

The remaining requirements in this section need only be addressed for those species that are likely to be affected by the proposal.

5.2 Discussion of conservation status

For each species or population likely to be affected, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or threat abatement plan applying to it (*Section* 110 (2)(c)).

An assessment of whether those species or populations are adequately represented in conservation reserves (or other similar protected areas) in the region (*Section* 110 (2)(e)).

An assessment of whether any of those species or populations is at the limit of its known distribution (*Section* 110 (2)(e1)).

Assessment should include reference to the threatening processes that are generally accepted by the scientific community as affecting the species or population and are likely to be caused or exacerbated by the proposal. Assessment should also include reference to any approved or draft recovery plans which may be relevant to the proposal; including those prepared by other state Governments of the Commonwealth Government.

5.3 Discussion of local and regional abundance

An estimate of the local and regional abundance of those species or populations (Section 110 (2)(d)).

5.3.1 Discussion of other known local populations

A discussion of other known populations in the locality shall be provided, along with an assessment of their regional significance. The long-term security of other habitats shall be examined as part of this discussion. The relative significance of the subject site for threatened species or endangered population in the locality shall be discussed.

5.3.2 Discussion of habitat utilisation

An estimate of the numbers of individuals utilising the area and how these individuals use the area (e.g. residents, transients, adults, juveniles, nesting, foraging). This should include discussion of the significance of these individuals to the viability of the threatened species or endangered population in the locality.

5.3.3 Description of vegetation

The vegetation present within the study area and the area covered by each vegetation community should be mapped and described, as previously stated in Section 4.3.2.

5.4 Assessment of habitat

A full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region (Section 110 (2)(f)).

5.4.1 Description of habitat values

Specific habitat features shall be described, such as frequency and location of stags, hollow bearing trees (including size), mature / old growth trees, culverts, rock shelters, rock outcrops, presence of feed tree / shrub / groundcover species (e.g. winter-flowering eucalypts, Acacia and Banksia trees, *Casuarina / Allocasuarina*, Mistletoes and areas of native grasses), crevices, caves, drainage lines, soaks etc.), and density of understorey vegetation / groundcover.

The condition of the habitat within the study area shall be discussed, including the prevalence of introduced species, species of weeds present and an estimate of the total weed cover as a percentage of each vegetation community, whether trampling or grazing is apparent, effects of erosion, prevalence of rubbish dumping, history of resource extraction or logging and proximity to roads, and assessment of the potential for native seed bank resilience in disturbed areas.

Details of the fire history of the subject site (e.g. frequency, time since last fire, intensity) and the source of fire history (e.g. observation, local records) shall be provided.

5.4.2 Extent of habitat removal

The location, nature and extent of habitat removal or modification (e.g. including impacts of Asset Protection Zones (APZs)) which may result from the proposed action including the cumulative loss and fragmentation (isolation) of habitat from the study area (including all Development Applications and those areas in the subject area already with development consent or identified for development) and the impacts of this on the viability of the threatened species or endangered population in the locality.

This shall include an assessment of the proportion of the habitat of the affected species to be affected by the proposal, in relation to the total extent of the habitat in the study area and subject site, and the impact of this on the viability of the affected species in the locality.

5.4.3 Consideration of corridors

Areas within the subject site which may act as local or regional corridors (or part thereof) for affected species must be identified and described. A geo-referenced map showing identified corridors must be

provided, and the impact of the proposal on these areas shall be discussed. If relevant, this section should include consideration of 'Key Habitats and Corridors for Forest Fauna' (NPWS Occasional Paper 32: Scotts 2003) and regional linkages, as identified within 'Regional Conservation Assessment, Lower Hunter and Central Coast Region' (Morison & House 2004), or other appropriate studies (e.g. Council specific LES, LEP documents and structure plans).

5.4.4 Impacts on Threatened Species and Populations in OEH Estate

This section only needs to be addressed when threatened species and populations in OEH estate (e.g. National Parks, Nature Reserves) are likely to be either directly or indirectly impacted upon.

The SIS must assess the potential impacts on any threatened species and populations which may likely be directly or indirectly impacted upon that reside with OEH estate, including but not limited to fragmentation or loss of connective linkages, edge effects (e.g. increased boundary to area ratio), increased predation potential, weed invasion, loss or impacts on pollination vectors, changes to hydrology, nutrient increases, pollution, anthropogenic impacts (e.g. increased visitation, refuse) etc.

5.5 Description of feasible alternatives

A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development (Section 110(2)(h)).

Where a Statement of Environmental Effects (SEE), Environmental Impact Statement (EIS) or Review of Environmental Factors (REF) deals with these matters, the SIS may refer to the relevant section of the SEE, EIS or REF.

This section must include details of the condition and use of other parts of the subject area and why these can or cannot be considered as feasible alternatives.

6 ASSESSMENT OF LIKELY IMPACTS ON ECOLOGICAL COMMUNITIES (ENDANGERED AND CRITICALLY ENDANGERED)

Section 6 need only be addressed when ecological communities are likely to be affected.

Assessment of impacts must include the assessment of indirect impacts and those of associated activities, including, but not restricted to: installation and maintenance of utilities, access and egress routes; and changes in surface water flows. These actions or impacts may occur on or off the subject land.

Assessment of impacts must also include an assessment of impacts from the provision of fire protection zones. If, as part of the development, there will be a requirement to provide fuel free or fuel reduced zones in retained bushland, the impacts of this on any endangered and critically endangered ecological communities must be addressed as part of the impacts of the overall proposal. Proponents should also consider recommendations in 'Planning for Bushfire Protection' (NSW Rural Fire Service 2006) and consider the use of perimeter roads as an option in providing fuel free zones and reducing impacts on retained bushland.

6.1 Assessment of ecological communities (both endangered and critically endangered) likely to be affected

A general description of the ecological community present in the area that is the subject of the action and in any area that is likely to be affected by the action (Section 110(3)(a)).

This must include reference to the ecological community as described by the NSW Scientific Committee, including maps of the extent and condition of the community with particular reference to

those parts of the community that may only be represented by soil stored seed with no above ground components of the community present.

6.2 Discussion of conservation status

For each ecological community present, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or any threat abatement plan applying to it (Section 110(3)(b)).

An assessment of whether those ecological communities are adequately represented in conservation reserves (or other similarly protected areas) in the region (Section 110(3)(b1)).

An assessment of whether any of those ecological communities is at the limits of its known distribution (Section 110(3)(b2)).

Assessment should include reference to the threatening processes that are generally accepted by the scientific community as affecting the endangered and critically endangered ecological community and are likely to be caused or exacerbated by the proposal. The assessment should also include reference to any approved or draft recovery plans which may be relevant to the proposal.

6.2.1 Significance within a local context

An assessment of the community on the subject site in relation to other sites in the study area and in the locality. The tenure and long term security of other localities shall be examined as part of this discussion.

The relative significance of the subject site for the endangered and critically endangered ecological community shall be discussed. The assessment of the community should be considered in terms of the following features including, the size of the remnant, the quality of the habitat and the level of disturbance on this site in comparison to other sites in the locality.

6.2.2 Discussion of corridor values

The potential of the proposal to increase fragmentation of the community and increase edge effects.

If corridors that allow connectivity between localities of endangered and critically endangered ecological communities are present within the subject site, the impact of the proposal on these areas shall also be discussed.

6.2.3 Discussion of regional significance

The significance of the locality for the community from a regional perspective shall be noted and discussed.

6.2.4 Impacts on Ecological Communities in OEH Estate

This section only needs to be addressed when endangered and critically endangered ecological communities in OEH estate are likely to be either directly or indirectly impacted upon.

The SIS must assess the potential impacts on any endangered and critically endangered ecological communities which may likely be directly or indirectly impacted upon that reside with OEH estate.

OEH notes a number of conservation estates which may contain ecological communities in the vicinity (5 km radius) as outlined in Section 5.4.4.

6.3 Assessment of habitat

A full description of the type, location, size and condition of the habitat of the ecological community and details of the distribution and condition of similar habitats in the region (Section 110 (3)(c)).

6.3.1 Description of disturbance history

If the site shows signs of disturbance, details should be provided of the site's disturbance history and an assessment should be made of the ability of the ecological community to recover to a pre-disturbance condition.

6.3.2 Extent of habitat removal

The location, nature and extent of habitat removal or modification which may result from the proposed action including the cumulative loss of habitat from the study area (including all proposed DAs and those areas in the subject area already with development consent or identified for development) and the impacts of this on the viability of the endangered and critically endangered ecological community in the locality.

This shall include an assessment of the proportion of the ecological community to be affected by the proposal, in relation to the total extent of the ecological community, and the impact of this on the viability of the ecological community in the locality.

6.4 Description of feasible alternatives

A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development (Section 110(3)(e)).

Where a Statement of Environmental Effects (SEE), Environmental Impact Statement (EIS) or Review of Environmental Factors (REF) deals with these matters, the SIS may refer to the relevant section of the SEE, EIS or REF.

In the discussion of feasible alternatives to the proposed development with regards to biophysical, economic and social considerations, and the principles of ecologically sustainable development, the SIS must also include details on the condition and use of other parts of the subject area and why these can or cannot be considered as feasible alternatives.

7 AMELIORATIVE MEASURES

7.1 Description of ameliorative measures

A full description and justification of the measures proposed to avoid or mitigate any adverse effect of the action on the species and populations and ecological community including a compilation (in a single section of the statement) of those measures (Section 110 (2)(i) and Section 110 (3)(f)).

7.1.1 Long-term management strategies

Consideration shall be given to developing long-term management strategies to protect areas within the study area which are of particular importance for the threatened species, endangered populations or endangered / critically endangered ecological communities likely to be affected. This may include proposals to restore, improve or provide long term protection for habitat on site where possible. Any such proposal is to be accompanied by a plan of management identifying the specific areas to be restored, improved or protected, the threatened species / ecological community values of those areas, and detailing the management actions to be implemented to maintain and protect those

values, including corrective actions to be taken in the event that monitoring indicates that management does not achieve specified objectives.

7.1.2 Compensatory strategies

OEH notes that its 'offset provision' principles (**Appendix 1**) state that impacts must be avoided first by using prevention and mitigation measures (DECC 2007a). Where significant modification of the proposal to minimise impacts on threatened species, populations or endangered / critically endangered ecological communities is not possible then compensatory strategies should be considered. These should include offsite or local area proposals that contribute to long term conservation of affected threatened species, population or ecological communities. If on or off-site compensatory habitat is not considered appropriate, justification must be provided. OEH is of the opinion that where a proposal which involves the clearing of threatened species habitat (i.e. native vegetation) that cannot be avoided or mitigated against, and then appropriate offsets which compensate for the clearing of the habitat must be provided. The proponent must provide proper survey plans of any biodiversity offsets with the SIS, as described in sections 2.2 and 4.5 above.

Compensatory benefits likely to result from such measures proposed for alternative sites are to be discussed and evaluated along with a discussion of mechanisms of how they might best occur.

The tenure of lands, land use and the future use of lands proposed to support compensatory habitat must be considered.

Justification for any area(s) proposed as compensatory habitat / offsets is to include an assessment of the threatened species / biodiversity values impacted on by the proposed works (i.e. those of the subject site) and a comparison of whether the proposed offset area(s) provides equivalent or greater values – 'improve or maintain important biodiversity values'.

To determine the adequate biodiversity offset required to compensate the loss of threatened species, populations, ecological communities and their habitat (e.g. vegetation communities) either one of the following methodologies are to be used:

- OEH's 'offsetting principles' (OEH 2014a), as outlined on OEH's website: *Principles for the use of biodiversity offsets in NSW* (OEH's website - www.environment.nsw.gov.au/biodivoffsets/index.htm) can be used as general guide for offsetting and compensatory habitat requirements
- a biodiversity assessment using BioBanking Assessment Methodology under Biodiversity Banking and Offsets Scheme, as outlined in the '*BioBanking Assessment Methodology 2014*' (OEH 2014b). This would provide details of the required ecosystem and species (threatened) credits that need to be retired to offset the impacts of the development.

Although the '*BioBanking Assessment Methodology (BBAM) 2014*' (OEH 2014b) under the Biodiversity Banking and Offsets Scheme previously represented an alternative pathway (i.e. BioBanking Statement) to that of the SIS for Part 4 matter, OEH is of the opinion that a biodiversity assessment using this process provides a transparent framework and a quantitative alternative to the principles-based approach (i.e. 'offset provision' principles as outlined in the biodiversity accreditation guideline - OEH 2014a – Appendix 1). Although this option is no longer formally available, the BBAM calculator is still operational and can be accessed during the Saving and Transitional arrangements associated with the 'interim designated areas'.

OEH acknowledges that in this instance BBAM is a voluntary process and not a requirement under the SIS CERs, but believes it provides a valuable insight and quantitative appraisal into what would be an acceptable offset package to compensate the likely impacts of the development. OEH notes that under the *Principles for the use of biodiversity offsets in NSW* – Principle 9 states that '*offsets must be quantifiable – the impacts and benefits must be reliably estimated*', in that offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. OEH is of the opinion that the BBAM represents the only currently recognised quantitative methodology that ensures offsets are quantifiable. Please note, if

BioBanking is not used then OEH would expect an alternative quantitative methodology is adopted that clearly indicates that the biodiversity values of an offset site is commensurate with those found at the impact site, whether it be with respect to size and scale, or as a measure of biodiversity credits (as per BioBanking). Under this scenario, it is likely OEH would undertake a desk-top (as a minimum) BioBanking assessment to assess the veracity of any alternative methods used. Please note - If BioBanking is used then all appropriate files must be sent via OEHs portal, credit reports, biometric assessment reports, figures (e.g. GIS) and data sheets need to be provided with the SIS when it is lodged.

Note: On 1 October 2014, the BioBanking Credit Calculator (BioBanking Assessment Methodology 2014 [OEH 2014b]) has become the compulsory version of the tool to use for BioBanking assessments (see www.environment.nsw.gov.au/biobanking/calculator.htm for more details). The credit calculator is now web-based and no longer produces 'xml' files. Instead a copy of the assessment can be sent electronically to OEH by following the steps outlined in **Appendix 2**. The requirement of submitting background files for OEH to use in checking the BioBanking assessment still stands and is also explained in **Appendix 2**.

The following principles are relevant to areas without an existing biodiversity offsets program. Offsets will require the proponent to consider adequate conservation in perpetuity, appropriate management regimes (including other habitat enhancement or mitigation measures) and financial security with respect to ongoing management. OEH would typically consider suitable measures to ensure conservation in perpetuity, such as:

- the establishment of BioBanking sites with BioBanking agreements under the TSC Act
- the retirement of BioBanking credits (where appropriate credits are available)
- the dedication of land as a public reserve under the NPW Act
- a Conservation Agreement in-perpetuity registered on title under s69A-KA of the NPW Act
- a Trust Agreement in-perpetuity registered on title under the Nature Conservation Trust Act 2001
- a Planning Agreement under s 93F (soon to be s116T) of the EP&A Act.

Note:

- OEH preferred method of securing an offset is under the BioBanking provisions of the *Threatened Species Conservation Act 1995* (i.e. a registered BioBanking Agreement site).
- OEH no longer supports public positive covenant under s88E of the *Conveyancing Act 1919* as an appropriate conservation mechanism to secure and manage biodiversity offsets.
- Although OEH supports the use of conservation agreements under the NPW Act as one of the acceptable offsetting mechanisms, we are reviewing this approach and it is advisable that if you are considering this mechanism you contact OEH's Conservation Partners Program (ph: 9995 6761) about its applicability.

OEH notes that its preference for compensatory measures is physical land offsets of a 'like-for-like' nature. OEH understands that the proponent is suggesting to supplement a potential short fall of physical land offsets with habitat enhancement measures, such as restoring land bridges and connective links for threatened species (e.g. koalas). As such the proponent will need to (i) clearly show with appropriate field data / studies that such links no longer operate within the study area and that the absence or degradation of these links are having an adverse impact on current population levels of affects species, and that (ii) such measures will benefit impacted species, improve connective links and overall lead to increases population growth and longevity.

To appropriately manage any proposed compensatory offsets, any retained habitat enhancement features within the development footprint and impact mitigation measures (including proposed rehabilitation and monitoring programs), OEH would require that an appropriate Management Plan (such as vegetation or habitat) be developed as a key amelioration measure. OEH acknowledges that where a proponent choses a BioBanking Agreement, Conservation Agreement or similar that a Management Plan will be specifically developed as part of their establishment process.

Management plans should be prepared prior to any potential approval of the development. Management Plans should clearly document how any retained vegetated areas or habitat features will be managed with respect to long-term conservation and viability, including clear details on how they will be funded. They should cover (where applicable), but not be limited to, the following issues:

- weed management (both control and suppression) and monitoring
- management of retained native vegetation and habitat (including buffer zones)
- feral animal control
- fire management (including asset protection zones [APZs])
- public access (including restriction of, increased traffic, and associated impacts, such as increased refuse and pets)
- size and management of buffer zones
- minimisation of edge effects and fragmentation
- stormwater control and changes to hydrology (including stormwater / runoff control and sediment / erosion control measures)
- management of specific habitat enhancement measures (e.g. hollow / habitat trees, animal fencing to facilitate movement, artificial hollows and nest boxes etc.)
- fauna displacement and if appropriate translocation (including any licence requirements)
- proposed surveys, such as pre-extraction baseline, pre-clearance and rehabilitation surveys
- details of long-term monitoring (including proposed timing)
- details of any rehabilitation program, including details of timing (including proposed staging details), rehabilitation measures (including details of proposed revegetation and species mix), and post-rehabilitation monitoring
- measures to ensure conservation in perpetuity (e.g. transfer to OEH [NPWS] estate, conservation agreements or covenants)
- funding details of long-term financial commitment to any proposed conservation measures, including any mechanisms to be implemented to achieve this.

7.1.3 Ongoing monitoring

Any proposed pre-construction flora, fauna or vegetation monitoring plans or on-going monitoring of the effectiveness of the mitigation measures shall be outlined in detail, including the objectives of the monitoring program, method of monitoring, reporting framework, duration and frequency. Generally, ameliorative strategies which have not previously been proved effective should be undertaken under experimental design conditions, appropriately monitored and appropriately analyzed. Data analysis could include an 'Analysis of similarities' (ANOSIM) assessment of changes in foliage cover of plant species recorded in fixed quadrats or transects between sampling periods (Clarke 1993). Objectives of any monitoring plans are to include identifying any modifications needed to improve the effectiveness of ameliorative measures. These aspects should also be covered in any relevant management plans. Additionally a review of management plans should be undertaken at regular interviews (e.g. 5 years) to ensure adaptive management, where required, is undertaken.

8 ASSESSMENT OF SIGNIFICANCE OF LIKELY EFFECT OF PROPOSED ACTION

An 'Assessment of Significance' (s. 5A EP&A Act) is to be provided for each of the affected species (threatened species, populations or ecological communities) identified in the SIS, incorporating relevant information from sections 5.1 to 7 of the SIS. On the basis of these assessments a conclusion is to be provided concerning whether, based on more detailed assessment through the SIS process and consideration of alternatives and ameliorative measures proposed in the SIS, the proposal is still considered likely to have a significant effect on threatened species, populations or ecological communities or their habitats.

The threatened species 'Assessment of significance' should be consistent with those procedures and assessment approaches contained within OEH publication:

- '*Threatened Species Assessment Guidelines: The Assessment of Significance*' (DECC – August 2007b). This document is available from OEH's website: http://www.environment.nsw.gov.au/surveys/GuidelinesForCarryingOutASurvey.htm

9 ADDITIONAL INFORMATION

9.1 Qualifications and experience

A species impact statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement (Section 110(4)).

You should have extensive experience in conducting field surveys and should be able to identify threatened species and their habitats relevant to the study area, as well as any similar species that may be confused with them. You should familiarise yourself with herbarium or museum specimens of any threatened species you are not already familiar with, before you conduct field surveys.

9.2 Other approvals required for the development or activity

A list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population or ecological community (Sections 110(2)(j) and 110(3)(g)).

In providing a list of other approvals the following shall be included:

- Where a consent is required under Part 4 of the *Environmental Planning and Assessment Act 1979*, the name of the consent authority and the timing of the development application should be included; or
- Where an approval(s) is required under Part 5 of the *Environmental Planning and Assessment Act 1979*, the name of the determining authority or authorities, the basis for the approval and when these approvals are proposed to be obtained should be included; or
- Where an approval(s) is required under *Native Vegetation Act 2003*, the name of the determining authority or authorities, the basis for the approval and when these approvals are proposed to be obtained should be included.

Environment Protection and Biodiversity Conservation Act 1999

An action will require the approval of the Federal Minister for the Environment (in addition to any State or Local Government approval or determination) if that action will have, or is likely to have, a significant impact on a matter of national environmental significance. Threatened species and communities listed in the Australian Government *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are considered to be a matter of national environmental significance.

Many of the species and ecological communities listed in the TSC Act are also listed in the EPBC Act.
Further information regarding the operation of the EPBC Act, including listed threatened species and communities, may be obtained by contacting the Australian Government Department of the Environment and Energy on 1800 803 772 or at the Department's website www.environment.gov.au/biodiversity/threatened/index.html.

9.3 Licensing matters relating to the survey

Persons conducting flora and fauna surveys must have appropriate licences or approvals under relevant legislation. The relevant legislation and associated licences and approvals that may be required are listed below:

National Parks and Wildlife Act 1974:

- General Licence (Section 120) to harm or obtain protected fauna (this may include threatened fauna).

- Licence to pick protected native plants (Section 131).
- Scientific Licence (Section 132C) to authorise the carrying out of actions for scientific, educational or conservation purposes.

Threatened Species Conservation Act 1995:

- Licence to harm threatened animal species, or pick threatened plants or damage the habitat of a threatened species (Section 91).

Animal Research Act 1985:

- Animal Research Authority to undertake fauna surveys.

Typically, you will require a licence under section 132C of the NPW Act to undertake an activity (e.g. survey) for scientific, educational or conservation purposes that is likely to result in one or more of the following:

- harm to any protected fauna, or to an animal that is a threatened species or is part of an endangered population or an endangered ecological community
- harm to any protected native plant, or any plant that is a threatened species or is part of an endangered population or an endangered ecological community. You will need a licence if you plan to collect voucher specimens for identification purposes, pick cuttings or whole plants, or collect seed
- damage to critical habitat
- damage to a habitat of a threatened species, an endangered population or an endangered ecological community.

Information pertaining to section 132C licences can be obtained from the following website:

- http://www.environment.nsw.gov.au/licences-and-permits

Section 132C licences came into effect in January 2003 and replaced the previous need for separate licences under other provisions of the NPW Act and the TSC Act.

It is a condition of all licences that you submit a report of the work carried out under the licence, including any results and specific details / locations of all flora and fauna, to OEH within two months of the expiry of the licence.

Also, be aware of the requirements relating to animal care and ethics when conducting wildlife surveys. The handling and capture of animals is regulated by the *Animal Research Act 1985* and the *Animal Research Regulation 1995*, which are administered by Department of Trade and Investment, Regional Infrastructure and Services. The Act requires that every person undertaking animal research must hold an Animal Research Authority. Under the Act, animal research includes the 'use' (e.g. handling, trapping etc.) of animals in field surveys. Details on animal ethics can be obtained from the following website:

- www.animalethics.org.au/home

All surveys must be carried out in accordance with the NSW Department of Trade and Investment, Regional Infrastructure and Service's Guidelines for wildlife surveys located at:

- www.animalethics.org.au/policies-and-guidelines/wildlife-research/wildlife-surveys

9.4 Section 110 (5) reports

Section 110(5) of the TSC Act has the effect of requiring OEH to provide that information regarding the State-wide conservation status of the subject species that it has available, in order to satisfy ss.110(2)&(3) of the Act. These documents are available on the internet at:

- http://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species

This website provides basic profiles for the majority of species listed as threatened, as well as links to the Scientific Committee determinations, more detailed profiles, environmental impact assessment guidelines and recovery plans, where these documents are available. OEH is unable to provide any further information for section 110(5) reports.

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APPENDIX 1:

Principles for the use of biodiversity offsets in NSW (OEH 2014)

Located at: www.environment.nsw.gov.au/biodivoffsets/oehoffsetprincip.htm

These principles have been developed by the Office of Environment and Heritage (OEH) to provide a useful framework when considering biodiversity impacts and appropriate offset requirements.

They are intended to be used for proposals other than those for state significant development (SSD) or state significant infrastructure (SSI). A Biodiversity Offsets Policy for Major Projects has been developed to deal with proposals for SSD and SSI.

1. Impacts must be avoided first by using prevention and mitigation measures.
Offsets are then used to address the remaining impacts. This may include modifying the proposal to avoid an area of biodiversity value or putting in place measures to prevent offsite impacts.

2. All regulatory requirements must be met.
Offsets cannot be used to satisfy approvals or assessments under other legislation, such as assessment requirements for Aboriginal heritage sites and for pollution or other environmental impacts (unless specifically provided for by legislation or additional approvals).

3. Offsets must never reward ongoing poor performance.
Offset schemes should not encourage landholders to deliberately degrade or mismanage offset areas in order to increase the value from the offset.

4. Offsets will complement other government programs.
A range of tools is required to achieve the NSW Government's conservation objectives, including the establishment and management of new national parks, nature reserves, state conservation areas and regional parks, and incentives for private landholders.

5. Offsets must be underpinned by sound ecological principles.
They must:

- include the conservation of structure, function and compositional elements of biodiversity, including threatened species
- enhance biodiversity at a range of scales
- consider the conservation status of ecological communities
- ensure the long-term viability and functionality of biodiversity.

Biodiversity management actions, such as enhancement of existing habitat and securing and managing land of conservation value for biodiversity, can be suitable offsets. Reconstruction of ecological communities involves high risks and uncertainties for biodiversity outcomes and is generally less preferable than other management strategies, such as enhancing existing habitat.

6. Offsets should aim to result in a net improvement in biodiversity over time.
Enhancement of biodiversity in offset areas should be equal to or greater than the loss in biodiversity from the impact site.
Setting aside areas for biodiversity conservation without additional management or increased security is generally not sufficient to offset the loss of biodiversity. Factors to consider include protection of existing biodiversity (removal of threats), time-lag effects, and the uncertainties and risks associated with actions such as revegetation.
Offsets may include:

- enhancing habitat
- reconstructing habitat in strategic areas to link areas of conservation value
- increasing buffer zones around areas of conservation value

- removing threats by conservation agreements or reservation.

7. Offsets must be enduring – they must offset the impact of the development for the period that the impact occurs.
As impacts on biodiversity are likely to be permanent, the offset should also be permanent and secured by a conservation agreement or reservation and management for biodiversity. Where land is donated to a public authority or private conservation organisation and managed as a biodiversity offset, it should be accompanied by resources for its management. Offsetting should only proceed if an appropriate legal mechanism or instrument is used to secure the required actions.

8. Offsets should be agreed prior to the impact occurring.
Offsets should minimise ecological risks from time-lags. The feasibility and in-principle agreements to the necessary offset actions should be demonstrated prior to the approval of the impact. Legal commitments to the offset actions should be entered into prior to the commencement of works under approval.

9. Offsets must be quantifiable – the impacts and benefits must be reliably estimated.
Offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. The methodology must be based on the best available science, be reliable and used for calculating both the loss from the development and the gain from the offset. The methodology should include:

- the area of impact
- the types of ecological communities and habitat or species affected
- connectivity with other areas of habitat or corridors
- the condition of habitat
- the conservation status and/or scarcity or rarity of ecological communities
- management actions
- level of security afforded to the offset site.

The best available information or data should be used when assessing impacts of biodiversity loss and gains from offsets. Offsets will be of greater value where:

- they protect land with high conservation significance
- management actions have greater benefits for biodiversity
- the offset areas are not isolated or fragmented
- the management for biodiversity is in perpetuity, such as secured through a conservation agreement.

Management actions must be deliverable and enforceable.

10. Offsets must be targeted.
They must offset impacts on the basis of like-for-like or better conservation outcomes. Offsets should be targeted according to biodiversity priorities in the area, based on the conservation status of the ecological community, the presence of threatened species or their habitat, connectivity and the potential to enhance condition by management actions and the removal of threats.

Only ecological communities that are equal or greater in conservation status to the type of ecological community lost can be used for offsets. One type of environmental benefit cannot be traded for another: for example, biodiversity offsets may also result in improvements in water quality or salinity but these benefits do not reduce the biodiversity offset requirements.

11. Offsets must be located appropriately.
Wherever possible, offsets should be located in areas that have the same or similar ecological characteristics as the area affected by the development.

12. Offsets must be supplementary.
They must be beyond existing requirements and not already funded under another scheme. Areas that have received incentive funds cannot be used for offsets. Existing protected areas on private land cannot be used for offsets unless additional security or management actions are implemented. Areas already managed by the government, such as national parks, flora reserves and public open space, cannot be used as offsets.

13. Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or contracts.
Offsets must be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes.

Page last updated: 8 September 2014

APPENDIX 2

Checklist of information required when utilising the Biobanking Assessment Methodology and Submitting BioBanking assessments to OEH using the BioBanking Credit Calculator v.4.0

An Assessors' Guide / Manual to Using the BioBanking Credit Calculator is available for download from the Office of Environment and Heritage (OEH) website http://www.environment.nsw.gov.au/biobanking/calculator.htm. The guide provides information on the operation and use of the web-based BioBanking Credit Calculator version.4.0.

To submit your assessment to OEH, open your assessment in *Edit* mode. Navigate to the *Assessment details* page and select the *Submit* button in the top right hand corner. A *Submit the assessment for approval* box will appear (Figure 1), where you can confirm submission (*OK* button) or cancel submission (*Cancel* button). Once a case has been submitted to OEH, the status of the case will change in your *My work* tab from *Work in progress (WIP)* to *submitted*. Please note that you cannot make any edits to an assessment that has been submitted, although you will be able to view the assessment.

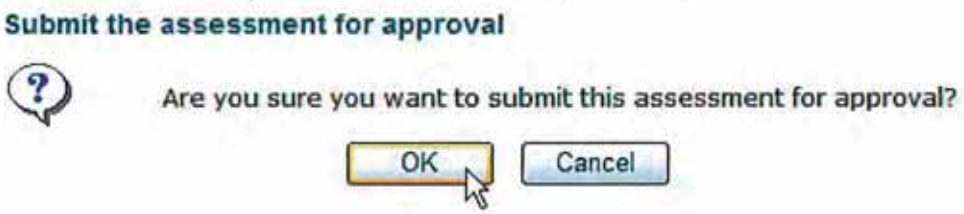

Figure 1: Submitting an assessment

The following documentation must be submitted with your Environmental Impact Statement or Species Impact Statement report (in hard copy and soft copy):

- BioBanking Assessment Report including a list of dominant indigenous species for overstorey, mid-storey and ground cover for each vegetation type and, where required:
  - local benchmark data,
  - request for increase in gain of site value,
  - a description of the proposed development,
  - measures to avoid and mitigate the impacts of development,
  - an assessment of indirect impacts,
  - a statement of onsite measures,
  - a description of the application of the BioBanking Assessment Methodology, including details of and assumptions made in utilising the methodology, such as (but not limited to) placement of assessment circles, remnant value, connectivity and reasoning behind selection of vegetation types in the Biometric Vegetation Type database,
  - plot and transect values including a list of the indigenous plant species identified in each of the plots,
  - a description of targeted threatened flora and fauna surveys, and any general baseline surveys (incl. vegetation specific surveys). These should be also be provided schematically, and

  Where required, the BioBanking Assessment Report should also include:
  - expert reports,
  - an application for a determination on red flag areas,
  - more appropriate use of local data for vegetation types, benchmarks or threatened species,
  - environmental contributions accompanied by a BioBanking Agreement Credit Report (if applicable), and
  - application for deferred retirement arrangements (if applicable).

- Copies of completed field data sheets, and updated with correct plant taxonomy in instances where field names have been used.

Maps (soft copy as A4 jpgs) of:

- offset site / BioBanking Agreement boundary or development footprint
- vegetation zones
- management zones
- and where required:
    - existing waste
    - existing erosion
    - existing structures (in waterways)

- Separate shape files should be supplied for all the maps mentioned above plus:
    - plots and transects
    - assessment circles
    - species polygons
    - polygons for adjacent remnant area
    - the location or habitat area of sensitive species, and the management area related to that sensitive species (as this information cannot be displayed publicly).

All maps must include:

- a title (as per the names above)
- the site's name, location and lot/DP numbers
- the scale
- the date it was prepared
- a clear and unambiguous legend.

Boundaries and zones must be confirmed on the site using a GPS. This information should be digitised onto an ortho-rectified aerial photo or SPOT-5 image. Maps must be easily readable and submitted to OEH as a Geographic Information System (GIS) file that is ESRI compatible. Shape files must use GDA94 datum. Name each shape file as: 'biobank site name_descriptor'. For example, 'Hill Farm_photo points' or 'Hill Farm_management zones'.

Photo points should be named A, B, C, D, E, F, G, etc. Photo points should be located in areas where change is expected (i.e. where replanting, natural regeneration, intensive weeding or other active management actions are to be carried out). As a rough guide, include at least one photo point in each management zone where active management actions will be undertaken. Boundaries and zones must be confirmed on the site using a GPS. This information should be digitised onto an ortho-rectified aerial photo or SPOT-5 image. Maps must be easily readable and submitted to OEH as a Geographic Information System (GIS) file that is ESRI compatible.

Shape files must use GDA94 datum. Name each shape file as: 'biobank/development site name_descriptor'. For example, 'Hill Farm_photo points' or 'Hill Farm_management zones'.

Additional requirements for offset sites that may be required (based on liaison with OEH):

- completed biobanking agreement management action template (provided in MS-Word format), and
- Biodiversity Credits Pricing Spreadsheet

Once the case has been received OEH will review the data entered, and any supporting documentation. For State Significant Development (SSD), State Significant Infrastructure and residual Part 3A (under the *Environmental Planning and Assessment Act 1979*) this review will take place during the assessment of the Environmental Impact Statement or Environmental Assessment report (for Part 3A matters).

ATTACHMENT B:

Checklist for determining if an SIS has met the requirements of the Chief Executive of the Office of Environment and Heritage

Under the *Environmental Planning and Assessment Act 1979*, where a significant effect on threatened species, populations or ecological communities is likely, a development application must be accompanied by concurrence from the Office of Environment and Heritage (OEH). A species impact statement prepared in accordance with Division 2 of Part 6 of the *Threatened Species Conservation Act 1995* (TSC Act) must accompany the application.

The development is taken not to significantly affect threatened species, populations or ecological communities, or their habitats if:

a) the development is to be carried out on biodiversity certified land (within the meaning of Part 7AA of the TSC Act, or

b) a BioBanking statement has been issued in respect of the development under Part 7A of the TSC Act.

Before deciding to issue consent or approval and consequently requesting the concurrence of the Chief Executive of OEH, it is required of the consent or determining authority to determine whether the SIS meets the Chief Executive's requirements (CERs).

This checklist has been drawn up to assist consent and determining authorities in this matter. A comments column has been included to allow authorities to provide, among other things, reasons for their decisions or comments on whether an omission is significant.

Note that this is a generic checklist and some items may not be relevant to the application being reviewed or the CERs issued. If the requirements do not specify one of the matters below, then it is recommended that this be noted in the comments column. Consultants preparing an SIS may also use this checklist as a brief guide to preparing the SIS.

Matter	Yes/No	Comments
Has the SIS been signed by both its author and the applicant for consent/approval?		
Has the description of the proposal included all associated activities and works, such as hazard reduction zones, access roads and road upgrades, utilities, etc?		
Have all requested plans, maps and aerial photographs been provided? This includes any A1 or A0 sized proper survey plans prepared by a registered surveyor that clearly show the location and boundaries of any proposed offsets.		
Has the SIS determined the subject species by reviewing the suggested list in the CERs, other available information and survey results and assessing which species, populations and ecological communities are to be impacted by the development?		
Has the survey undertaken provided sufficient information to determine the likely impacts of the proposal on threatened species, populations and ecological communities?		

Matter	Yes/No	Comments
Have surveys been undertaken during the appropriate season(s) for the detection of the species that may possibly occur on site?		
Have surveys been undertaken during appropriate weather conditions?		
Have climatic conditions preceding the surveys (e.g. drought c.f. wet) affected the possibility of subject species being detected?		
Have all specific survey methods, techniques and intensities requested in the CERs been followed completely?		
Has the documentation of survey effort, locations and techniques provided sufficient information to determine the above?		
Has the assessment of impacts included the impacts of ALL activities associated with the development, including fire hazard reduction requirements, access road upgrades, downstream and downslope impacts, detention basins, severing of fauna movement corridors, etc.		
Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species' in the locality (locality is defined in the CERs)?		
Has the SIS discussed the significance of the population/remnant to be affected, relative to others within the locality?		
Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species in the region (region is defined in the TSC Act).		
Has the SIS discussed the significance of the population/remnant to be affected, relative to others within the region?		
Have alternatives to the proposal been discussed? Alternatives may include relocation of infrastructure or, for example, reducing minimum lot size so that a similar number of lots may be realised whilst retaining a larger conservation lot within a subdivision, or changing mining techniques.		
Has the discussion of alternatives included assessment of the social and economic (not merely financial) aspects of these alternatives (particularly, of not proceeding)?		
Has the discussion included an assessment of how the project meets the principles of Ecologically Sustainable Development, as defined in section 6(2) of the *Protection of the Environment Administration Act 1991*?		
Have all proposals for compensatory actions (e.g. purchase of similar vegetation / habitat or revegetation of habitat, where appropriate) been discussed with the relevant landowners/manager?		
Is there documented agreement for sale or		

Matter	Yes/No	Comments
revegetation activities?		
Is there agreement to change zoning or enter into a covenant on title in order to secure the conservation of the properties being purchased or revegetated?		
If translocation is proposed, has the impact of the translocation on the recipient site(s) been assessed?		
Is there a 'Plan of Management' or similar titled document?		
Has the SIS utilised relevant information from published draft and final recovery plans? If no plan has been published, but it is known that one is being prepared, has the SIS utilised advice from the NPWS as to the likely contents of that recovery plan (liaison to obtain this advice may have been specified in the CERs)? For example, would the proposal result in the loss of a local population or remnant that a recovery plan describes as being of particular importance to the conservation of the species, population or ecological community?		
If a BioBanking assessment has been done for the proposal have the following been provided: copies of BioBanking Credit reports, copies of field datasheets, and copies of a checklist that includes all data used in the credit calculator and the underlying assumptions, such as how local vegetation communities were assigned to BioMetric vegetation types?		
Has the SIS discussed the relationship of the proposal to any listed Key Threatening Processes (e.g. does the proposal result in the need for High Frequency Fire as a fire hazard reduction measure, or does it result in the Clearing of Native Vegetation)?		
Has the SIS discussed the relationship of the proposal to any published Threat Abatement Plan (e.g. does the proposal result in an increased threat in a manner that is specifically at odds with a published plan)?		
Has a revised Part 5A assessment of significance been included?		
Has the 'Additional Information' specified in section 9 of the CERs been provided?		
Have the qualifications and experience of those involved in the surveys been included?		
Have other approvals which are required for the development or activity been documented?		
Any licensing requirements (e.g. s.91 under TSC Act).		

Appendix B

CER Compliance Table

Table 11.1 Compliance Table

Matter	Yes/No	Comments
Has the SIS been signed by both its author and the applicant for consent/approval?	Yes	
Has the description of the proposal included all associated activities and works, such as hazard reduction zones, access roads and road upgrades, utilities, etc?	Yes	See SEE
Have all requested plans, maps and aerial photographs been provided? This includes any A1 or AO sized proper survey plans prepared by a registered surveyor that clearly show the location and boundaries of any proposed offsets.	Yes	
Has the SIS determined the subject species by reviewing the suggested list in the CERs, other available information and survey results and assessing which species, populations and ecological communities are to be impacted by the development?	Yes	
Has the survey undertaken provided sufficient information to determine the likely impacts of the proposal on threatened species, populations and ecological communities?	Yes	
Have surveys been undertaken during the appropriate season(s) for the detection of the species that may possibly occur on site?	Yes	
Have surveys been undertaken during appropriate weather conditions?	Yes	
Have climatic conditions preceding the surveys (e.g. drought c.f. wet) affected the possibility of subject species being detected?	No	
Have all specific survey methods, techniques and intensities requested in the CERs been followed completely?	Yes	
Has the documentation of survey effort, locations and techniques provided sufficient information to determine the above?	Yes	
Has the assessment of impacts included the impacts of ALL activities associated with the development, including fire hazard reduction requirements, access road upgrades, downstream and downslope impacts, detention basins, severing of fauna movement corridors, etc.	Yes	
Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species' in the locality is defined in the CERs?	Yes	
Has the SIS discussed the significance of the population/remnant to be affected, relative to others within the locality?	Yes	
Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species in the region (region is defined in the TSC Act).	Yes	
Has the SIS discussed the significance of the population/remnant ta be affected, relative to others within the region?	Yes	
Have alternatives to the proposal been discussed? Alternatives may include relocation of infrastructure or, for example, reducing minimum lot size so that a similar number of lots may be realised whilst retaining a larger conservation lot within a subdivision, or changing mining techniques.	Yes	
Has the discussion of alternatives included assessment of the social and economic (not merely financial) aspects of these alternatives (particularly, of not proceeding)?	Yes	
Has the discussion included an assessment of how the project meets the principles of Ecologically Sustainable Development, as defined in section 6(2) of the Protection of the Environment Administration Act 1991?	Yes	

Matter	Yes/No	Comments
Have all proposals for compensatory actions (e.g. purchase of similar vegetation I habitat or revegetation of habitat, where appropriate) been discussed with the relevant landowners/manager?	Yes	
Is there documented agreement for sale or revegetation activities?	Yes	
Is there agreement to change zoning or enter into a covenant on title in order to secure the conservation of the properties being	Yes	
If translocation is proposed, has the impact of the translocation on the recipient site(s) been assessed?	N/A	
Is there a 'Plan of Management' or similar titled document?	Yes	
Has the SIS utilised relevant information from published draft and final recovery plans? If no plan has been published, but it is known that one is being prepared, has the SIS utilised advice from the NPWS as to the likely contents of that recovery plan (liaison to obtain this advice may have been specified in the CERs)? For example, would the proposal result in the loss of a local population or remnant that a recovery plan describes as being of particular importance to the conservation of the species, population or ecological community?	Yes	
If a BioBanking assessment has been done for the proposal have the following been provided: copies of BioBanking Credit reports, copies of field datasheets, and copies of a checklist that includes all data used in the credit calculator and the underlying assumptions, such as how local vegetation communities were assigned to BioMetric vegetation types?	No	
Has the SIS discussed the relationship of the proposal to any listed Key Threatening Processes (e.g. does the proposal result in the need for High Frequency Fire as a fire hazard reduction measure, or does it result in the Clearing of Native Vegetation)?	Yes	
Has the SIS discussed the relationship of the proposal to any published Threat Abatement Plan (e.g. does the proposal result in an increased threat in a manner that is specifically at odds with a published plan)?	Yes	
Has a revised Part 5A assessment of significance been included?	Yes	
Has the 'Additional Information' specified in section 9 of the CERs been provided?	Yes	
Have the qualifications and experience of those involved in the surveys been included?	Yes	
Have other approvals which are required for the development or activity been documented?	Yes	
Any licensing requirements (e.g. s.91 under TSC Act).	No	

Appendix C

Biodiversity Management Plan

BIODIVERSITY MANAGEMENT PLAN

Kings Hill Conservation Area

PR130430
Kings Hill Biodiversity Management Plan
6
24 July 2020

rpsgroup.com

Document status

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Approval for issue

Mark Aitkens 24 July 2020

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GLOSSARY OF TERMS

Term	Definition
BC Act	*Biodiversity Conservation Act 2016*
BMP	Biodiversity Management Plan
CEEC	Critically endangered ecological community
CERs	Chief Executives Requirements
EEC	Endangered ecological community
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999
LEP	Local Environment Plan
LGA	Local Government Area
Locality	The area within a 5km radius of the Conservation Area
OEH	NSW Office of Environment and Heritage
PCT	Plant community type
Proposal	Proposed development of the subject site
SEE	Statement of Environmental Effects
SIS	Species Impact Statement
Conservation Area	The area owned by KHD as shown in **Figure 1** for biodiversity conservation
TEC	Threatened ecological community
TSC Act	*Threatened Species Conservation Act 1995*
VMP	Vegetation Management Plan

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1 INTRODUCTION

The purpose of this Biodiversity Management Plan (BMP) is to provide a management framework necessary for delivering the amelioration measures specified in Section 7 of the Species Impact Statement (SIS) (RPS 2020a) for impacts incurred on threatened biodiversity by the Concept Development Application for Residential Subdivision and Stage 1 Subdivision Works (the 'Proposal'). The BMP applies to the area referred to as the 'Conservation Area', as shown in **Figure 1**, which is located at 3221 Pacific Highway, Kings Hill (Lot 41 DP1037411 and Lot 4821 DP852073) in the Port Stephens Council Local Government Area (LGA).

The BMP is anticipated to have an operation life of up to 5 years and will end following the successful establishment of enhancement, enrichment and other impact minimisation and mitigation measures described in Section 7 of the SIS (RPS 2020a). Cessation of the BMP is signified by the commencement of an approved in-perpetuity conservation mechanism, hereafter referred to as the 'Agreement'. The Agreement, which is to operate following cessation of this BMP, will specify the ongoing biodiversity management obligations for the Conservation Area through a separate fully funded management action plan bound to that Agreement.

1.1 Need for a BMP

The Proposal, which was developed and designed with detailed consideration for impact avoidance, minimisation and mitigation recommendations specified by EcoBiological (2009), will have the effect of removing and retaining native vegetation and habitat occupied by threatened species and ecological communities. The sensitive approach to the future development of the site incorporates an extensive impact minimisation and mitigation strategy where the purpose is to alleviate impacts on threatened species to an extent that avoids a significant impact outcome (RPS 2020a). This BMP provides the management framework to meet the amelioration package outlined in Section 7 of the SIS (RPS 2020a) and in so doing is expected to meet and exceed the EcoBiological (2009) recommendations for protecting threatened biodiversity.

Retained native vegetation and habitat is to be vested into the Conservation Area for the purposes of protecting high biodiversity values for listed threatened species such as the Koala (*Phascolarctos cinereus*), Brush-tailed Phascogale (*Phascogale tapoatafa*), forest and woodland birds, large forest owls, wetland birds and orchid species. The expected operation life of up to 5 years [the period -2 to +3 years (i.e. end of Phase 1)], as coordinated with development activity, is outlined in **Table 1**. A graphical representation of the Proposal relative to the operation of the BMP is provided in **Chart 1**.

Table 1: BMP Implementation Timetable

Phase	BMP Objective	Time (years)
Phase 0: Pre-construction habitat restoration and enhancement works	• Early implementation of amelioration measures specified in Section 7 of the SIS (RPS 2020a) to fast track future ecological benefit • Collect baseline dataset for monitoring program	-2 to 0
Phase 1: Construction of main east – west road connecting the Pacific Highway interchange with Newline Road plus development areas of reduced biodiversity value adjacent to these roads	• Maintain mitigation measures and initiate monitoring program • Support the successful application for the Agreement	0 to 3
Phase 2: Selective construction of development areas	• Underpin the successful implementation of the Management Action Plan prepared for the Agreement	>3 to 8
Phase 3: Construction of residual approved development areas		>8 +

TITLE : FIGURE 1: THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 1 Conservation Area B A3 20200721.mxd

CLIENT: **PM NO 1 PTY LIMITED**
JOB REF: **PR130430**

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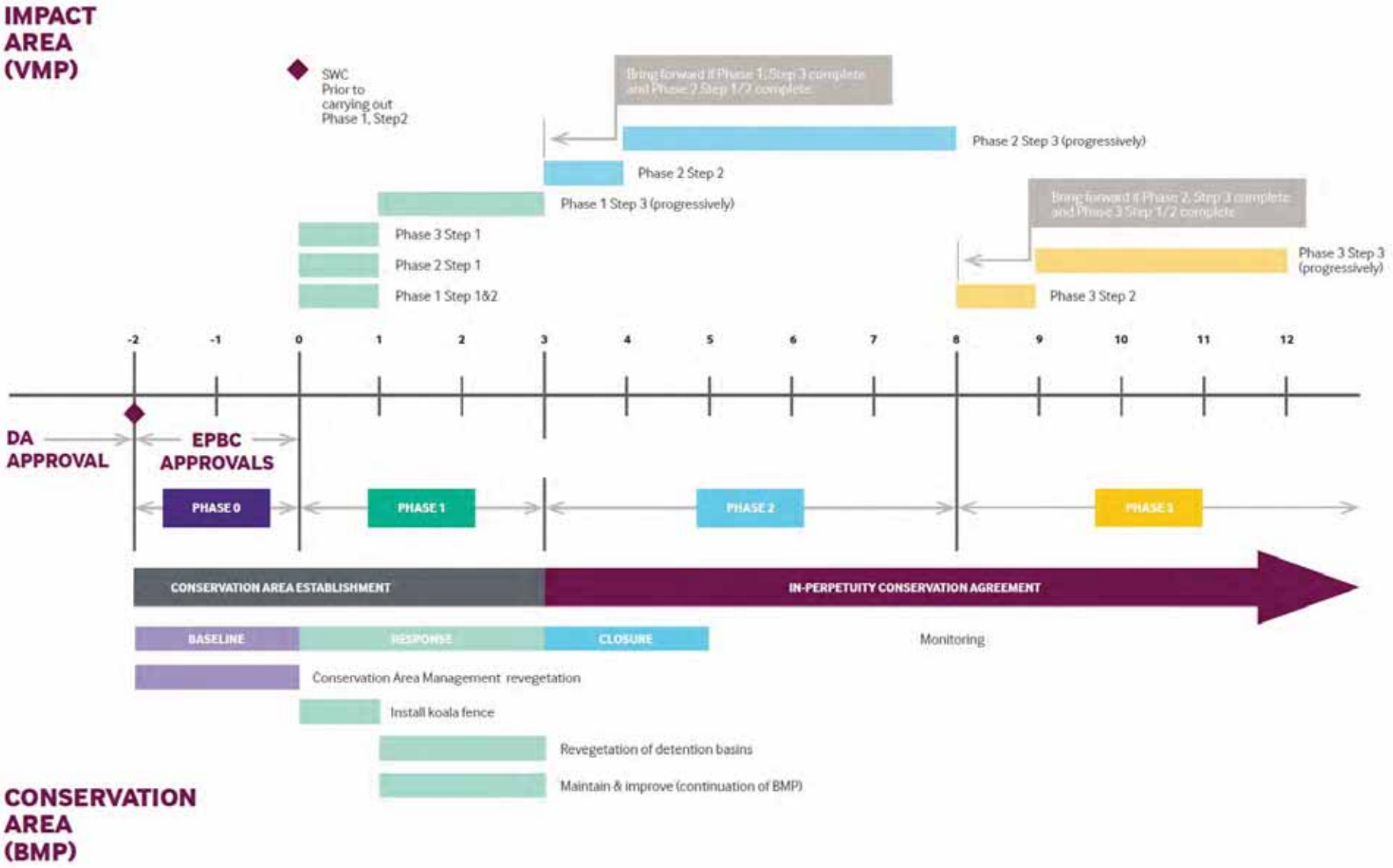
Chart 1: Operation of the BMP relative to the Proposal



1.2 Objectives

The management objectives for the Conservation Area aim to:

- Protect, manage and restore areas of high ecological, scientific, cultural or aesthetic values contained within the Conservation Area.
- Maintain viable local populations of threatened species and ecological communities through the successful implementation of mitigation works recommended in Section 7 of the SIS (RPS 2020a).
- Establish the Conservation Area in preparation for a long term passive management regime orchestrated under a regulator approved Agreement for this area.

Establishment of the Conservation Area aims to produce a management environment requiring only maintenance level interventions over the medium to long term. In this respect, the BMP is to:

- Provide a clear description of management objectives, prescriptions and targets necessary to address matters that adversely impact biodiversity conservation outcomes;
- Provide guidance on the management specifications that may be required to deliver on the BMP objectives;
- Identify and assign responsibilities for ongoing management actions for the implementation period;
- Define the framework for detailing annual management specifications and their delivery;
- Define the framework for the analysis of monitoring data to evaluate the performance of detailed annual management specifications;
- Define an adaptive management framework for managing unforeseen circumstances;
- Outline pre-clearance flora and fauna management protocols for areas impacted by the Proposal; and
- Define the review process for the BMP.

1.3 Roles and Responsibilities

Six key roles responsible for the implementation of this BMP are outlined in **Table 2**.

Table 2: BMP Roles and Responsibilities

Role	Qualification	Responsibility
Project Conservation Manager	• Minimum Diploma or Degree in Natural resource management or related discipline • 10 or more years' experience	• Implementation of BMP • Point of contact
Licensed seed collector	• Licence under the *National Parks and Wildlife Act* 1974 to collect and propagate seed	• Seed collection • Propagation
Project Bushfire Specialist	• FPAA - Building Planning & Design Level 2 Accredited	• Oversee delivery of fuel load maintenance and track establishment and/ or maintenance
Project Forester	• Degree in forest sciences, forest science and management or equivalent; and • Five or more years' experience	• Forest enrichment preparatory works
Project Ecologist	• Tertiary qualifications in ecology; and • 10 or more years' experience	• Forest enrichment • Monitoring • BMP compliance (audit)
Land Holder	• NA	• Implementation of this plan in consultation with suitably experienced and qualified service providers

1.4 Implementation

The primary objective of the BMP is to implement and complete the relevant mitigation measures specified in Section 7 of the SIS (see Section 5), as necessary, for the establishment of a long term maintain or improve local biodiversity outcome. It is proposed to complete these works within a five year period, and prior to the establishment of the Agreement for the Conservation Area, thereby reducing the intensity of future Conservation Area management to a largely maintenance regime.

The BMP is designed to cease operation following an evidence-based evaluation of performance targets against monitoring results that demonstrates completion. The evaluation of performance targets (see **Sections 3.2** and **3.3**) is to be performed annually using data obtained from the monitoring program and associated analysis of results (see **Section 4**). The decision framework used to evaluate the efficacy of the BMP is described in **Section 5** (Adaptive Management), which also allows for the introduction of adjustments, where necessary, to maintain a timely delivery on the BMPs objectives.

In practice, it is expected that the evaluation of plan performance will be conducted annually and reported with the annual monitoring results. This report will also detail an 'Annual Works Program' for Council approval and implementation in the forthcoming 12-month management period (**Section 5.2**). Once it is determined that the BMP has been adequately implemented by achieving its objectives, it is expected that its subsequent operation will cease and be replaced by a separate 'maintenance' focused management regime that will form part of the Agreement.

1.4.1 Consultation

This BMP has been prepared as a prescriptive management document for an annualised implementation as guided by monitoring results and performance assessment. The annual monitoring and performance assessment results are to be issued to Port Stephens Council together with a detailed Annual Works Program for review and approval. Following Council's approval of the Annual Works Program, the Project Conservation Manager will proceed with its implementation as guided by the principles outlined in this plan. This outcome focused process is expected to provide an orderly implementation of management actions that aim to achieve the objectives of the BMP.

1.4.2 Aboriginal Matters of Significance

The implementation of this BMP will acknowledge and be sensitive to area of Aboriginal cultural significance such as the elevated ridgelines and rock outcrops. Activities in line with the BMP are to be done sensitively and with regard to the significance and, where necessary, in consultation with LALC. Recommended BMP works are to consider involving this input to define areas with sensitivity during the planning stages of the works to be carried out through engagement of LALC and the indigenous community in those areas and within the BMP area generally.

1.4.3 Plan Revision

Revisions to the BMP are not expected during its intended ~5 year life as any variations to the prescriptions and methods specified in this plan can be handled through a process outlined in **Section 5.1** ('Adaptive Management') and **Section 5.2** ('Annual Works Program').

Following completion of the BMP, the ongoing management of the Conservation Area operation is likely to be performed in accordance with a funded 'maintenance' focused management plan [e.g. 'Biodiversity Conservation Area Management Plan' (BCAMP)]. Unlike the BMP, the BCAMP will seek to consolidate and maintain the establishment works achieved through the BMP by focusing on the maintenance of weeds, feral fauna and infrastructure within an in-perpetuity management arrangement. The management framework, specifications and costs of the BCAMP would be developed in collaboration with PSC to ensure the lasting protection of biodiversity values contained within the Conservation Area. The BCAMP would be finalised and executed under the VPA, which will 'run with the land' to ensure in-perpetuity conservation outcomes.

1.5 Legislation

Environmental regulation relevant to the preparation of this BMP are listed below:

- Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act);
- NSW *Biodiversity Conservation Act* 2016 (BC Act);
- NSW *Biosecurity Act* 2015;
- NSW *Water Management Act* 2000 (WM Act);
- *Rural Fires Act* 1997 (RF Act);
- State Environmental Planning Policy (SEPP) (Vegetation in Non-Rural Areas) 2017 (Vegetation SEPP);
- State Environmental Planning Policy (SEPP) (Coastal Management) 2018 (Coastal SEPP); and
- Port Stephens Council Comprehensive Koala Plan of Management (PSC CKPoM) (PSC 2002).

The relevance of these statutes is outlined in the following sections.

1.5.1 *Environmental Protection and Biodiversity Conservation Act* 1999

The purpose of the EPBC Act is to ensure that actions likely to cause a significant impact on Matters of National Environmental Significance (MNES) undergo a process of assessment. Under the EPBC Act, an action includes a Proposal, undertaking, development or activity that may impact MNES. An action that 'has, will have or is likely to have a significant impact on a MNES' is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Commonwealth Minister for the Department of the Agriculture, Water and Environment (DAWE). MNES categories listed under the EPBC Act are:

- World heritage properties;
- National heritage places;
- Wetlands of international importance (Ramsar wetlands);
- Threatened species and ecological communities (Section 18 and 18A);
- Migratory species;
- Commonwealth marine areas;
- Nuclear actions (including uranium mining); and
- A water resource, in relation to coal seam gas development and large coal mining development.

The first step in considering MNES protected under the EPBC Act (e.g. Section 18 and 18A) is a self-assessment performed in accordance with the Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (DoE 2013). This is performed to determine if there is likelihood for an action to have a significant impact on MNES. Regulatory approval from the Commonwealth Minister for the Environment is required for actions that have, or are likely to have, a significant impact on MNES.

1.5.2 *Biodiversity Conservation Act* 2016

The BC Act and supporting regulations establish a modern and integrated legislative framework for land management and conservation in NSW. The purpose of the BC Act, with reference to the assessment of development (Part 4 of the EP&A Act) or activities (Part 5 of the EP&A Act), is:

> *(k) to establish a framework to avoid, minimise and offset the impacts of proposed development and land use change on* biodiversity

(l) to establish a scientific method for assessing the likely impacts on biodiversity values of proposed development and land use change, for calculating measures to offset those impacts and for assessing improvements in biodiversity values

(m) to establish market-based conservation mechanisms through which the biodiversity impacts of development and land use change can be offset at landscape and site scales.

1.5.3 *Biosecurity Act* 2015

The NSW *Biosecurity Act* 2015 divides NSW into regions based on combined LGAs and priority weeds for a region. Some weeds are managed at a state level as they form part of a broader containment strategy. The legislation complements listed Weeds of National Significance (WoNS). The Act provides for the identification and classification of listed weeds to identify the duty required for management. The duty assigned to the weed informs land managers and owners of their role and responsibility in managing the weed within the site. Weeds identified as occurring within the site listed as a priority weed within the region, need to be managed according to the duty assigned to the species in NSW WeedWise (NSW DPI 2019).

1.5.4 *Water Management Act* 2000

The objects of the *Water Management Act* 2000 are to provide for the sustainable and integrated management of the water sources for the benefit of both present and future generations and, in particular:

- Ecologically sustainable development;
- Protect, enhance and restore water recourses;
- Recognise and foster social and economic benefits;
- Recognise the role of the community;
- Provide efficient and equitable sharing of water;
- Management of water sources with other aspects of the environment including native vegetation and native fauna;
- Encourage the sharing of responsibility and efficient use of water; and
- Encourage best practice management and use of water.

In NSW, the regulator and policy maker for water resource management is the NSW Department of Industry – Water (DoI Water). The department develops natural resource management policy frameworks, strategies and plans related to water management.

1.5.5 *Rural Fires Act* 1997

Section 63 of the *Rural Fires Act 1997* identifies the duty of the owner or occupier of land to take the notified steps and any other practical steps to prevent the occurrence of bush fires on, and to minimise the danger of the spread of bush fire on or from that land. Notified steps include any directions that the Bush Fire Coordinating Committee (BFCC) advise to take under Section 4 of the *Rural Fire Act 1997*, and include any steps identified in the Bush fire risk management plan for that land.

The development of a Kings Hill Bush fire Management Plan (BMP) consistent with Lower Hunter Bush Fire Risk Management Plan (BFRMP) provides practical steps to conform with s63 to minimise the danger of the spread of bush fire on or from that land.

1.5.6 SEPP (Vegetation in Non-Rural Areas) 2017

A permit or consent is likely required under Part 3 of the SEPP for the clearing of native vegetation on non-rural lands unless matters identified in Clause 8 of the SEPP apply, which are listed below:

8 Clearing that does not require authority under this Policy

(1) An authority to clear vegetation is not required under this Policy if it is clearing of a kind that is authorised under section 60O of the Local Land Services Act 2013 (Clearing authorised under other legislation) or under Part 5B (Private native forestry) of that Act. This subclause does not apply to clearing merely because it is a part of or ancillary to the carrying out of exempt development.

(2) An authority is not required under this Policy for the removal of vegetation that the council or Native Vegetation Panel is satisfied is dying or dead and is not required as the habitat of native animals.

(3) An authority is not required under this Policy for the removal of vegetation that the council is satisfied is a risk to human life or property.

Existing use rights apply to the tracks and tails of the Conservation Area with their ongoing maintenance periodically requiring the clearing of native vegetation. The extent to which this clearing is allowable is defined by the classifications assigned to the tracks/ trails and associated intended uses. For the purposes of the BMP, tracks and trails have adopted the classification scheme provided for in the following guiding documents:

- NSW Planning for Bush Fire Protection 2019 (PFBP 2019);
- The NSW Rural Fire Service Fire Trail Standards - Version 11 (2016); and
- NSW Rural Fire Service Fire Trail Design, Construction and Maintenance Manual developed by the Soil Conservation Service for the NSW Rural Fire Service.

These guiding documents provide specifications for the safe use of bush fire fighting appliances on tracks and trails according to their classification (and intended use). Among the multiple uses intended for these tracks/ trails, the highest priority use is the provision of safe movement paths for bush fire fighting appliances throughout the Conservation Area. To satisfy this requirement, tracks and trails will be maintained to the relevant specifications, with the associated periodic management of vegetation to be performed under cl.8(3) of the Vegetation SEPP.

1.5.7 SEPP (Coastal Management) 2018

The aim of the Coastal SEPP is to promote an integrated and co-ordinated approach to land use planning in the coastal zone in a manner consistent with the objects of the *Coastal Management Act* 2016, including the management objectives for each coastal management area, by:

(a) managing development in the coastal zone and protecting the environmental assets of the coast, and

(b) establishing a framework for land use planning to guide decision-making in the coastal zone, and

(c) mapping the 4 coastal management areas that comprise the NSW coastal zone for the purpose of the definitions in the *Coastal Management Act* 2016.

The Coastal SEPP regulates development in the coastal zone for the purpose of protecting values such as Littoral Rainforest and Coastal Wetlands, inclusive of ‘proximal areas’ as defined by relevant buffers to these features. In this respect, the Conservation Area comprises lands within the coastal zone to which this policy applies.

This BMP has the purpose of restoring and enhancing lands occurring within the coastal zone that are currently degraded from past land use activities through interventions such as weed management, revegetation works and exclusion from human activity.

1.5.8 Port Stephens CKPoM

Section 5.3 of the Port Stephens CKPoM provides performance criteria for development applications. These are listed below:

a. Minimise the removal or degradation of native vegetation within Preferred Koala Habitat or Habitat Buffers;

b. Maximise retention and minimise degradation of native vegetation within Supplementary Koala Habitat and Habitat Linking Areas;

c. Minimise the removal of any individuals of preferred koala food trees (PKFTs), wherever they occur on a development site. In the Port Stephens LGA these tree species are Swamp Mahogany (*Eucalyptus robusta*), Parramatta Red Gum (*Eucalyptus parramattensis*) and Forest Red Gum (*Eucalyptus tereticornis*). An additional list of tree species that may be important to koalas based on anecdotal evidence is included in Appendix 8 of the Port Stephens Council CKPoM (as recommended by the CKPoM Consultative Committee);

d. Make provision, where appropriate, for restoration or rehabilitation of areas identified as Koala Habitat including Habitat Buffers and Habitat Linking Areas over Mainly Cleared Land. In instances where Council approves the removal of koala habitat (in accordance with dot points 1-4 of the above waive clause), and where circumstances permit, this is to include measures which result in a "net gain" of koala habitat on the site and/or adjacent land;

e. Make provision for long term management and protection of koala habitat including both existing and restored habitat;

f. Not compromise the potential for safe movement of koalas across the site. This should include maximising tree retention generally and minimising the likelihood that the proposal would result in the creation of barriers to koala movement, such as would be imposed by certain types of fencing;

g. Be restricted to identified envelopes which contain all buildings and infrastructure and fire fuel reduction zone; and

h. Include measures to effectively minimise the threat posed to koalas by dogs, motor vehicles and swimming pools by adopting minimum standards for these threats.

This BMP has the purpose of facilitating outcomes that align with the majority of these performance criteria through restoration works (e.g. weed control), revegetation using PKFTs, provision of infrastructure to prevent koala movement into the urban area or domesticated dog entry into the Conservation Area and provide functional movement pathways for Koalas to move freely throughout the locality to and from available habitat.

1.6 Relationship with other Management Plans

The Proponent will enter into an integrated management framework involving the implementation of this BMP in association with a Vegetation Management Plan (VMP) (RPS 2020b), with the latter applying to the Proposal footprint and areas of new tracks established within the Conservation Area. The VMP, which is primarily restricted to the Proposal footprint (with the exception of new tracks in the Conservation Area), outlines the management actions required for minimising the effects of native vegetation and habitat loss from within the development area. Objectives stated in the VMP that are relevant to this BMP are listed below:

- Protect threatened species, endangered ecological communities and habitat trees from unauthorised impacts;
- Outline the management framework for minimising impacts on vegetation and habitat within the impact area;
- Specify appropriate measures for the revegetation;
- Identify the appropriate timing of works including site preparation, planting, weed management and also providing a schedule of works;
- Identify and assign responsibilities for ongoing management actions over an 8+ year period; and

- Ensure that the project is planned, designed and implemented by informed experienced contractors in order to avoid harm to the quality, stability and natural functions of remnant bushland and riparian areas.

This BMP provides guidance on the performing of pre-clearance flora and fauna management protocols, which have the purpose of minimising impacts on biodiversity located within the development area of the Proposal. Preparatory works designed to accommodate the relocation of any fauna removed from the areas to be cleared are also detailed (e.g. nest box installations).

In accordance with Part 3 Division 4 of the *Rural Fires Act* 1997 a Bush Fire Risk Management Plan (BFRMP) has been developed by the Lower Hunter Bush Fire Management Committee (BFMC) which was endorsed in March 2009. In exercising the functions under the *Rural Fires Act* 1997, including the preparation of a BFRMP, the Lower Hunter BFMC is required to have regard to the principles of ecologically sustainable development (ESD) and covers both public and private lands. Any fire management plans should have the objective of being consistent with the BFRMP.

2 EXISTING ENVIRONMENT

2.1 Overview

A summary of the existing environment, as detailed within the SIS (RPS 2020a), is provided in the following sections and has been used as the basis for the preparation of management precincts, actions and prescriptions for the Conservation Area. Project documentation was reviewed in conjunction with a detailed site investigation. The documentation listed below has been used to evaluate the key biodiversity values:

- Kings Hill Development Species Impact Statement (RPS 2020a); and
- Kings Hill Vegetation Management Plan (RPS 2020b).

Supplementary information was obtained from a site investigation performed on 13 May 2019 to:

- Map existing tracks for use in the implementation of the BMP;
- Validate and characterise areas of high weed infestation;
- Refine management areas most suitable for habitat enrichment for the koala;
- Perform condition analysis of vegetation associated with creeks and/or other water bodies; and
- Identify any areas of erosion, rubbish dumping and/or degradation to be rehabilitated.

2.2 Previous land uses and events

Notable disturbances evident within the Conservation Area and more broadly operating in the local area include:

- Historical land clearing and logging;
- Track constructions within native vegetation;
- Construction of turkey nest and inline dams;
- Past and current livestock grazing; and
- Firewood collection.

The extent and influence of these disturbances varies across the Conservation Area and is largely determined by access (i.e. changes in terrain). Steeper, rockier lands have no discernible evidence of past/ current livestock grazing as the suitability and access to these areas is poor. Similarly, there is limited evidence of feral deer grazing in these areas owing to the ground conditions (i.e. lands generally less suitable for this species). These areas do exhibit signs of past selective logging (i.e. tree stumps) and associated high weed cover. The extent of weed cover in these areas is likely attributed to the combined influence of past selective logging and absence of livestock/ feral deer grazing that would otherwise inhibit weed growth/ spread.

The more arable forested parts of the KHD owned lands typically coincides with the subject site footprint and is comparatively grassier with lower weed densities. Past logging is also evident in these areas as is firewood collection. The presence of turkey nest and inline dams is likely associated with more extensive historical livestock grazing practices, with the majority of livestock grazing now restricted to the predominantly treeless and lightly wooded parts of the eastern and western parts of the KHD lands. Feral deer activity is relatively high in these parts of the Conservation Area, with the associated herbivory of this species likely to be influencing understorey structure (i.e. simplified shrub and grassier groundcover stratum).

2.3 Fire History

The fire history of the study area is unknown prior to 2012 (RFS 2019). A small isolated fire event was recorded in the north-western part of the study area in July 2016 (RFS 2019). No wildfire or hazard reduction

burns have been recorded within the subject site since 2012. Further, field surveys indicate there is no evidence of any recent fire events (e.g. last 15 years). Indications are that the study area comprises vegetation with minimal influence from recent fire activity.

2.4 Flora

2.4.1 Plant Community Types

Seven native plant community types (PCTs) are mapped as occurring within the Conservation Area (RPS 2020a) and are listed in **Table 3**. Threatened ecological communities (TEC) are also detailed within **Table 3**. The spatial extent of each PCT is shown in **Figure 2**.

Table 3: PCTs occurring within the Conservation Area

PCT	PCT Name	Area (ha)
783	Coastal freshwater swamps of the Sydney Basin Bioregion[1]	9.21
1230	Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	0.15
1525	Sandpaper Fig - Whalebone Tree warm temperate rainforest[2]	2.42
1584	White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	101.51
1590	Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	111.36
1600	Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter[3]	1.05
1728	Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast	5.49
Total		**231.19**

2.4.2 Threatened Flora

Three threatened flora species are known to occur within the Conservation Area as outlined in **Table 4**, which also provides estimates of the number of individuals from direct counts and habitat area mapping using a 30 m buffer from recorded individuals.

Table 4: Threatened Flora within the Conservation Area

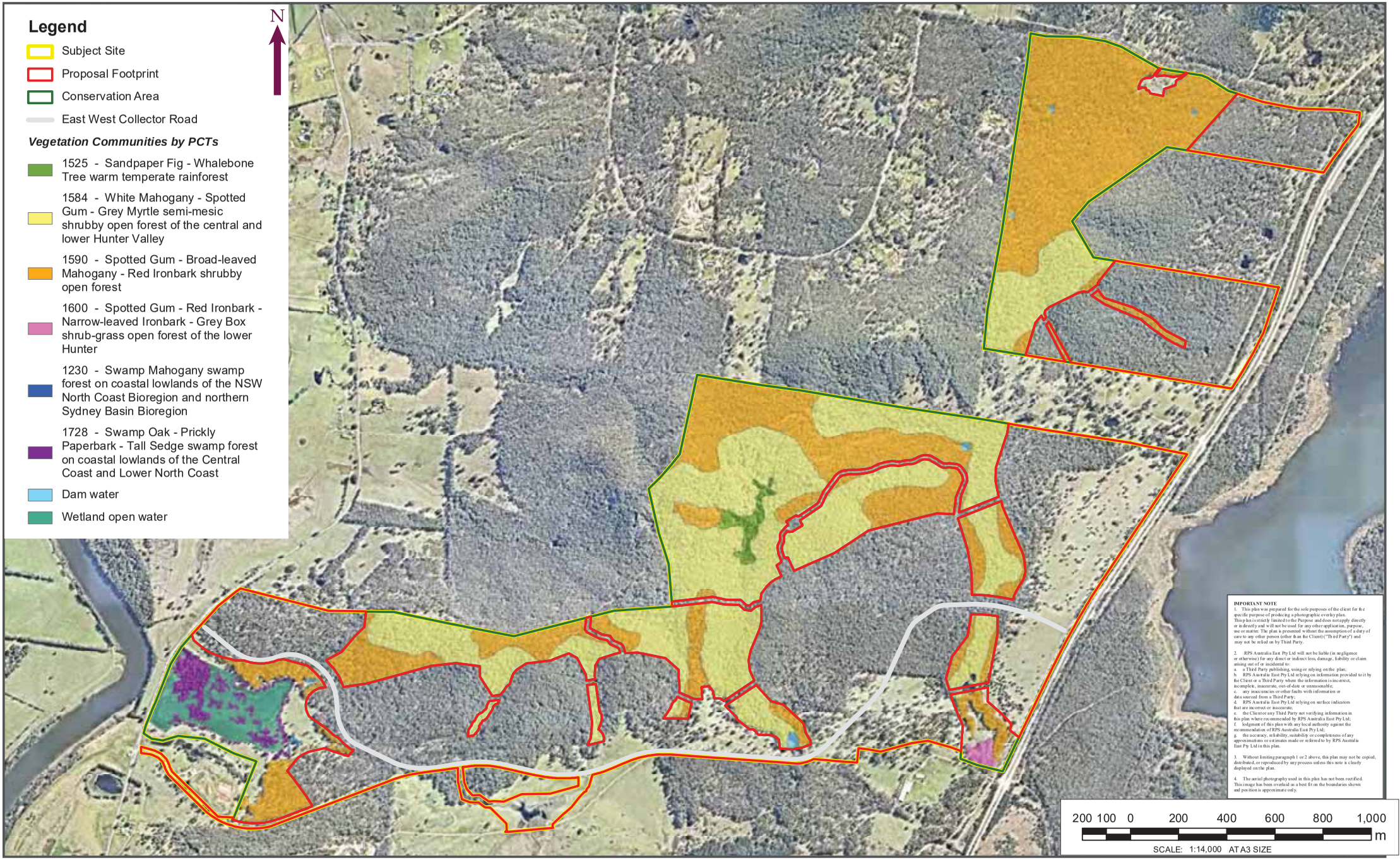
Species	BC Act	Abundance and Habitat	
		Count	Habitat Area (ha)
Maundia triglochinoides	Vulnerable	42	0.48
Pterostylis chaetophora	Vulnerable	468	3.72
Corybas dowlingii	Endangered	1,467	8.62

The location of threatened flora species within the Conservation Area is shown in **Figure 3**. A general description of each species habitat and ecology is provided in the following sections.

[1] Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC

[2] Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions VEC

[3] Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin and North Coast Bioregions EEC



TITLE : FIGURE 2: PCTS WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 2 PCTs within the Conservation Area B A3 20200721.mxd

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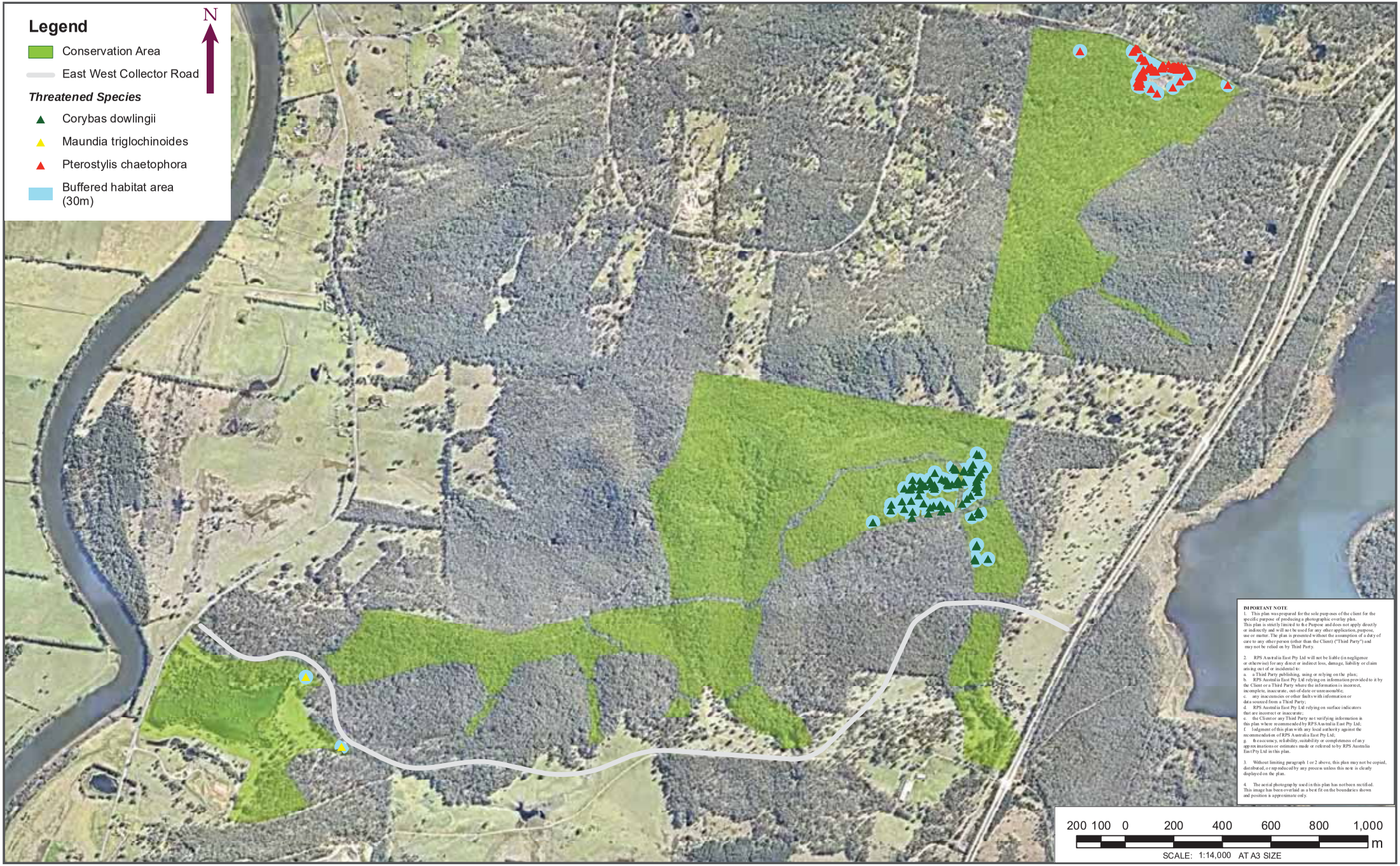

TITLE : FIGURE 3: THREATENED FLORA WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 3 Threatened flora within the Conservation Area B A3 20200721.mxd

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2.4.2.1 *Maundia triglochinoides*

Harden (1993) describes *Maundia triglochinoides* as a wetland species that "grows in swamps or shallow freshwater in heavy clay; north from southern Sydney". According to the Threatened Species Profile Database (BCD 2019), the ecology and habitat of *Maundia triglochinoides* is as follows:

- Grows in swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients;
- Flowering occurs during warmer months;
- Associated with wetland species (e.g. *Triglochin procerum*);
- Probably wind pollinated;
- Diaspore is the seed and root tubers, which are probably dispersed by water;
- Spreads vegetatively, with tufts of leaves arising along rhizome. Populations expand following flood events and contract to more permanent wetlands in times of low rainfall; and
- Flowers November-January.

According to the NSW Scientific Committee (2001), the habitats in which *Maundia triglochinoides* grows is vulnerable to filling, changes in hydrology, water quality and weed invasion. Locally, it appears that the growth of Alligator Weed (*Alternanthera philoxeroides*) in combination with livestock grazing (i.e. highly palatable species) has substantially impacted the numbers of individuals observed within the Conservation Area. Recent observations indicate the species is now restricted to the southern location shown in **Figure 3**, with it now being absent (temporarily) from the northern recorded occurrence.

2.4.2.1.1 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Maintaining habitat integrity through prevention of weed invasion and dominance;
- Prevention of herbivory by livestock and feral deer; and
- Managing micro habitat requirements through the maintenance of water occurrence and depth.

2.4.2.2 *Pterostylis chaetophora*

Pterostylis chaetophora belongs to a clade of greenhoods commonly referred to as Rustyhoods or *Oligochaetochilus*. According to the Threatened Species Profile Database (BCD 2019), the ecology and habitat of *Pterostylis chaetophora* is as follows:

- Prefers seasonally moist, dry sclerophyll forest with a grass and shrub understorey.
- Flowers from September to November. Vegetative reproduction is not common in this group of Greenhoods, but some species may form more than one dropper annually. Fails to flower in dry seasons.
- Plants are deciduous and die back to the large, underground tubers after seed release. New rosettes are produced following soaking autumn and winter rains.

The species occurs in two conservation reserves being Columbey National Park and Wingen Maid Nature Reserve. Observations from local occurrences at Columbey National Park, Wallaroo State Forest, Grahamstown West and the Conservation Area provide additional context for defining the habitat preferences for this species, these being:

- A species rich mix of tree species with open forest structure and canopy gaps. Species include Grey Box (*Eucalyptus moluccana*), Ironbarks [mostly Broad-leaved Ironbark (*Eucalyptus fibrosa*)], Forest Redgum (*Eucalyptus tereticornis*) and Spotted Gum (*Corymbia maculata*) with the latter species never being dominant.

- The proximal incidence of *Melaleuca nodosa*. The presence of this species, which is likely linked to imperfectly drained soils, could represent favourable soil conditions reflective of locally retaining elevated soil moisture levels after sufficient autumn – winter rainfall events. This habitat preference may be important in the perennial survival of orchid tubers and also serve to activate flowering events.

This greenhood group comprises members adapted to semi-arid to arid conditions, with continental distributions reflective of these characteristics (i.e. largely inland distribution). Key adaptations of this group include:

- Multiple flowers per raceme for increased seed production (i.e. ~ 3,500 seeds per fertilised flower);
- Flower height (i.e. elevated position to maximise dispersal potential);
- Flowering time (i.e. typically in spring where the production of dehisced seed coincides with increased windiness to aid dispersal potential); and
- Longer lived seed to survive the drier hotter summer months (~ 1 year versus ~ 0.5 years for non rustyhoods).

The germination and later survival of *Pterostylis chaetophora* is solely dependent on its relationship with the symbiotic fungus *Ceratobasidium cornigerum* (Dr Mark Clements pers. coms. 2019); this being consistent with findings from earlier mycorrhizal – *Pterostylis* studies (Warcup 1981). Without this fungus, *Pterostylis chaetophora* is unable to germinate then reproduce.

2.4.2.2.1 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Maintaining patch integrity through management of edge effects (e.g. weed invasion and dominance); and
- Managing micro habitat requirements through the maintenance of bare earth patches.

2.4.2.3 *Corybas* x *dowlingii*

The habitat of *Corybas* x *dowlingii*, a stable hybrid between *C. barbarae* and *C. aconitiflorus* (Wagner et al 2020), is described in the NSW Scientific Committee (2007) final determination as “typically grows in gullies in tall open forest on well-drained gravelly soil at elevations of 10-200m”. It forms clonal colonies, an aspect of its ecology that has allowed for the successful translocation of this species at Bulahdelah in response to an impact from the construction of the Pacific Highway bypass at that location.

The final determination (NSW Scientific Committee 2007) identifies three populations of *C.* x *dowlingii*. The Bulahdelah population of *C.* x *dowlingii* includes approximately 3,400 plants, while the Port Stephens populations include approximately 15,000 plants. The size of the Freemans Waterhole population is unknown. In relation to the latter, a recent study for 1,000 ha of native vegetation near Freemans Waterhole in the Awaba – Eraring locality resulted in the detection of an estimated 325,000 individuals of *C.* x *dowlingii* at 2,132 locations (i.e. mean ~152 plants/ location) (RPS 2020 *in prep*.). This is in addition to numerous finds of this species in the Mandalong valley (RPS 2014).

While not noted to occur in the conservation reserve network (NSW Scientific Committee 2007), *C.* x *dowlingii* Bell (2009) has recorded it within Columbey National Park with a portion of the above-mentioned Awaba – Eraring population occurring within the Lake Macquarie City Council administered BioBank site.

2.4.2.3.1 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Maintaining patch integrity through management of edge effects (e.g. weed invasion and dominance); and
- Managing fire intervals.

2.4.3 Exotic Flora Species

2.4.3.1 Species with Regulatory Management Specifications

Exotic flora requiring management occur within the Conservation Area are listed in **Table 5** along with their Biosecurity Duty as specified in the Hunter Regional Strategic Weed Management Plan 2017-2022 (Hunter Local Land Services 2017).

Table 5: Exotic flora requiring management within the Conservation Area

Exotic Species	Classification	Biosecurity Duty (Hunter Local Land Services 2017)
Lantana (*Lantana camara*)	Weed of National Significance (WoNS) *Biosecurity Act* 2015	Weed of community concern for agricultural and environmental outcomes All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Alligator Weed (*Alternanthera philoxeroides*)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective - CONTAINMENT An owner or occupier of land in the Alligator weed biosecurity zone on which there is the weed *Alternanthera philoxeroides* (Alligator Weed) must: a) if the weed is part of a new infestation of the weed on the land, notify the local control authority for the land as soon as practicable in accordance with Part 6, and b) eradicate the weed or if that is not practicable destroy as much of the weed as is practicable and suppress the spread of any remaining weed.
Water Hyacinth (*Eichhornia crassipes*)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective - CONTAINMENT An owner or occupier of land in the Water Hyacinth biosecurity zone on which there is the weed *Eichhornia crassipes* (Water Hyacinth) must: a) if the weed is part of a new infestation of the weed on the land, notify the local control authority for the land as soon as practicable in accordance with Part 6, and b) eradicate the weed or if that is not practicable destroy as much of the weed as is practicable and suppress the spread of any remaining weed.
Blackberry (*Rubus fruticosus species aggregate*)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective – ASSET PROTECTION
Asparagus (*Asparagus* spp.)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective – ASSET PROTECTION
Fireweed (*Senecio madagascariensis*)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective – ASSET PROTECTION
African Olive (*Olea europaea* subsp. *cuspidata*)	*Biosecurity Act* 2015	Regional Priority Weed Objective – ASSET PROTECTION

The Regional Strategic Response for Alligator Weed and Water Hyacinth is:

- Detailed surveillance and mapping to locate all infestations.
- High level pathways analysis to identify potential introduction areas and preventative options.
- Implement quarantine and/or hygiene protocols.
- Monitor progress towards eradication.

Known point locations for Alligator Weed and Water Hyacinth is shown in **Figure 4**.

TITLE : FIGURE 4: LOCATION OF ALLIGATOR WEED AND WATER HYACINTH WITHIN THE CONSERVATON AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 4 Aligator Weed B A3 20200721.mxd

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Mapping showing the occurrence and estimated pre-management per cent cover for Lantana, Blackberry and *Asparagus* spp. is provided in **Figures 5**, **6** and **7**. The Regional Strategic Response for these species is:

- Develop region-wide coordinated campaigns for collaborative management
- Identification of regional containment zones where required
- Identification of key sites/assets in the geographic area
- Species managed in accordance with published weed management plan

Mapping showing the occurrence and estimated pre-management per cent cover for African Olive is provided in **Figure 8**. The Regional Strategic Response for African Olive is:

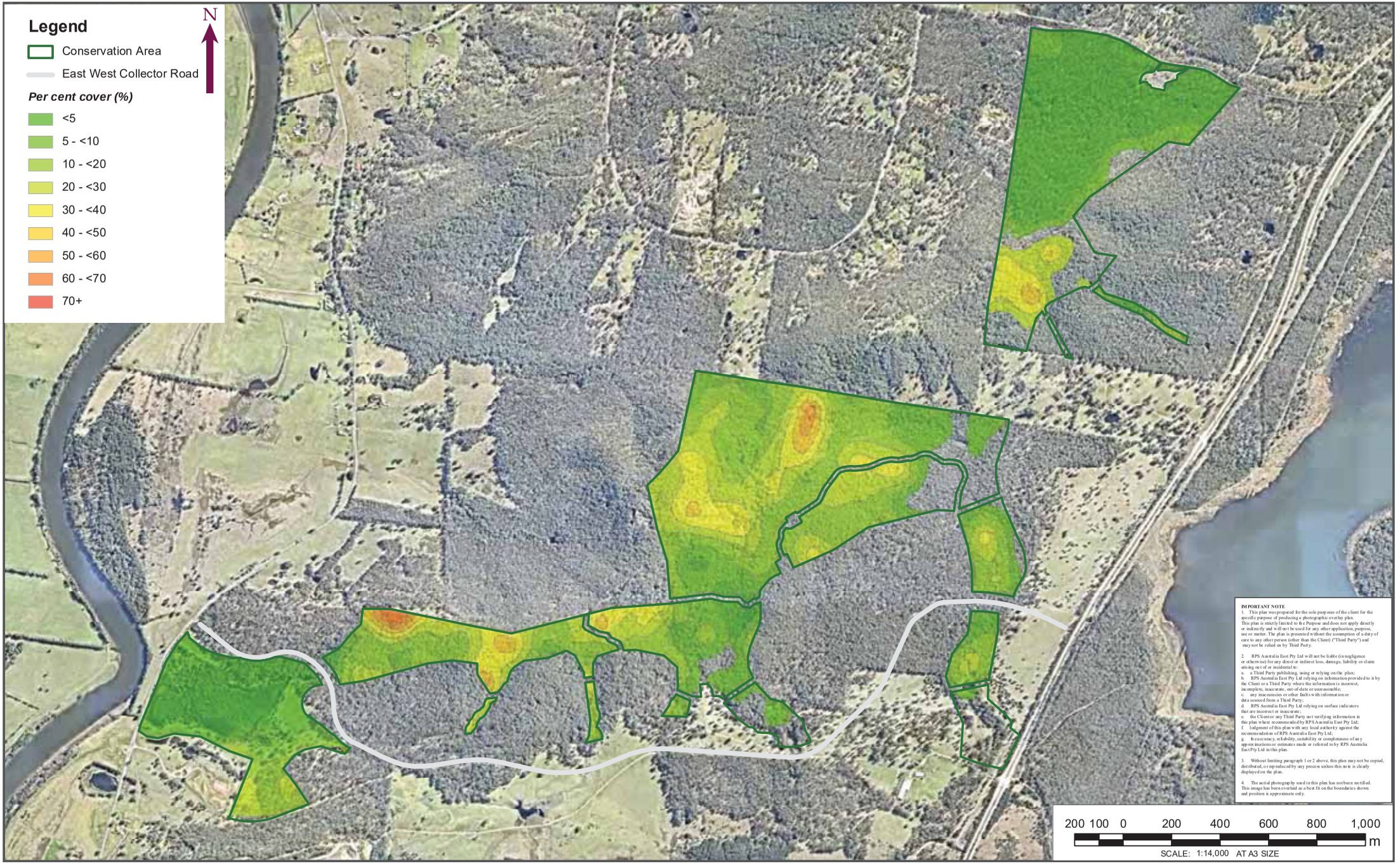
- Establish agreed quarantine and/or hygiene protocols.
- Surveillance and mapping to locate all infested properties.
- Monitor change in current distribution to ensure containment of spread.
- High level analysis of pathways to identify potential introduction areas and preventative options.
- Identification of key sites/assets in the geographic area
- Develop region-wide coordinated campaigns for collaborative management.
- Species managed in accordance with published weed management plans.

2.4.3.2 Species for Management Consideration

Other notable exotic species recorded within the Conservation Area that are deserving of management focus are listed below:

- Carpet Grass (*Axonopus fissifolia*);
- Spear Thistle (*Cirsium vulgare*);
- Whiskey Grass (*Andropogon virginicus*);
- Wild Tobacco (*Solanum mauritianum*);
- Large-leaved Privet (*Ligustrum lucidum*);
- Small-leaved Privet (*Ligustrum sinense*);
- Crofton Weed (*Ageratina adenophora*);
- Cotton Bush (*Gomphocarpus fruticosus*);
- Camphor Laurel (*Cinnamomum camphora*); and
- Mickey Mouse Plant (*Ochna serrulata*).

Where identified, these species should be supressed and/ or eradicated to prevent further invasion or erosion of the biodiversity values within the Conservation Area. Mapped locations for Crofton Weed, Wild Tobacco and Large-leaved Privet is shown in **Figure 9**.



TITLE : FIGURE 5: LANTANA PERCENT FOLIAGE COVER WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 5 Lantana Percent Foliage Cover within the CA B A3 20200721.mxd

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TITLE : FIGURE 6: BLACKBERRY PERCENT FOLIAGE COVER WITHIN CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 6 Blackberry Percent Foliage Cover within SS B A3 20200721.mxd

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TITLE : FIGURE 7: LOCATIONS OF ASPARAGUS WITHIN CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 7 Locations of Asparagus within within CA B A3 20200721.mxd

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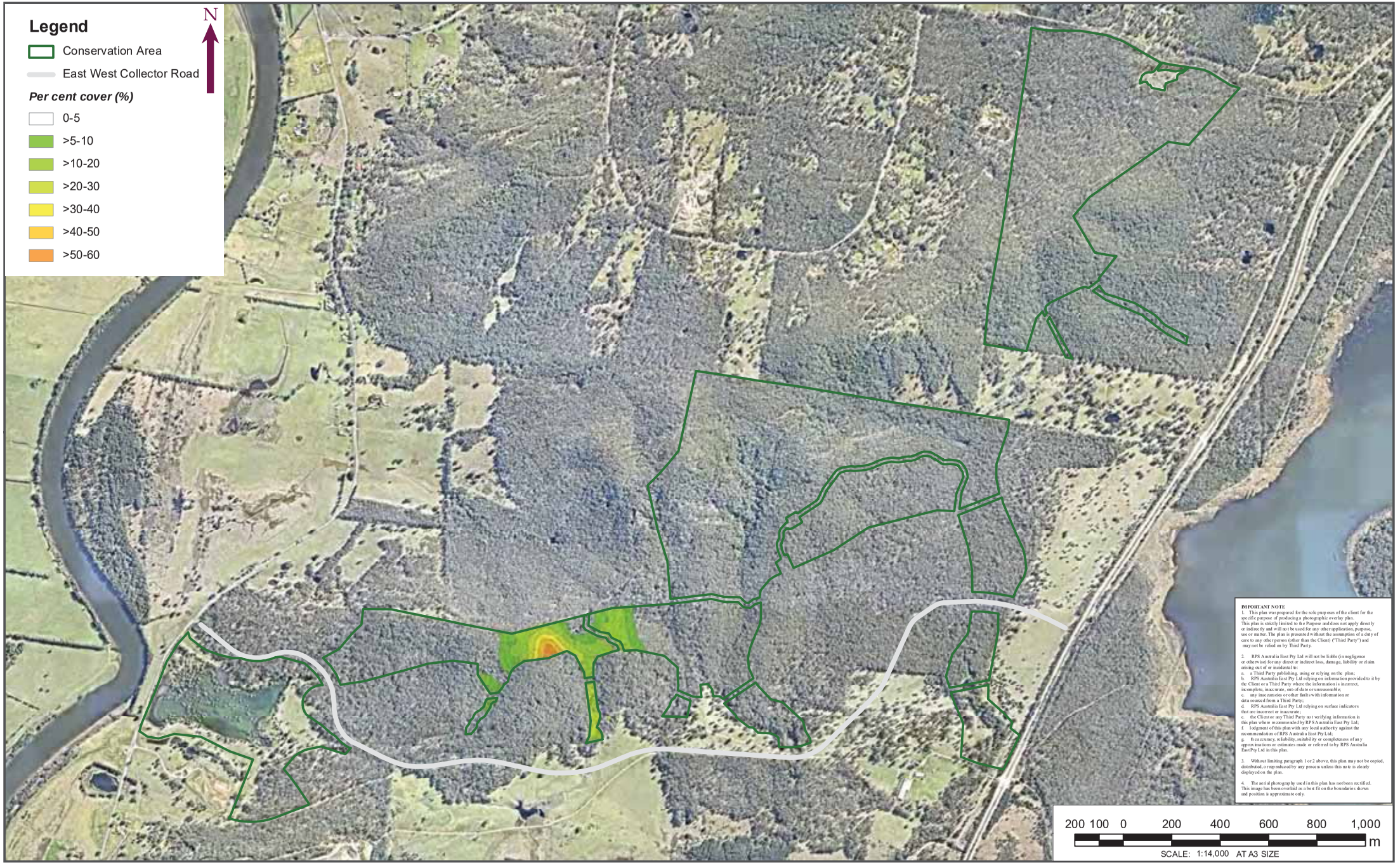

TITLE : FIGURE 8: AFRICAN OLIVE PERCENT FOLIAGE COVER WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 8 African Olive Percent Foliage Cover within the CA b A3 20200721.mxd

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TITLE : FIGURE 9: EXOTIC FLORA OF MANAGEMENT CONSIDERATION WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 9 Exotic Flora of Management Consideration within the CA B A3 20200721.mxd

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2.5 Fauna

2.5.1 Habitat

Fauna of the Conservation Area can be broadly characterised by those occupying habitats described as dry sclerophyll and mesic forests on various geomorphic surfaces (e.g. soils, aspect, slope) dissected by 1st to 3rd order streams and some floodplain environs. The catchment mostly comprises ephemeral 1st and 2nd order streams on moderately steep grades that exhibit short duration flows following effective rainfall events. These flows ultimately drain into wetlands located on the coastal floodplain in the south and west. Few instances of naturally prolonged water accumulations occur within these drainages outside the floodplain environment.

In some drainages, these flows are intercepted by constructed online water detention structures built for the purposes of watering livestock. Also, there are scattered turkey nest dams throughout the Conservation Area acting as additional offline watering points.

The hydrogeomorphology of a third order stream in the east of the Conservation Area is characterised by small semipermanent pools interconnected by dry elongated clayey riffle zones with no gravel substrate. Flows in this stream are rainfall dependant and are generally stagnant outside rainfall events.

Rocky ground is commonly seen on elevated lands, which on mid to lower slopes breaks to clayey soils. A heterogenous distribution of fallen logs and hollow-bearing trees was observed; these representing habitat features with positive influence on bird, mammal and reptile species diversity.

2.5.1.1 Hollow-bearing Trees

The distribution of hollow-bearing trees across the Conservation Area is not even and varies in accordance with historical land use. Relatively inaccessible lands generally comprise higher densities of hollow-bearing trees, as these forests were more difficult to clear or log.

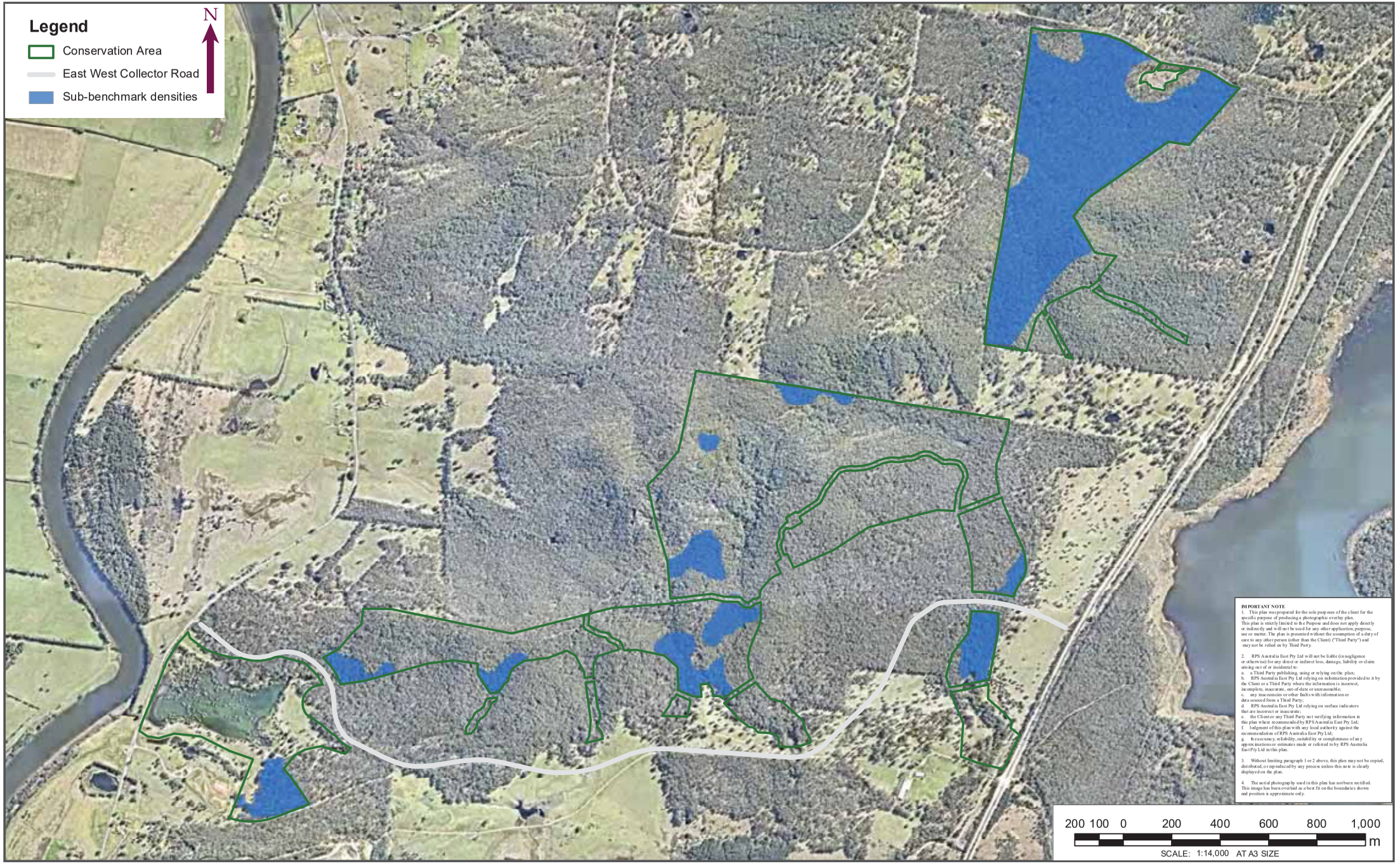
The predicted hollow-bearing tree deficit for the Conservation Area was constructed from a comparison of the modelled distribution (RPS 2020a) and a benchmark state of 10 hollow-bearing trees/ ha. The predicted deficit is shown in **Figure 10** and is to be used for the targeted application of enhancement works.

2.5.1.2 Fallen Logs

The predicted fallen log length deficit for the Conservation Area was constructed from a comparison of the modelled distribution (RPS 2020a) and a benchmark state of 45 m/ ha or greater for PCT 1590 and 70 m/ ha for PCT 1584. The predicted deficit is shown in **Figure 11** and is to be used for the targeted application of enhancement works.

2.5.2 Connectivity

Habitat connectivity throughout the Conservation Area provides continuous links through the landscape to the north, south and tentatively to the east beyond the immediately adjacent Pacific Highway. The Hunter River to the west creates discontinuity to habitats on the western side of the river. High canopy connectivity habitats are prevalent throughout the site, providing strong habitat resources for a range of arboreal fauna species. Important movement pathways identified in the Conservation Area are shown in **Figure 12**.



TITLE : FIGURE 10: SUB-BENCHMARK DISTRIBUTION OF HOLLOW-BEARING TREES

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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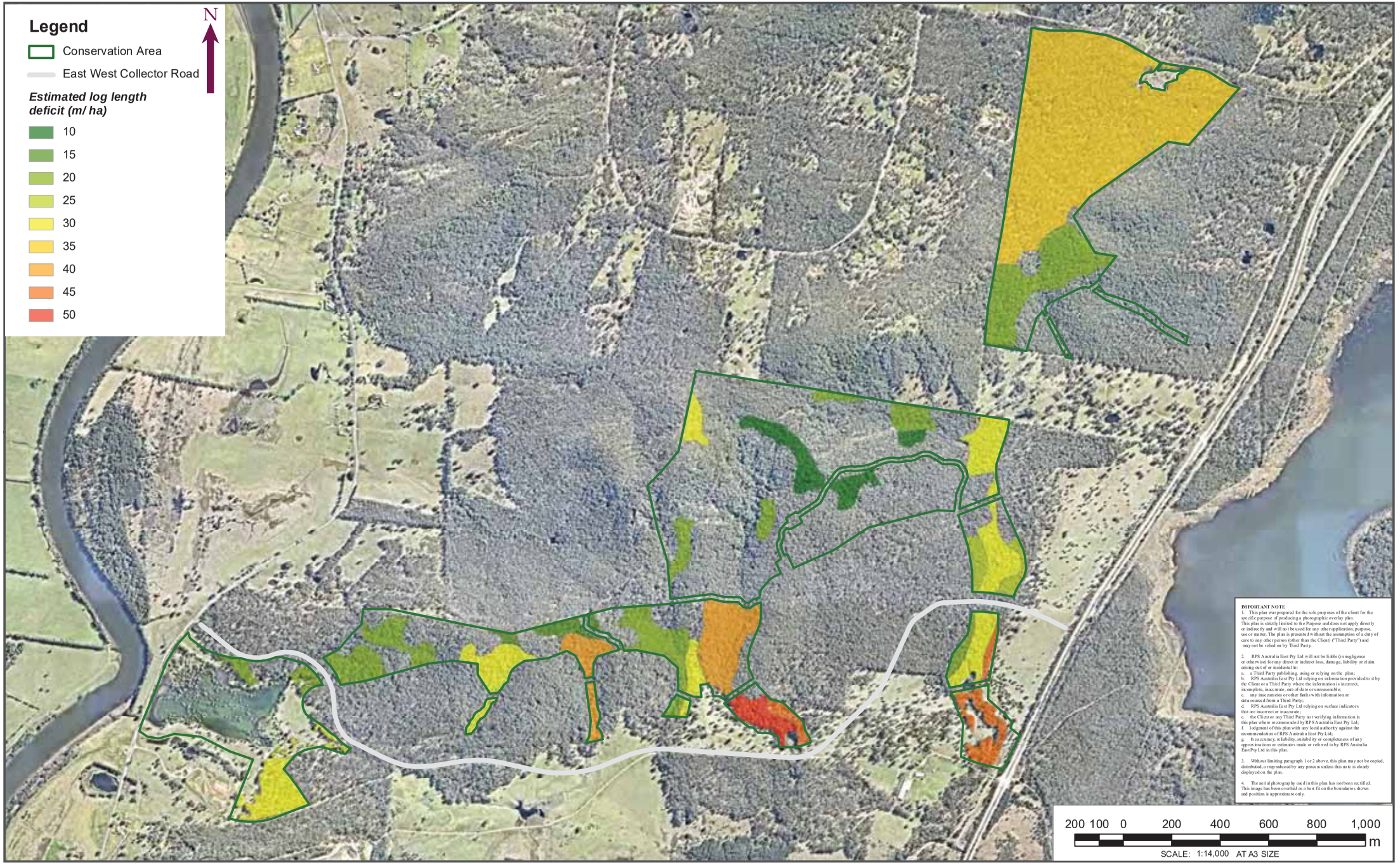

TITLE : FIGURE 11: MODELLED FALLEN LOG LENGTH DEFICIT WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 11 Fallenlogs_deficit B A3 20200721.mxd

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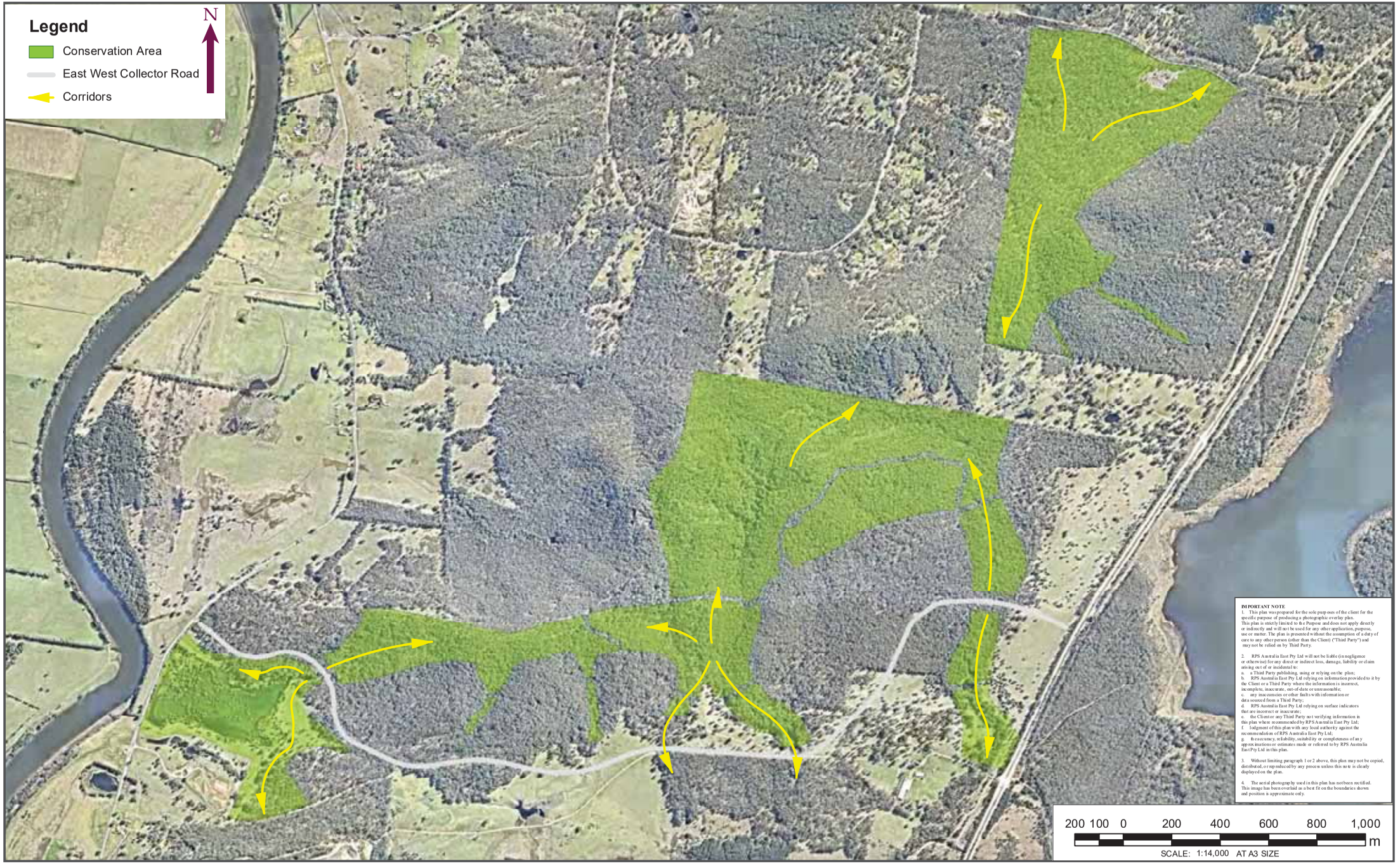

TITLE : FIGURE 12: WILDLIFE MOVEMENT PATHS WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 2020072 1\130430 Figure 12 Wildlife Movement Paths within the Conservation Area B A3 20200721.mxd

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2.5.3 Threatened Fauna Species

Eighteen threatened fauna species have been recorded within the Conservation Area with recorded locations shown in **Figure 13**. By habitat type, species observations are as follows:

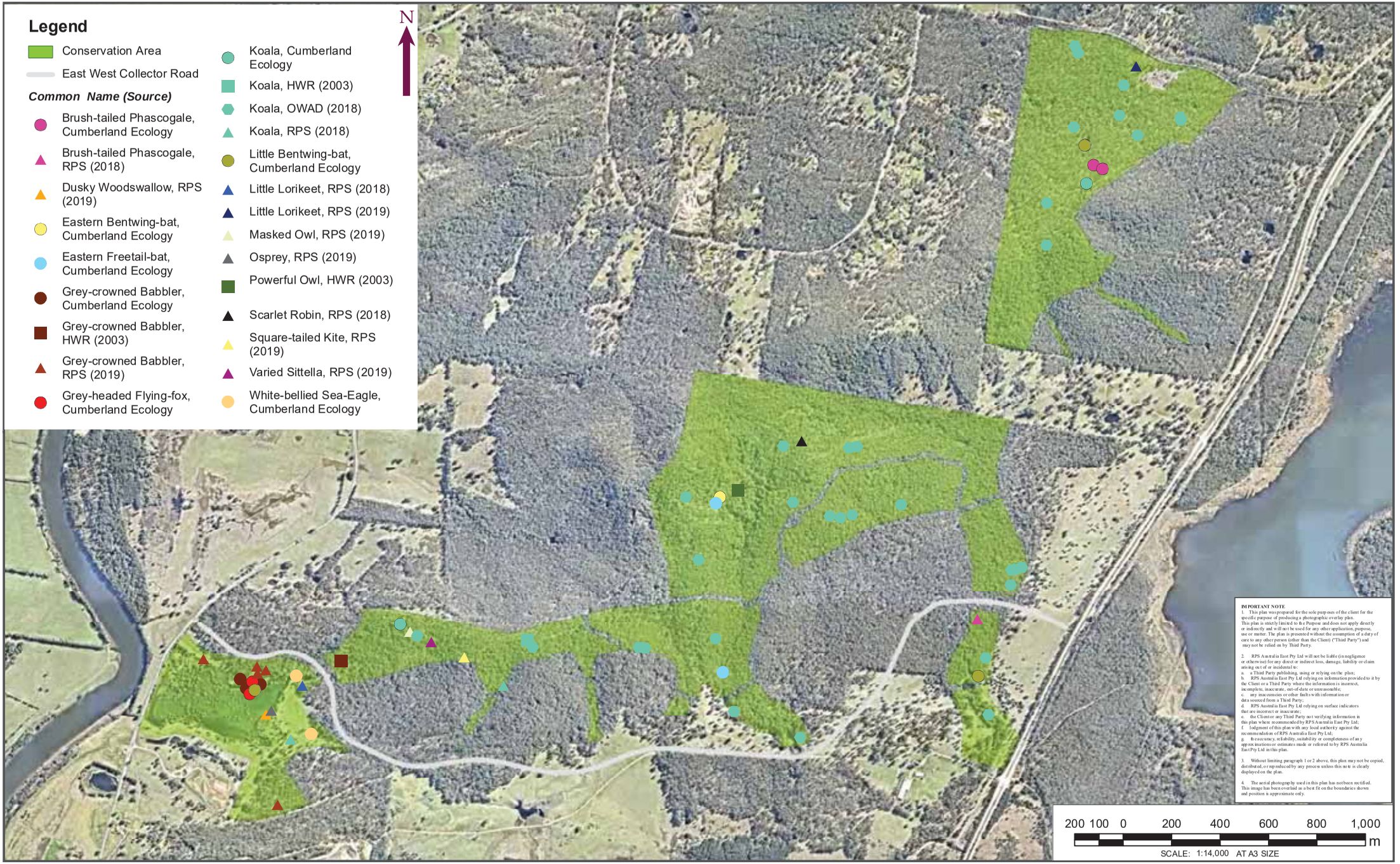
Wetland area (PCTs 783, 1230, 1728)

- White-bellied Sea Eagle (*Haliaeetus leucogaster*) (vulnerable under the BC Act);
- Grey-crowned Babbler (*Pomatostomus temporalis*) (vulnerable under the BC Act);
- Dusky Woodswallow (*Artamus cyanopterus*) (vulnerable under the BC Act); and
- Black-necked Stork (*Ephippiorhynchus asiaticus*) (endangered under the BC Act).

Sclerophyll Forest (PCTs 1584 and/ or 1590)

- Grey-crowned Babbler (vulnerable under the BC Act);
- Glossy-black Cockatoo (*Calyptorhynchus lathami*) (vulnerable under the BC Act);
- Scarlet Robin (*Petroica boodang*) (vulnerable under the BC Act);
- Brown Treecreeper subspecies (*Climacteris picumnus victoriae*) (vulnerable under the BC Act);
- Varied Sittella (*Daphoenositta chrysoptera*) (vulnerable under the BC Act);
- Little Lorikeet (*Glossopsitta pusilla*) (vulnerable under the BC Act);
- Powerful Owl (*Ninox strenua*) (vulnerable under the BC Act);
- Masked Owl (*Tyto novaehollandiae*) (vulnerable under the BC Act);
- Squirrel Glider (*Petaurus norfolcensis*) (vulnerable under the BC Act);
- Brush-tailed Phascogale (*Phascogale tapoatafa*) (vulnerable under the BC Act);
- Koala (*Phascolarctos cinereus*) (vulnerable under the BC Act and EPBC Act);
- Eastern Freetail Bat (*Mormopterus norfolkensis*) (vulnerable under the BC Act);
- Grey-headed Flying-fox (*Pteropus poliocephalus*) (vulnerable under the BC Act and EPBC Act);
- Little Bentwing Bat (*Miniopterus australis*) (vulnerable under the BC Act); and
- Eastern Bentwing Bat (*Miniopterus schreibersii oceanensis*) (vulnerable under the BC Act).

A more detailed analysis for the White-bellied Sea Eagle, Grey-crowned Babbler, Black-necked Stork, large forest owls (Powerful and Masked Owl), Squirrel Glider, Brush-tailed Phascogale, Koala and Grey-headed Flying Fox is provided in the following sections to assist with the scoping of management actions and specifications provided in this BMP.



TITLE : FIGURE 13: THREATENED FAUNA OF THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 13 Threatened Fauna of the Conservation Area B A3 20200721.mxd

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2.5.3.1 White-bellied Sea Eagle

2.5.3.1.1 Lifecycle

The White-bellied Sea-eagle reaches sexual maturity at approximately 6 years old (Marchant and Higgins 993; DoE 2015). The juvenile birds have a high mortality rate; however, they can live up to 30 years (Parks and Wildlife Service Tasmania 2006; as cited by, DoE 2015). White-bellied Sea-eagles breed in single monogamous pairs and only raise one clutch of 1-2 rarely 3 per year. Although a second clutch may be laid in the same nest or in a nearby nest if a nest fails early in incubation (Marchant and Higgins 1993; NSW Scientific Committee 2016). The breeding period is typically from June to January (NSW Scientific Committee 2016), however, it varies by a month or two between Northern and Southern Australia with commencement earlier in the north and cessation later in the south (DoE 2015). Eggs are mostly laid in June to September and young birds remain in the nest for 65–70 days (Marchant and Higgins 1993). After fledging, young birds are fed by the parents for up to three months after fledging the nest before being driven out of the breeding territory at approximately four months later (DoE 2015).

2.5.3.1.2 Habitat

The White-bellied Sea Eagle is found in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands (DoE, 2017a). It occupies habitat characterised by the presence of large areas of open water (larger rivers, swamps, lakes, the sea) and have been recorded in (or flying over) a variety of terrestrial habitats (DoE, 2017a). This species has been recorded at or in the vicinity of freshwater swamps, lakes, reservoirs, billabongs, saltmarsh and sewage ponds. Within the locality, there are 71 recorded locations of the White-bellied Sea Eagle, scattered throughout and predominantly in association with Grahamstown Dam in the east and along larger riparian areas and wetlands.

The White-bellied Sea-eagle nests are primarily built in tall emergent eucalypt trees and they may be built in a variety of sites including; bushes, mangroves, cliffs, rocky outcrops, caves, crevices, on the ground or even on artificial structures (Marchant & Higgins 1993; DoE 2015). Nest trees often have emergent dead branches which are used as ‘guard roosts’ (Dennis et al. 2011b; Debus et al. 2014; as cited by, NSW Scientific Committee 2016). In subtropical eastern NSW White-bellied Sea-eagles nest at least 220 m from human settlements (mean 460 m, O’Donnell and Debus 2012; NSW Scientific Committee 2016). Spencer and Lynch (2005; as cited by, NSW Scientific Committee 2016) report the White-bellied Sea-eagle avoids nesting near urban areas. Nests may be abandoned if disturbed (Debus et al. 2014; as cited by, NSW Scientific Committee 2016).

2.5.3.1.3 Local Occurrence

A pair of White-bellied Sea Eagle’s has been repeatedly recorded in the Conservation Area using a large Forest Redgum for breeding purposes. The White-bellied Sea Eagle nest is located in close proximity to Wetland 803. Habitat is largely restricted to the estuarine environment with limited foraging opportunities evident in the Conservation Area. Habitat and recorded locations for this species are shown in **Figure 14**.

2.5.3.1.4 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Maintaining existing nest tree and unabated access to the Williams River;
- Maintain wetland wetting and drying; and
- Provide additional potential nest sites as alternatives to existing nest location.

TITLE : FIGURE 14: WHITE-BELLIED SEA EAGLE HABITAT WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 14 White-bellied Sea Eagle Habitat within the Conservation Area B A3 20200721.mxd

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2.5.3.2 Grey-crowned Babbler

2.5.3.2.1 Lifecycle

The Grey-crowned Babbler is primarily an insectivore that occasionally eats seed. It is terrestrial and arboreal species favouring the latter behaviour when compared to other babbler species. Foraging forays are commonly seen on the ground where it turns leaf litter, bark and small stones to uncover prey and also low shrubs and trees in feeding flocks of 2-15 birds. Feeding flocks maintain a tight association and rarely separated by more than 30 m at any one time for social and predator evasion reasons (Higgins and Peter 2002).

Co-operatively breeding groups comprise a breeding pair and several non-breeding birds who are helpers of auxiliaries. Helpers or auxiliaries aid in the building/ maintenance of dome shaped brood and roost nests in addition to feeding young. Nests often build in tall shrubs and small trees (saplings), with *Casuarina glauca* and *Melaleuca styphelioides* favoured on site. Groups often roost in one nest for warmth and predator evasion reasons (Higgins and Peter 2002).

Groups typically comprise 4-12 birds with declining populations often identified by small groups of 1-3 birds and linked to fragmentation (i.e. >300m separation between habitat patches), predation and habitat simplification (i.e. burning for fuel reduction, tree dieback, removal of fallen timber/ logs, cattle grazing and invasion of pasture grasses/ exotic plants). Habitat simplification is often denoted by the loss of important resources for feeding and nest building through depletion of an accumulated leaf litter layer, increase in groundcover plant species and loss of shrub layer (Higgins and Peter 2002).

Groups live in permanent territories, often adjoining others, which are aggressively defended throughout the year. Home ranges or territories vary in area (e.g. 1.5 to 50 ha) with territory size dependant on resource availability and quality and not necessarily the number of birds. Offspring often stay with the breeding pair for up to two years, with dispersal occurring into neighbouring unoccupied habitat thereafter and form new breeding groups once sexually mature (i.e. 2-4 years) (Higgins and Peter 2002).

2.5.3.2.2 Habitat

The Grey-crowned Babbler can be found in open Box-Gum Woodlands on the slopes, Box-Cypress pine and open Box Woodlands on alluvial plains and in woodlands on fertile soils in coastal regions (OEH, 2019). Woodlands typically have regenerating trees, tall shrubs and an intact ground cover of grass and forbs (NSW Scientific Committee, 2011c). Nests for this species are dome-shaped and built from sticks and are usually located in shrubs or saplings, and may also be built on the outermost leaves of low branches of larger eucalypts (OEH, 2019).

2.5.3.2.3 Local Occurrence

There are 13 recorded locations of the Grey-crowned Babbler within the locality. Recent surveys of the study area recorded two Grey-crowned Babblers and one nest. Habitat for this species is not widespread throughout the Conservation Area and is restricted and generally concentrated to the vegetated margins of wetland 803 where a complex of young trees and understory structure is apparent; a localised circumstance consistent with habitat occupancy by a second flock of this species in the periphery of wetland 804 to the south west (Mark Aitkens pers obs 2019). Habitat and the recorded locations for this species are shown in **Figure 15**.

2.5.3.2.4 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Maintaining patch size and connectivity for foraging and dispersal;
- Improve ground layer habitat complexity to enhance foraging values, especially for smaller habitat patches; and
- Promoting diversity in vegetation structure for nesting.

TITLE : FIGURE 14: WHITE-BELLIED SEA EAGLE HABITAT WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report7. BMP\Latest Figures 20200721\130430 Figure 15 Grey-crowned Babbler Habitat within the Conservation Area B A3 20200721.mxd

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2.5.3.3 Black-necked Stork

2.5.3.3.1 Lifecycle

Black-necked Storks build large nests high in tall trees close to water that usually provide clear observation of the surroundings and are at low elevation (reflecting the floodplain habitat) (OEH 2019b). In NSW, breeding activity occurs May – January. Recorded nesting in Tomago NSW in 2017 involved a nest built in a Narrow-leaved Paperbark (*Melaleuca linariifolia*) approximately three metres tall, growing in wetland dominated by Common Reed (*Phragmites australis*). The tree had multiple trunks and the crown was broad and flattened at the top (Lindsey 2019).

2.5.3.3.2 Habitat

This species inhabits tropical and warm-temperate terrestrial wetlands, estuarine and littoral habitats and occasionally grassland and wooded areas (Marchant and Higgins 1990). Foraging occurs in fresh or saline waters up to 0.5m deep, preferring extensive sheets of shallow freshwater over grassland or sedgeland; shallow swamps with short emergent vegetation and abundant aquatic flora and permanent billabongs and pools on floodplains (Marchant and Higgins 1990). Less common in intertidal waters, littoral and estuarine mudflats or areas of fringing mangroves (Marchant and Higgins 1990).

2.5.3.3.3 Local Occurrence

The Black-necked Stork has been rarely observed in the Conservation Area despite frequent surveys by local ornithologists/ bird enthusiasts since 2016 and less frequent observations since 2000. The infrequent occurrences of this species are restricted to Wetland 803 where it is likely to have been moving through the locality or potentially foraging. Habitat for this species is restricted to the western part of the Conservation Area and is restricted to Wetland 803.

2.5.3.3.4 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Maintain wetland wetting and drying; and
- Provide, through plantings of *Melaleuca* spp., additional potential nest sites as alternatives to existing nest location.

2.5.3.4 Large forest owls (Powerful and Masked Owls)

2.5.3.4.1 Lifecycle

The Powerful Owl (*Ninox strenua*) reaches sexual maturity at 2 years of age in captivity and it is thought to reach sexual maturity at 3 to 4 years in the wild. The Powerful Owl is monogamous and lives in large permanent home ranges from 300 ha to 1500 ha depending on the habitat quality (DEC 2006). Breeding is strictly seasonal, occurring from mid-May to mid-July. A single clutch of 1-2 eggs is laid per year, although, a replacement clutch may be laid if the first attempt fails early on (DEC 2006). Juveniles are dependent for 6-7 months post-fledging and lifespan is up to 25+ years in captivity and thought to be approximately 15 years in the wild (Data from Fleay 1979, Schodde and Mason 1980, Hollands 1991, Debus and Chafer 1994, McNabb 1996, Kavanagh 1997, Higgins 1999; as cited by DEC 2006).

2.5.3.4.2 Habitat

The Powerful Owl inhabits a range of vegetation types from woodland and open sclerophyll forest to tall open wet forest and rainforest (OEH 2019b). It typically utilises large areas of connected woodland or forest habitat, however, it can also occur in fragmented habitats.

The Powerful Owl forages in open or closed sclerophyll forest or woodlands and may also hunt in open habitats (OEH 2019b). As a hunter of arboreal prey, the Powerful Owl feeds predominantly on Common

Ringtail Possums, Common Brush-tailed Possums, Greater Gliders and Sugar Gliders (Bain et al., 2014). Large eucalypts that are at least 150 years old, with hollows at least 0.5m deep are the primary nesting habitat for this species (OEH 2019b). Smaller trees with hollows and a shrub layer within which prey species reside are also habitat components for the Powerful Owl (OEH 2019b). Moist forest in unlogged corridors in gully systems is used for nesting and roosting (DEC 2006). Optimal breeding habitat contains; mature forest stands with large hollow bearing trees, dense understorey shrubs for fledglings and high densities of arboreal marsupials (Schodde and Mason 1980, McNabb 1996, Kavanagh 1997, Higgins 1999; as cited by, DEC 2006).

The Masked Owl *(Tyto novaehollandiae*) is a large forest owl that occupies dry eucalypt forests and woodlands from sea level to 1100 m. Pairs have a large home-range of 500 to 1000 hectares and is not a species exhibiting seasonal variation in its distribution. It roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting with a preference for vertical hollows in large trees.

Masked Owls feed mainly on small mammals, such as rodents, rabbits and bandicoots. Other prey animals include possums, reptiles, birds and insects, with hunting taking place in the early hours of night. The birds sit on low perches listening for prey which, once detected, is taken from the ground or from the tree branches.

The LMCC (2014) identify specific conservation priorities for Large Forest Owls with reference to nest and/or breeding roost tree habitat. Habitats for conservation priority include:

- Confirmed nest sites (including a 100m buffer), breeding roost trees (including a 50m buffer) and sustainable home range extant habitat around such sites;
- Riparian habitat;
- Corridor connectivity along riparian corridors and between major habitat fragments; and
- Old growth forest.

2.5.3.4.3 Local Occurrence

Knowledge on the known area of occurrence of Large Forest Owls within the Conservation Area is derived from recent stag watch surveys (RPS 2020a), owl calling surveys (RPS 2020a) and historical data obtained from HWR (2004). No roost hollows have been observed within the Conservation Area. However, stag watching of suitable trees within the Conservation Area is incomplete.

HWR (2004) report a Powerful Owl roost site in Conservation Area. This observation was in dense vegetation (John-Paul King pers com 2019). A Masked Owl was heard calling in the western part of the Conservation Area during stag watching in that location. Current observations indicate that Large Forest Owls are foraging throughout the Conservation Area, with no current known breeding nest trees identified at this stage.

Habitat and the recorded locations for large forest owls are shown in **Figure 16**.

2.5.3.4.4 Management Implications

The following lifecycle/ habitat related factors represent management matters for large forest owl species:

- Maintaining patch size and connectivity for foraging and dispersal;
- Enhance den site density for prey species such as the Brush-tailed Possum, Ringtail Possum, Sugar Glider and Squirrel Glider through installation of nest boxes/ natural hollows to locally increase the carrying capacity of the Conservation Area; and
- Retain riparian corridors with widths of 100 m or greater to facilitate movement.

TITLE : FIGURE 16: LARGE FOREST OWL HABITAT WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report7. BMP\Latest Figures 20200721\130430 Figure 16 Large Forest Owl Habitat within the Conservation Area B A3 20200721.mxd

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2.5.3.5 Squirrel Glider

2.5.3.5.1 Lifecycle

Gliders nest in tree hollows and live in family groups of 2 to 9 individuals, typically comprising a mature male, one or more adult females and their offspring. They live for approximately 3 - 4 yrs (Murray 2007 pers. comm.; Sharpe & Goldingay 2010; as cited in, LMCC 2015) and have an average adult weight of about 200g. Reproduction peaks in late autumn and winter with food availability influencing timing of reproduction (Millis & Bradley 2001; Goldingay, Sharpe, Beyer & Dobson 2006; Sharpe & Goldingay 2010 as cited in, LMCC 2015).

High population density is only achievable in habitats with abundant hollow bearing trees (>4 habitat trees/ha) and abundant food trees (Smith and Murray 2003; van der Ree 2000; Sharpe & Goldingay 2010). Dead trees (stags) are an important habitat component and are used when available (Rowston 1998; Ball, Goldingay & Wake 2011; Beyer, Goldingay & Sharpe 2008).

2.5.3.5.2 Habitat

Squirrel gliders are sparsely distributed in eastern Australia, from northern Queensland to western Victoria (OEH 2019b). Populations of this species are highly localised and dependent on availability of suitable foraging habitat with tree hollows. Colonies require multiple den trees within their home ranges (LMCC 2015).

This species prefers a range of dry and moist sclerophyll forest, swamp forest, and woodland vegetation communities dominated by winter flowering eucalypts or flowering banksias, (Quin et al. 2004; Sharpe 2004; Sharpe & Goldingay 2010, HWR Ecological 2003), or summer flowering eucalypts with an understorey of acacia species that provide edible gum exudates in winter (e.g. *A. irrorata*, *A. parramattensis*, and *A. longifolia*) (Smith and Murray, 2003).

Squirrel gliders eat nectar from flowers, pollen and sugary plant and insect exudates (LMCC 2015). In addition to pollen and nectar, arthropods are an important food source (Sharpe & Goldingay 1998; Dobson, Goldingay & Sharpe 2005; Ball et al. 2009).

2.5.3.5.3 Local Occurrence

Recent surveys indicate the Squirrel Glider is likely absent from the location (RPS 2020a). However, marginal habitat is considered to present with nectar resources restricted to the eucalypt canopy. Potential habitat within the Conservation Area is largely limited to patches of Forest Redgum, Grey Ironbark, Grey Gum and *Melaleuca styphelioides* occurrences with a preference for lower elevations (HWR 2004). The potential habitat area is mapped in **Figure 17**.

2.5.3.5.4 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Maintaining patch size and connectivity for foraging and dispersal;
- Enhance den site density using appropriately dimensions nest boxes/ natural hollows to locally increase the carrying capacity of the Conservation Area;
- Retain riparian corridors with widths of 100 m or greater to act as habitat and movement pathways; and
- Include nectar rich tree and shrub species in revegetation plantings to provide foraging resources in important areas such as the lower parts of the Conservation Area.

TITLE : FIGURE 17: SQUIRREL GLIDER HABITAT WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 17 Squirrel Glider Habitat within the Conservation Area B A3 20200721.mxd

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2.5.3.6 Brush-tailed Phascogale

2.5.3.6.1 Lifecycle

The Brush-tailed Phascogale (*Phascogale tapoatafa*) is a bark foraging insectivore (Scarff et al 1998; Scarff and Bradley 2006) nocturnally active species occupying hollows as diurnal refugia and breeding. Mating occurs May - July; males die soon after the mating season whereas females can live for up to three years, but generally only reproduce once (OEH 2019b).

Female Brush-tailed Phascogale have exclusive territories of approximately 20 - 40 ha, whilst males have overlapping territories often greater than 100 ha (OEH 2019b); although home ranges of 2.3 – 8 ha have been reported in high quality spatially limited habitat (van der Ree et al 2001). Brushed-tailed Phascogales reside in tree hollows with entrances 2.5 - 4 cm wide and use many different hollows over a short time span (OEH 2019b). van der Ree et al (2001) indicates a preference for hollows occurring within trees with 80 cm diameter at breast height (DBH) or greater, although Rhind (2003) and Beyer and Goldingay (2006) note the frequent usage of nest boxes by this species.

2.5.3.6.2 Habitat

The Brush-tailed Phascogale broadly prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter; although is also known in rainforest and wet sclerophyll forest (OEH 2019b). This species preferentially uses a habitat complex comprising groundcover layer features (e.g. fallen logs) and arboreal features such as hollow-bearing trees for denning and *"rough barked trees of 25 cm DBH or greater"* (OEH 2019b) for foraging.

The Brush-tailed Phascogale is a scansorial species (i.e. adapted to climbing) and forages on trees for invertebrates. High value habitat comprises vegetation with high invertebrate biomass and is linked to 'arboreal surface roughness' (i.e. tree trunks with high habitat values for invertebrates), and is thus an indicator of forage resource availability (e.g. increased abundance of prey species such as invertebrates). This habitat factor is consistent with findings presented in local studies on this species (Firebird 2013), where the species was observed in several Ironbark trees, including *Eucalyptus crebra* (Narrow-leaved Ironbark), *E. siderophloia* (Grey Ironbark) and *E. fibrosa* (Red Ironbark). A den site located to the northwest of the Conservation Area was located in a dead hollow-bearing 'stag' tree.

Data representing the distribution of 'rough-barked trees' species with a DBH of 30 cm or more was used identify habitat that is likely to represent high value foraging habitat for this species. Tree species used to model 'arboreal surface roughness' are listed below:

- Grey Gum and Small-fruited Grey Gum;
- White Mahogany;
- White Stringybark;
- Blackbutt;
- Red Bloodwood; and
- All ironbark species.

The combined consideration of key habitat features (i.e. fallen logs, hollow-bearing trees and arboreal surface roughness) represents the likely extent of habitat of importance to the Brush-tailed Phascogale within the Conservation Area (i.e. breeding and high value foraging habitat), as shown in **Figure 18.**

2.5.3.6.3 Local Occurrence

The distribution pattern of the Brush-tailed Phascogale is likely controlled by the seasonal reliability of rainfall and diversity of food resources (Scarff et al 1998), with abundance in its habitat being highly variable over time and most likely in response to the distribution of key habitat features (e.g. hollows and rough-barked trees) at a range of scales (Mansfield et al 2017).

Brush-tailed Phascogale within the Conservation Area will preferentially occupy vegetation in hollow rich areas, particularly where trees are >80cm DBH, and where coincident with a high occurrence of rough-barked trees suitable for foraging **Figure 18**.

Local ecological studies and threatened species assessments performed within and adjacent the Conservation Area have recorded the occurrence of the Brush-tailed Phascogale (e.g. HWR Ecological 2004; 2005; EcoBiological 2010). Firebird (2013) identified the presence of actively breeding individuals in Spotted Gum Ironbark vegetation located immediately to the north of the Conservation Area and noted a likely broad and connected occurrence in the locality north through to Wallaroo State Forest and National Park.

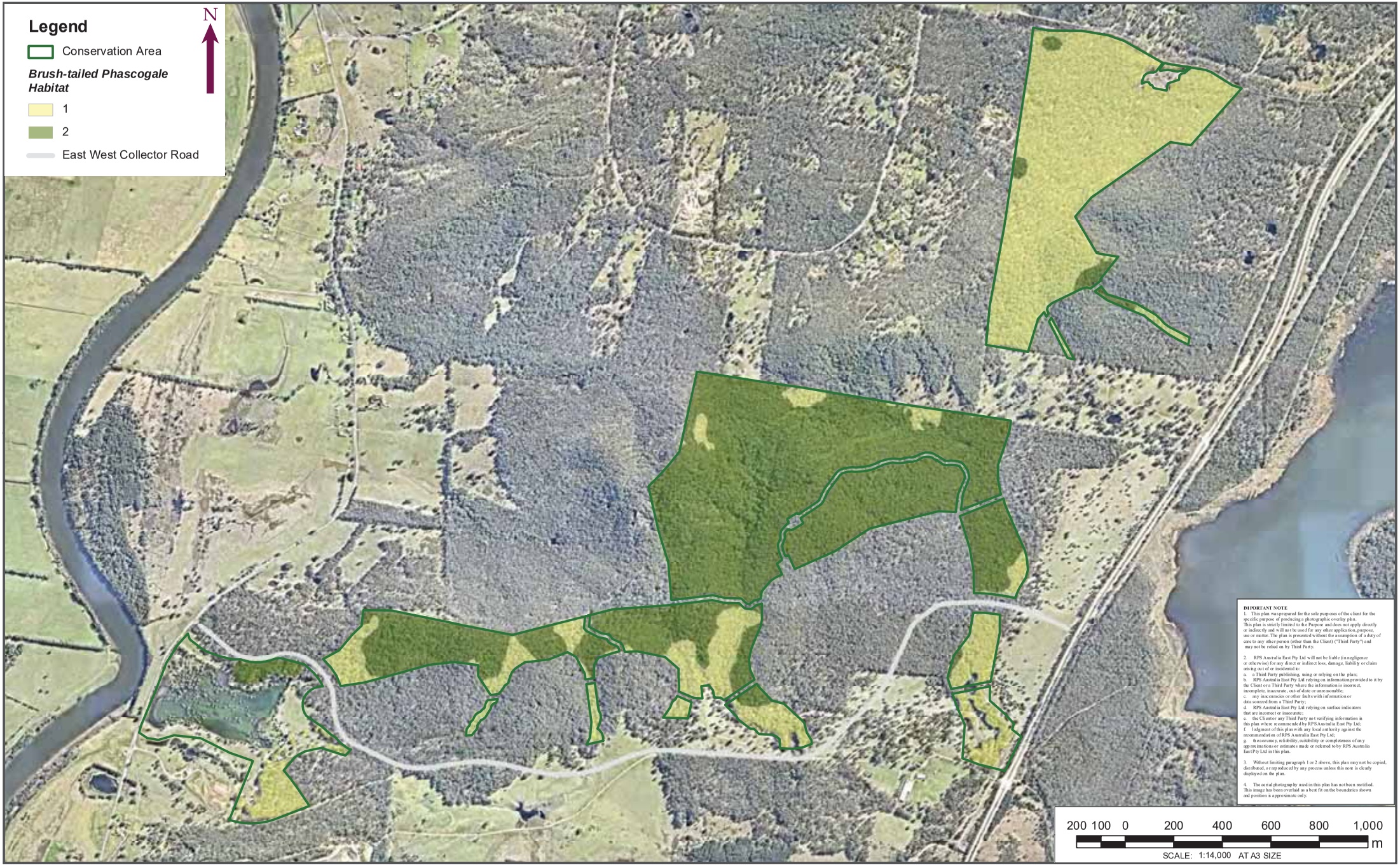
There are at least 25 recorded observations of the Brush-tailed Phascogale north from the Conservation Area to the Balickera Channel (Italia Road). To the west there are at least 40 recorded occurrences between the Williams River to Paterson and north to Clarence Town, with reporting frequency in this area likely associated with a relatively greater number of ecological studies for development applications. To the east there are numerous reported occurrences along the northern shoreline of Port Stephens and Grahamstown Dam.

Given the propensity of this species to disperse, the abundance of habitat connections north from the Conservation Area to large areas of habitat known comprising this species (Firebird 2013), it is considered that this species is widely distributed locally throughout numerous habitat patches. The maintenance of habitat suitability and connections there between represent the main conservation focus for the local population of this species.

2.5.3.6.4 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Increase the abundance of roost/ denning sites through enhancement works involving the installation of appropriately dimensions nest boxes/ natural hollows;
- Retain riparian corridors with widths of 100 m or greater to act as habitat and movement pathways;
- Strategically install nest boxes/ natural hollows in movement areas to enhance habitat connectivity (Beyer and Goldingay 2006); and
- Install fallen logs, preferably those with rough barks, to increase ground layer complexity to improve movement opportunities and foraging values.



TITLE : FIGURE 18: BRUSH-TAILED PHASCOGALE HABITAT WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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2.5.3.7 Koala

2.5.3.7.1 Lifecycle

Koalas reach sexual maturity at 2 years of age and produce one Koala a year or rarely twins. Koalas live for between 10 and 20 years, and generally breed between September and February (DPIE 2019) comprising male bellowing, fighting and scent marking in in the period between August to October. Gestation is approximately 2 months and a newborn Koala resides in the pouch until around 7 months, with emergence starting from September. When the young koala is about one year old, its mother is able to mate again (DPIE 2019).

Koalas are typically solitary and dominant males are territorial, often driving off young males (DPIE 2019). Koalas rest for most of the day and at night they move between feed trees and along the ground in open woodland or cleared areas (DPIE 2019).

2.5.3.7.2 Habitat

Koalas inhabit open eucalypt forest and woodland and feed on approximately 70 species of eucalypt and 30 species of non-eucalypt trees within NSW; however, local occurrences are more likely limited a small number of preferred feed tree species. Measures for total and digestible nitrogen and plant secondary metabolites (PSMs) obtained from the Conservation Area (Marsh and Youngentob 2019) confirmed local Koala feed tree preferences to include *Eucalyptus tereticornis* (Forest Red Gum), *Eucalyptus punctata* (Grey Gum), *Eucalyptus microcorys* (Tallowwood), *Eucalyptus moluccana* (Grey Box) and *Eucalyptus propinqua* (Small-fruited Grey Gum) and supplementary feed tree *Eucalyptus globoidea* (White Mahogany) as listed in PSC (2002) and OEH (2018).

BioLink (2017) note the following in relation to the mapping PKH within the PSC LGA and the dominant vegetation type of the Conservation Area:

“Seaham Spotted Gum - Ironbark Forest contain one or more PKFTs and so warrants recognition as PKH. However, field data indicates that constituent PKFTs are a sub-dominant feature of the tallest-stratum, hence implying the need to downgrade both PCTs from Secondary (Class B) – which requires dominance by one or more Secondary PKFTs, to the lower and more marginally aligned Secondary (Class C/B)” (BioLink (2017).

However, the distribution of preferred koala feed trees within the Conservation Area does not correlate with vegetation mapping. Therefore, the extent of higher value koala foraging habitat varies with the distribution of these PKFTs.

Koala habitat selection is not exclusively restricted to browse preferences as Koalas are a species limited by low energy budgets from a low nutrient Eucalypt diet (Krockenberger 2003). For this reason, and where possible, Koalas preferentially occupy a home range that simultaneously satisfies all key habitat factors within the smallest possible area (e.g. minimise energy cost) provided the threat of predation risk is acceptable. Therefore, a more accurate habitat model that accounts for key factors additional to browse preference would include dietary need and the consideration of:

- Seasonal thermoregulation and water budget requirements (Briscoe et al 2014; Ellis et al 2011; Ellis et al 2018); and
- Threat avoidance to minimise the propensity for predation.

Habitat accommodating key habitat needs is likely to be characterised by forests comprising a variety of PKFTs with high canopy connectedness, which provides cooler microclimates for thermoregulation and sponsors inter-tree canopy movements (Goldingay and Taylor 2016) to minimise the threat of predation. These areas of habitat are also likely to comprise larger trees, which also provide additional shelter from predators and shade from the summer heat (Moore and Foley 2005; Matthews et al. 2007).

A map showing the extent of habitat within the Conservation Area is provided in **Figure 19**.

TITLE : FIGURE 19: KOALA HABITAT WITHIN THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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2.5.3.7.3 Local Occurrence

The Koala has been consistently recorded throughout Port Stephens LGA. It occurs in the east at Tomaree in high densities amid small areas of primary habitat through to low density occurrence in the west within the Conservation Area, with intervening noteworthy occurrences at Grahamstown Dam, Medowie and Salt Ash to Bobs Farm. According to BioLink (2019), historical occurrences at Tomago and Williamstown appear to have been negatively impacted by frequent intense fires in this area; a known threat to the survival of the Koala.

Recent genetic studies of Koalas at multiple sites in the Port Stephens including Tomaree, Karuah, Grahamstown West and the Conservation Area (Hogan et al 2019 in prep) identified two distinct genetic clusters, this being the basis for the identification of two separate Koala populations. The population in the east is likely bounded by movement barriers located in the Salt Ash area, where anthropogenic influences are likely to have negatively influenced east - west geneflow thereby geographically isolating this population from proximal occurrences.

BioLink (2019) indicate a geographic limit to the Kings Hill hub, which includes the Conservation Area, by reference to movement barriers such as the Pacific Highway, Williams River and Italia Road/ Balickera Channel. However, the genetic study indicates otherwise, showing geneflow between Koalas within the Conservation Area and that west of the Pacific Highway and north of Balickera Channel. The abundance of Koala habitat north and east of the Conservation Area, and limited amount to the south, indicate the Conservation Area is likely located at the southern extremity of an unbounded population that extends north/ north west from Wallaroo National Park and east of Karuah.

2.5.3.7.4 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Maintaining patch size and connectivity for foraging and dispersal;
- Retain riparian corridors with widths of 100 m or greater to act as habitat and movement pathways, particularly with the Wetland 803 area;
- Protection of individuals from mortality through the installation of fences and grids to prevent koala movement into the urban zone where threats exists and bridges for Koalas needing to move back into the Conservation Area when trapped within the urban zone;
- Revegetate the treeless periphery of Wetland 803 with high value PKFTs including Swamp Mahogany, Forest Redgum and Tallowwood to provide an area of Primary habitat; and
- Enrich at least 100 ha of the Conservation Area with high value PKFTs including Forest Redgum, Grey Gum, Grey Box and Tallowwood to improve the current classification of Koala habitat from Supplementary C to Supplementary B (BioLink 2019).

2.5.3.8 Grey-headed Flying Fox

2.5.3.8.1 Lifecycle

Australian flying-foxes are seasonal, synchronous and polygamous breeders (DECCW 2009a, Eby 2008 as cited by GeoLINK 2013). Mating behaviour in Grey-headed Flying-foxes commences in January with conception occurring in April / May (Nelson 1965, Martin et al. 1996). They have a low reproductive rate, with a single pup generally born from October to December (Martin and McIlwee 2002; Divljan 2008 as cited by, DoEE 2017). Individuals reach sexual maturity in the second year of life, but typically do not successfully raise young until the third year (McIlwee and Martin 2002; as cited by DoEE 2017).

Newborn flying-foxes are incapable of thermoregulation (Bartholomew et al. 1964; as cited by, GeoLINK 2013) and the young cling to their mothers for approximately four to five weeks. Flying-foxes can live for over 16 years in the wild, however, average life expectancy is more likely to be under seven years (Divljan et al. 2006; as cited by, GeoLINK 2013).

2.5.3.8.2 Habitat

According to DoEE (2017), Grey-headed Flying-fox has historically occupied forests and woodlands in the coastal lowlands, tablelands and slopes of south-eastern Australia, from Bundaberg in Queensland to Geelong in Victoria, with rare sightings outside its range. More recently, camps have established in Adelaide, the Australian Capital Territory and inland areas of central and southern New South Wales and Victoria.

GeoLINK (2013) identified that the Lower Hunter supports 20 known camps of the GHFF, seven of which are identified as critical to the survival (CTS) of the GHFF in the Lower Hunter: Millfield, Martinsville, Morisset, Blackbutt Reserve, Anna Bay, Medowie and Tocal. Six camps were clearly not CTS of the GHFF: Black Hill, Belmont, Glenrock, Hannan Street, Italia Road and Raymond Terrace. However, in a review of the Raymond Terrace camp, PSC (2017) identified this camp to qualify as CTS.

The flowering phenology described by Eby and Law (2008), as adjusted for the Lower Hunter region (GeoLINK 2013) for important feed tree species present on site are listed in **Table 6** according to their bi-monthly flowering phenology. Scores for duration represent the length in months of individual flowering events. The winter and spring food bottleneck, which is shaded in **Table 6**, is a sensitive period for the Grey-headed Flying Fox as this period coincides with gestation and immediately precedes birth and lactation.

Table 6: Flowering Phenology for Grey-headed Flying Fox Important Nectar Species

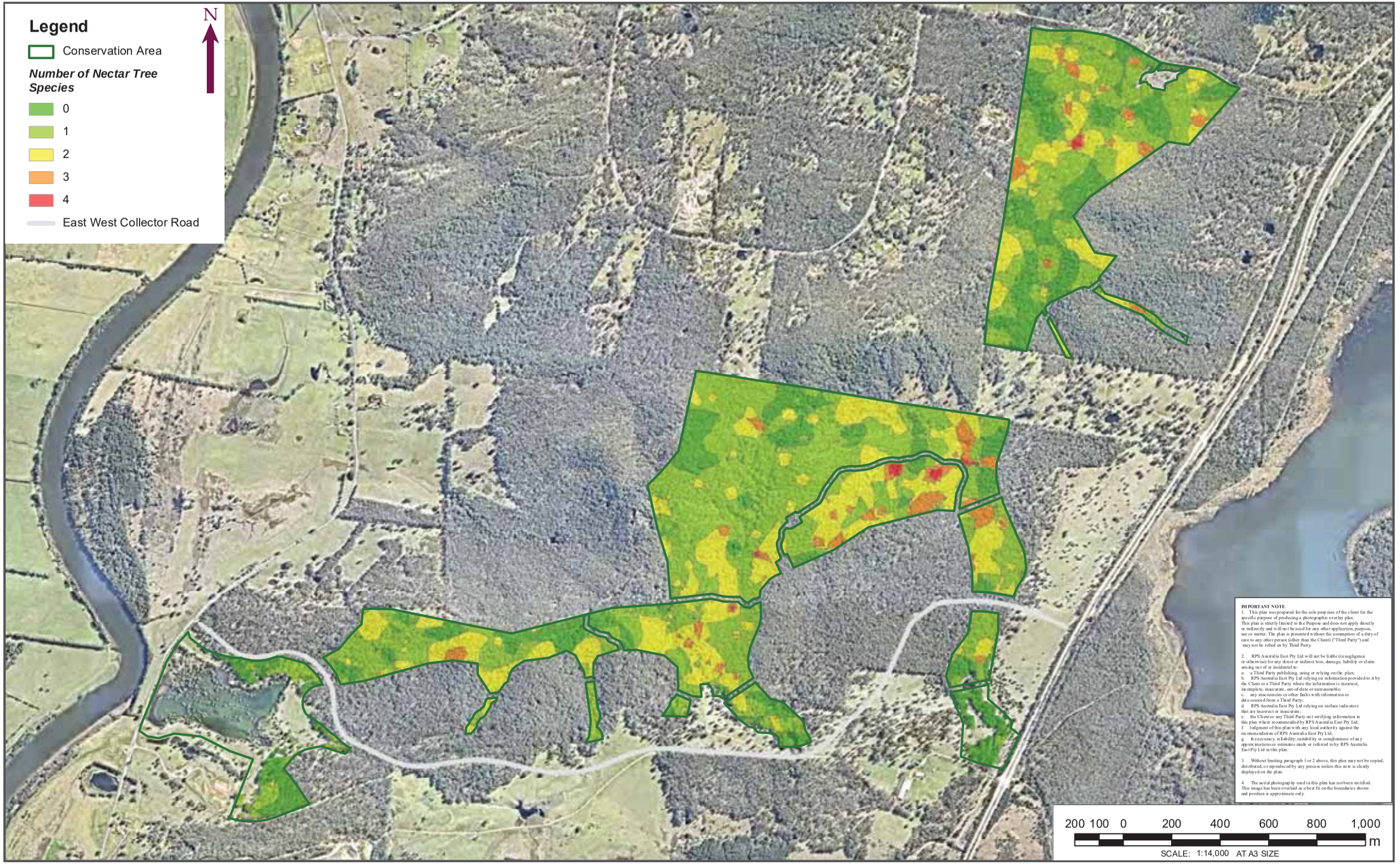
Species	D-J	F-M	A-M	J-J	A-S	O-N	Duration
Corymbia gummifera			x				1
Corymbia maculata			x	x	x		≤3
Eucalyptus acmenoides	x					x	1
Eucalyptus fibrosa	x					x	2
Eucalyptus molucanna		x					2
Eucalyptus pilularis	x	x					2
Eucalyptus propinqua	x	x					2
Eucalyptus punctata	x	x					1
Eucalyptus robusta			x	x			≥3
Eucalyptus siderophloia	x					x	2
Eucalyptus tereticornis					x	x	2

The distribution of nectar feed tree species according to the bimonthly phenology outlined in Table 6 has been modelled for each bimonthly period is shown in **Figures 20** to **25**.

2.5.3.8.3 Local Occurrence

Port Stephens Local Government Area currently supports nine known flying-fox camps. The nearest camp to the Conservation Area is located at Raymond Terrace, hereafter referred to as the Ross Walbridge Reserve Camp, and is the only constantly utilised flying-fox camp in the LGA. According to Port Stephens Council (2017), the Ross Walbridge Reserve Camp contains at least 8,000 individuals (of three different species) with a maximum record of 21,000 in April 2016. Other flying-fox camps in the local government area include:

- Anna Bay, Tomago (Fullerton Cove), Wallaroo NP (Italia Rd) and North of Italia Road and are currently classed as historical.
- Bob's Farm (two Camps 3km apart) where a large number of animals were recorded in 2015, but no other evidence of sustained camp usage has been recorded.
- Medowie where animals were recorded in 2013 and 2014, but in no other year.
- Schnapper Island; where a small number of animals were observed roosting in 2014.



TITLE : FIGURE 20 : GREY-HEADED FLYING FOX NECTAR SOURCES: DECEMBER TO JANUARY

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 20 Grey-headed Flying Fox Dec_Jan B A3 20200721.mxd

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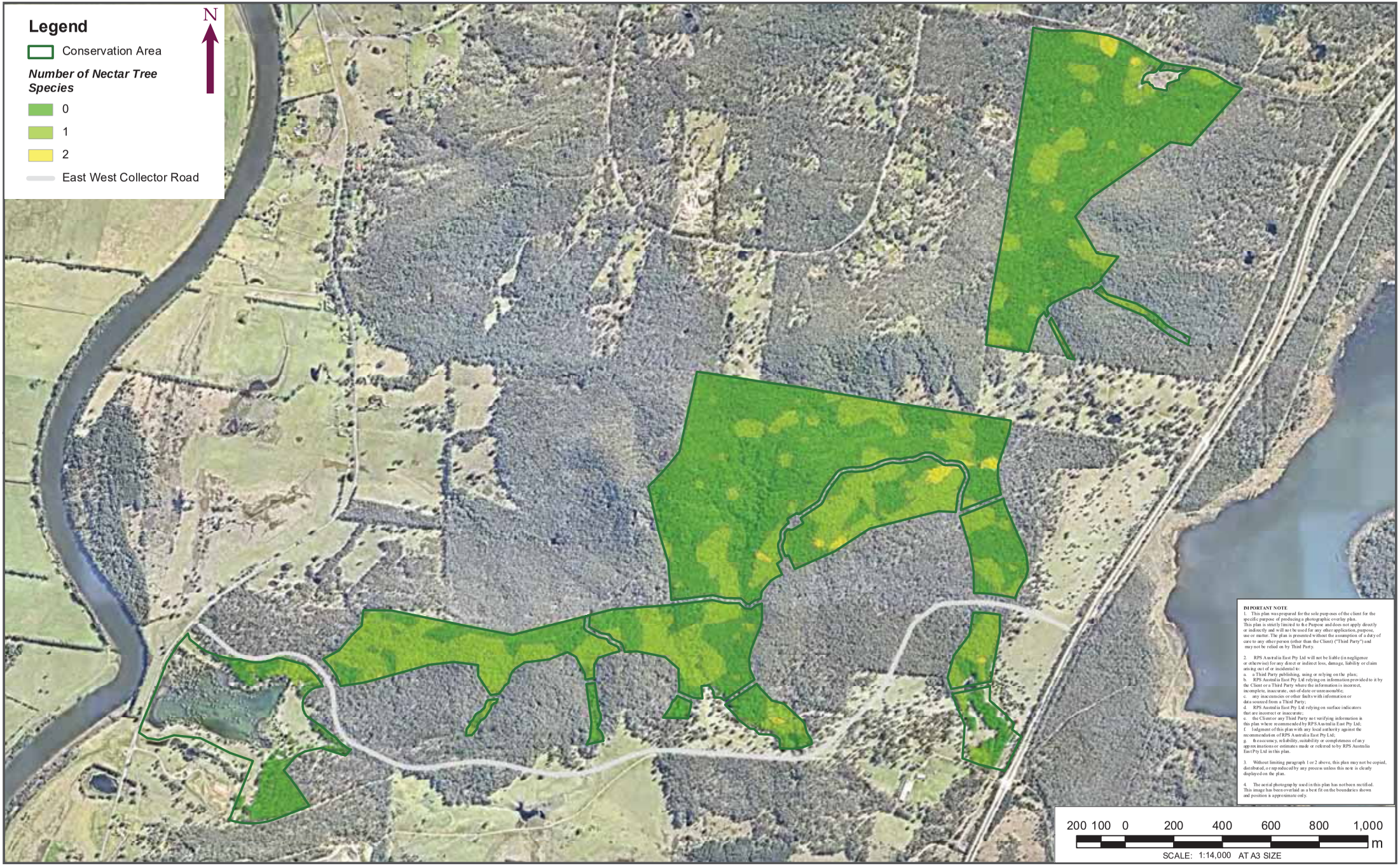

TITLE : FIGURE 21: GREY-HEADED FLYING FOX NECTAR SOURCES: FEBRUARY TO MARCH

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report7. BMP\Latest Figures 20200721\130430 Figure 21 Grey-headed Flying Fox Nectar Sources Feb_Mar B A3 20200721.mxd

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TITLE : FIGURE 22: GREY-HEADED FLYING FOX NECTAR SOURCES: APRIL TO MAY

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report7. BMP\Latest Figures 20200721\130430 Figure 22 Grey-headed Flying Fox Nectar Sources Apr_May B A3 20200721.mxd

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TITLE : FIGURE 23: GREY-HEADED FLYING FOX NECTAR SOURCES: JUNE TO JULY

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report7. BMP\Latest Figures 20200721\130430 Figure 23 Grey-headed Flying Fox Nectar Sources Jun_Jul B A3 20200721.mxd

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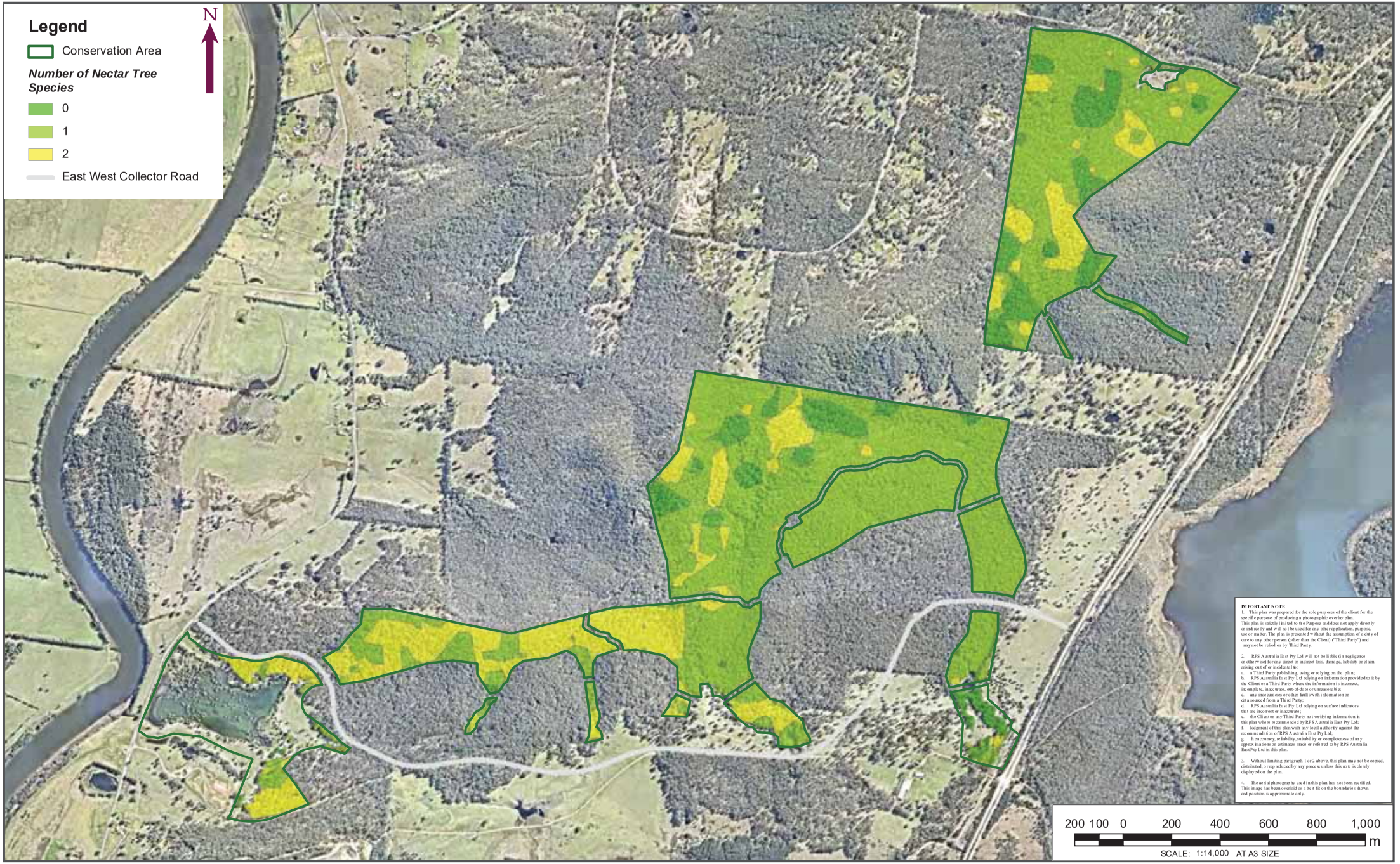

TITLE : FIGURE 24: GREY-HEADED FLYING FOX NECTAR SOURCES: AUGUST TO SEPTEMBER

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report7. BMP\Latest Figures 20200721\130430 Figure 24 Grey-headed Flying Fox Nectar Sources Aug_Sep B A3 20200721.mxd

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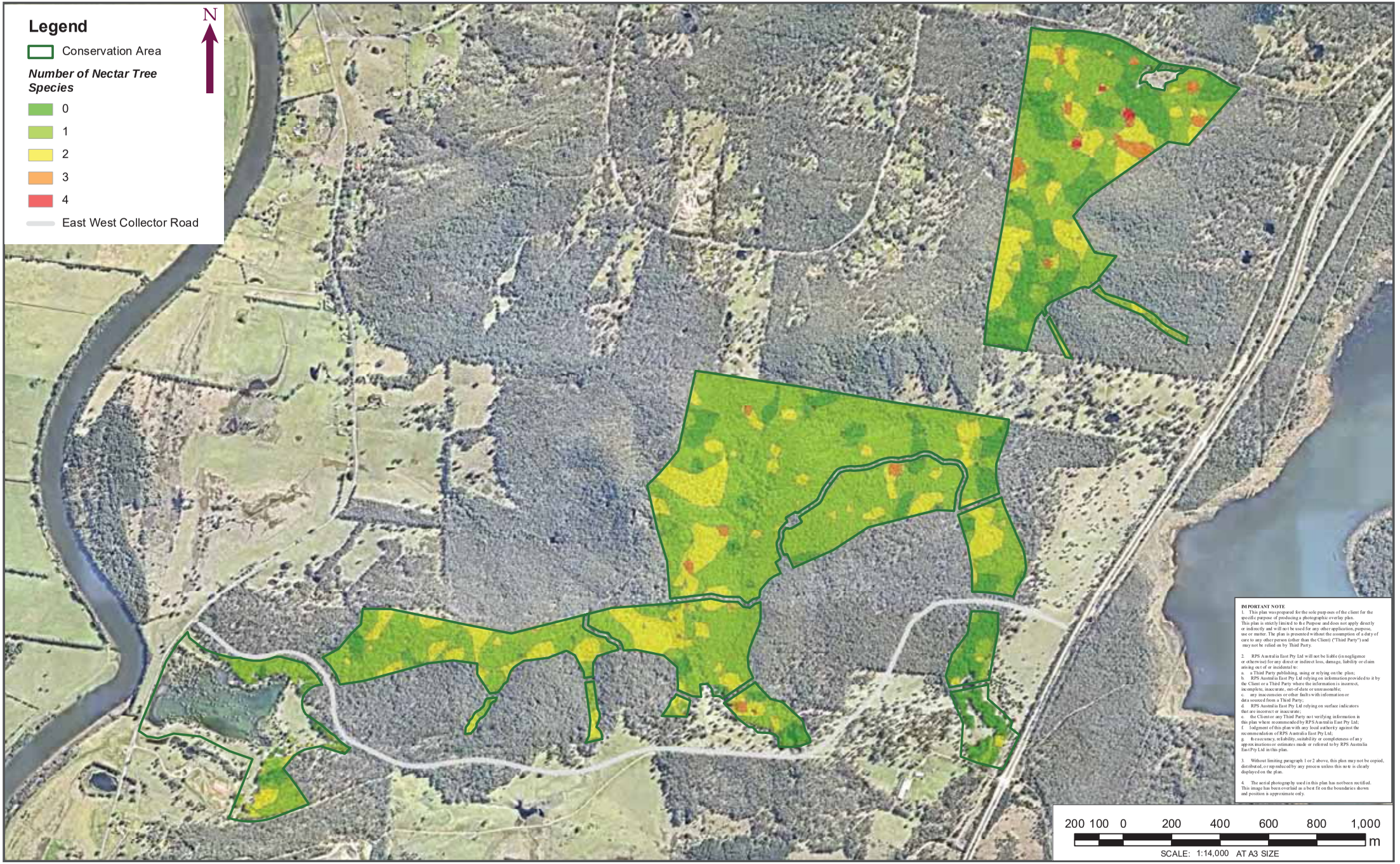

TITLE : FIGURE 25: GREY-HEADED FLYING FOX NECTAR SOURCES: OCTOBER TO NOVEMBER

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report7. BMP\Latest Figures 20200721\130430 Figure 25 Grey-headed Flying Fox Nectar Sources Oct_Nov B A3 20200721.mxd

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The Ross Walbridge Reserve Camp has been permanently occupied since 2013 and due to the number of animals consistently utilising the site, it was designated a Nationally Significant Flying-fox Camp. The proportion of Grey-headed Flying Fox within this camp has varied from 1.1-30.1% relative to the total number of individuals within the Hunter Region, with the camp occupancy routinely spiking during the cooler months (i.e. bottle food period). More recently (i.e. post 2015 winter period), camp numbers in the food bottleneck period of the year are considerably less than historical levels, presumably due to wildfire related disruptions to nectar resources throughout the Port Stephens area (Port Stephens Council 2017).

Approximately 51% of land within 20 km of the Raymond Terrace site supports native forests and woodlands in patches ranging in size from small remnants to extensive tracts in conservation reserves and state forests. Rainforest is rare and rainforest fruit provides insignificant food resources for flying-foxes during late summer and autumn. By contrast, approximately 85% of the forested land within 20km of Raymond Terrace contains flowering trees visited by the animals (Port Stephens Council 2017).

2.5.3.8.4 Management Implications

The following lifecycle/ habitat related factors represent management matters for this species:

- Maintaining patch size and connectivity for foraging and dispersal;
- Retain riparian corridors with widths of 100 m or greater to act as habitat;
- Revegetate the treeless periphery of Wetland 803 with high value winter nectar species including Swamp Mahogany and Broad-leaved Paperbark and spring nectar species including Forest Redgum; and
- Enrich at least 100 ha of the Conservation Area with high value spring nectar species including Forest Redgum and Grey Gum and summer nectar species including Grey Box to improve the foraging value of the Conservation Area during winter and spring food bottle necks.

2.5.4 Exotic Fauna

Pests such as the fallow deer (*Dama dama*), European fox (*Vulpes vulpes*) and Wild dog (excluding Dingo) occur within the locality, with fallow deer and wild dog commonly found in the Conservation area. These pest species represent a threat to native vegetation and structure and for fauna such as the Koala.

2.6 Infrastructure

2.6.1 Fencing

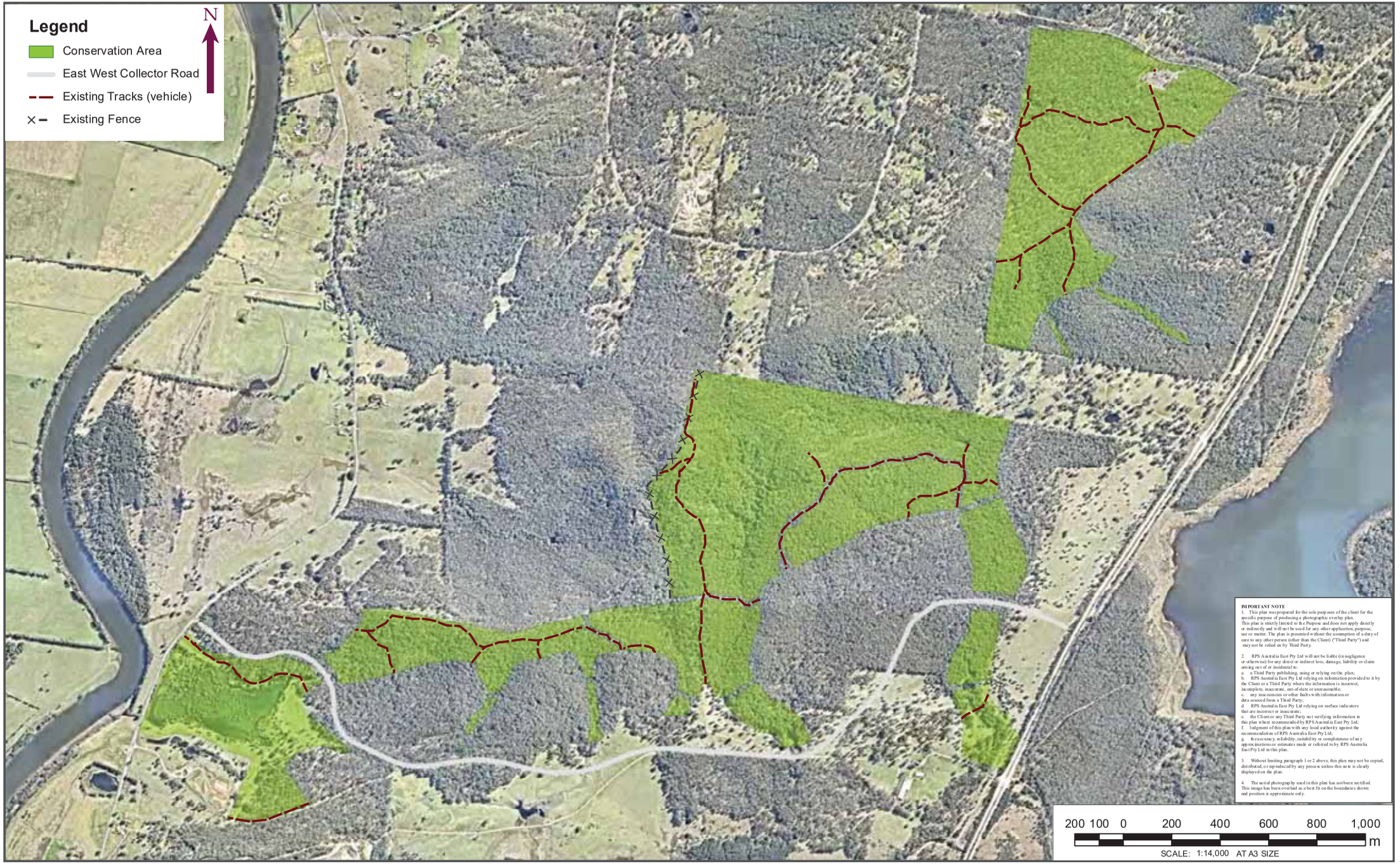
The Conservation Area is incompletely fenced with the variable condition observed ranging from dilapidated to good). The extent of current fencing is shown in Figure 26.

2.6.2 Access

The Conservation Area comprises a network of unmanaged tracks with no specific provisions for access control (i.e. gates). Existing vehicle traversable tracks, as shown in **Figure 26**, will be used as the basis for establishing the access infrastructure for the Conservation Area.

The site has approximately 10.58 km of trail system which provides the required access to facilitate land management operations including water provisions, noxious weeds, vertebrate pest and fire management practises.

Trails that have a principle use of fire management must be delegated a category. The intent is to provide a functional, strategic network of fire trails which permits access for firefighting vehicles in order to support fire management and bush firefighting.



TITLE : FIGURE 26: EXISTING TRACKS AND FENCES OF THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report7. BMP\Latest Figures 20200721\130430 Figure 26 Existing Tracks and Fences of the Conservation Area B A3 20200721.mxd

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3 MANAGEMENT ZONES

3.1 Units, Timing and Frequency

Management prescriptions specified in this BMP are to be implemented over a five year period at differing scales using management units outlined in **Table 7**.

Table 7: Types of Management Units

Management Unit	Scale	Focus of Management Actions
Conservation Area Management Zone	Landscape	Access, fencing, feral fauna control and fire management
Biodiversity Management Zone	Targeted	High threat weed control, habitat enhancement, threatened flora protection, forest nutrient enrichment and wetland protection

A guide for the timing and frequency of management actions within these management units is outlined in **Table 8**.

Table 8: Timing and Frequency Guidance for Management Actions

Management Actions	Timing	Frequency
Access and fencing	Staged with works occurring at the start of Phase 0 and ending in Phase 1	Once
Feral fauna management	Autumn - winter	Quarterly for two years, then annually for three years (Phases 0 and 1)
Fire	Consultation with RFS	Integrated with weed control and habitat enhancement works
Weed control	Spring and summer	Annually for five years
Habitat Enhancement	Autumn - winter	Consistently with annual targets
Threatened flora protection	As required	Annually
Forest foliar nutrient enrichment	Autumn - winter	Annually for five years and integrated with weed control and fire management

The objectives, performance targets, actions and specification guidance for each management unit are described in the following sections.

3.2 Conservation Area Management Zone

The management zone is a landscape scale management unit bounded by the Conservation Area. Management actions performed at this scale are focused on minimising the effects of anthropogenic impacts through controlling access, managing unwanted impacts from herbivore grazing or protecting sensitive species such as the koala (i.e. fencing), controlling highly mobile exotic herbivore with large home ranges and protecting fauna and their habitats from wild fire. The following sections provide details on these management matters.

3.2.1 Access and Fencing

3.2.1.1 Overview

The rural and urban zoned land adjoining the Conservation Area represents a potential source for impacts that may negatively influence the protection of biodiversity values. Access management is a preventative approach that seeks to avoid the occurrence of these impacts. It also provides opportunity for the establishment of managed trafficable pathways for passive recreation purposes or implementation of management actions.

Access management aims to protect the biodiversity values of the Conservation Area by preventing impacts from unauthorised access, livestock grazing and exposure of threatened species to threats commonly found in adjoining urban and rural environments. Access management includes the installation of fences, gates/ signage and tracks. Fencing serves two main outcomes:

- Protect vegetation and habitat contained within the Conservation Area from damage caused by livestock and anthropogenic activity associated with unauthorised entry (unauthorised logging, dumping of waste, bushfire threats etc); and
- Separate native fauna such as the koala from threats present in the adjoining urban/ rural environment.

3.2.1.2 Objectives and Performance Targets

The objectives and performance targets for access management works is provided in **Table 9**.

Table 9: CMA Access and Fencing Objectives and Performance Targets

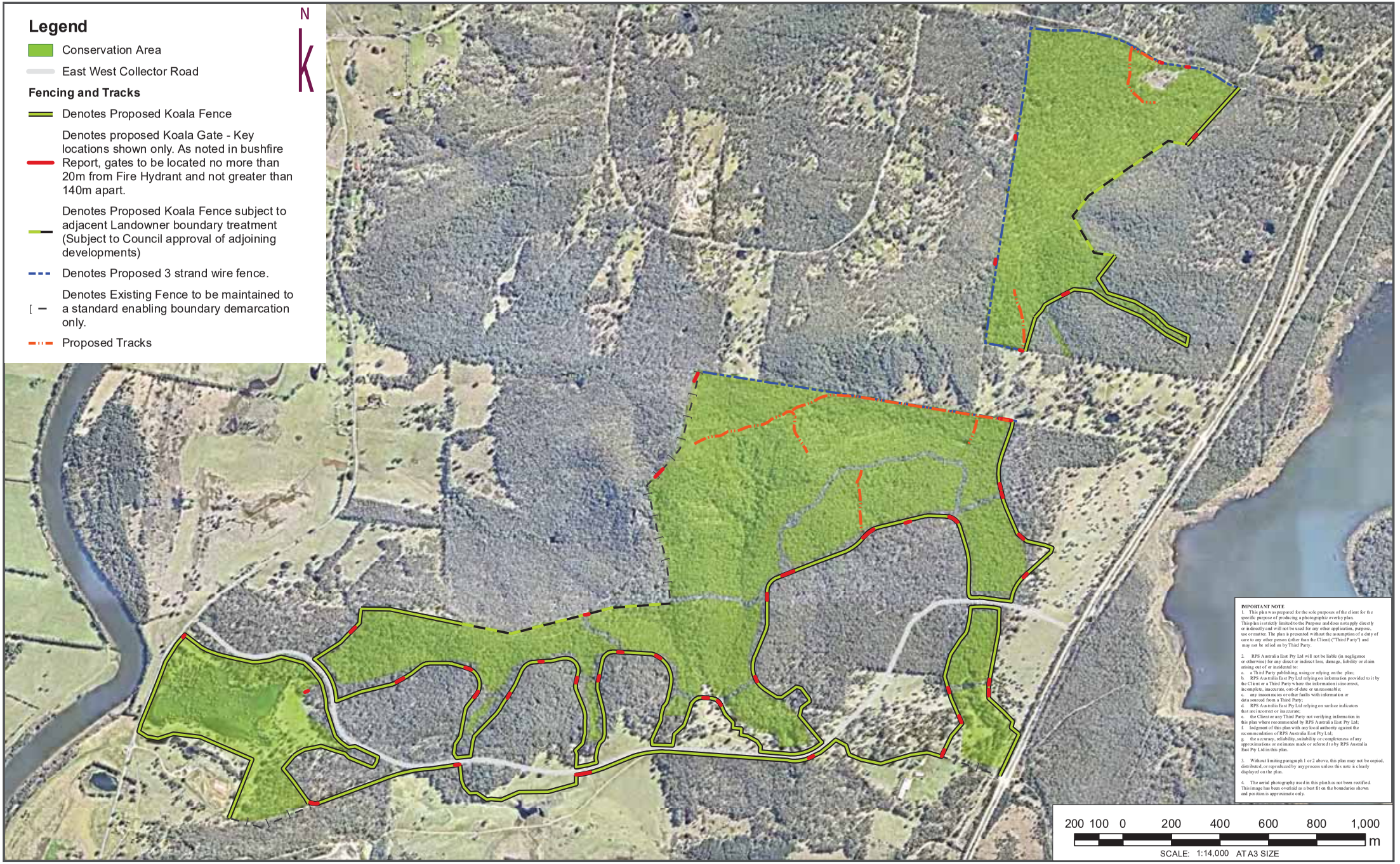
Management Objective	Performance Target	
	Phase 0	Phase 1
• Prevent movement of livestock into Conservation Area • Prevent unauthorised access into Conservation Area	• Locked gates and upgraded fencing to be installed along rural/environment protection – Conservation Area interface	• Koala fence installed along Conservation Area – urban land interface • Gates and fences maintained in functional order

3.2.1.3 Management Actions

The annual works program is to have regard for the proposed management actions outlined in **Table 10** and as shown in **Figure 27**.

Table 10: CMA Proposed Access and Fencing Management Actions

Year	Proposed Management Actions
Phase 0 (yr -2)	Install/ repair all perimeter fencing where adjacent to rural/ environmental protection zoned land Install locked gates as indicated in Figure 19 where coincident with fencing along the rural/ environmental protection zone interface Audit, upgrade, map and register trails to enable site access and management (refer also to Bushfire 3.2.3 below).
Phase 0 (yr -1)	Monitoring and manage fences and gates
Phase 1 (yr +1)	Install koala fence along interface between Conservation Area and urban interface Install gates along koala fence Monitoring and manage fences and gates
Phase 1 (yr +2)	Monitoring and manage fences and gates
Phase 1 (yr +3)	Monitoring and manage fences and gates



TITLE : FIGURE 27: PROPOSED TRACKS AND GATES OF THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **24/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (mark.aitkens)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 27 Proposed Tracks and Fences of the Conservation Area B A3 20200721.mxd

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3.2.1.4 Specification Guidance

3.2.1.4.1 Fencing

Fencing and gates separating the future developed urban area from the Conservation Area is not yet established/ in proper functioning condition. Fencing designed to prevent the movement of Koalas into the urban environment is to be installed during Phase 1 works along the boundary between the Conservation and the future urban interface. This fence is to be designed to prevent the Koala from entering the developed landscape thus manage the risk of domestic animal attack or mortality through vehicle strike or swimming pools. The fence is to include a one way 'koala bridge' to facilitate the movement of Koalas from the development side of the fence into the Conservation Area thus away from the urbanised environment. A description of the fence and bridge is provided as follows, with a description of koala grids also provided for use in certain circumstances.

- Koala fence

Fencing is required to create a barrier between the wildlife habitat within the lands to be retained and managed for conservation purposes and that of the adjoining development precincts. The intent of fencing should be to contain koala movement within the designated environmental lands while at the same time restricting access to the corridor by people and domestic animals. This barrier effect can be achieved by way of a standard floppy-top design typically deployed on road upgrades.

However, a recent review of the efficacy of fencing (in terms of impeding koala movement) that we completed for NSW Roads & Maritime Services (Phillips and Fitzgerald 2014), provided strong *defacto* support for acceptance of a broader range of fence types being recognised as capable of influencing/ impeding koala movement. This knowledge has allowed us to promote less expensive designs that are capable of achieving the same end result. By example (see **Plate 3.1**), the fencing standard used for Ocean Drive Road Corridor Koala Management Framework (Biolink 2014) comprises 1500 - 1800 mm x 50 mm x 50 mm galvanised mesh supported above ground by 60mm galvanised pipe uprights at 3m intervals.

Plate 1 Example of Koala Fence

- Koala bridge

Koala bridges are timber structures that enable koalas to traverse barriers such as fences that function form an obstacle to linear passage. On the Kings Hill site, one-way and two-way koala bridges will be required, the former to enable passive (one-way) egress from vegetated areas that are located within identified development precincts (once fenced), the second to enable two-way movement by koalas both into and out of areas such being managed for environmental purposes.

The design of both instances is the same (**Appendix 1**), the one-way effect created by use of a galvanised metal sleeve 600 – 900 mm wide (upper edge located 1 m off the ground) on the lower end of the bridge on that side of the fence where a reverse crossing is not to be enabled. Koala bridges should be located at ~ 250 m intervals along fenced areas intended to that separate development precincts from areas to be managed for environmental purposes.

- Koala Grids

Koala-grids will be required at all access points into areas that are dedicated to environmental management, including gated areas. The intent of the koala-grid is to enforce the exclusion concept of fencing at locations where vehicular crossings occur or where access is otherwise required for management purposes. Originally designed for purposes of the Skyline Road upgrade undertaken by Lismore City Council in 2004, koala-grids proved 100% effective in restricting access by koalas over the course of a 5-year monitoring program (Biolink 2009). Koala-grids are constructed using 60mm tubular steel pipe at 200 mm centres as a means of restricting access by koalas to an exclusion area.

Figure 1. Koala-grid / fence –end configurations. The grid on the far right reflects recent design modifications initiated by NSW RMS as part of retro-fitting modifications on the Gulgan Road interchanges that afford access to the Pacific Highway between Ewingsdale and Chinderah on the NSW north coast.

3.2.1.4.2 Tracks

The constructed and maintained tracks of each category shall be in accordance the performance criteria (Width, Capacity, Grade, Crossfall, Clearance, Passing, Turnarounds, and Drainage) for each category. The NSW Rural Fire Service Fire Trail Standards - Version 11 (2016) and NSW Rural Fire Service Fire Trail Design, Construction and Maintenance Manual developed by the Soil Conservation Service for the NSW Rural Fire Service are guiding documents for these performance requirements. Trail categories used within the Conservation Area are listed below with a description of these provided in **Table 11**:

- Category 1;
- Category 7;
- Category 9; and
- Dormant.

Standardised signs should be installed and maintained throughout the fire trail network, bridges and water points so that fire assets are easily identified when required for firefighting activities and fire management, including in times of limited visibility. Signs will be required for all fire trails on public land, while signs to be installed on private land will be subject to category of track suitability and landowner agreement.

Table 11: Fire trail Category and Standards

Category	Requirement	Performance	Acceptable Solution
Category 1 Trails	Vehicle specifications	Length 8200 mm, Width 2400 mm, Height 3700 mm (including 600 mm for aerials), Ground clearance 310 mm, Approach angle 35º, Departure angle 25º, Wheelbase 4700 mm, turning circle – wall to wall 22m diameter, Weight 14200kg, Maximum axle loading 9,000kg	
	Width	The width of the trail provides for safe, reliable and unobstructed passage by a Category 1 firefighting vehicle within acceptable operational limits.	The trafficable surface has a width of 4 metres except for short constrictions to 3.5 metres for no more than 30 metres in length where an obstruction cannot be reasonably avoided or removed. Curves have a minimum inner radius of 6 metres. The minimum distance between inner and outer curves is 6 metres.
	Capacity	The construction and formation of the trail is trafficable under all weather conditions (other than due to flood, storm surge or snowfall) for a Category 1 firefighting vehicle.	Trail surfaces and crossing structures are capable of carrying vehicles with a gross vehicle mass of 15 tonnes and an axle load of 9 tonnes.
	Grade and crossfall	The vertical profile of the trail provides for traction and safe working angle within the physical operational capability of a Category 1 firefighting vehicle. *Note: This includes design that does not impede the undercarriage of a vehicle.*	The maximum grade of a trail is not more than 15 degrees. The crossfall of the trail surface is not more than 6 degrees. Drainage structures, feature crossings, or other significant changes in the grade of the trail shall be in accordance with the NSW RFS Fire Trail Design, Construction and Maintenance Manual.
	Clearance	A cleared corridor is provided around the trail which permits the unobstructed passage of a Category 1 firefighting vehicle and for a working corridor either side of the vehicle to enable firefighters to exit from, and access equipment in, the vehicle.	A minimum vertical clearance of 4 metres is provided above the surface of the trafficable surface clear of obstructions.
	Passing	The trail provides for two Category 1 firefighting vehicles to pass at appropriate intervals so as to avoid unacceptable delays in operations.	Capacity for passing is provided every 250 metres comprising: • A widened trafficable surface of at least 6 metres for a length of at least 20 metres; or • A 6 metre-wide and 8 metre-long area clear of the trafficable surface with a minimum inner curve radius of 6 metres and minimum outer radius of 12 metres; or • A turnaround as provided for in this table.
	Turnarounds	The trail provides for a turning manoeuvre for a Category 1 firefighting vehicle to return in the direction from which it came at appropriate intervals and at the termination of a trail.	A turning area is provided at the termination of a trail and every 500 metres and is achieved by: • An area clear of the trafficable surface 6 metres wide and 8 metres deep, with a minimum inner curve radius of 6 metres and outer minimum radius of 12 metres; or • A turning circle of minimum 22 metre diameter.

Category	Requirement	Performance	Acceptable Solution
			• A T-junction with each terminating end of the junction being at least 10 metres in length from the intersection of the roads and the inner radius of that intersection being at least 6 metres • A fire trail or road intersection
	Drainage	The fire trail is drained effectively to manage rainfall runoff to prevent damage to the trafficable surface.	Drainage of the trail is designed and constructed in accordance with the NSW RFS Fire Trail Design, Construction and Maintenance Manual.
Category 7	Vehicle specifications	Length 6200mm, Width 2040mm, Height 3050mm (including 600 mm for aerials), Ground clearance 230mm, Approach angle 35º, Departure angle 30º, Wheelbase 3395mm, turning circle – wall to wall 17m diameter, Weight 7500kg, Maximum axle loading 5600kg.	
	Width	The width of the trail provides for safe, reliable and unobstructed passage by a Category 7 firefighting vehicle within acceptable operational limits.	The trafficable surface has a width of 3.5 metres except for short constrictions to 3 metres for no more than 30 metres in length where an obstruction cannot be reasonably avoided or removed. Curves have a minimum inner radius of 5 metres. The minimum distance between inner and outer curves is 5 metres.
	Capacity	The construction and formation of the trail is trafficable under all weather conditions (other than due to flood, storm surge or snowfall) for a Category 7 firefighting vehicle.	Trail surfaces and crossing structures are capable of carrying vehicles with a gross vehicle mass of 8 tonnes and an axle load of 6 tonnes.
	Grade and crossfall	The vertical profile of the trail provides for traction and safe working angle within the physical operational capability of a Category 7 firefighting vehicle. *Note: This includes design that does not impede the undercarriage of a vehicle.*	The maximum grade of a trail is not more than 15 degrees. The crossfall of the carriageway is not more than 6 degrees. Drainage structures, feature crossings, of other significant changes in the grade of the trail shall be in accordance with the NSW RFS Fire Trail Design, Construction and Maintenance Manual
	Clearance	A cleared corridor is provided around the trail which permits the unobstructed passage of a Category 7 firefighting vehicle and for a working corridor either side of the vehicle to enable firefighters to exit from, and access equipment in, the vehicle.	A minimum vertical clearance of 3.5 metres is provided above the surface of the trafficable surface clear of obstructions.
	Passing	The trail provides for two Category 7 firefighting vehicle to pass at appropriate intervals so as to avoid unacceptable delays in operations.	Capacity for passing bays are provided every 250 metres comprising: • A widened trafficable surface of at least 5.5 metres for a length of at least 15 metres; or, • A 5.5 metre wide and 6 metre long area clear of the trafficable surface with a minimum inner curve radius of 5 metres and minim
	Turnarounds	The trail provides for a turning manoeuvre for a Category 7 firefighting vehicle to return in the direction from which it came at appropriate intervals and at the termination of a trail.	A turning area is provided at the termination of a trail and every 500 metres and is achieved by: • An area clear of the trafficable surface 5.5 metres wide and 6 metres deep, with a minimum inner curve radius of 5 metres and outer minimum radius of 10 metres; or • Turning circle of minimum 17 metre diameter.

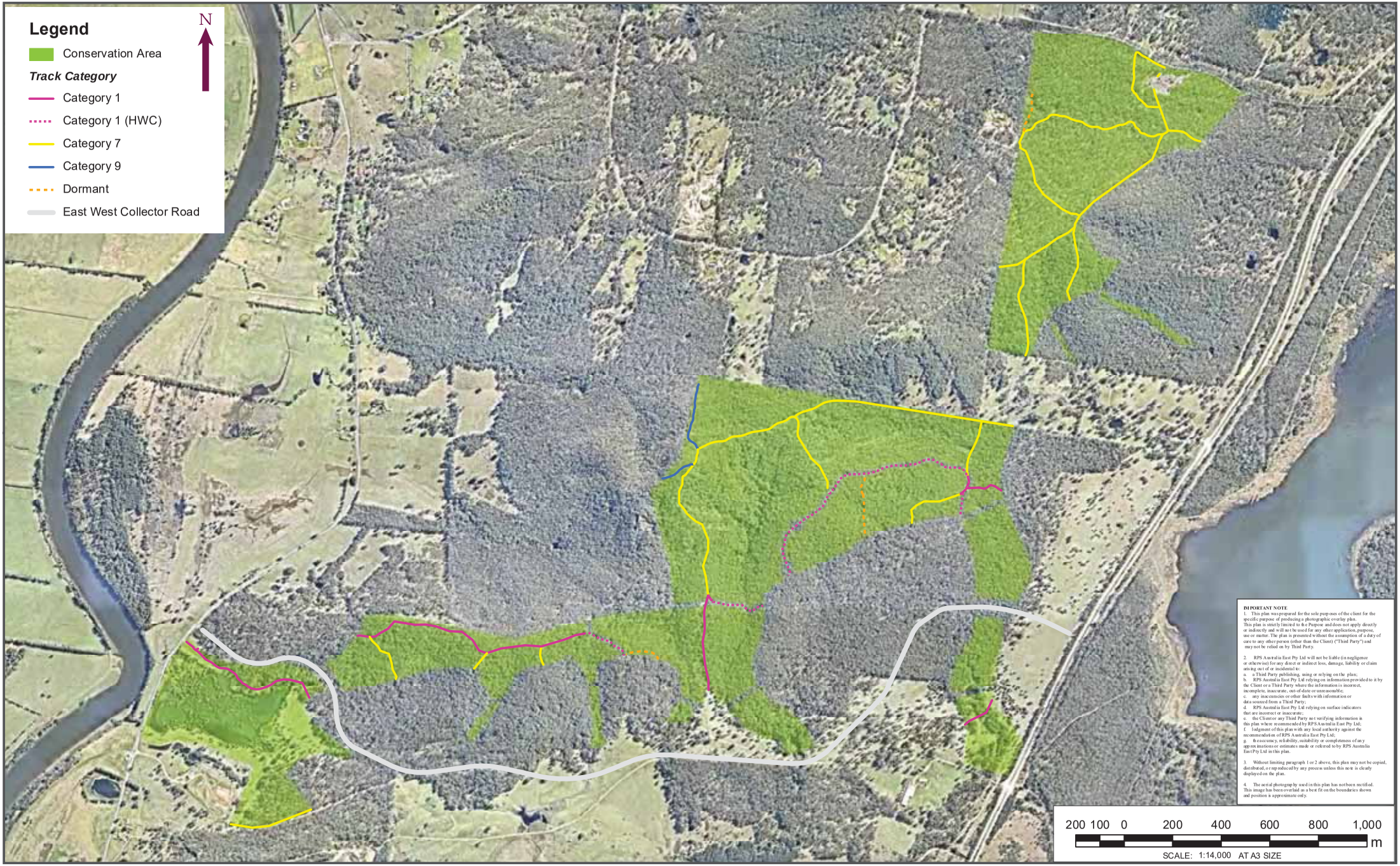
Category	Requirement	Performance	Acceptable Solution
	Drainage	The fire trail is drained effectively to manage rainfall runoff to prevent damage to the trafficable surface.	Drainage of the trail is designed and constructed in accordance with the NSW RFS Fire Trail Design, Construction and Maintenance Manual.
Category 9	Vehicle specifications	Length 5300mm, Width 1750mm, Height 2600 mm (including 600 mm for aerials), Ground clearance 220mm, Approach angle 35º, Departure angle 30º, Wheelbase 3180mm, turning circle – wall to wall 16m diameter, Weight 3700 kg, Maximum axle loading 2000kg	
	Width	The width of the trail provides for safe, reliable and unobstructed passage by a Category 9 firefighting vehicle within acceptable operational limits.	The trafficable surface has a width of 3 metres except for short constrictions to 2.5 metres for no more than 30 metres in length where an obstruction cannot be reasonably avoided or removed. Curves have a minimum inner radius of 5 metres. The minimum distance between inner and outer curves is 5 metres.
	Capacity	The construction and formation of the trail is trafficable under all weather conditions (other than due to flood, storm surge or snowfall) for a Category 9 firefighting vehicle.	Trail surfaces and crossing structures are capable of carrying vehicles with a gross vehicle mass of 4 tonnes and an axle load of 2 tonnes.
	Grade and crossfall	The vertical profile of the trail provides for traction and safe working angle within the physical operational capability of a Category 9 firefighting vehicle. *Note: This includes design that does not impede the undercarriage of a vehicle.*	The maximum grade of a trail is not more than 15 degrees. The crossfall of the trail surface is not more than 6 degrees. Drainage structures, feature crossings, or other significant changes in the grade of the trail shall be in accordance with the NSW RFS Fire Trail Design, Construction and Maintenance Manual.
	Clearance	A cleared corridor is provided around the trail which permits the unobstructed passage of a Category 9 firefighting vehicle and for a working corridor either side of the vehicle to enable firefighters to exit from, an access equipment in, the vehicle.	A minimum vertical clearance of 3 metres is provided above the surface of the trafficable surface clear of obstructions.
	Passing	The trail provides for two Category 9 firefighting vehicles to pass at appropriate intervals so as to avoid unacceptable delays in operations.	Capacity for passing bays are provided every 250 metres comprising: • A widened trafficable surface of at least 5 metres for a length of at least 15 metres; or, • A 5.5 metre-wide and 6 metre-long area clear of the trafficable surface with a minimum inner curve radius of 5 metres and minimum outer radius of 10 metres.
	Turnarounds	The trail provides for a turning manoeuvre for a Category 9 firefighting vehicle to return in the direction from which it came at appropriate intervals and at the termination of a trail.	A turning area is provided at the termination of a trail and every 500 metres and is achieved by: • An area clear of the trafficable surface 5.5 metres wide and 6 metres deep, with a minimum inner curve radius of 5 metres and outer minimum radius of 10 metres; or • Turning circle of minimum 16 metre diameter.
	Drainage	The fire trail is drained effectively to manage rainfall runoff to prevent damage to the trafficable surface	Drainage of the trail is designed and constructed in accordance with the NSW RFS Fire Trail Design, Construction and Maintenance Manual.

Category	Requirement	Performance	Acceptable Solution
Dormant	Vehicle specifications	Dormant fire trails are designated if they don't facilitate a principle land management objective. These trails have no construction standards of management schedules, are allowed to be over-grown and will only be re-opened when needed as control lines for bush fire management operations. Following use, erosion control measures are implemented and allowed to regenerate naturally.	

Specification on grade, surface drainage, outfalls, drainage line and wet swampy area crossing are determined by the soil erodibility /stability class of the landscape. Trail widths. Clearances, passing and turn-around requirements are determined by the category of the trail

An important consideration is the application and placement of bridges, culverts, batter stabilisation, access control infrastructure (gate and fencing) and construction material which is required to ensure long-term stability of the fire trail system.

The application of the trail classification scheme described in **Table 11** to the Conservation Area is shown in **Figure 28**. Allowances to maintain existing tracks without approval and independent of the Proposal and operation of the BMP are provided for under cl. 8(3) of the Vegetation SEPP (see **Section 1.5.6**). Vegetation clearing required for proposed tracks has been allowed for in the SIS (RPS 2020a), with a maximum allowance of 2.4 ha provided for the proposed tracks shown in **Figure 27** noting the applicable classifications represented in **Figure 28**.



TITLE : FIGURE 28: TRACKS CLASSIFICATIONS OF THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): A A3 (Natalie.Wood)

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3.2.2 Feral Fauna Control

3.2.2.1 Overview

Introduced species pose direct and indirect threats to native fauna either through predation or competition. Pests such as the fallow deer (*Dama dama*), European fox (*Vulpes vulpes*) and Wild dog (excluding Dingo) can pose threats to native fauna through excessive predation and competition for grazing and habitat removal. Their management is important for maintaining native fauna populations and encouraging recolonisation of native species into rehabilitated areas.

3.2.2.2 Objectives and Performance Targets

The objectives and performance targets for access management works is provided in **Table 12**.

Table 12: CMA Access and Fencing Objectives and Performance Targets

Management Objective	Performance Target	
	Phase 0	Phase 1
• Eradicate Wild Dog (excl. Dingo) • Maintain low abundance of European Fox • Eradicate Feral Deer	• Reduced abundance of Wild Dog • No evidence of European Fox • Reduced abundance of Feral Deer	• No evidence of Wild Dogs • No evidence of European Fox • No evidence of Feral Deer

3.2.2.3 Management Actions

The annual works program is to have regard for the proposed management actions outlined in **Table 13**.

Table 13: CMA Proposed Feral Fauna Management Actions

Year	Proposed Management Actions
Phase 0 (yr -2)	Perform baiting program for Wild Dogs and European Foxes Cull Feral Deer using appropriate control methods
Phase 0 (yr -1)	Perform baiting program for Wild Dogs and European Foxes Cull Feral Deer using appropriate control methods
Phase 1 (yr +1)	Cull Feral Deer using appropriate control methods
Phase 1 (yr +2)	Perform baiting program for Wild Dogs and European Foxes Cull Feral Deer using appropriate control methods
Phase 1 (yr +3)	Cull Feral Deer using appropriate control methods

3.2.2.4 Specification Guidance

Typical management actions that will be implemented for pest species within the Bush Fire Management Zones (BMZs) include, but are not limited to:

- Inspections by a qualified ecologist to detect pest species diversity and abundance on site using infrared cameras and site inspections;
- Coordinated culling of feral deer in associated with other landowners and Local Land Services;
- Baiting using canid pest injectors to control European fox and wild dog;
- Destruction of rabbit warrens;
- Trapping and removal program for wild dogs and feral cats; and
- Fence maintenance.

3.2.3 Fire

3.2.3.1 Overview

Fire intensity and frequency shapes the natural environment. Frequent fire doesn't allow plants enough time to develop their fire recovery adaptations and may lead to localised species extinctions or a contraction of a plant community extent. Conversely, prolonged inter fire intervals can lead to a dominance of a small suite of longer-lived taxa to the detriment of other plant community species. Fire may also be used to aid in the management of other matters such as high threat weeds and feral fauna.

3.2.3.2 Objectives and Performance Targets

The objectives and performance targets for fire management works is provided in **Table 14**.

Table 14: CMA Fire Management Objectives and Performance Targets

Management Objective	Performance Target	
	Phase 0	Phase 1
• Record and analyse all fire suppression assets on site to inform future bush fire management planning (e.g. tracks and trails)	• Install or maintain fire suppression assets to facilitate proposed fire management activities	• Maintain fire suppression assets
• Establish Bushfire Management Zones (BMZs) consistent with surrounding landscape and bush fire disturbance (burning and mechanical) regimes for identified threatened species	• Compartmentalise the site into Assets Protection Zones (APZ), Strategic Fire Advantage Zones (SFAZ), Fire Exclusion Zones (FEZ) and Land Management Zones (LMZ).	• Install or maintain fire suppression assets to consolidate the BMZs.
• Determine Bush fire Mitigation Measures (BMMs) in accordance with PFBP (2019) that impact on the forested landscape and natural heritage values	• Determine the distances for APZ, landscaping requirements, water provisions, emergency service access arrangements and community shelter/evacuation.	• Complete any work required to support the implementation of BMMs and furnish the development of a Bush fire
• Development of Bush fire Management Plan for the landscape	• Nil	• Provide a document that mitigates the risk of bush fire to life, property and the environment.

3.2.3.3 Management Actions

The annual works program is to have regard for the proposed management actions outlined in **Table 15** and shown in **Figure 28**.

Table 15: CMA Proposed Fire Management Actions

Year	Proposed Management Actions
Phase 0 (yr -2)	Undertake assessment of bush fire suppression assets (trails, roads, water points, trail signage and access gates) and determine suitability for fire management operations. Prepare the planning documentation to undertake prescribed burning in two forestry enrichment planting burn blocks. Undertake installation and maintenance to bush fire suppression assets in preparation of implementing prescribed burns.

Year	Proposed Management Actions
Phase 0 (yr -1)	Undertake ecological prescribed burn in priority areas, implementing cultural and cold burning practises.
Phase 1 (yr +1)	Undertake ecological prescribed burn in priority areas, implementing cultural and cold burning practises.
Phase 1 (yr +2)	Undertake ecological prescribed burn in priority areas, implementing cultural and cold burning practises.
Phase 1 (yr +3)	Development of Bush fire Risk Management Plan to inform the development of a Bush fire Management Plan for ongoing fire management activities.

3.2.3.4 Specification Guidance

Fire management is to be completed in consultation with RFS and have regard for the management objectives stated in this BMP. Prescribing burns for ecological management is to include the consideration of the following factors:

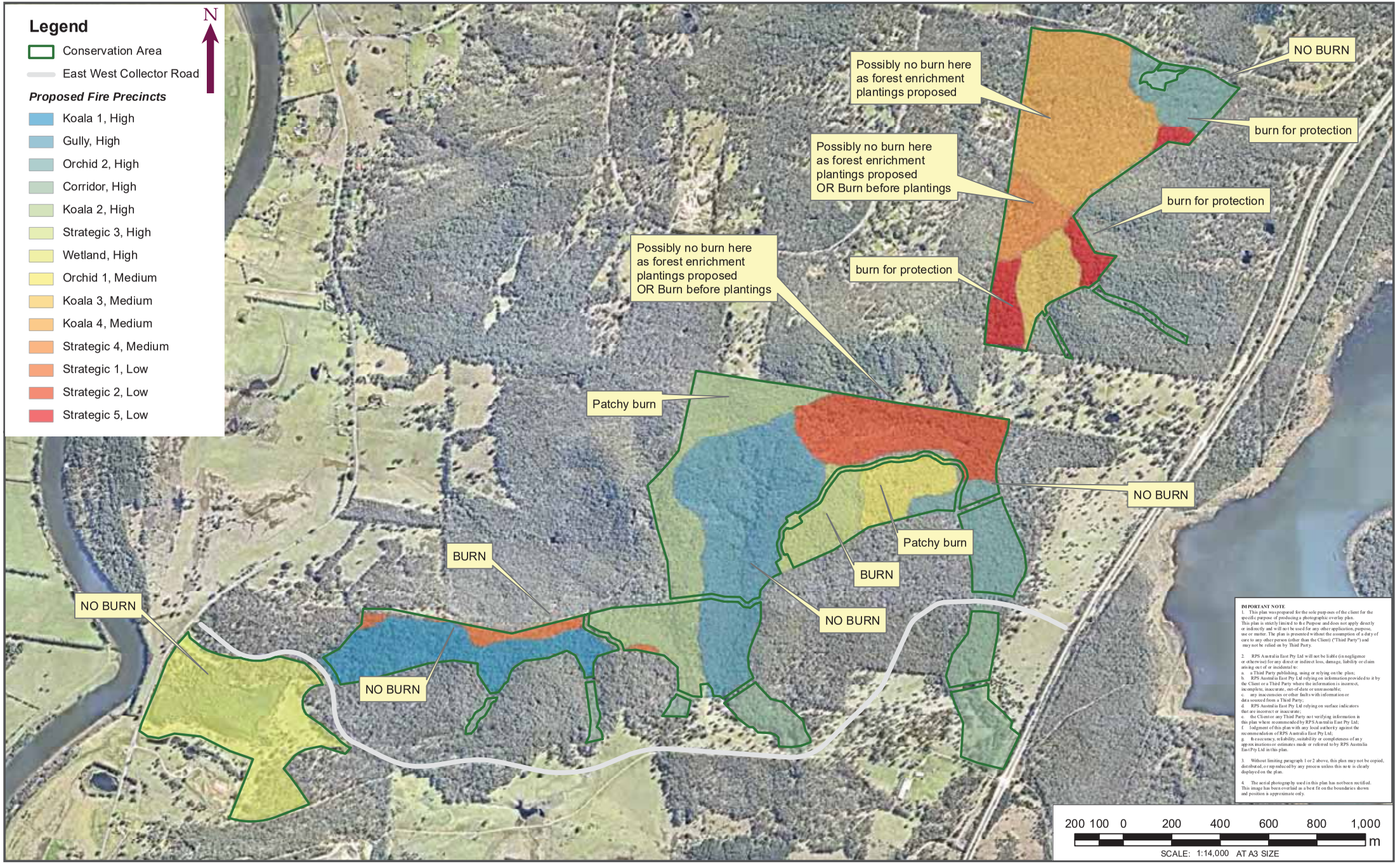
- Protection of revegetation works;
- Protection of Koala feed tree enrichment plantings;
- Protection of Koala fence; and
- Use of appropriate fire intervals to maximise biodiversity values.

In making decisions on fire management it is important for land managers to be aware of the appropriate fire intervals for the specific vegetation types when considering either hazard reduction burns or ecological burns (for biodiversity enhancement). Recommended inter-fire intervals are listed below in **Table 16** for the native vegetation types recorded within the EPAs on the NPWS (2004).

Table 16: Recommended Inter-fire Intervals

PCT Name	Vegetation Formation (NPWS 2004)	Minimum Interval (Years)	Maximum Interval (Years)
783 Coastal freshwater swamps of the Sydney Basin Bioregion	Estuarine and saline wetland	Fire should be avoided	
1525 Sandpaper Fig - Whalebone Tree warm temperate rainforest	Rainforest	Fire should be avoided	
1584 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	Dry sclerophyll shrub /grass forest	5	50
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	Dry sclerophyll shrub forest	7	30
1600 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	Dry sclerophyll shrub /grass forest	5	50
1230 Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	Swamp sclerophyll forest	7	35
1728 Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast	Swamp sclerophyll forest	7	35

Appropriate inter-fire intervals are the time needed between fire events to allow for sustainable vegetation community recovery. A plant's post fire recovery adaptations require time to develop and include reaching a maturity and size that will allow for reproduction to produce adequate seed for 'storage' in soil and/or canopy to survive subsequent fire events, and to have developed sufficient vegetative mass or parts to protect against fire and enable it to resprout after a fire.



TITLE : FIGURE 29: FIRE MANAGEMENT PRECINCTS OF THE CONSERVATION AREA

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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3.3 Biodiversity Management Zones

3.3.1 Overview

Five Biodiversity Management Zones (BMZs) are to be used to provide the targeted delivery of ecological benefit within the Conservation Area through an optimised and coordinated application of biodiversity management actions. BMZs have been delineated through an examination of current biodiversity values known to occur within this Conservation Area as outlined in **Section 2**. BMZ descriptions and management focus are described in **Table 17**.

Table 17: BMZ Descriptions and Management Focus

BMZ	Descriptor	Management Area	Management Focus
1	Habitat Enhancement	128 ha (see **Figure 30**)	Installation of habitat features utilised by threatened fauna (i.e. hollow-bearing tree/ fallen logs) in areas where such features are in limited abundance
2	High Threat Weed Control	158 ha (see **Figure 31**)	Provision of intense control measures for high threat weeds with per cent cover generally > 20%
3	Threatened Flora Protection	85 ha (see **Figure 32**)	Protecting habitat known to comprise a threatened flora species
4	Tree Nutrient Enrichment	143 ha (see **Figure 33**)	Targeting vegetation where the number of preferred koala feed tree species is low and corresponds with low estimates of digestible foliar nitrogen
5	Wetland Protection	32 ha (see **Figure 34**)	Targeting the wetland and proximal lands to deliver maintain or improve outcomes for wetland vegetation and associated threatened species

TITLE : FIGURE 30 : BIODIVERSITY MANAGEMENT ZONE 1 - HABITAT ENHANCEMENT

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

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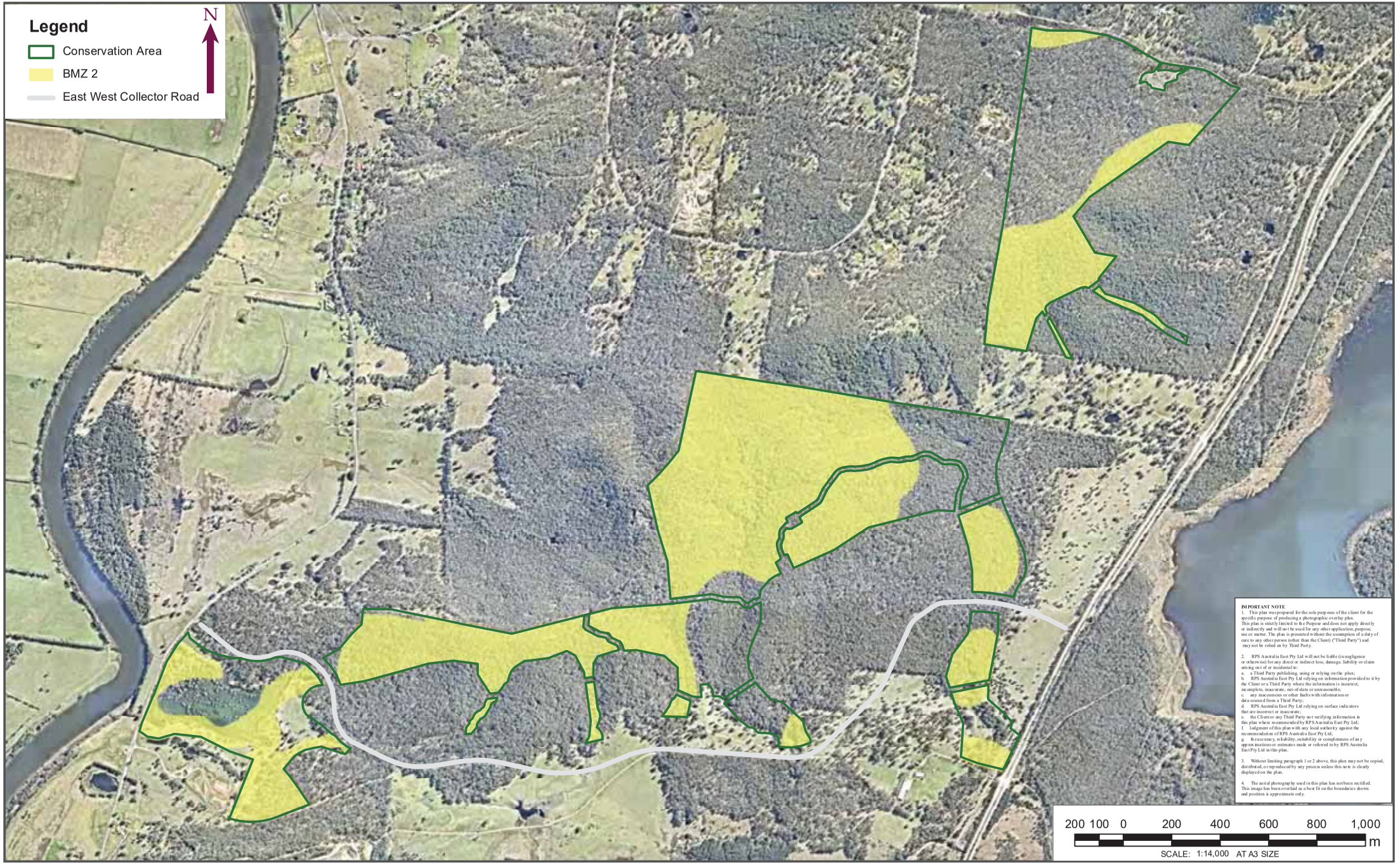

TITLE : FIGURE 31: BIODIVERSITY MANAGEMENT ZONE 2 - HIGH THREAT WEED CONTROL

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

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TITLE : FIGURE 32 : BIODIVERSITY MANAGEMENT ZONE 3 - THREATENED FLORA PROTECTION

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 32 BMZ 3 - Threatened Flora Protection B A3 20200721.mxd

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TITLE : FIGURE 33: BIODIVERSITY MANAGEMENT ZONE 4 - TREE NUTRIENT ENRICHMENT

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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TITLE : FIGURE 34: BIODIVERSITY MANAGEMENT ZONE 5 - WETLAND PROTECTION

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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3.3.2 BMZ 1 – Habitat Enhancement

3.3.2.1 Overview

The loss of hollow-bearing trees and ground habitat (i.e. fallen logs) through site preparation works is to be mitigated by the strategic installation of artificial nest boxes/ salvaged natural hollows and fallen logs within the Conservation Area. Habitat enhancement prescriptions aim to improve the potential for habitat occupancy by fauna dependant on hollow-bearing trees and/ or fallen logs broadly throughout the Conservation Area in advance of impacts arising from site preparation works. These enhancement works are to focus on areas where existing habitat values are substantially below natural levels. Examples of installed salvaged natural hollows and artificial nest boxes is shown in **Plate 1**.

Plate 2 An example of natural salvaged hollows and nest boxes

Preference is for the use of salvaged natural hollows and logs obtained from the development area during Phase 1, with artificial nest boxes and selective thinning practices to be used during Phase 0 in lieu of resource availability (i.e. salvage works cannot commence until Phase 1 of site preparation works).

3.3.2.1.1 Hollows

Hollows of different sizes will be chosen to provide habitat for a range of fauna species, with a preference for small to medium hollows to tailor enhancement works too small to medium sized mammals and passerine birds. For example:

- Large hollows for large forest owls (i.e. hollow opening > 200mm);
- Medium hollows for owls, possums, large birds such as ducks, cockatoos (i.e. hollow opening 100-200mm);
- Small hollows for smaller hollow bearing birds such as parrots, pardalotes etc, gliders (i.e. hollow opening 50-100mm); and

- Tiny hollows/gaps for microbats (i.e. hollow opening < 50mm).

Hollow installation will begin with artificial structures in Phase 0 as harvesting opportunities for natural hollows is yet to be encountered. A mix of artificial and natural hollows are to be installed during Phase 1 with a preference for the installation of natural hollows.

3.3.2.1.2 Logs

Log emplacements have the purpose of enhancing ground layer habitat complexity. It requires the combined consideration of log length and width. Logs of minimum 100mm diameter for its entire length are proposed.

3.3.2.2 Objectives and Performance Targets

The objectives and performance targets for habitat enhancement works is provided in **Table 18**.

Table 18: BMZ 1 Management Objectives and Performance Targets

Management Objective	Performance Target	
	Phase 0	Phase 1
• Hollow-bearing trees > 10 per ha • Fallen log length of > 750 m per ha for areas classed as PCT 1584 • Fallen log length of > 450 m per ha for areas classed as PCT 1590	• Install ~750 artificial hollows • Apply selective thinning methods to emplace fallen logs within areas of poor access. An estimated 1,000 m log length of a total ~3,800 m target is proposed	• Install ~1,000 natural hollows • The balance of the estimated total log length (i.e. 3,800 m) is installed by the end of Phase 1

3.3.2.3 Management Actions

The annual works program is to have regard for the proposed management actions outlined in **Table 19** and shown in **Figure 35**.

Table 19: BMZ 1 Proposed Management Actions

Year	Proposed Management Actions
Phase 0 (yr -2)	Perform hollow-bearing tree and fallen log surveys across the Conservation Area to refine proposed prescriptions for hollow installation works (i.e. location and number of hollow/ log installations) Install ~750 artificial hollows as per guidance shown in **Figure 34**/ relevant approved work program
Phase 0 (yr -1)	Perform pre-clearance surveys for Phase 1 clearing area to identify candidate trees for use in the procurement of natural hollows Monitor installed artificial hollows
Phase 1 (yr +1)	Salvage ~500 natural hollows and prepare for installation works Monitor installed artificial hollows
Phase 1 (yr +2)	Salvage ~500 natural hollows and prepare for installation works Install ~500 natural hollows as per guidance shown in **Figure 34**/ relevant approved work program Monitor installed artificial hollows
Phase 1 (yr +3)	Install ~500 natural hollows as per guidance shown in **Figure 34**/ relevant approved work program Monitor all installed hollows

3.3.2.4 Specification Guidance

3.3.2.4.1 Hollow-bearing Tree Survey

The purpose of the hollow-bearing tree survey for the Conservation Area is as follows:

- Refine (validate) proposed hollow installation prescriptions relative to the management objective; and
- Map all natural hollow occurrences for use in the threatened species monitoring program.

TITLE : FIGURE 35: BIODIVERSITY MANAGEMENT ZONE 1 - PROPOSED MANAGEMENT ACTIONS

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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3.3.2.4.2 Artificial Hollows

Table 20 lists the artificial hollow types suited to the Conservation Area.

Table 20: Artificial Hollow Types

Artificial Hollow Type	Image (La Trobe University)	Target Species
Microbat Box		All tree roosting microbat species
Brushtail Possum Box		Brush-tailed Possum
Ringtail Possum Box		Ringtail Possum
Sugar Glider Box		Sugar Glider Squirrel Glider Brush-tailed Phascogale

Artificial Hollow Type	Image (La Trobe University)	Target Species
Kookaburra Box		
Lorikeet Box (Horizontal)		Little Lorikeet Brown Treecreeper

Nest box design is to have regard for specifications provided in PSC Technical Specification – Nest Boxes (http://www.portstephens.nsw.gov.au/trim/other?RecordNumber=PSC2015-03638%2F014).

3.3.2.4.3 Natural Hollows

Salvageable natural hollows are to be harvested from the impact area during Phase 1 clearing works. The process is to be generally in accordance with the following process:

- Natural hollows are to be identified under the direction of the Project Ecologist and Project Arborist in Phase 0 as part of early pre-clearance works. Candidate trees are to be marked in the field with a tree number and recorded using GPS;
- Pre-clearance surveys and clearance supervision is to be performed under the direction of the Project Ecologist for identified trees. Fauna salvaged from these works are to be processed in accordance with procedure outlined in Appendix A.
- Salvaged hollows will be inspected by the Project Ecologist and Project Arborist for suitability. Selected hollows are to be cut to size, sealed on the base and preserved with linseed oil and stored for installation works;
- Offcuts and hollow logs will also be preserved for ground logs; and
- Hollows will be attached to trees under the direction of the Project Ecologist and Project Arborist.

3.3.2.4.4 Fallen Logs

The total sawn log length is to be installed within the Conservation Area during Phase 1 works with an annual target of 1,000 m assuming ~1,000 m of log length is installed through selective thinning practices in Phase 0. Fallen logs will be identified and prepared by the Project Forester. The specifications for these logs are as follows:

- Minimum 100 mm diameter for the entire log length; and
- Minimum 1 m cut lengths with average log length being 2 – 5 m; and
- Logs are to be placed mainly within BMZ 1 under the guidance of the Project Ecologist.

3.3.2.4.5 Installation

Natural/ artificial hollows are to be installed with reference to the PSC Technical Specification – Nest Boxes (http://www.portstephens.nsw.gov.au/trim/other?RecordNumber=PSC2015-03638%2F014), which has had particular reference to the NSW Government 2011, "Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects - Guide 8: Nest boxes", prepared by the Roads and Traffic Authority, September 2011 and NSW Government 2008, "Guidelines for the design, construction and placement of nestboxes", prepared by the Department of Environment, Climate Change and Water, Biodiversity Conservation Section. procedure outlined in **Table 21**.

Table 21: Hollow Installation Guidance

Action	Timing	Responsibility
Request installation of nest/roost boxes at least one month before the commencement of clearing operations	One month prior to installation	Project Conservation Manager
Identify tree location, hollow type and orientation (i.e. avoid hot afternoon sun and the predominant aspects of severe storms) for installation. Supply details to Project Arborist	Two weeks prior to installation	Project Ecologist
Install hollows having regard for height (i.e. 4 to 6 m from ground level) and method (habisure system)	Installation	Project Arborist
Submit a completion report to the Project Conservation Manager for each nest/roost box detailing: • Type of hollow • Identification number • GPS location (using coordinate system MGA 94) • Tree species and diameter at breast height (DBH) • Height • Orientation	Within 30 days of installation	Project Arborist Project Ecologist

3.3.3 BMZ 2 – High Threat Weed Control

The removal of all weeds from the Conservation Area is the desired outcome; however, there are limitations regarding the extent to which this can be achieved. A realistic approach consistent with the objectives for these species established under the Biosecurity Act involves controlling and suppressing weed species, thus providing a better opportunity for native flora to germinate, grow and establish dominance.

Areas of dense weeds, specifically Lantana, African Olive and other noxious weeds will be targeted during VMP actions; however, these efforts will need ongoing inspections and maintenance as prolific and noxious weeds are difficult to control. Weed maintenance will also continue to extend into uncleared areas of development (i.e. Phase 2 and 3) to a 100m buffer, to improve the efficacy of weed management in the short term (i.e. minimise the potential for recolonisation from unmanaged sources).

3.3.3.1 Objectives and Performance Targets

The objectives and performance targets for the management of high threat weeds is provided in **Table 22**.

Table 22: BMZ 2 Management Objectives and Performance Targets

Management Objectives	Performance Target	
	End of Phase 0	End of Phase 1
• Keep weed levels at <5% • Utilise fire to aid in weed management	• High threat weed cover is < 20% • Stimulate weed propagules through the use of fire	• High threat weed cover is < 5% • High threat weed seed bank reduced through selective use of fire

3.3.3.2 Management Actions

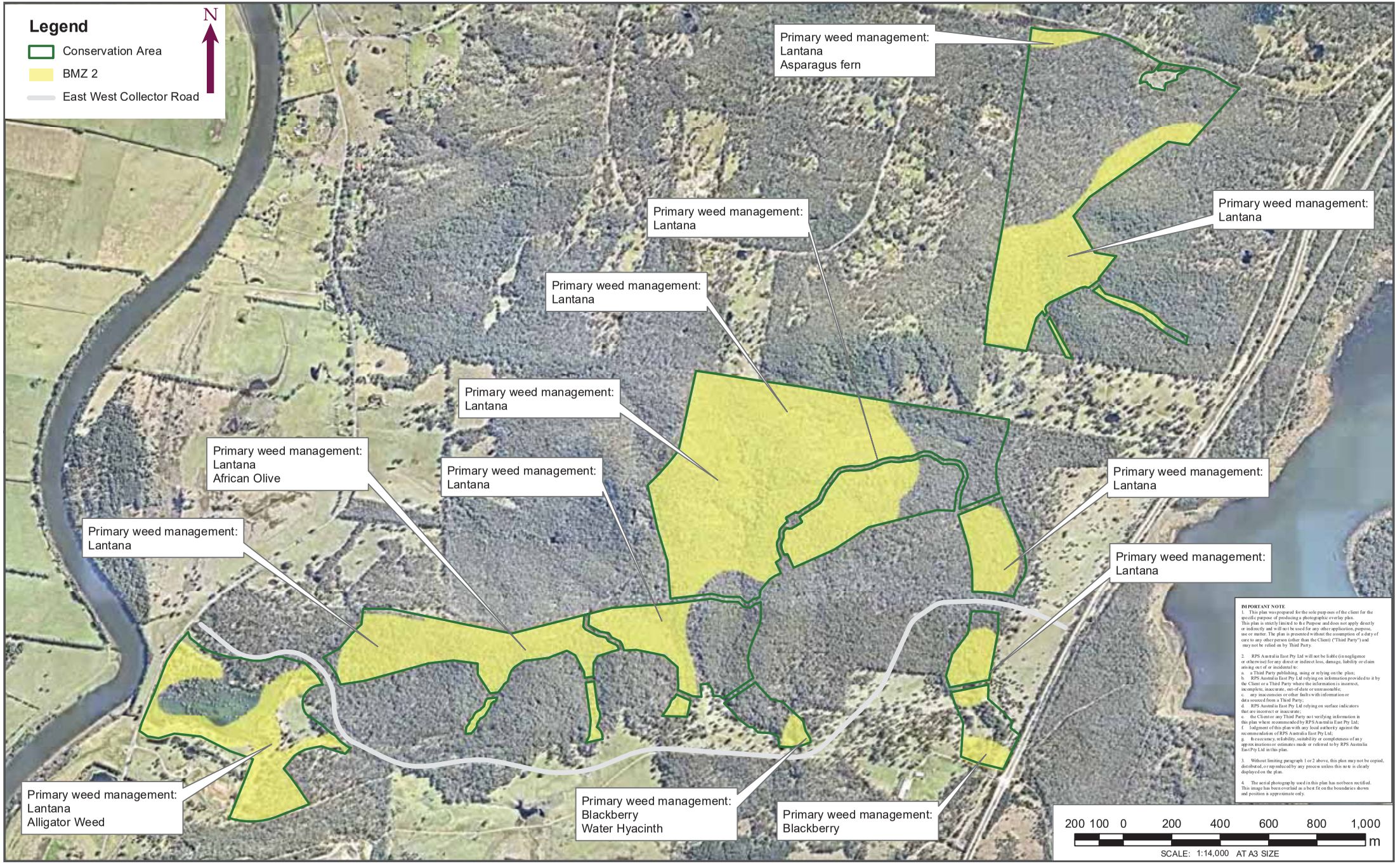
The annual works program is to have regard for the proposed management actions outlined in **Table 23** and shown in **Figure 36**.

Table 23: BMZ 2 Proposed Management Actions

Year	Proposed Management Actions
Phase 0 (yr -2)	Primary weed management in areas with > 10% weed cover Secondary weed management in areas with <10% weed cover
Phase 0 (yr -1)	Primary weed management in areas with > 10% weed cover Secondary weed management in areas with <10% weed cover Targeted use of fire to stimulate weed seed bank
Phase 1 (yr +1)	Secondary weed management Targeted primary weed management in response to monitoring results
Phase 1 (yr +2)	Secondary weed management Targeted primary weed management in response to monitoring results
Phase 1 (yr +3)	Secondary weed management Targeted primary weed management in response to monitoring results

3.3.3.3 Specification Guidance

The VMP target is set at <5% total weed cover by the completion of works. The BMP proposes to maintain this value and pursue the complete removal of weeds from the BMZs. However, as the removal of all weeds is difficult, and not likely an achievable outcome, the target for ongoing management of the site is the maintenance of <5% cover.



TITLE : FIGURE 36: BIODIVERSITY MANAGEMENT ZONE 2 - PROPOSED MANAGEMENT ACTIONS

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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Weed management actions will include a combination of the following control methods:

- Herbicide;
- Manual Removal; and
- Fire.

General guidance on these control methods is provided in the following sections. Further details can be found in the VMP.

3.3.3.3.1 Herbicide

Herbicide is considered appropriate for larger weed species and areas of large infestation containing few natives. Bio-active Glyphosate is a non-residual, broad-spectrum systemic herbicide and it is still considered to be the most effective chemical control for most applications. Glyphosate is especially useful for larger weed species in areas of homogenous infestations containing few natives such as Lantana thickets. The application of herbicides for weeding purposes should only be applied by qualified personnel and should be kept to a minimum. Caution must be used when applying herbicides around waterways and environmentally sensitive areas. Where chemical usage is unavoidable environmentally friendly herbicides shall be utilised (i.e. use Bio-active Glyphosate as opposed to straight Glyphosate as this does not Bio-accumulate in aquatic species).

3.3.3.3.2 Manual Removal

In sensitive environments such as heavily forested areas, threatened ecological communities and in sparse weed infestations manual removal of herbaceous weeds, regrowth and seedlings is the preferred method of weed management. If intensive weeding is required, the soil should be stabilised or planted out with native seedlings by the end of each working day. Fire may also be used to assist in the initial suppression of weeds by removing vegetative cover and improving access to follow-up treatment applications.

Disposal of removed weed matter is particularly important and offsite disposal or destruction at a suitable facility is essential. An offsite disposal location will be nominated prior to commencement of weeding on site. Weed removal works will be undertaken outside the seeding period of the target weeds, particularly weeds which produce large qualities of seed. Generally, the most effective time for undertaking weed management activates is during spring when majority of weed species are undertaking new growth and flowering. Where weeding must be undertaken within seeding periods, seed will be collected, bagged and destroyed offsite, ensuring that no seed remains on site.

Follow up weed removal must be undertaken at regular intervals to reduce recolonization of weeds from the seed bank.

3.3.3.3.3 Fire

An integrated weed management program may consider the use of cool burn as a management aid in the suppression of landscape scale weed infestations. The use of cool burns or traditional Aboriginal burning may be used to improve access to weed infested areas, which in turn can be used to improve the effectiveness of targeted suppression methods. Fire can also be used to stimulate the weed seed bank to hasten the reduction of propagules while simultaneously aiding native species with fire dependency.

The use of fire would be performed judiciously and in consultation with the NSW Rural Fire Service and relevant Local Aboriginal Land Council. Refer to **Section 3.1.4** for further details.

3.3.3.3.4 Unplanned Weed Management Response

Ongoing suppression is the most pragmatic approach for managing weeds following implementation of primary weed management actions. Guidance for determining a weed management response is outlined in **Table 24**.

Table 24: Unplanned Weed Management Response Framework

Performance Targets	Measure (% cover)	Management Response
Within target	<5%	• No specific management response other than ongoing ad hoc suppression works • Continue monitoring activities
Approaching target	5 to 10%	• Perform targeted secondary weed management practices • Investigate to identify possible causation for weed increases and refine • management practices to match need • Monitor effectiveness of suppression activities in addition to normal monitoring works
Outside acceptable weed cover	>10%	• Map weed occurrence and percent cover as a baseline • Perform targeted primary and widespread secondary weed management practices • Investigate to identify possible causation for weed increases and refine management practices to match need • Monitor effectiveness of suppression activities in addition to normal monitoring works. Consider revisions to monitoring design to reflect any change in weed distributions and/ or density

3.3.4 BMZ 3 – Threatened Flora Protection

3.3.4.1 Overview

Three threatened flora species occur within the Conservation Area. The main threats to these occurrences include the potential for displacement through rubbish dumping/ weed invasion, alteration of hydrological regimes and impacts from fire.

3.3.4.2 Objectives and Performance Targets

The objectives and performance targets for the management of threatened flora is provided in **Table 25**.

Table 25: BMZ 3 Management Objectives and Performance Targets

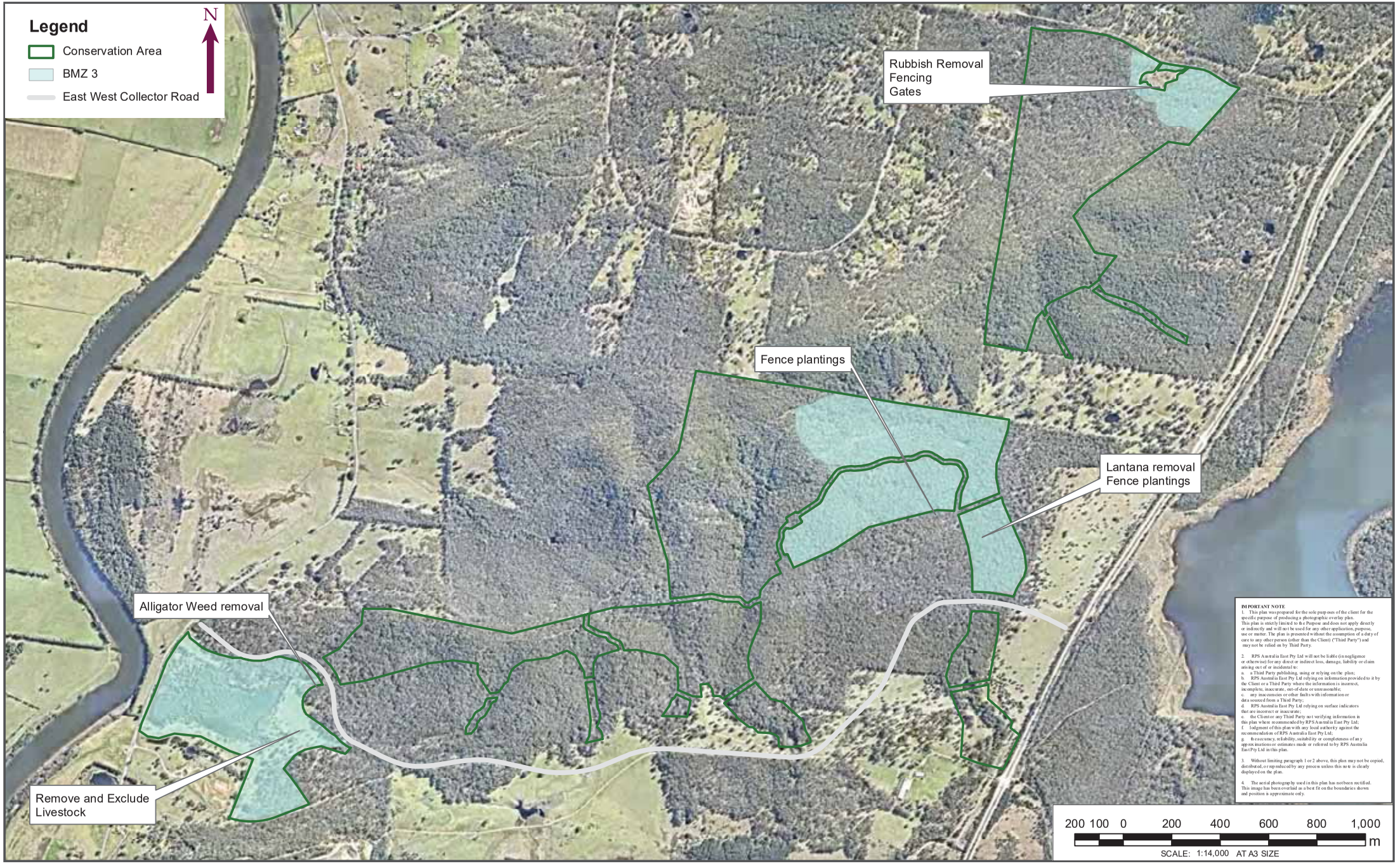
Management Objective	Performance Target	
	Phase 0	Phase 1
• Prevent habitat loss from livestock grazing, feral deer herbivory, rubbish dumping, weed invasion and altered hydrology • Improve habitat for population increase	• Fencing and gates successfully prevent rubbish dumping • Alligator Weed incidence is reduced to 10% or less where occurring with *Maundia triglochinoides* • Weed management successfully implemented to prevent loss from habitat displacement • Habitat constructed in cleared parts of the Wetland BMZ for *Maundia triglochinoides*	• Fencing and gates successfully prevent rubbish dumping • Alligator Weed is removed from areas where *Maundia triglochinoides* occurs • Weed management successfully implemented to prevent loss • Evidence of *Maundia triglochinoides* in constructed habitat • Plantings of Melaleuca nodosa along fence lines adjacent to *Corybas dowlingii*

3.3.4.3 Management Actions

The annual works program is to have regard for the proposed management actions outlined in **Table 26** and shown in **Figure 37**.

Table 26: BMZ 3 Proposed Management Actions

Year	Proposed Management Actions
Phase 0 (yr -2)	Remove Alligator Weed from *Maundia triglochinoides* habitat area Use sensitive weed management practices in close proximity to threatened plant populations (i.e. hand weeding and careful use of chemical methods) Integrate ecology of threatened species into fire management prescriptions Construction of habitat area for *Maundia triglochinoides* within wetland BMZ Remove rubbish from quarry area, fence and gate this area
Phase 0 (yr -1)	Remove Alligator Weed from *Maundia triglochinoides* habitat area Use sensitive weed management practices in close proximity to threatened plant populations (i.e. hand weeding and careful use of chemical methods) Plant Melaleuca nodosa along the fence line adjacent to *Corybas dowlingii* for micro climate management
Phase 1 (yr +1)	Use sensitive weed management practices in close proximity to threatened plant populations (i.e. hand weeding and careful use of chemical methods)
Phase 1 (yr +2)	Use sensitive weed management practices in close proximity to threatened plant populations (i.e. hand weeding and careful use of chemical methods)
Phase 1 (yr +3)	Use sensitive weed management practices in close proximity to threatened plant populations (i.e. hand weeding and careful use of chemical methods) Evidence of *Maundia triglochinoides* within constructed habitat



TITLE : FIGURE 37: BIODIVERSITY MANAGEMENT ZONE 3 - PROPOSED MANAGEMENT ACTIONS

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

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3.3.5 BMZ 4 – Tree Nutrient Enrichment

3.3.5.1 Overview

Habitat loss is one of the main threats to koala populations. Revegetation is universally recognised as a key management strategy to mitigate impacts of habitat loss by improving areas of potential habitat and creating wildlife corridors that link isolated populations. Unfortunately, the nutritional quality of existing and replanted trees has been largely overlooked in koala conservation efforts. There is a real risk that revegetation projects that do not consider forage quality might not provide the key nutritional elements that support viable populations of eucalypt folivores, and therefore, mitigation goals will go unrealised.

The enrichment plantings will use existing site-level forage quality information to identify high-quality trees to source seed for revegetation. Seedlings grown from selected trees will form the foundations for the revegetation and enrichment works proposed in the Conservation Area.

3.3.5.2 Objectives and Performance Targets

The objectives and performance targets for the tree nutrient enrichment is provided in **Table 27**.

Table 27: BMZ 4 Management Objectives and Performance Targets

Management Objective	Performance Target	
	Phase 0	Phase 1
• Establish high value Preferred Koala Feed Tree Species • Increase habitat carrying capacity for the Koala	• Establish 10,400 high nutrient value trees within the management area	• Evidence of Koala activity in areas with low or no recorded activity

3.3.5.3 Management Actions

The annual works program is to have regard for the proposed management actions outlined in **Table 28** and shown in **Figure 38**.

Table 28: BMZ 4 Proposed Management Actions

Year	Proposed Management Actions
Phase 0 (yr -2)	Obtain local provenance seed from identified Forest Redgum, Tallowwood, Grey Gum and Grey Box Grow ~6,000 trees in standard forestry tubes Plant in northern enrichment area Maintain and monitor plantings Perform selective thinning areas in southern enrichment area and prepare for planting in following year Implement a cool burn in the southern enrichment area where possible
Phase 0 (yr -1)	Grow ~6,000 trees in standard forestry tubes Plant in southern enrichment area Maintain and monitor plantings
Phase 1 (yr +1)	Maintain and monitor plantings
Phase 1 (yr +2)	Maintain and monitor plantings
Phase 1 (yr +3)	Maintain and monitor plantings

TITLE : FIGURE 38: BIODIVERSITY MANAGEMENT ZONE 4 - PROPOSED MANAGEMENT ACTIONS

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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3.3.5.4 Specification Guidance

Important factors to be adhered to in performing enrichment plants are listed below:

- Use of local provenance seed from trees with high measured foliage nutrient value and low PSMs levels (Ford and Youngentob 2019). Species to be used include Forest Redgum, Grey Gum, Grey Box or Tallowwood;
- Preferential use of Forest Redgum wherever possible, with use of Grey Gum and Grey Box in drier areas mapped as PCT 1590 and Tallowwood in wetter areas mapped as PCT 1584;
- Use appropriate establishment and management measures to maximise revegetation success; and
- Use of appropriately timed thinning practices to maintain high biomass production in the tree crown (i.e. preventing adverse impacts from conspecific competition).

Refer to **Section 3.3.6.4.3** for further guidance on plantings specifications.

3.3.6 BMZ 5 – Wetland Protection

3.3.6.1 Overview

Wetland 803 comprises habitat for wader bird species including migratory species, with the currently treeless periphery utilised for livestock grazing, which is likely to have had an adverse impact on threatened species.

3.3.6.2 Objectives and Performance Targets

The objectives and performance targets for the management of high threat weeds is provided in **Table 29**.

Table 29: BMZ 5 Management Objectives and Performance Targets

Management Objective	Performance Target	
	Phase 0	Phase 1
• Remove livestock • Increase habitat area for *Maundia triglochinoides* • Plant high value PKFTs • Install nest poles for White-bellied Sea Eagle to encourage additional nesting sites	• Livestock removed from area • Prepare habitat suitable for *Maundia triglochinoides* • Revegetate treeless lands surrounding the wetland with preferred Koala feed Tree species • Three White-bellied Sea Eagle nest poles installed	• Natural regeneration in previously grazed areas • Evidence of *Maundia triglochinoides* within constructed habitat • Evidence of Koala activity in revegetated area

3.3.6.3 Management Actions

The annual works program is to have regard for the proposed management actions outlined in **Table 30** and shown in **Figure 39**.

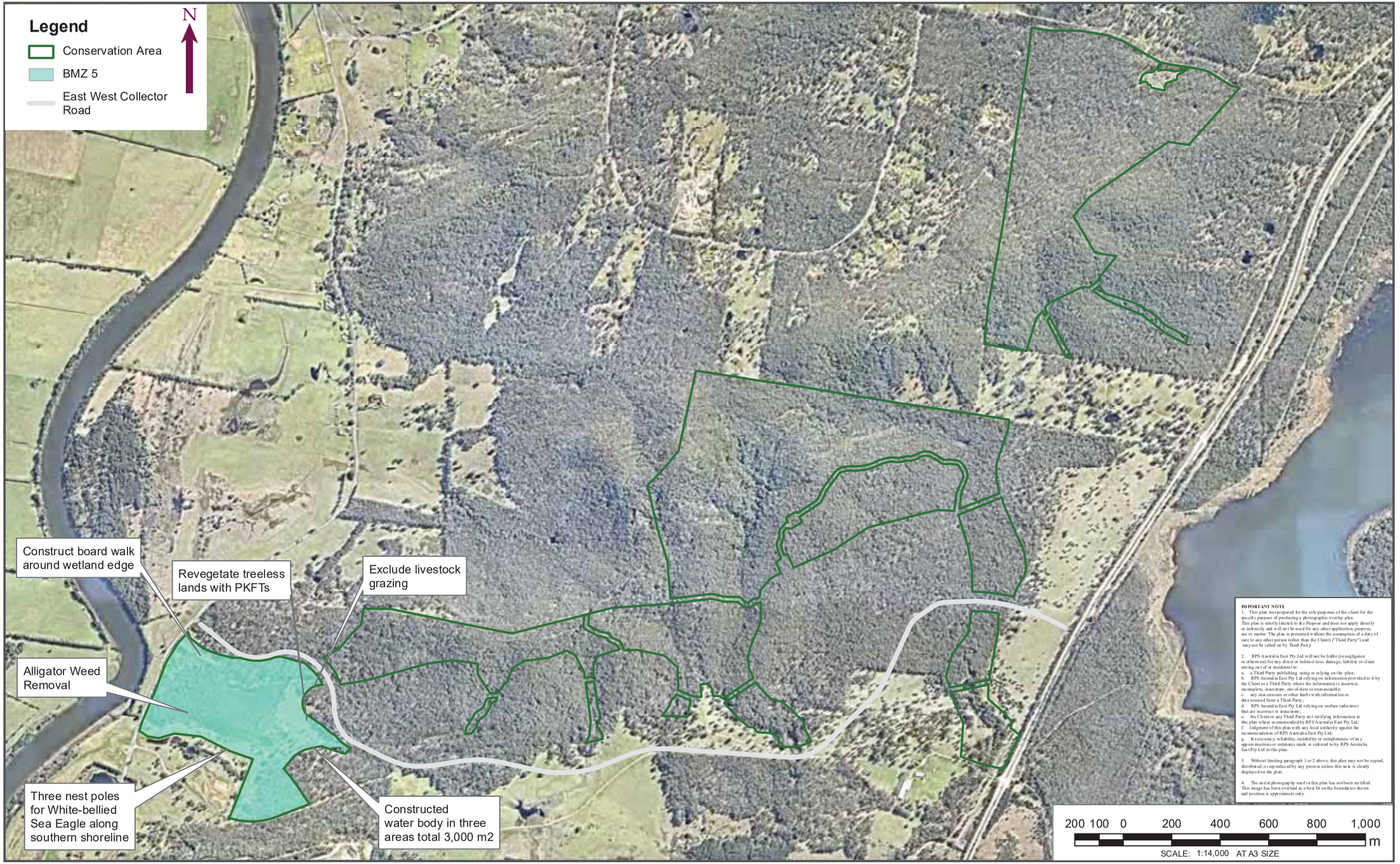
Table 30: BMZ 5 Proposed Management Actions

Year	Proposed Management Actions
Phase 0 (yr -2)	Construct ~ 3,000m^2 of habitat suitable for occupancy by *Maundia triglochinoides* Install three artificial nest poles for the White-bellied Sea Eagle Revegetate treeless lands with PKFTs Remove all livestock
Phase 0 (yr -1)	Manage revegetation area to maintain outcome Exclude all livestock
Phase 1 (yr +1)	Install fallen logs where possible Exclude all livestock
Phase 1 (yr +2)	Install fallen logs where possible Exclude all livestock
Phase 1 (yr +3)	Install fallen logs where possible Exclude all livestock

3.3.6.4 Specification Guidance

3.3.6.4.1 *Maundia triglochinoides* habitat

Constructed habitat is proposed outside the mapped boundary of Irrawang Swamp comprising a combined area of 3,000m^2 in three separate, but linked, ~1,000 m^2 closed depressions of 30-60cm depth located in line and below current incidences. The constructed habitat is to act like a chain of ponds thereby allowing propagules from the source occupied habitat area to be invaded and also to provide an opportunity for the early identification of invasive water plants and their control prior to entry into Irrawang Wetland.



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TITLE : FIGURE 39: BIODIVERSITY MANAGEMENT ZONE 5 - PROPOSED MANAGEMENT ACTIONS

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

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3.3.6.4.2 White-bellied Sea Eagle Habitat

Three poles of 20m + height is to be installed on the southern edge of Irrawang Wetland. The poles are to be of telephone/ electricity standard for permanency. A platform of 2X2m is to be placed at the top of the pole suitable for occupation by nesting birds.

3.3.6.4.3 Revegetation with PKFTs

The revegetation prescription is to generally follow the principles outlined in *Silvicultural guidelines: Private Native Forestry Code of Practice* (DECC 2007), bearing in mind that the key revegetation objective is the rapid establishment of a tree canopy for foliage biomass production. Important guidance is listed below:

- Preferential use of direct seeding in treeless areas to encourage natural species patterns;
- Planting rate of 1,100 stems per hectare (forestry tubes) where direct seeding is less suitable;
- Preferential use of Swamp Mahogany in landscapes supportive of 'Swamp Sclerophyll Forests';
- Preferential use of Forest Redgum and Tallowwood adjoining/ fringing 'Swamp Sclerophyll Forests';
- Preferential use of Forest Redgum, Tallowwood and Grey Gum in drier terrestrial areas;
- Use of local provenance seed from trees with high measured foliage nutrient value and low PSMs levels (Ford and Youngentob 2019);
- Use appropriate establishment and management measures to maximise revegetation success; and
- Use of appropriately timed thinning practices to maintain high biomass production in the tree crown (i.e. preventing adverse impacts from conspecific competition).

Plant Species and densities

Plant species recommended for use in the wetland plantings are listed in **Table 31**.

Table 31: Plant Species and Densities for Revegetation works in BMZ 5

Plant species	BMZ 5 subzone a	BMZ 5 subzone b	Density
Eucalyptus microcorys (Tallowwood)	X	X	1,100 per hectare (tube or seed)
Eucalyptus punctata (Grey Gum)	X	X	1,100 per hectare (tube or seed)
Eucalyptus robusta (Swamp mahogany)	X	X	1,100 per hectare (tube or seed)
Eucalyptus tereticornis (Forest Redgum)	X	X	1,100 per hectare (tube or seed)
Melaleuca quinquenervia (Broad-leaved Paperbark)	X		Every 2-5 m around the wetland
Shrubs			
Breynia oblongifolia	-	X	Tube stock 100 per hectare
Acacia irrorata	-	X	Tube stock 100 per hectare
Melaleuca linariifolia	X	-	Tube stock 50 per hectare
Glochidion ferdinandi	X	-	Tube stock 50 per hectare
Groundcover			
Dichondra repens	-	X	Tube stock 100 per hectare
Lomandra filiformis	-	X	Tube stock 100 per hectare
Cymbopogon refractus	-	X	Seed
Microlaena stipoides	X	X	Seed
Echinopogon caespitosus	X	X	Seed
Gahnia aspera	X	-	Seed
Oplismenus aemulus	X	-	Seed

Revegetation parameters

Important revegetation prescription parameters are listed below:

- Preferential use of direct seeding in treeless areas to encourage natural species patterns;
- Planting rate as specified in **Table 31**;
- Preferential use of Swamp Mahogany in landscapes supportive of 'Swamp Sclerophyll Forests' (i.e. BMZ 5a);
- Preferential use of Forest Redgum and Tallowwood in areas directly adjoining/ fringing 'Swamp Sclerophyll Forests' (i.e. boundary between BMZ 5a and b);
- Preferential use of Forest Redgum, Tallowwood and Grey Gum in drier terrestrial areas (i.e. BMZ 5b);
- Use of local provenance seed from trees with high measured foliage nutrient value and low plant secondary metabolites;
- Implement appropriate establishment and management measures to maximise revegetation success; and
- Use of appropriately timed thinning practices to maintain high biomass production in the tree crown (i.e. preventing adverse impacts from conspecific competition).

Plant Stock

Existing site-level forage quality information collected at Kings Hill (RPS 2020b) will be used to identify high-quality trees to source seed for revegetation. Seedlings grown from selected trees will form the foundations for the revegetation works proposed within BMZ 5.

Timing

Re-planting will be undertaken by a suitably experienced contractor who will be able to assess the site and develop a site-specific approach. The planting of additional vegetation will increase the coverage of the tree, and shrub layers within existing stands, enriching koala foraging and breeding habitat, and enhancing existing vegetation community structure to increase the resilience of the PCT as a whole. Where possible planting should occur in the cooler months (April to September) to allow for plants to become acclimatised to the site before drier conditions occur over summer.

Establishment

The most important factors for plant establishment are:

- The surrounding soil is moist at the time of planting. Mulch is a safe and effective way of ameliorating soil conditions. It helps control soil water loss, soil temperature fluctuations and weed invasion (Buchanan 1989);
- All plants are protected by bags (plastic sleeves) and bamboo stakes;
- Plants actively growing at the time of planting;
- Sufficient rain occurs and / or watering is provided in the following months; and
- The plants are free of weed competition. Weeds around planted vegetation shall be controlled during regular associated maintenance works.

Mulching will only be used if required in VMZ 5 primarily to act as a weed suppressant. It is not desirable to use mulch in areas where natural regeneration can occur as it will prevent native seedlings from regenerating. If mulching is required, weed free leaf and woodchip mulch will be used at the discretion of the regeneration contractor following site civil works and establishment / preparation.

All mulch shall be free of contaminants such as seeds and propagules of weeds. Avoid the use of pine mulch as the acidity level is not suitable for the native vegetation being used. Mulch will be established to a minimum depth of 75 mm prior to planting. Mulch has been shown to increase the survival rate of plants in

soils with poor water holding ability (including the sandy soil that occurs on the site) however mulching will limit the likelihood of natural regeneration. It is recommended that once tube stock become established that mulching ceases to encourage seed germination of native plants. Where possible mulch should be sourced from local landscape centres

Fertilisers

Fertilisers are not to be used.

Tree Guards

In all parts of the site, tree protection measures for existing trees shall be implemented in accordance with Australian Standards 4970-2009 ‘Protection Of Trees On Development Sites’ before the commencement of site works, including driveways and services, filling, excavation or regrading. To aid in the protection of existing trees, at no time will there be stockpiling, storage, disposal or mixing of materials/liquids, parking of vehicles or machinery or positioning of sheds or offices within the drip lines of trees on site.

4 MONITORING AND ANALYSIS

4.1 Overview

The Project Ecologist is to perform routine monitoring and inspection work to measure the performance of the BMP over the initial 5 years (see monitoring frequency in **Table 32**). The Project Ecologist will be responsible for:

- Auditing the annual management prescriptions as approved by Council in the corresponding annual works program;
- Obtain monitoring data for comparison against baseline conditions to evaluate the efficacy of management actions;
- Prepare an annual works program following review of monitoring data and the estimated management prescriptions outlined in this BMP; and
- Prepare an annual report outlining the audit/ monitoring results and proposed annual works program for review and approval by Port Stephens Council.

The first monitoring report is to provide baseline dataset (**Section 4.3**) using the monitoring framework (**Section 4.2**) for future reference/ comparison against objectives and performance targets specified in **Sections 3.2** and **3.3**. This report is also to provide a clear Annual Works Program for Council approval (**Section 5.2**), as varied by any adaptive management prescriptions (**Section 5.1**), thereby provide clear definition of the management actions to be reviewed in the next monitoring cycle.

4.2 Monitoring

4.2.1 Methods

4.2.1.1 Point Intercept Transect

The per cent cover of weed species is to be measured using the point intercept method for a 50 m long transect. The presence of a weed species is to be measured at every metre along the 50 m transect with the result multiplied by two to produce a score out of 100 (i.e. per cent). Data generated from annual monitoring events will be compared with baseline data (to be collected during Phase 0). Compliance with performance targets and completion criteria is to be determined from this comparison.

4.2.1.2 Vegetation Integrity

Monitoring plots to measure vegetation integrity are to be performed in accordance with the *Biodiversity Assessment Method Order* 2017, hereafter referred to as BAM plots. The configuration of a BAM plot is shown in **Figure 40**.

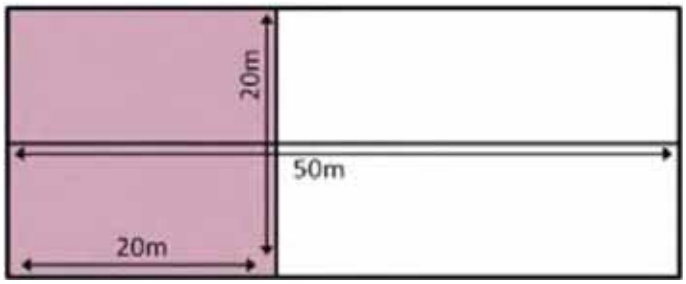

Figure 40 BAM Plot Dimensions

Each plot includes the measurement of the following variables:

- One standard 20 x 20 m (400m^2) plot, to assess the composition and structural attributes, including trees, shrubs, grasses, forbs, ferns and other growth forms;
- One standard 20 x 50 m (1,000m^2) plot, to assess functional attributes including: number of large trees with a diameter at breast height (DBH) > 50 cm, number of trees in stem size classes (i.e. <5, 5–9, 10–19, 20–29, 30–49, 50–79, and 80+ cm), tree regeneration, total length of fallen logs, high threat exotic vegetation cover and hollow-bearing trees (HBT); and
- Five 1 x 1 m (1 m^2) sub-plots to assess average litter cover for the plots.

NPSR is to be recorded within a 400m^2 floristic plot nested within the 1,000m^2 BAM plot. Cover as a percentage and abundance estimate was recorded for each plant species observed in the nested 400m^2 floristic plot.

Photographs are to be taken at the start and end of each BAM plot from a standardised point coincident with the transect origin (i.e. recorded GPS point) at an approximate height of 1.5 m. At least a 5 megapixel was used for each photograph. A horizontal field of view of approximate 40 degrees is achieved, which is within the central angle of view for human vision (i.e. 40-60 degrees).

Plots are to be placed randomly in accordance with design and frequency specifications outlined in **Sections 4.2.2** and **4.2.3** then permanently marked for repeated measures sampling. The location of each monitoring plot including start and end points of the 50m axis is to be reported in the first annual monitoring report (baseline), with future monitoring events to repeat these monitoring locations for temporal comparison.

4.2.1.3 Photograph Points

The progressive visual monitoring of the Management Area using fixed photograph points will provide a visual appreciation for the success or failure of management actions performed under this BMP. They will enable contractors to adjust review and adjust works accordingly to enhance the quality of retained vegetation further and provide required information for ongoing monitoring reports.

Photo monitoring will be performed as part of the vegetation integrity monitoring (i.e. co-located photo monitoring points) as supplemented by additional locations to monitor key features such as gates and weed infested areas. Photos supplied are to be date stamped together with location (GPS) and bearing for central view in photo.

Photographs are to be taken from a standardised point (i.e. recorded GPS point) at an approximate height of 1.5 m. At least a 5 megapixel was used for each photograph. A horizontal field of view of approximate 40 degrees is achieved, which is within the central angle of view for human vision (i.e. 40-60 degrees).

Photograph points are to be placed randomly in accordance with design and frequency specifications outlined in **Sections 4.2.2** and **4.2.3** and permanently marked for repeated measures sampling. The location of each monitoring plot is to be reported in the first annual monitoring report (baseline), with future monitoring events to repeat these monitoring locations for temporal comparison.

4.2.1.4 Camera Trapping

Unbaited camera trapping will be used to evaluate pest species type and estimated activity within the BMZs. Monitoring locations will be determined during the first monitoring event (i.e. baseline survey). Camera deployment will comprise one camera trap per 6.25 ha regularised monitoring grid (see **Section 4.2.2**) for a period of three consecutive weeks performed in early autumn. Opportunist sightings of feral fauna will also be recorded.

Camera trapping points are to be placed randomly in accordance with design and frequency specifications outlined in **Sections 4.2.2** and **4.2.3** and permanently marked for repeated measures sampling. The location of each monitoring plot is to be reported in the first annual monitoring report (baseline), with future monitoring events to repeat these monitoring locations for temporal comparison.

4.2.1.5 Nest Box Inspection

Nest box monitoring will involve the inspection of a sample of installed nest box (natural hollows and nest boxes) to provide information on utilisation of installed nest boxes and whether maintenance is required. A random sample equal to or greater than 10% of the total number installed are to be inspected, with spatial representation of this inspection to be guided by the design and frequency specifications outlined in **Sections 4.2.2** and **4.2.3**.

The objectives of monitoring are to determine occupancy of targeted species and eviction of any feral occupancy (such as feral bees, common myna birds etc). Hollows occupied by non-target species would be identified and included into management specifications in the next Annual Works Program.

Subsequent monitoring events are to exclude prior inspected nest boxes/ natural hollows unless otherwise recommended in the Annual Monitoring Report (i.e. resurvey of some occupies nest boxes/ natural hollows may be recommended if occupies by a threatened species). Cumulatively, it is anticipated that 30-50% of installed nest boxes/ hollows will be inspected over the life of the BMP.

4.2.1.6 Revegetation/ Enrichment Plantings

Monitoring of tree plantings is to measure success against performance targets. All planted trees are to be inspected to evaluate survivorship for the first two years. If alive, the tree height is to be measured for growth rate evaluation. If dead, recommendation for replacement is to be evaluated following consideration of performance measures. Monitoring post the initial two year period is to randomly sample 10% of plantings.

4.2.1.7 Wetland Water Column

A height marker with 1 cm increments is to be installed in the deepest part of Wetland 803 for routine measurement. The marker is to be installed at the start of Phase 0 to generate a baseline measure for at least two years.

4.2.1.8 Bird Survey

A monthly bird survey is to be performed in BMZ 5 at the same time as the wetland water column measurement. The survey is to comprise a walked transect around the wetland for a period of ~1 hr. All bird species observed are to be recorded together with a count. Grey-crowned Babbler nests are to be mapped.

4.2.1.9 Threatened Flora

The monitoring of threatened flora populations will involve an annual count of individuals located at the locations specified in **Figure 9**. The location of each individual plant is to be recorded using suitable GPS equipment with high accuracy (e.g. differential global positioning system for post processing). Additional surveys elsewhere in the Conservation Area may be performed to determine if new previously undetected sub-populations are emerging.

The requirement to monitor is contingent on the listing status of the species identified in the BMP. In relation to the taxon *Corybas dowlingii,* recently published scientific literature indicates that this is not a species, rather a 'stable hybrid between *Corybas aconitiflorus* and *Corybas barbarae*'. As the taxon *Corybas dowlingii* is no longer recognised as a species, rather *Corybas x dowlingii*, it is no longer recognised as forming part of the endangered species listing under the BC Act. It is important to note that the listing advice provided at the time for this taxon did not recognise hybrids between two other species as forming part of the listing. Therefore, on this basis, it is considered that monitoring for *Corybas x dowlingii* does not form a mandatory requirement in this monitoring program.

4.2.1.10 Koala

The purposes of monitoring for the koala is to determine if the Koala remains in the Conservation Area and is breeding. Monitoring may be performed using a variety of methods as outlined in DoE (2014). Prior surveys of the Conservation Area have included the use of accepted methods such as detection dogs (OWAD 2019),

searches for faecal pellets (BioLink 2018) and spotlighting (RPS 2020a). Monitoring may adopt any of these methods, as previously applied, and/ or use emerging detection methods such as passive acoustic and sound recognition techniques (Law et al 2018) to detect bellowing males during the breeding season.

Monitoring points are to be placed randomly in accordance with design and frequency specifications outlined in **Sections 4.2.2** and **4.2.3**. The location of each monitoring point is to be reported in the first annual monitoring report (baseline), with future monitoring events to repeat these monitoring locations for temporal comparison.

4.2.2 Design

The monitoring grid shown in **Figure 41** is to be used as the basis for obtaining spatially representative monitoring data using the methods specified in **Section 4.2.1**. Grid numbering corresponds with the koala sampling grid used in the impact assessment (RPS 2020a), thereby allowing for comparison with prior conditions. Refer to **Section 4.2.3** for recommended sampling replication/ sampling restrictions.

4.2.3 Frequency and Replicates

Monitoring events are to be performed each year using appropriate frequency and replicates. Guidance by monitoring method is outlined in **Table 32** together with recommended timing.

Table 32: Monitoring Frequency Guidance

Monitoring Method	Frequency	Replicates per Grid Cell	Recommended Timing
Point Intercept	Twice a year	Two	September and March
Vegetation Integrity	Once a year	One	September
Photograph Points	Once a year	Three	September
Camera Trapping	Once a year	One	March - April
Nest Box Inspection	Once a year	5-10 boxes	March - April
Revegetation/ Enrichment Plantings	Once a year	n/a	September
Wetland Water Column	Monthly	n/a	1st day of every calendar month
Bird Survey	Monthly	Cells 60 and 62	1st day of every calendar month
Threatened Flora	Once a year	Cells 3, 4, 6, 25, 26, 29, 62	*Corybas dowlingii* in peak flower ~July *Pterostylis chaetophora* in peak flower ~October *Maundia triglochinoides* in peak flower ~December
Koala	Once a year	One	Breeding season (August – October)

4.3 Baseline

A baseline monitoring event will be performed at the start of Phase 0 to quantify the pre-management conditions of the Conservation Area. Data defining the baseline condition state is to be provided in the first annual monitoring report. This data is to be used for comparison with subsequent monitoring events to evaluate net change and progression against performance targets.

4.4 Data Analysis

4.4.1 Point Intercept

Point intercept transect results are to be reviewed empirically against baseline/ prior monitoring events and performance targets. Results are to be used to refine management prescriptions.

IMPORTANT NOTE

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4. The aerial photography used in this plan has not been rectified. This image has been overlaid as a best fit on the boundaries shown and position is approximate only.

TITLE : FIGURE 41: MONITORING GRID

LOCATION : KINGS HILL

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\7. BMP\Latest Figures 20200721\130430 Figure 41 Monitoring Locations B A3 20200721.mxd

CLIENT: **PM NO 1 PTY LIMITED**

JOB REF: **PR130430**

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4.4.2 Vegetation Integrity

BAM plot data is to be used to calculate the vegetation integrity score for direct comparison with baseline/ prior monitoring events. An increasing vegetation integrity score indicates an improvement in habitat conditions and, depending on the rate of improvement, may allow indicate no further need for analysis.

If a reduced vegetation integrity score is calculated then additional analysis is warranted to investigate causation. An analysis of the individual BAM plot measures (i.e. non-Metric Multidimensional Scaling) and/ or vegetation integrity scores (e.g. t-test/ ANOVA) could be used evaluate whether the change is significant over time.

4.4.3 Camera Trapping

Camera trap results are to be used to calculate an activity score by summing the daily presence/ absence feral fauna encounters for the three week monitoring period (i.e. maximum activity score of 21 reflective of 21 daily encounters for the monitoring period). The results are to be reviewed against baseline and prior monitoring events to evaluate year on year activity levels and spatial patterns. Results are to be used to refine management prescriptions.

4.4.4 Nest Box Inspection

Occupancy by nest box/ natural hollow type (i.e. target species) is to be analysed to test for benefit. The data may be used to adjust the type of nest box/ natural hollow type used in subsequent installations.

4.4.5 Revegetation/ Enrichment Plantings

The total number of live planted trees is to be comparted against the performance target to determine if corrective actions are required. Mean tree heights by species are to be plotted to evaluate growth rates.

4.4.6 Wetland Water Column

A basic hydrograph showing the monthly change in water column height is to be plotted for year on year comparisons. Consideration of rainfall quotas from the nearest Bureau of Meteorology measurement station is to be included in the analysis to evaluate the effect of the altered catchment.

4.4.7 Bird Survey

The wetland bird survey data is to analysed using annualised total counts for each species and compared with baseline and subsequent annual results. If significant differences are observed, then additional analysis using monthly datasets and water column results will be used to determine if the detected difference relates to changes in hydrology or an unrelated factor.

4.4.8 Threatened Flora

Threatened flora monitoring results are to be analysed using total counts and spatial distributions to evaluate annual variation. Comparison with baseline conditions is to be used to determine if decline or growth is occurring. A threat analysis is to be performed to determine if variation observed is related to a matter that can be managed or is simply a reflection of natural variation.

4.4.9 Koala

The analysis of monitoring data is to be used to determine if Koala breeding activity remains within the Conservation Area. This would be determined by one or more of the following observations:

- Evidence of male bellowing in the breeding period (August to October); and/ or
- Presence of female koalas.

Activity monitoring using scat searches (Phillips and Callaghan 2011) and/ or dog detection would be used to gain an appreciation of habitat occupancy. The latter method would be used to collect faecal matter for DNA analysis, with the results from this method offering superior insight on Koala status within the Conservation Area.

4.5 Reporting

An annual monitoring report is to be prepared detailing the progress of the BMP and submitted to Port Stephens Council at least one month prior to financial year end through to the completion of the BMP plus an additional year after completion of the BMP to validate cessation. The annual monitoring reports will:

- Report on the progress of management actions including details on what was performed for auditing against the annual works program (see **Section 5.2** for details on the annual works program);
- Provide monitoring results and analysis against baseline and management targets; and
- Discuss any problems encountered in implementing the BMP.

The adaptive management framework is to be considered as outlined in **Section 5.1**. Recommendations regarding timing and responsibility for corrective measures are to be discussed together with a detailed prescription for the forthcoming annual work program for review and approval by Port Stephens Council.

5 ADAPTIVE MANAGEMENT

5.1 Framework

To account for uncertainties and to improve management response, all impacts to biodiversity will be adaptively managed using an Adaptive Management Framework. The adaptive management framework actions are detailed below noting this BMP represents steps 1 to 4, with any specifications for adaptive management to be determined through steps 5 to 7.

1. **Describe -** Undertake and complete comprehensive baseline biodiversity data collection.
2. **Model** – Model the biological environment and its response to certain management actions/decisions.
3. **Identify** – Set clear biodiversity management objectives.
4. **Do** – Implement the modelled biological management action.
5. **Learn** – Use the monitoring program to evaluate the biological response to management actions against objectives and performance targets. Where required, prepare draft adaptive management response and include in annual monitoring report.
6. **Consult** – Share draft adaptive management response with relevant stakeholders (i.e. Port Stephens Council). Seek approval to implement revised management actions.
7. **Adapt** – Implement revised and approved adaptive management actions.

Draft adaptive management responses are to be defined through Step 5 and approved and reported through the Annual Monitoring Report as specifications in the 'Annual Works Program'.

5.2 Annual Works Program

The Annual Works Program represents a set of detailed Council approved management prescriptions for the forthcoming management year as determined through the combined review of proposed management actions outlined in **Section 3** and preceding monitoring results. This process of adapted management has the purpose of maintaining a focus on delivering the BMP objectives within the 5 year life of the plan. The Annual Works Program is to be drafted for review and approval by Council prior to its implementation, as outlined in Steps 5 to 7 in the above framework section. The Annual Works Program is to be implemented on a financial year cycle. Council is to receive a draft Annual Works Program at least 1 month before the end of the financial year to enable evaluation and approval of the final Annual Works Program in time for implementation.

6 VEGETATION CLEARANCE ACTIVITIES

A procedure for clearing vegetation is outlined in the VMP for the Proposal (RPS 2020b), which explains the process and measures to be implemented prior to, during and after vegetation clearing for construction activities and identifies who is responsible for implementing each component. The relevant part of the VMP is to be applied to works involving the establishment of new tracks as shown in **Figure 27**.

The assessment of the Proposal has made an allowance to clear 2.4 ha for the establishment of new tracks within the Conservation Area (RPS 2020a). The works involved in the establishment of these new tracks is to have regard for the specifications provided in **Table 11** and classifications shown in **Figure 28**.

7 REFERENCES

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Appendix A

Koala Infrastructure Specifications

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Mark Aitkens
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29th November 2019

Dear Mark

RE: Kings Hill Developments (KHD): Infrastructure Advice.

This advice has been prepared in response to a request for infrastructure detail enforcing the principles of enclaving in so much as this relates to each of the identified development precincts that occur across lands owned by KHD. The intent of enclaving in areas of koala habitat is to effectively segregate / partition areas of development such that they are no longer accessible to koalas, thus reducing any associated threats such as domestic dog attack, vehicle-strike and/or misadventure. Given the current vegetated landscape that occurs within envisioned development precincts on KHD lands, there is also a need to accommodated egress from such areas of koalas that may have part or all of their respective home range areas within the development precincts. This advice thus focuses on 3 key infrastructure requirements that we consider necessary to assist longer-term koala management objectives for KHD lands as follows:

1. Koala bridges

Koala bridges are timber structures that enable koalas to traverse barriers such as fences that function form an obstacle to linear passage. On the Kings Hill site, one-way and two-way koala bridges will be required, the former to enable passive (one-way) egress from vegetated areas that are located within identified development precincts (once fenced), the second to enable two-way movement by koalas both into and out of areas such being managed for environmental purposes. The design of both instances is the same (Appendix 1), the one-way effect created by use of a galvanised metal sleeve 600 – 900 mm wide (upper edge located 1 m off the ground) on the lower end of the bridge on that side of the fence where a reverse crossing is not to be enabled.

On the Kings Hill site, koala bridges should be located at ~ 250 m intervals along fenced areas intended to that separate development precincts from areas to be managed for environmental purposes.

2. Fencing

Fencing is required to create a barrier between the wildlife habitat within the lands to be retained and managed for conservation purposes and that of the adjoining development precincts. The intent of fencing should be to contain koala movement within the designated environmental lands while at the same time restricting access to the corridor by people and domestic animals. This barrier effect can be achieved by way of a standard floppy-top design typically deployed on road upgrades. However, a recent review of the efficacy of fencing (in terms of impeding koala movement) that we completed for NSW Roads & Maritime Services (Phillips and Fitzgerald 2014), provided strong *defacto* support for acceptance of a broader range of fence types being recognised as capable of influencing/impeding koala movement. This knowledge has allowed us to promote less expensive designs that are capable of achieving the same end result. By example, the fencing standard we have recommended for purposes of the Ocean Drive Road Corridor Koala Management Framework (Biolink 2014) comprises 1500 - 1800 mm x 50 mm x 50 mm galvanised mesh supported above ground by 60mm galvanised pipe uprights at 3m intervals.

3. Koala grids

Koala-grids will be required at all access points into areas that are dedicated to environmental management, including gated areas. The intent of the koala-grid is to enforce the exclusion concept of fencing at locations where vehicular crossings occur or where access is otherwise required for management purposes. Originally designed for purposes of the Skyline Road upgrade undertaken by Lismore City Council in 2004, koala-grids proved 100% effective in restricting access by koalas over the course of a 5-year monitoring program (Biolink 2009). Koala-grids are constructed using 60mm tubular steel pipe at 200 mm centres as a means of restricting access by koalas to an exclusion area (Figure 1).

Figure 1. Koala-grid / fence –end configurations. The grid on the far right reflects recent design modifications initiated by NSW RMS as part of retro-fitting modifications on the Gulgan Road interchanges that afford access to the Pacific Highway between Ewingsdale and Chinderah on the NSW north coast.

Please don't hesitate to contact the undersigned if you require any further information.

Yours Sincerely

Dr. Stephen Phillips
M/Director / Principal Research Scientist

Attachment – Appendix 1 Koala Bridge specifications

References

Biolink (2014). Ocean Drive Road Corridor: Koala Management Framework. Final Report to Port Macquarie Hastings Council.

Phillips, S., and Fitzgerald, M. (2014). Review of koala road-kill data and issues relating to underpass use by koalas: Pacific Highway upgrades from Clothier's Creek to Ewingsdale, NSW. Final Report to NSW Roads & Maritime Services. Biolink Ecological Consultants.

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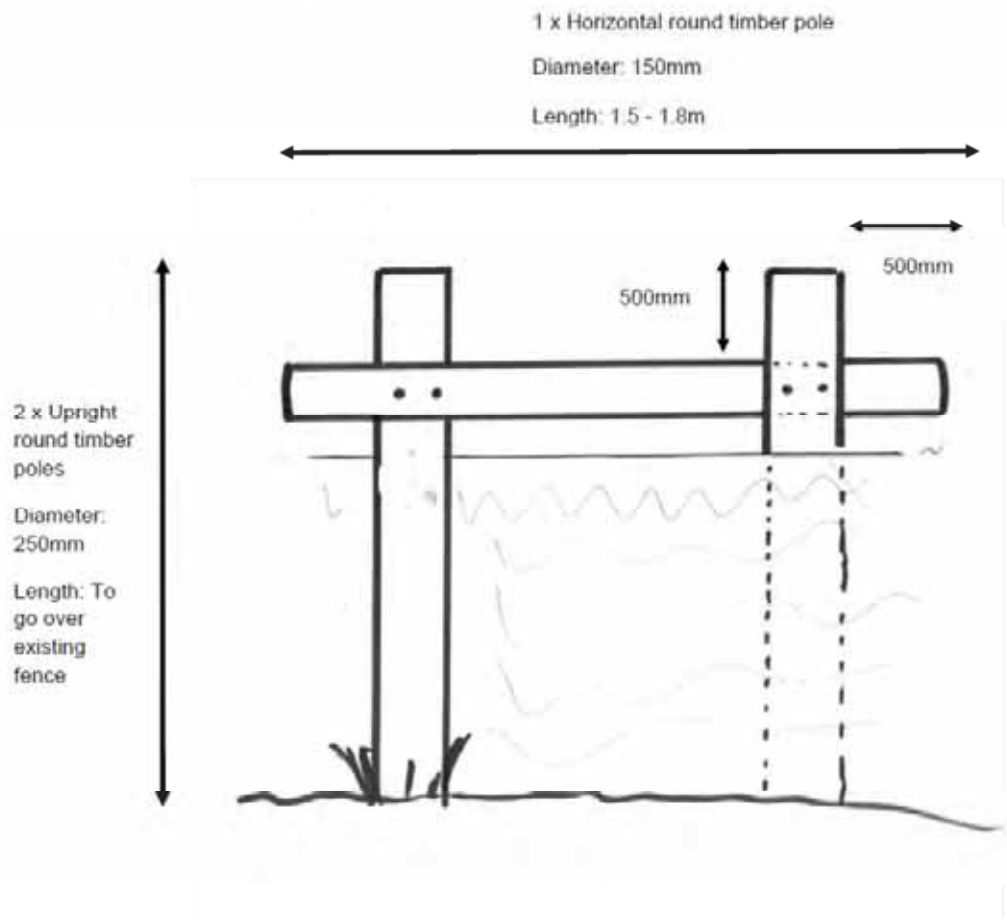
APPENDIX 1
Typical Koala Bridge

Not to scale

a) Koala bridge design concept



b) View of koala bridge design from above

Appendix D

Vegetation Management Plan

VEGETATION MANAGEMENT PLAN
LOT 41 DP1037411 AND LOT 4821 DP852073
'KHD LAND' – KINGS HILL

Stage 1 Subdivision Works (Initial Site Preparation)

130430
Vegetation Management Plan
4
24 July 2020

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Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
1	FINAL	Lauren Eather	Mark Aitkens	Lauren Eather	20 May 2019
2	Amendments after Council RFI	Mark Aitkens	Lauren Eather	Mark Aitkens	13 December 2019
3	FINAL (minor amendments)	Mark Aitkens		Mark Aitkens	13 March 2020
4	FINAL (minor amendments for tracks)	Mark Aitkens	Jason Wasiak Adam Smith	Mark Aitkens	24 July 2020

Approval for issue

Mark Aitkens 24 July 2020

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1 INTRODUCTION

This Vegetation Management Plan (VMP) has been prepared to accompany a Concept Development Application for subdivision comprising stage 1 subdivision works (initial site preparation works) ('the Proposal') on land legally described Lot 41 DP 1037411 and Lot 4821 DP 852073, 3221 Pacific Highway and 35 Six Mile Road, Kings Hill (the 'subject site'). The subject site forms part of the Kings Hill Urban Release Area (KHURA), which is zoned and endorsed by local and State governments to enable a mix of urban development and environmental outcomes.

The KHURA has been the subject of considerable environmental assessment since 2003, culminating most recently in an extensive biodiversity assessment and Species Impact Statement (SIS) (RPS 2020a) for the subject site [that is, land owned by Kings Hill Developments Pty Ltd (KHD)]. This VMP has been prepared based on the recommendations within the abovementioned SIS and consequently, is intended to guide the management of initial site preparation works. For the purposes of this document:

- Urban areas proposed by the Concept DA within the subject site are referred to as the 'Impact Area';
- Environmental areas proposed by the Concept DA within the subject site are referred to as 'Conservation Areas'; and
- Site Preparation Works are subdivision works proposed in the Impact Area, including activities such as progressive vegetation modification and/or removal, resource harvesting, weed and pest management, earthworks, drainage and erosion management, and bushfire protection works. Such works may also support activities detailed in the Biodiversity Management Plan (BMP) prepared for the adjoining Conservation Area (e.g. resource recovery and establishment of new tracks).

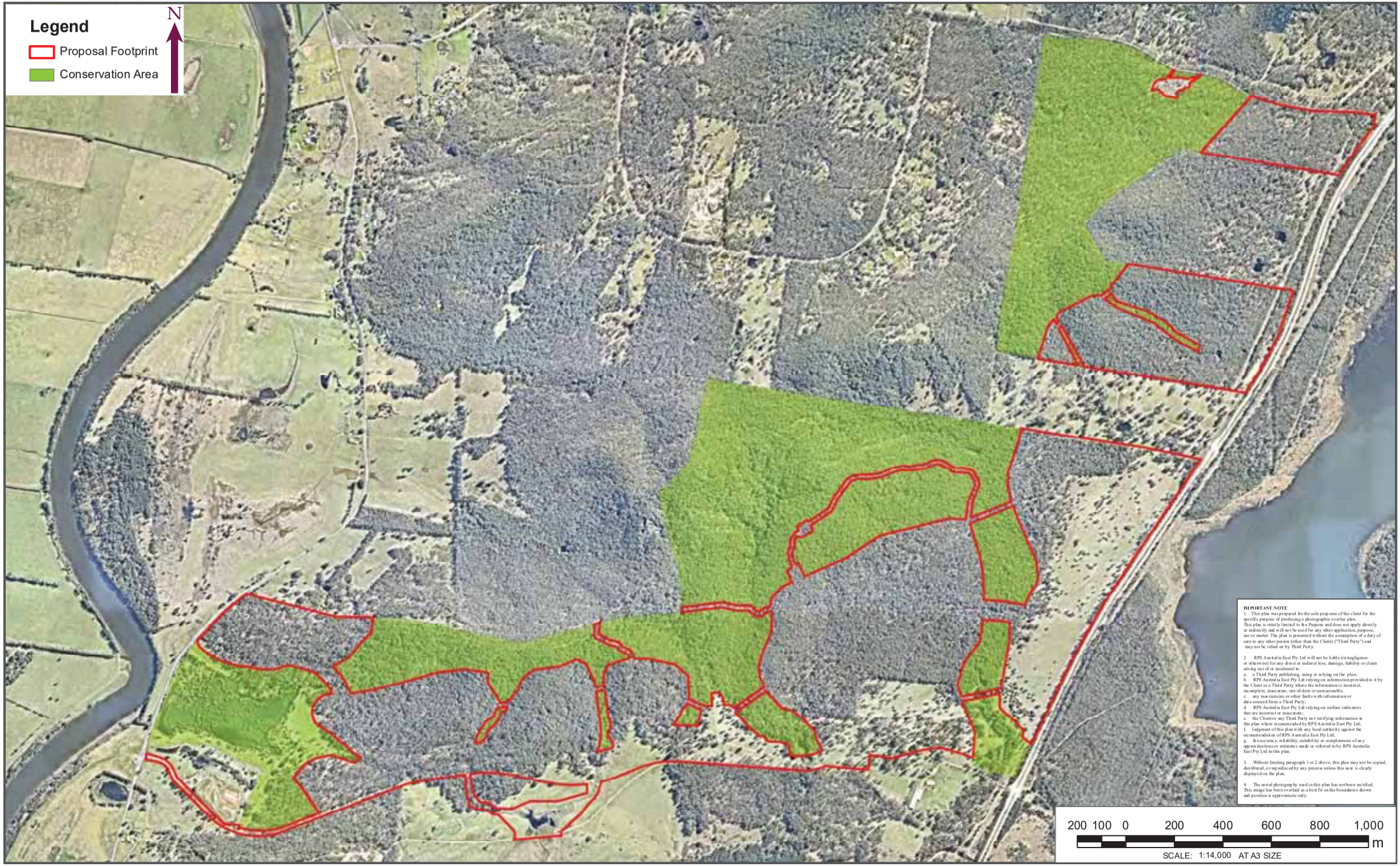
This VMP pertains to the 'Management Area' as shown in **Figure 1** as divided by three phases of initial site preparation as shown in **Figure 2**.

1.1 Need for a VMP

A VMP is required under Section D14.33 of the Port Stephens Development Control Plan (DCP) 2014 where vegetation is to be impacted. The removal and/or modification of vegetation is proposed as part of the Stage 1 site preparation works, and such works are to be managed in accordance with this VMP. The duration of the proposed site preparation works is expected to be 8+ years, as outlined in **Table 1** and **Figure 2**.

Table 1: VMP Implementation by Proposal Phase

Proposal Phase	VMP Focus	Time (years)
Phase 0: Pre-construction Site Preparation works	• Perform weed management works in key areas to supplement management activities in the adjoining Conservation Area, as per the BMP, notably in the western half of the management area where heavy woody weed invasions occur	-2 to 0
Phase 1: Construction of main east – west road connecting the Pacific Highway interchange with Newline Road plus development areas of reduced biodiversity value adjacent to these roads	• Implement a coordinated stepwise clearing procedure that aims minimises biodiversity harm through gradual sensitive clearing actions • Provide mechanisms for the salvaging of habitat for use in the Conservation Area, or salvage of other natural resources such as timber, native plants, bushrock etc • Continue the management of weed and other items under Phase 0	0 to 3
Phase 2: Selective construction of development areas with reduced biodiversity value	• Continue implementation of the stepwise clearing procedure to minimise biodiversity harm through gradual sensitive clearing actions • Support the ongoing protection of biodiversity values within the Conservation Area through continued suppression of weed species, sensitive vegetation clearing and management of fauna displaced by clearing works	>3 to 8
Phase 3: Construction of residual approved development areas		>8 +



TITLE : **FIGURE 1: MANAGEMENT AREA**

LOCATION : **KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 1 Management Area B A3 20200722.mxd

CLIENT: **PM NO 1 PTY LIMITED**

JOB REF: **PR130430**

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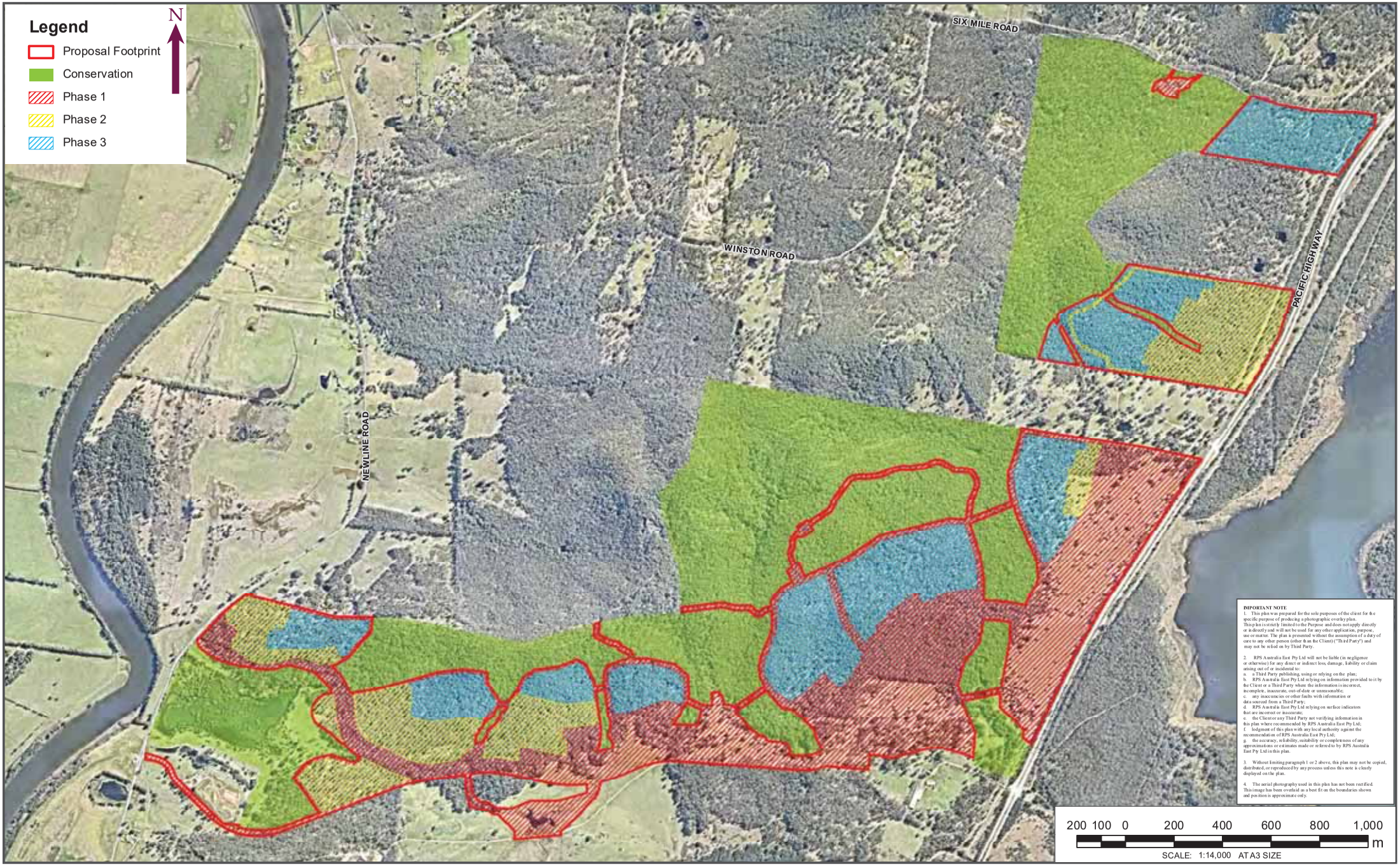

TITLE : **FIGURE 2: PROPOSAL PHASES**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 2 Proposal Phases B A3 20200722.mxd

CLIENT: **PM NO 1 PTY LIMITED**

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1.2 VMP Objectives

The aim of this VMP is to provide a considered and orderly approach to the removal and/or modification of vegetation and habitat during the site preparation works, particularly the removal of vegetation and habitat (i.e. impact minimisation) in a manner consistent with the Section D14.33 of Port Stephens Council DCP 2014 (i.e. impact minimisation). More specifically, the VMP objectives are to:

- Restore and protect creek line and riparian areas;
- Manage impacts on threatened species, endangered ecological communities and habitat trees through implementation of a progressive clearing process that allows time for species to adjust and/or relocate from Impact areas to Conservation Areas;
- Outline the management framework for minimising impacts on vegetation and habitat within the Impact Area;
- Identify the appropriate timing of works including site preparation, resource recovery (extraction of timber, native plants and bushrock etc), planting, weed management, and also providing a schedule of works;
- Identify and assign responsibilities for ongoing management actions over an 8+ year period; and
- Ensure that the project is planned, designed and implemented by informed experienced contractors in order to avoid harm to the quality, stability and natural functions of remnant bushland and riparian areas.

The management proposed is also aimed at supporting management and habitat enhancement efforts recommended by the SIS and proposed to be applied through implementation of a Biodiversity Management Plan (BMP) for the Conservation Area. Native vegetation and habitat vested into the Conservation Area is to be managed for the protection of high biodiversity values identified for listed threatened species such as the Koala (*Phascolarctos cinereus*), Brush-tailed Phascogale (*Phascogale tapoatafa*), Squirrel Glider (*Petaurus norfolcensis*), forest and woodland birds, large forest owls, wetland birds and orchid species. In this regard, the VMP outlines resource recovery processes (e.g. harvesting of natural hollows and logs) for use in the BMP such as habitat mitigation, or for use in future landscaping and/or other resource reuse activities.

1.3 Site Preparation Works - Vegetation Clearing Procedure

To deliver the objectives of this VMP, the removal and/or modification of vegetation and habitat during site preparation works is to occur in a manner consistent with Section D14.33 of Port Stephens Council DCP 2014 (i.e. impact minimisation). To that end, the removal and/or modification of vegetation during the Phases outlined in **Table 1** ought to occur sequentially as follows:

- Step 1: Targeted removal of exotic species where a duty under Section 21 of the *Biosecurity Act* 2015 is required. Species with a biosecurity duty are to be eliminated and/ or minimised to an extent that is consistent with prescribed control measures. Such activities apply to the whole subject site (i.e. both Proposal and Conservation Area) with notable species with a biosecurity duty including:
  - African Olive (*Olea europaea* subsp. *cuspidata**);
  - Lantana (*Lantana camara**);
  - Ground Asparagus (*Asparagus aethiopicus**);
  - Blackberry (*Rubus fruticosus** species *aggregate*);
  - Alligator Weed (*Alternanthera philoxeroides**); and
  - Water Hyacinth (*Eichhornia crassipes**).
- Step 2: Partial vegetation removal where the purpose of this intermediate step is to:
  - Gradually establish areas proposed for future urban purposes (impact areas), to:

  - Provide adequate time for impact mitigation measures to be established in [or at the interface with (e.g. fencing)] the Conservation Area; and
  - Minimise impact intensity on native flora and fauna in lieu of a future complete clearing event (i.e. minimise the temporal effects by delaying the clearing of important habitat thereby provide opportunity for displaced fauna to gradually relocate to improved habitat in the adjoining Conservation Area).
- Provide an opportunity for the recovery of habitat resources for use in mitigation works performed within the Conservation Area (i.e. recover logs, bushrock, and natural hollows); and
- Provide separation between the bushfire threat and development through the construction of bushfire Asset Protection Zones (APZ) for all staged clearing and development as outlined in Section 3.2.1 “Staged Development” of Planning for Bushfire Protection 2018.

The prescription for partial vegetation removal is to meet the following specifications:

- Maintenance of all retained vegetation to an APZ standard to ensure radiant heat exposure < 29kW/m^2 towards residential development and < 10kW/m^2 towards Special Fire Protection Purpose Developments;
- Retention of Preferred Koala Feed Trees (PKFT) with a diameter at breast height (dbh) of 300 mm or more; and
- Retention of hollow-bearing trees and/or other tree species deemed suitable by an arborist and bushfire consultant for inclusion in urban landscapes to enhance visual amenity and provide foraging and roosting habitat for species adapted to urban landscapes.

The partially cleared state is, at all times, required to demonstrate sufficient landform stability (e.g. negligible evidence of erosion) to maintain satisfactory water quality standards at the catchment scale.

- Step 3: Complete native and exotic vegetation removal with the exception of trees deemed suitable by an arborist and bushfire consultant for inclusion in urban landscape, subject to compatibility with engineered structures. Consideration should be given to the integration of suitable tree species into the urban landscape. Soil and erosion management procedures are to be applied in this step to ensure satisfactory water quality standards at the catchment scale, with specific details of these management specifications to be provided in the approved subdivision works certificate for the corresponding construction activities. Manage harm to fauna through observance of preclearance surveys and clearing supervision (for further details to refer to **Appendix A**).

To avoid doubt, Step 3 in any phase can only occur to the extent that consent is granted for development within that phase, thereby preventing indiscriminate clearing. This requires the satisfactory competition of Steps 1 and 2, each having the purpose of minimising impacts over time on affected species. Notwithstanding, Step 1 can occur at any time in any phase where consistent with regulated biosecurity obligations. To ensure impact minimisation, Step 2 of Phase 2 cannot proceed until Step 3 of Phase 1 is completed for all areas contained within Phase 1 (i.e. a process facilitating the movement of fauna into adjoining vegetation). Similarly, Step 2 of Phase 3 cannot proceed until Step 3 of Phase 2 is completed.

A specification guideline for each of these steps is provided in **Section 3**. Pre-clearance and clearing supervision to minimise harm on fauna in Step 3 is described in **Section 8**.

1.4 Roles and Responsibilities

Six key roles responsible for the implementation of this VMP are outlined in **Table 2**.

Table 2: Staff and Responsibilities

Role	Qualification	Responsibilities
Vegetation Management Contractor	Minimum Certificate II Bush Regeneration (or equivalent) Five or more years' experience	Implementation of VMP Vegetation Management Point of contact
Licensed seed collector	Licence under the *National Parks and Wildlife Act* 1974 to collect and propagate seed	Seed collection Propagation
Project Bushfire Specialist	FPAA - Building Planning & Design Level 2 Accredited	Oversee delivery of fuel load maintenance
Project Arborist	Australian Qualifications Framework Level 5; and Five or more years' experience	Oversee relevant parts of Step 3 in the clearing procedure
Project Ecologist	Tertiary qualifications in ecology; and 10 or more years' experience	VMP compliance (audit) Oversee relevant parts of the clearing procedure (steps 1, 2 and 3) Monitoring and adjustment if necessary
Landholder	NA	Implementation of this plan, and subsequent VMPs, in consultation with suitably qualified and experienced service providers

1.5 Implementation

This VMP accompanies a Concept DA for subdivision that on approval, will only authorise the carrying out of work proposed under Stage 1 (site preparation works). Further development applications will need to be made to 'carry out' subdivision of the land and any associated construction works.

As a Concept DA, the provisions of section 4.24(2) of the *Environmental Planning and Assessment Act* 1979 (as amended) apply, which state:

… the determination of any further development application in respect of the site cannot be inconsistent with the consent for the concept proposals for the development of the site.

It follows that any further development consent enabling the carrying out of construction for the purpose of subdivision and/or other development (for example, roads) must not be inconsistent with the Concept DA (once approved) or the Species Impact Statement, VMP or BMP (upon which the Concept DA is based).

It is expected that any further development consent enabling the carrying out of construction for the purpose of subdivision and/or other development be conditioned to ensure that the VMP for Stage 1 is progressively executed (to the extent relevant to that application) to Council's satisfaction, prior to the commencement of any works enabled by that consent.

The VMP is to be implemented for a period of 8+ years upon approval of the Concept DA for Subdivision and Stage 1 Subdivision Works. Implementation of the VMP is not contingent on the timing or granting of any further development consents.

1.6 Regulatory Framework

This VMP has been prepared to address Section D14.33 of the Port Stephens DCP 2014 in response to Port Stephens Council request for further information dated 11 July 2019 (DA 16-2018-772-1). The requirements of Section D14.33 in the Port Stephens DCP 2014 are outlined in **Table 3**.

Table 3: Port Stephens DCP 2014 Requirements for VMPs (Section D14.33)

Requirement	Section
Applications for development on land zoned E2 Environmental Conservation or subject to terrestrial biodiversity controls in the Local Environmental Plan within each environmental precinct provide a VMP to that satisfaction of Council in accordance with the vegetation management technical specification. The VMP is provided within the precinct plan for the relevant environmental precinct boundaries identified by Figure DAC (p.D-61). The VMP also addresses the following location specific information:	This report
• Requirements to protect the creek line and other areas to be conserved, such as fencing, sediment control devices and appropriate signage; and	This report
• Details of revegetation, restoration and weed control, including riparian corridors. Areas affected by degradation, erosion and/or rubbish dumping should also be rehabilitated. • A draft is provided with the development application and the final signed off by Council prior to the release of the construction certificate.	This report

Other relevant environmental regulation that this VMP has had regard for is listed below:

- Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act);
- NSW *Biodiversity Conservation Act* 2016 (BC Act);
- NSW *Biosecurity Act* 2015;
- NSW *Water Management Act* 2000 (WM Act);
- NSW *Rural Fires Act* 1997 (RF Act);
- State Environmental Planning Policy (SEPP) (Vegetation in Non-Rural Areas) 2017 (Vegetation SEPP);
- State Environmental Planning Policy (SEPP) (Coastal Management) 2018 (Coastal SEPP); and
- Port Stephens Council Comprehensive Koala Plan of Management (PSC CKPoM) (PSC 2002).

1.6.1 *Environmental Protection and Biodiversity Conservation Act* 1999

The purpose of the EPBC Act is to ensure that actions likely to cause a significant impact on Matters of National Environmental Significance (MNES) undergo a process of assessment. Under the EPBC Act, an action includes a Proposal, undertaking, development or activity that may impact MNES. An action that 'has, will have or is likely to have a significant impact on a MNES' is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Commonwealth Minister for the Department of the Environment and Energy (DoEE). MNES categories listed under the EPBC Act are:

- World heritage properties;
- National heritage places;
- Wetlands of international importance (Ramsar wetlands);
- Threatened species and ecological communities (Section 18 and 18A);
- Migratory species;
- Commonwealth marine areas;
- Nuclear actions (including uranium mining); and
- A water resource, in relation to coal seam gas development and large coal mining development.

The Proposal is to be referred under the EPBC Act for assessment. Any conditions of consent arising from this process will be integrated, where required, into this VMP.

1.6.2 *Biodiversity Conservation Act* 2016

The BC Act and supporting regulations establish a modern and integrated legislative framework for land management and conservation in NSW. The purpose of the BC Act, with reference to the assessment of development (Part 4 of the EP&A Act) or activities (Part 5 of the EP&A Act), is:

> *(k) to establish a framework to avoid, minimise and offset the impacts of proposed development and land use change on* biodiversity
>
> *(l) to establish a scientific method for assessing the likely impacts on biodiversity values of proposed development and land use change, for calculating measures to offset those impacts and for assessing improvements in biodiversity values*
>
> *(m) to establish market-based conservation mechanisms through which the biodiversity impacts of development and land use change can be offset at landscape and site scales.*

The BC Act applies only in respect to the provision of a method for assessing impacts on biodiversity (i.e. utilise the Biodiversity Assessment Method Order 2017 as the monitoring method) as approvals for the clearing of vegetation have already been concluded.

1.6.3 *Biosecurity Act* 2015

The *Biosecurity Act* 2015 divides NSW into regions based on combined LGAs and priority weeds for a region. Some weeds are managed at a state level as they form part of a broader containment strategy. The legislation complements listed Weeds of National Significance (WoNS). The Act provides for the identification and classification of listed weeds to identify the duty required for management. The duty assigned to the weed informs land managers and owners of their role and responsibility in managing the weed within the site. Weeds identified as occurring within the site listed as a priority weed within the region, need to be managed according to the duty assigned to the species in NSW WeedWise (NSW DPI 2019).

1.6.4 *Water Management Act* 2000

The objects of the *Water Management Act* 2000 are to provide for the sustainable and integrated management of the water sources of the state for the benefit of both present and future generations and, in particular:

- Ecologically sustainable development;
- Protect, enhance and restore water recourses;
- Recognise and foster social and economic benefits;
- Recognise the role of the community;
- Provide efficient and equitable sharing of water;
- Management of water sources with other aspects of the environment including native vegetation and native fauna;
- Encourage the sharing of responsibility and efficient use of water; and
- Encourage best practice management and use of water.

In NSW, the regulator and policy maker for water resource management is the NSW Department of Industry – Water (DoI Water). The department develops natural resource management policy frameworks, strategies and plans related to water management.

1.6.5 *Rural Fires Act* 1997

The site is identified as being bushfire prone in accordance with s10.3 *Environmental Planning and Assessment Act 1979.* The development is designated as an ‘integrated development’ *through s4.46 EP&A*

Act and *s100B Rural Fires Act 1997* and any assessment shall adhere to the methodology and procedures outlined in Appendix 1 of Planning for Bush fire Protection (2018) and *cl.44 Rural Fire Regulation 2013.*

A Bush Fire Assessment Report (BFAR) is required to establish the setbacks and bush fire mitigation measures required in consideration of Planning for Bush fire Protection 2018 (PBP2018). The BFAR should inform the early stages of the subdivision design to ensure compliance of the final design with PBP2018 and elements of Australian Standard 3959:2018 Construction of Buildings in Bush fie prone areas.

The BFAR shall support the Development Application processes and a Bush Fire Safety Authority application to NSW Rural Fire Service. A BFAR will be required to ensure that appropriate Bush fire mitigation measures are implemented to manage risk are included in indicative layout plan and the development control plan. Bush fire mitigation measures include:

- Asset Protection Zones;
- Building Construction & Design;
- Landscaping;
- Water Supply & Utilities;
- Access; and
- Emergency management arrangements.

Where a new dwelling entitlement is created, it is important to ensure that appropriate bush fire mitigation measures are provided within the new allotment. This allows for measures to be fully incorporated at the design stage of development.

1.6.6 SEPP (Vegetation in Non-Rural Areas) 2017

A permit or consent is to be under Part 3 of the SEPP for the clearing of native vegetation on non-rural lands unless matters identified in Clause 8 of the SEPP apply, which are listed below:

8 Clearing that does not require authority under this Policy

(1) An authority to clear vegetation is not required under this Policy if it is clearing of a kind that is authorised under section 60O of the Local Land Services Act 2013 (Clearing authorised under other legislation) or under Part 5B (Private native forestry) of that Act. This subclause does not apply to clearing merely because it is a part of or ancillary to the carrying out of exempt development.

(2) An authority is not required under this Policy for the removal of vegetation that the council or Native Vegetation Panel is satisfied is dying or dead and is not required as the habitat of native animals.

(3) An authority is not required under this Policy for the removal of vegetation that the council is satisfied is a risk to human life or property.

Existing use rights apply to the existing tracks and trails of the Conservation Area with their ongoing maintenance periodically requiring the clearing of native vegetation. The extent to which this clearing is allowable is defined by the classifications assigned to the tracks/ trails and associated intended uses. For the purposes of the BMP, tracks and trails have adopted the classification scheme provided for in the following guiding documents:

- NSW Planning for Bush Fire Protection 2019 (PFBP 2019);
- The NSW Rural Fire Service Fire Trail Standards - Version 11 (2016); and
- NSW Rural Fire Service Fire Trail Design, Construction and Maintenance Manual developed by the Soil Conservation Service for the NSW Rural Fire Service.

These guiding documents provide specifications for the safe use of bush fire fighting appliances on tracks and trails according to their classification (and intended use). Among the multiple uses intended for these tracks/ trails, the highest priority use is the provision of safe movement paths for bush fire fighting appliances

throughout the lands owned by KHD. To satisfy this requirement, tracks and trails will be maintained to the relevant specifications, with the associated periodic management of vegetation to be performed under cl.8(3) of the Vegetation SEPP.

1.6.7 SEPP (Coastal Management) 2018

The aim of the Coastal SEPP is to promote an integrated and co-ordinated approach to land use planning in the coastal zone in a manner consistent with the objects of the *Coastal Management Act* 2016, including the management objectives for each coastal management area, by:

(a) managing development in the coastal zone and protecting the environmental assets of the coast, and

(b) establishing a framework for land use planning to guide decision-making in the coastal zone, and

(c) mapping the 4 coastal management areas that comprise the NSW coastal zone for the purpose of the definitions in the *Coastal Management Act* 2016.

The Coastal SEPP regulates development in the coastal zone for the purpose of protecting values such as Littoral Rainforest and Coastal Wetlands, inclusive of 'proximal areas' as defined by relevant buffers to these features. In this respect, the Conservation Area comprises lands within the coastal zone to which this policy applies.

This BMP has the purpose of restoring and enhancing lands occurring within the coastal zone that are currently degraded from past land use activities through interventions such as weed management, revegetation works and exclusion from human activity.

1.6.8 Port Stephens Comprehensive Koala Plan of Management

Section 5.3 of the Port Stephens Comprehensive Koala Plan of Management (CKPoM) provides performance criteria for development applications. These are listed below:

a. Minimise the removal or degradation of native vegetation within Preferred Koala Habitat or Habitat Buffers;

b. Maximise retention and minimise degradation of native vegetation within Supplementary Koala Habitat and Habitat Linking Areas;

c. Minimise the removal of any individuals of preferred koala food trees, wherever they occur on a development site. In the Port Stephens LGA these tree species are Swamp Mahogany (*Eucalyptus robusta*), Parramatta Red Gum (*Eucalyptus parramattensis*) and Forest Red Gum (*Eucalyptus tereticornis*). An additional list of tree species that may be important to koalas based on anecdotal evidence is included in Appendix 8 of the Port Stephens Council CKPoM (as recommended by the CKPoM Consultative Committee);

d. Make provision, where appropriate, for restoration or rehabilitation of areas identified as Koala Habitat including Habitat Buffers and Habitat Linking Areas over Mainly Cleared Land. In instances where Council approves the removal of koala habitat (in accordance with dot points 1-4 of the above waive clause), and where circumstances permit, this is to include measures which result in a "net gain" of koala habitat on the site and/or adjacent land;

e. Make provision for long term management and protection of koala habitat including both existing and restored habitat;

f. Not compromise the potential for safe movement of koalas across the site. This should include maximising tree retention generally and minimising the likelihood that the proposal would result in the creation of barriers to koala movement, such as would be imposed by certain types of fencing;

g. Be restricted to identified envelopes which contain all buildings and infrastructure and fire fuel reduction zone; and

h. Include measures to effectively minimise the threat posed to koalas by dogs, motor vehicles and swimming pools by adopting minimum standards for these threats.

These matters have been addressed in **Section 2.1.2.10.2** of the SIS (RPS 2020).

1.7 Relationship with other Management Plans

An integrated management framework is required to manage, protect and conserve biodiversity. This is to be achieved through the dual implementation of this VMP and the BMP including the annual works program prepared for the Conservation Area. Key co-related tasks requiring an integrated implementation include:

- The salvaging of natural hollows and fallen logs for installation in the Conservation Area.
- Weed management activities to minimise the potential for weed invasions into the Conservation Area.
- Fauna management during the clearing process (i.e. pre-clearance surveys and vegetation clearance supervision).
- Vegetation clearing for the establishment of new tracks within the Conservation Area.

This VMP, as required by the Port Stephens DCP (2014), is guided by the proposed vegetation clearing procedure outlined in **Section 1.3**. The progressive approach to vegetation clearing focuses on harm minimisation (i.e. minimise impacts on the koala and hollow-dependent fauna), which is further elaborated on in **Section 3** of this VMP. In relation to the clearing of vegetation for the proposed tracks specified in the BMP for the Conservation Area, a maximum allowance of 2.4 ha has been provided and assessed as per the location of these proposed tracks (RPS 2020b) and the associated track specification.

1.8 Consultation

This VMP has been prepared as a prescriptive management document for implementation during site preparation works. It is recommended that any Development Consent for Stage 1 Site Preparation Works be conditioned to require the submission of an annual monitoring and performance review/ audit until Stage 1 works have been finalised. Similarly, all subsequent Development Applications for the Subject Site should be conditioned to ensure Stage 1 Site Preparation Works have been carried out to Council's satisfaction in accordance with the VMP, prior to the issue of a Subdivision Works Certificate or Construction Certificate for that proposal.

This outcome focused process is expected to provide an orderly implementation of management actions that aim to minimise the effects of vegetation clearing and supplement the functioning of the BMP for adjoining the Conservation Area.

1.9 Definitions

A number of terms used throughout this report require defining as to eliminate any discrepancies as the recommended management requirements (refer to **Table 4**).

Table 4: Definitions

Term	Definition
Local provenance	Refers to seed collected from natural populations growing in the same vegetation community and position in the landscape within a reasonable (closest possible) distance of the area being restored. Existing site-level forage quality information collected at Kings Hill to identify high-quality trees will be used to source seed for revegetation. Seedlings grown from selected trees will form the foundations for the revegetation and enrichment works.
Native vegetation	Native vegetation includes all the vegetation that is indigenous to Australia, covering individuals as well as communities that existed prior to European Settlement
Regeneration	Describes the restoration of natural ecosystems through the natural cyclic processes of renewal and self maintenance of species and their populations

Term	Definition
Rehabilitation	Any attempt to restore elements of structure or function to an ecological system without necessarily attempting complete restoration to any specific prior condition
Revegetation	Replanting of native vegetation
Vegetation Conservation Area	An area selected for vegetation rehabilitation subject to a range of management actions
Weed	Non native plant species that have moved into areas of native vegetation

2 EXISTING ENVIRONMENT

2.1 Overview

A summary of the existing environment, as detailed within the SIS (RPS 2020a), is provided in the following sections and has been used as the basis for defining management zones for the Management Area. Project documentation was reviewed in conjunction with a detailed site inspection. Documentation reviewed to identify, evaluate and quantify the key biodiversity values requiring consideration in the VMP is listed below:

- Kings Hill Development Species Impact Statement (RPS 2020a); and
- Kings Hill Development Biodiversity Management Plan (RSP 2020b).

Supplementary information was obtained from a site investigation was performed on 13 May 2019 to:

- Map existing tracks for use in the implementation of the VMP;
- Validate and characterise areas of high weed infestation;
- Refine Conservation Areas most suitable for habitat enrichment for the koala;
- Perform condition analysis of vegetation associated with creeks and/or other water bodies; and
- Identify any areas of erosion, rubbish dumping and/or degradation to be rehabilitated.

2.2 Flora

2.2.1 Plant Communities

Three native plant community types (PCTs) are mapped as occurring within the Management Area as listed in **Table 5** with the spatial extents shown in **Figure 3**.

Table 5: PCTs of the Management Area

PCT Name	Area (ha)
1584 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	47.94
1590 Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	159.05
1600 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter[1]	5.15
Total	**212.14**

Vegetation described as exotic grasslands occupies the remaining parts of the management area.

2.2.2 Threatened Flora

Three threatened flora species are known to occur within the Management Area, including:

- *Corybas dowlingii* (endangered – BC Act);
- *Maundia triglochinoides* (vulnerable – BC Act); and
- *Pterostylis chaetophora* (Taree Rusty Greenhood) (vulnerable – BC Act).

Locations are shown in **Figure 3**.

[1] *Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin and North Coast Bioregions* EEC

TITLE : **FIGURE 3: VEGETATION COVER AND THREATENED SPECIES**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 3 Vegetation cover and threatened species B A3 20200722.mxd

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2.2.3 Exotic Flora

2.2.3.1 Species with Regulatory Management Requirements

Exotic flora requiring management occur within the Management Area are listed in **Table 6** along with their Biosecurity Duty as specified in the Hunter Regional Strategic Weed Management Plan 2017-2022 (Hunter Local Land Services 2017).

Table 6: Exotic flora requiring management within the Management Area

Exotic Species	Classification	Biosecurity Duty (Hunter Local Land Services 2017)
Lantana (*Lantana camara*)	Weed of National Significance (WoNS) *Biosecurity Act* 2015	Weed of community concern for agricultural and environmental outcomes All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Alligator Weed (*Alternanthera philoxeroides*)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective - CONTAINMENT An owner or occupier of land in the Alligator weed biosecurity zone on which there is the weed *Alternanthera philoxeroides* (Alligator Weed) must: a) if the weed is part of a new infestation of the weed on the land, notify the local control authority for the land as soon as practicable in accordance with Part 6, and b) eradicate the weed or if that is not practicable destroy as much of the weed as is practicable and suppress the spread of any remaining weed.
Water Hyacinth (*Eichhornia crassipes*)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective - CONTAINMENT An owner or occupier of land in the Water Hyacinth biosecurity zone on which there is the weed *Eichhornia crassipes* (Water Hyacinth) must: a) if the weed is part of a new infestation of the weed on the land, notify the local control authority for the land as soon as practicable in accordance with Part 6, and b) eradicate the weed or if that is not practicable destroy as much of the weed as is practicable and suppress the spread of any remaining weed.
Blackberry (*Rubus fruticosus species aggregate*)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective – ASSET PROTECTION
Asparagus (*Asparagus* spp.)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective – ASSET PROTECTION
Fireweed (*Senecio madagascariensis*)	WoNS *Biosecurity Act* 2015	State Priority Weed Objective – ASSET PROTECTION
African Olive (*Olea europaea* subsp. *cuspidata*)	*Biosecurity Act* 2015	Regional Priority Weed Objective – ASSET PROTECTION

The Regional Strategic Response for Alligator Weed and Water Hyacinth is:

- Detailed surveillance and mapping to locate all infestations.
- High level pathways analysis to identify potential introduction areas and preventative options.
- Implement quarantine and/or hygiene protocols.
- Monitor progress towards eradication.

The Regional Strategic Response for these species is:

- Develop region-wide coordinated campaigns for collaborative management
- Identification of regional containment zones where required
- Identification of key sites/assets in the geographic area
- Species managed in accordance with published weed management plan

The Regional Strategic Response for African Olive is:

- Establish agreed quarantine and/or hygiene protocols.
- Surveillance and mapping to locate all infested properties.
- Monitor change in current distribution to ensure containment of spread.
- High level analysis of pathways to identify potential introduction areas and preventative options.
- Identification of key sites/assets in the geographic area
- Develop region-wide coordinated campaigns for collaborative management.

2.2.3.2 Species for Management Consideration

Other notable exotic species recorded within the Conservation Area that are deserving of management focus are listed below:

- Carpet Grass (*Axonopus fissifolia*);
- Spear Thistle (*Cirsium vulgare*);
- Whiskey Grass (*Andropogon virginicus*);
- Wild Tobacco (*Solanum mauritianum*);
- Large-leaved Privet (*Ligustrum lucidum*);
- Small-leaved Privet (*Ligustrum sinense*);
- Crofton Weed (*Ageratina adenophora*);
- Cotton Bush (*Gomphocarpus fruticosus*);
- Camphor Laurel (*Cinnamomum camphora*); and
- Mickey Mouse Plant (*Ochna serrulata*).

2.3 Fauna

2.3.1 Habitat

Fauna of the Conservation Area can be broadly characterised by those occupying habitats described as dry sclerophyll and mesic forests on various geomorphic surfaces (e.g. soils, aspect, slope) dissected by 1st to 3rd order streams and some floodplain environs. The catchment mostly comprises ephemeral 1st and 2nd order streams on moderately steep grades that exhibit short duration flows following effective rainfall events. These flows ultimately drain into wetlands located on the coastal floodplain in the south and west. Few instances of naturally prolonged water accumulations occur within these drainages outside the floodplain environment.

In some drainages, these flows are intercepted by constructed online water detention structures built for the purposes of watering livestock. Also, there are scattered turkey nest dams throughout the Conservation Area acting as additional offline watering points.

The hydrogeomorphology of a third order stream in the east of the Conservation Area is characterised by small semipermanent pools interconnected by dry elongated clayey riffle zones with no gravel substrate. Flows in this stream are rainfall dependant and are generally stagnant outside rainfall events.

Rocky ground is commonly seen on elevated lands, which on mid to lower slopes breaks to clayey soils. A heterogenous distribution of fallen logs and hollow-bearing trees was observed; these representing habitat features with positive influence on bird, mammal and reptile species diversity.

2.3.1.1 Hollow-bearing Trees

The modelled distribution of hollow-bearing trees within the Management Area (RPS 2020a) is not even and varies in accordance with historical land use as shown in **Figure 4**. Relatively inaccessible lands generally comprise higher densities of hollow-bearing trees, as these forests were more difficult to clear or log.

2.3.1.2 Fallen Logs

The modelled distribution of fallen logs within the Management Area (RPS 2020a) is not even and varies in accordance with historical land use as shown in **Figure 5**. This is provided to assist in the identification of areas requiring fauna management.

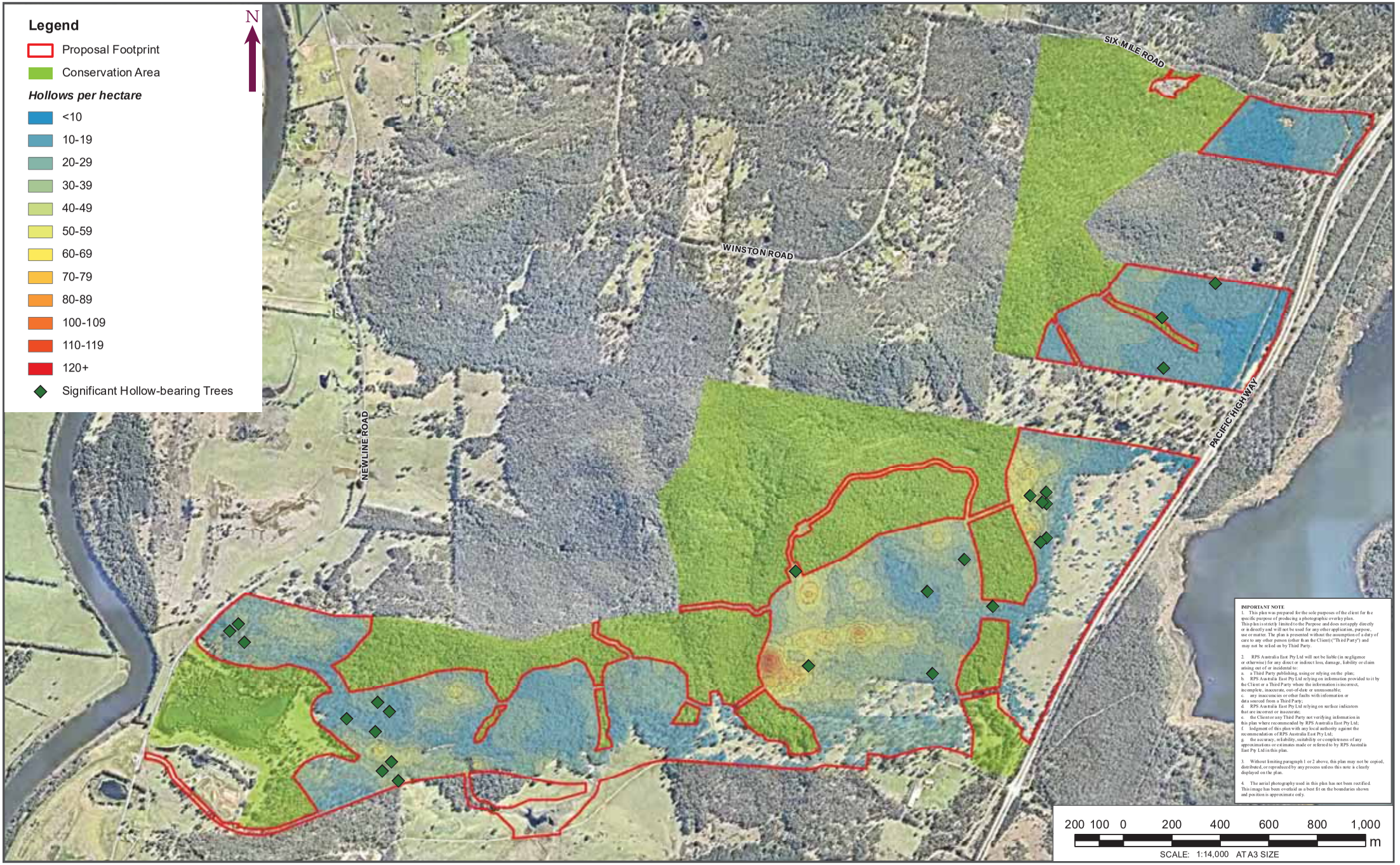
2.3.2 Threatened Fauna Species

Fourteen threatened fauna species have been recorded within the Management Area with recorded locations shown in **Figure 6**. Species observations are as follows:

- Grey-crowned Babbler (vulnerable under the BC Act);
- Glossy-black Cockatoo (*Calyptorhynchus lathami*) (vulnerable under the BC Act);
- Scarlet Robin (*Petroica boodang*) (vulnerable under the BC Act);
- Brown Treecreeper subspecies (*Climacteris picumnus victoriae*) (vulnerable under the BC Act);
- Varied Sittella (*Daphoenositta chrysoptera*) (vulnerable under the BC Act);
- Little Lorikeet (*Glossopsitta pusilla*) (vulnerable under the BC Act);
- Powerful Owl (*Ninox strenua*) (vulnerable under the BC Act);
- Squirrel Glider (*Petaurus norfolcensis*) (vulnerable under the BC Act);
- Brush-tailed Phascogale (*Phascogale tapoatafa*) (vulnerable under the BC Act);
- Koala (*Phascolarctos cinereus*) (vulnerable under the BC Act and EPBC Act);
- Eastern Freetail Bat (*Mormopterus norfolkensis*) (vulnerable under the BC Act);
- Grey-headed Flying-fox (*Pteropus poliocephalus*) (vulnerable under the BC Act and EPBC Act);
- Little Bentwing Bat (*Miniopterus australis*) (vulnerable under the BC Act); and
- Eastern Bentwing Bat (*Miniopterus schreibersii oceanensis*) (vulnerable under the BC Act).

2.4 Connectivity

Habitat connectivity throughout the Conservation Area provides continuous links through the landscape to the north, south and tentatively to the east beyond the immediately adjacent Pacific Highway. The Hunter River to the west creates discontinuity with habitats on the western side of the river. High canopy connectivity habitats are prevalent throughout the site, providing strong habitat resources for a range of arboreal fauna species.



TITLE : **FIGURE 4: MODELLED DISTRIBUTION OF HOLLOW-BEARING TREES WITHIN THE MANAGEMENT AREA**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 4 Modelled Distribution of Hollow-bearing Trees within the Management Area B A3 20200722.mxd

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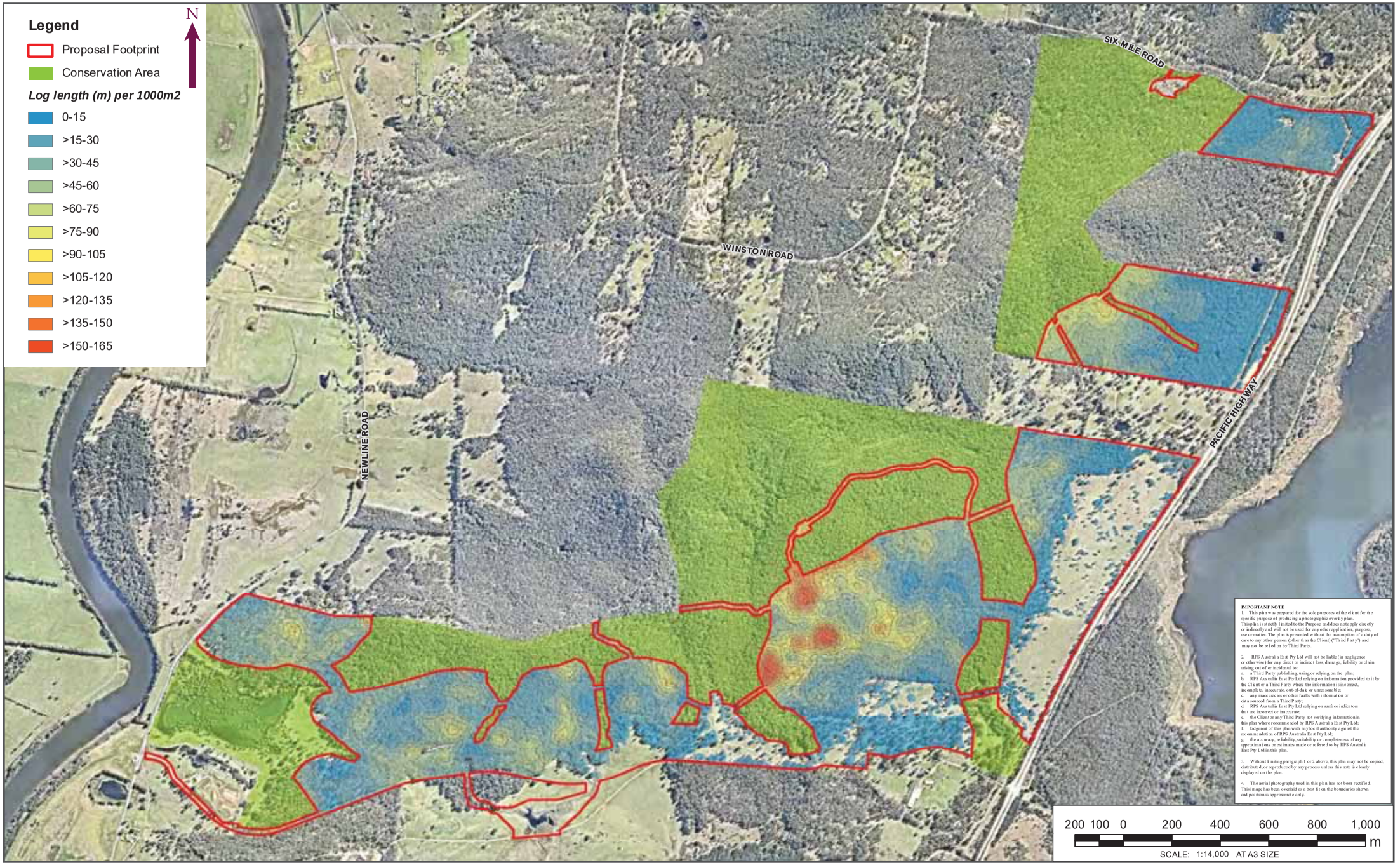

TITLE : **FIGURE 5: MODELLED DISTRIBUTION OF FALLEN LOGS WITHIN THE MANAGEMENT AREA**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 5 Modelled Distribution of Fallen Logs within the Management Area B A3 20200722.mxd

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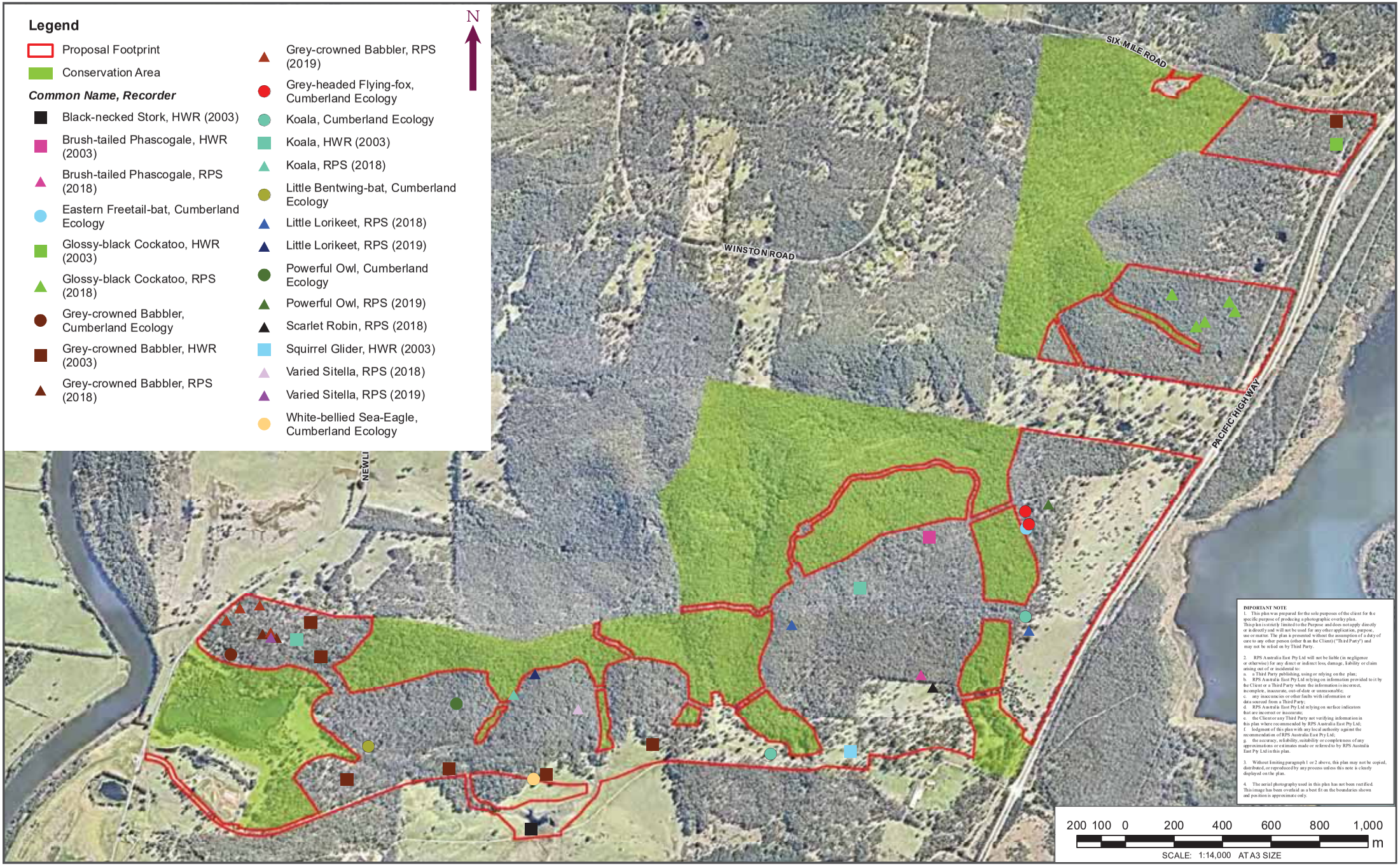

TITLE : **FIGURE 6: LOCATION OF THREATENED FAUNA SPECIES DETECTED IN THE MANAGEMENT AREA**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Ecol\Report\6. VMP\130430 Figure 6 Location of Threatened Fauna Species detected in the Management Area B A3 20200722.mxd

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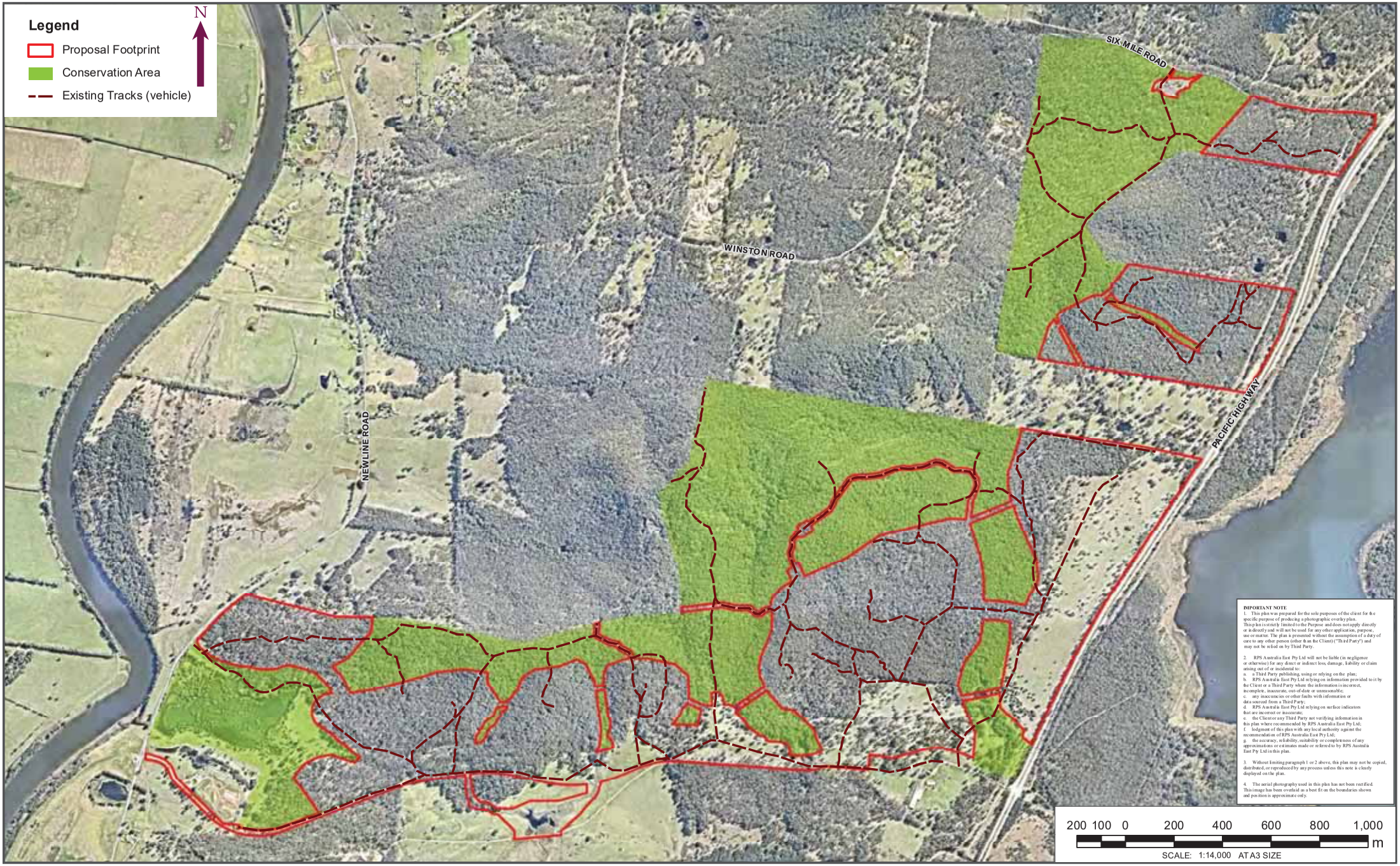
2.5 Tracks and Trails



TITLE : **FIGURE 7: EXISTING TRACKS OF THE CONSERVATION AREA**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 7 Existing Tracks of the Conservation Area B A3 20200722.mxd

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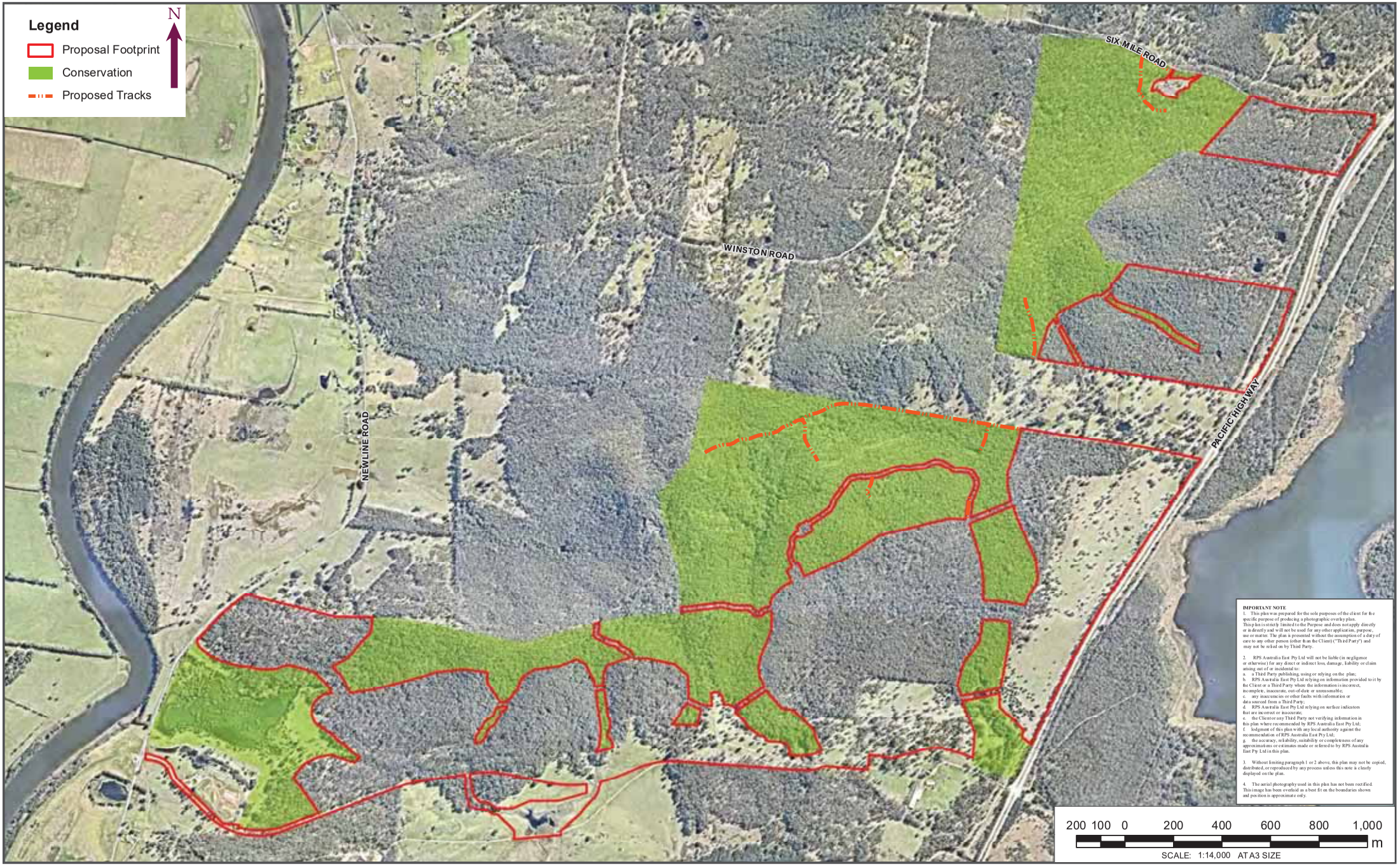

TITLE : **FIGURE 8: PROPOSED TRACKS OF THE CONSERVATION AREA**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 8 Proposed Tracks of the Conservation Area B A3 20200722.mxd

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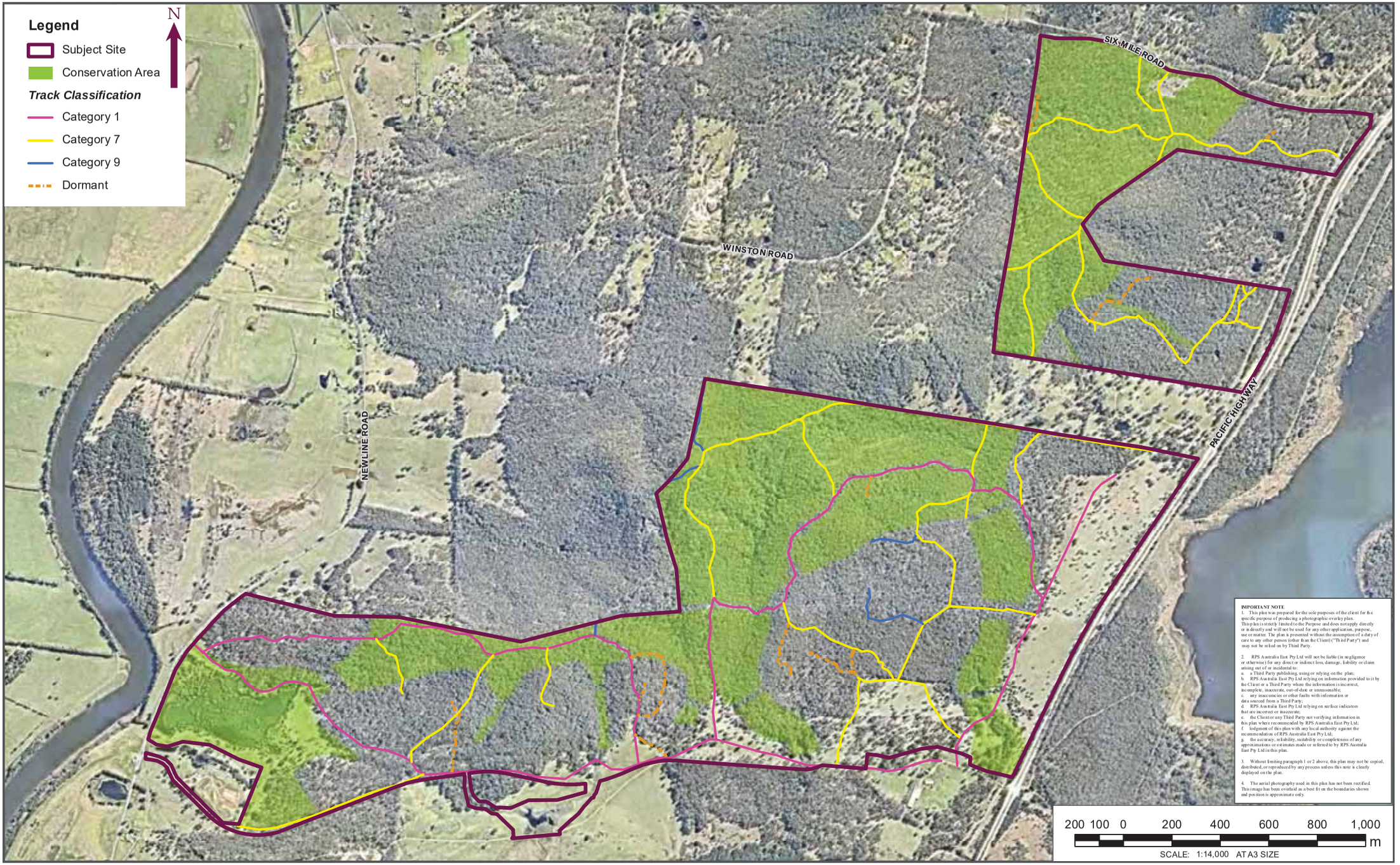

TITLE : **FIGURE 9: TRACK CLASSIFICATIONS OF THE CONSERVATION AREA**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): B A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 9 Track Classifications of the Conservation Area B A3 20200722.mxd

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3 VEGETATION CLEARING SPECIFICATION

3.1 Overview

Vegetation clearing is to occur within the Proposal footprint and within the Conservation Area for the following purposes:

- Proposal footprint: Site preparation works; and
- Conservation Area: Establishment of infrastructure such as new tracks.

The following sections provide details on how vegetation clearing is to be performed.

3.2 The Proposal

As discussed in **Section 1.3**, vegetation removal arising as a consequence of the Proposal will gradually occur across all phases of the Proposal using the three removal techniques for each Phase of works as listed below:

- Step 1: Exotic flora removal;
- Step 2: Partial vegetation removal; and
- Step 3: Complete vegetation removal.

To avoid doubt, Step 1 requires ongoing management in all Phases (see **Figure 2**), while Step 2 of Phase 2 cannot proceed until Step 3 of Phase 1 is completed. To ensure impact minimisation, Step 2 of Phase 3 cannot proceed until Step 3 of Phase 2 is completed AND only to the extent that consent is granted for development within Phase 3.

Clearing activities are guided by the procedure outlined in the SIS (RPS 2020a), as reproduced in **Section 1.3**, and the specification guidance provided in the following sections.

3.2.1 Exotic Flora Removal

Step 1 in the vegetation clearing procedure (**Section 1.3**) involves the removal of exotic vegetation can occur within any part of the Management Area at any time expressly for the purpose of meeting biosecurity obligations specified under the *Biosecurity Act* 2015 and regional weed management plan. Target species include Lantana, African Olive, Alligator Weed and Water Hyacinth.

3.2.2 Partial Vegetation Removal

Step 2 in the vegetation clearing procedure for each Phase (**Section 1.3**) is a progressive, partial vegetation removal process that can occur after or concurrently with Step 1. It that makes allowance for the management of bush fire threat at a landscape level and orderly recovery of habitat for enhancement works in the Conservation Area while minimising the impact intensity of the clearing works on fauna. It also provides an opportunity to integrate suitable tree species into an urban landscape to provide patchy habitat that may support the lifecycle of highly mobile species known to utilise urban landscapes such as foraging and/ or roosting [e.g. Grey-headed Flying Fox (Port Stephens Council 2017), the Powerful Owl and Powerful Owl prey species) (Powerful Owl Coalition 2018)]. The following sections outline the specifications for each step in the vegetation clearing procedure including guidance for circumstances where conflicts arise.

3.2.2.1 Bushfire Threat Management

3.2.2.1.1 Background

The size of the APZ required around assets depends on the nature of the asset, the slope of the area, the type and structure of nearby vegetation and whether the vegetation is managed. This process and distances

are typically outlined within the relevant Bushfire Assessment Report for the future development and has not been determined in this VMP for the Proposal.

3.2.2.1.2 Prescription Types

An APZ can be divided into two components being either an 'ínner' or 'outer' area. As a general prescription, partial clearing works are to preferentially meet the standards for an 'inner protection area', unless conflicts arise with other partial clearing specifications specified in **Sections 3.3.2** and **3.3.3**. Where conflicts arise, the partial clearing prescription is to adopt the 'outer protection area' standard. A description of each kind of zone prescription is outlined in the following sections.

Inner Protection Area of the APZ

Trees:

- Canopy cover should be less than 15% (at maturity);
- Trees (at maturity) should not touch or overhang the building;
- Lower limbs should be removed up to a height of 2 m above ground;
- Canopies should be separated by 2 to 5 m; and
- Preference should be given to smooth barked and evergreen trees.

Shrubs:

- Create large discontinuities or gaps in the vegetation to slow down or break the progress of fire towards buildings shrubs should not be located under trees;
- Shrubs should not form more than 10% ground cover; and
- Clumps of shrubs should be separated from exposed windows and doors by a distance of at least twice the height of the vegetation.

Grass:

- Should be kept mown (as a guide grass should be kept to no more than 100 mm in height); and
- Leaves and vegetation debris should be removed.

Outer Protection Area of the APZ

Trees:

- Tree canopy cover should be less than 30%;
- Trees should have canopy separation;
- Canopies should be separated by 2 to 5 m.

Shrubs:

- Shrubs should not form a continuous canopy; and
- Shrubs should form no more than 20% of ground cover

Grass:

- Should be kept mown (as a guide grass should be kept to no more than 100mm in height); and
- Leaf and other debris should be mown, slashed or mulched.

3.2.2.2 Habitat Salvaging

Habitat enhancement works proposed within the Conservation Area are to be installed in accordance with specifications in the BMP. The clearing that forms part of this VMP is to be complimentary to these enhancement works to the extent where salvage works are required to aid in the acquisition of habitat

features necessary for these outcomes. Materials to be salvaged during partial clearing works include natural hollows and logs.

3.2.2.2.1 Natural Hollows

The harvesting of natural hollows will rely heavily on site based decisions made by the Project Ecologist at the time of partial clearing works. The Project ecologist will identify suitable trees capable of being cut into shorter sections for refurbishment into natural hollows. Cut lengths will vary and will take into consideration the portability of the final product, knowing that manual handling will be integral to the relocation and installation of the hollow elsewhere in the Conservation Area. Collaboration with the Project Arborist is required to manage hollow sizing as manual handling limitations are likely to apply.

Salvageable natural hollows are to be harvested during Phase 1 clearing works. The process is to follow the BMP specifications as indicated below:

- Natural hollows are to be identified under the direction of the Project Ecologist and Project Arborist in Phase 0 as part of early pre-clearance works. Candidate trees are to be marked in the field with a tree number and recorded using GPS;
- Pre-clearance surveys and clearance supervision is to be performed under the direction of the Project Ecologist for identified trees. Fauna salvaged from these works are to be processed in accordance with procedure outlined in Appendix A of the BMP.
- Salvaged hollows will be inspected by the Project Ecologist and Project Arborist for suitability. Selected hollows are to be cut to size, sealed on the base and preserved with linseed oil and stored for installation works; and
- Offcuts and hollow logs will also be preserved for ground logs.

Hollows are to be placed in the Conservation Area as per the guidance provided in the BMP.

3.2.2.2.2 Fallen Logs

Fallen logs are to be harvested from trees felled during this stage of the clearing process. Tree stems are to be acquired and translocated to the Conservation Area for emplacement in accordance with the BMP.

As detailed in the BMP, the total sawn log length to be installed within the Conservation Area during Phase 1 works has an annual target of 1,000 m (assuming ~1,000 m of log length is installed through selective thinning practices in Phase 0). Fallen logs will be identified and prepared by the Project Forester.

The specifications for these logs are as follows:

- Minimum 100 mm diameter for the entire log length; and
- Minimum 1 m cut lengths with average log length being 2 – 5 m.

Logs are to be placed in the Conservation Area as per the guidance provided in the BMP.

3.2.2.3 Resource Recovery

Selective timber felling (for mobile milling of fence posts etc), native plant and bushrock recovery for reuse in landscaping within the KHURA. Felled timber is to be assessed for sustainable reuse options whether they be on site (e.g. mulching for soil management) or offsite for use in local industry.

3.2.2.4 Minimising Impact of Habitat Loss

Fauna species sensitive to clearing related reconfigurations in habitat patches within the Management Area include the Koala (e.g. loss of preferred feed trees) and hollow-tree dependent species such as the Brush-tailed Phascogale. Impacts on these species is to be minimised during this step of the clearing process through the preferential retention of PKFTs and hollow-bearing trees, subject to any conflicts that may arise through clearing works for bush fire threat management works.

Additionally, native species that are known to utilise the peri urban environment, such as the Grey-headed Flying Fox and the Powerful Owl, may benefit from the selective retention of trees species. Subsequently, consideration should be given to the retention of trees suitable for urban landscapes without restricting bushfire mitigation measures and impeding development on individual lots of the future Proposal design.

Where possible, it is recommended that five trees per hectare, on average, be integrated into the urban landscape to support these highly mobile species. This recommendation is most practical for public spaces such as nature strips and public verges but can be refined during the design stages of the Proposal.

Specifications for the preferential retention of habitat features useful in minimising impacts on targets species are as listed as follows:

- Where possible, avoid the clearing of the following PKFTs where the tree has a diameter at breast height exceeding 300 mm:
  - Forest Redgum (*Eucalyptus tereticornis*);
  - Grey Gum (*Eucalyptus punctata*);
  - Small-fruited Grey Gum (*Eucalyptus propinqua*);
  - Tallowwood (*Eucalyptus microcorys*); and
  - Grey Box (*Eucalyptus moluccana*);
- Hollow-bearing trees with the following hollow types:
  - Medium sized hollows (i.e. 5-20 cm opening); and
  - Large sized hollows opening (i.e. >20 cm opening).
- Where practical, retain the following tree species > 300 mm dbh:
  - White Stringybark (*Eucalyptus globiodea*);
  - Grey Ironbark (*Eucalyptus siderophloia*);
  - Smooth-barked Apple (*Angophora costata*);
  - Blackbutt (*Eucalyptus pilularis*); and
  - Spotted Gum (*Corymbia maculata*).

Conflicts with specifications mentioned in **Section 3.3.1** and or **3.3.2** are to be managed as follows:

- Utilise an outer protection area specification if clearing for an inner protection area will result in unacceptable loss and there will be no impact on bushfire management objectives; and
- Selectively remove hollow-bearing trees where habitat salvaging requirements dictate such a need.

The rate of vegetation clearing in this step would be governed by need, however, should consider a steady process so as to minimise impacts on fauna. It is recommended that a monthly rate of 2-3 ha be considered an appropriate framework for clearing.

3.2.3 Complete Removal of Vegetation

Step 3 in the vegetation clearing procedure (**Section 1.3**) for each Phase involves complete removal of native vegetation and can only occur after satisfactory completion of the preceding two steps. It is only proposed to occur immediately prior to subdivision construction works, and only to the extent that the land is approved for development, as part of the impact minimisation process. Clearing associated with this last stage of the Proposal is detailed in **Table 7**.

Table 7: Clearing Activities

Actions	Timing	Responsibility
All site personnel involved in construction activities must be inducted during Toolbox Talks on the requirements of this VMP prior to commencing work in the Management Area. Site personnel are to be: • Made aware of the clearing limits and how they are marked. • Informed that they are not to encroach on areas beyond the clearing limits. • Are to be informed of the 2 stage clearing process for habitat trees. • Made aware of the locations of trees that will be retained, measures required to protect them, and the consequences of damage to these areas. • Made aware of threatened and migratory species known or likely to occur in the Management Area and their habitat.	Immediately prior to the commencement of clearing	Foreman and Project Ecologist
Undertake a two-stage approach to clearing habitat trees: • Stage 1: under-scrubbing of the entire Management Area should be carried out by a 4 x 4 tractor with a slashing deck and a layer of mulch is to be left to aid in soil retention. Non-hollow-bearing tree and non-habitat trees will be cleared in a sequence that leaves trees that allow fauna to move to adjacent vegetation to be retained. • Stage 2: After a period of up to two weeks, clearing of hollow-bearing and habitat trees that are not being retained will commence. Trees not requiring arborist attention are to be knocked with an excavator bucket or other machinery to encourage fauna to evacuate the tree immediately prior to felling. Trees should be “soft-felled”. Felled trees must be left for a short period of time on the ground to give any fauna trapped in the trees an opportunity to escape before further processing of the trees.	During clearing activities	Project Ecologist, Contractors
Hollow-bearing trees felled within the subject site are to be considered for reuse as fauna habitat in the Conservation Area (see Table 16 and Table 17 of the BMP for management objectives of this action).	Phase 1	Project Ecologist, Project Forester
Trees felled within the Management Area will be considered for reuse in the Conservation Area as fallen logs. Parameters for the logs are: • Minimum 100 mm diameter for the entire log length; and • Minimum 1 m cut lengths with average log length being 2 to 5 m; and • Logs are to be placed in designated locations.	Phase 1	Project Ecologist, Project Forester

3.3 Conservation Area

The establishment of the Conservation Area is to be in accordance with the BMP prepared for this area (RPS 2020b). Establishment works will require the establishment of new tracks, as shown in **Figure 8**, for the purposes of managing bush fire risk and providing access for management works. The SIS makes an allowance of 2.4 ha for the clearing of native vegetation to establish these new tracks.

The use of this allowance is subject to demonstrating impact avoidance, minimisation and mitigation outcomes. To this end, the establishment new tracks is to be performed in a manner that complies with steps 2 and 3 as described in **Section 3.2**. This will require a pre-clearance survey to be performed by a suitably qualified ecologist to define a path that will result in least number of trees to be removed noting a priority for the avoidance of hollow-bearing trees and high value Koala feed trees (i.e. Grey Gum, Small-fruited Grey Gum, Forest Red Gum, Tallowwood and Grey Box). The avoidance of threatened flora species must also be demonstrated, although it is noted that the proposed tracks in **Figure 8** do not currently pass within close proximity of a known threatened flora species occurrence.

The works area associated with the construction of the track is to be defined by temporary fencing (e.g. rope) to limit inadvertent vegetation clearing outside the required specifications for the track. Finally, the total area of vegetation clearing performed is to be documented by survey and retained on a register to ensure the total clearing performed within the Conservation Area for new tracks does not exceed the allowance of 2.4 ha.

4 MANAGEMENT ZONES

4.1 Zones and Objectives

Vegetation Management Zones (VMZs) 1, 2 and 3, as shown in **Figure 7**, reflect the Proposal phasing and have the purpose of partitioning management effort according to need and timeframes. The fourth VMZ, which overlaps parts of the preceding VMZs makes allowance for the implementation of revegetation works following the completion of site preparation works. These are described in **Table 8**.

Table 8: VMZ Descriptors and Objectives

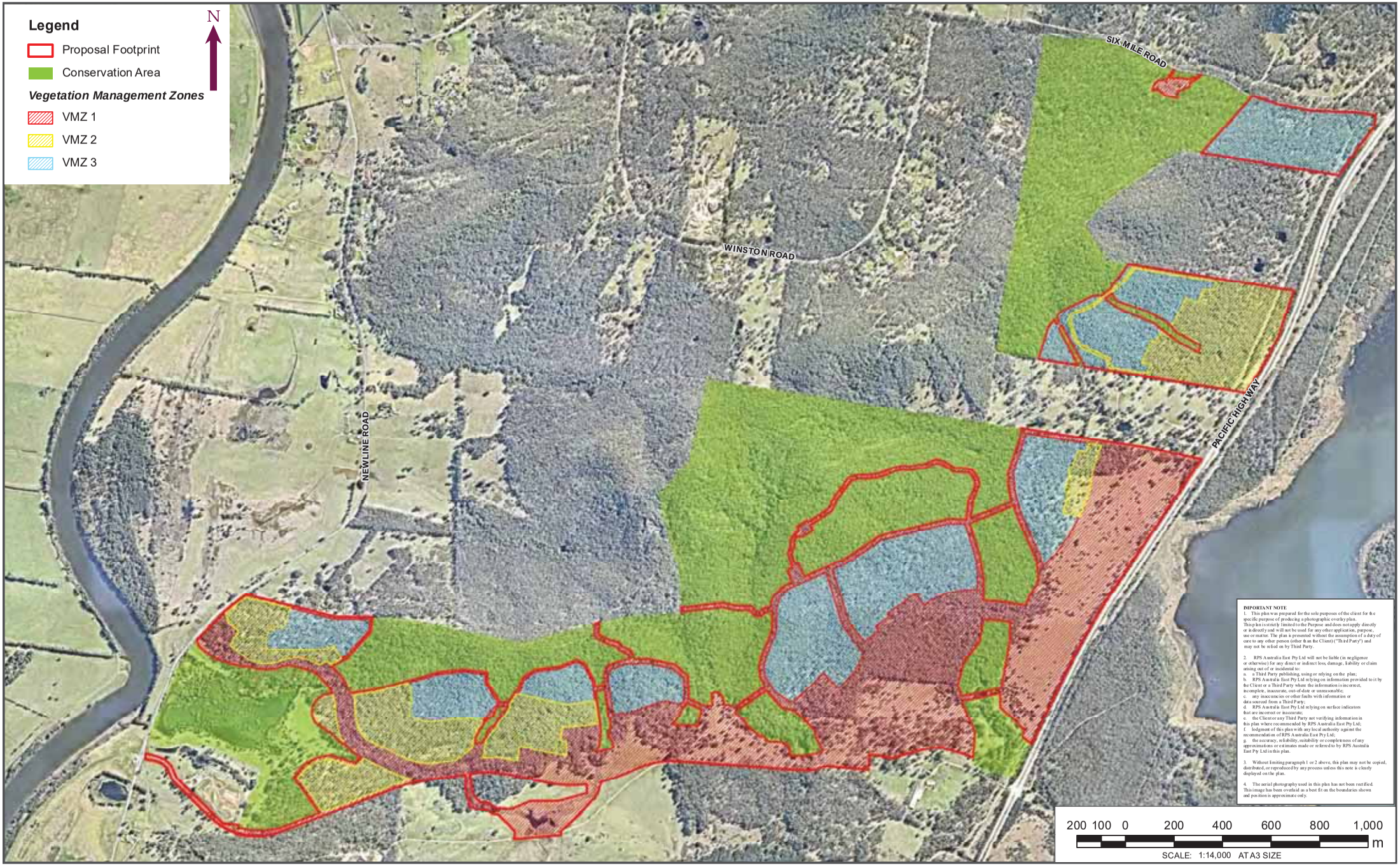
VMZ	Descriptor	Objectives
1	Phase 1	Complete steps 1 and 2 of vegetation clearing procedure within 12 months of initiating Phase 1 Complete step 3 of the vegetation clearing procedure, as required, by the end of Phase 1
2	Phase 2	Initiate step 1 of vegetation clearing procedure during Phase 1 Only upon completion of Step 3, Phase 1: • Complete steps 1 and 2 of vegetation clearing procedure within 24 months of initiating Phase 2 • Complete step 3 of vegetation clearing procedure, as required, by the end of Phase 2
3	Phase 3	Initiate step 1 of vegetation clearing procedure during Phase 1 Only upon completion of Step 3, Phase 2 AND only to the Extent of Development Consent within Phase 3: • Complete steps 1 and 2 of vegetation clearing procedure within 24 months of initiating Phase 3 • Complete step 3 of vegetation clearing procedure, as required, by the end of Phase 3
4	Revegetation	Revegetate detention basins with high value preferred Koala feed tree species

4.2 Performance Targets

Performance targets are outlined in **Table 9**.

Table 9: VMZ Performance Targets by Phase

VMZ	Performance Target			
	Phase 0	Phase 1	Phase 2	Phase 3
1	• Complete step 1 of clearing procedure by end of Phase 0 • No rubbish in VMZ • Erosion measures in place where weeds removed • Install temporary fencing to delineate boundary between VMZ 1 and 2 • Source propagules for plantings performed in Phase 1	• Maintain weed management • Complete step 2 of clearing procedure within 24 months of starting Phase 1 • Complete step 3 of clearing procedure by end of Phase 1 • No rubbish in VMZ • Erosion managed • Salvage ~1,000 natural hollows • Salvage ~3,000 m logs • Revegetate identified detention basins with winter and spring nectar species (e.g. Swamp Mahogany)	• Clearance Procedure Complete • Revegetate identified detention basins with winter and spring nectar species (e.g. Swamp Mahogany) • Replace unsuccessful plantings	• Clearance Procedure Complete • Replace unsuccessful plantings • Revegetated landscapes comprise high value winter nectar feed trees for species such as the Grey-headed Flying Fox
2	• Initiate step 1 of clearing procedure as required • No rubbish in VMZ • Erosion measures in place where weeds removed	• Complete step 1 of clearing procedure by end of Phase 1 • No rubbish in VMZ • Erosion managed	• Maintain weed management • Complete step 2 of clearing procedure within 24 months of starting Phase 2 • Complete step 3 of clearing procedure by end of Phase 2 • No rubbish in VMZ • Erosion managed	• Clearance Procedure Complete
3	• Initiate step 1 of clearing procedure as required • No rubbish in VMZ • Erosion measures in place where weeds removed	• Maintain weed management • No rubbish in VMZ • Erosion managed	• Complete step 1 of clearing procedure by end of Phase 2 • Implement bushfire threat management measures • No rubbish in VMZ • Erosion managed	• Maintain weed management • Complete step 2 of clearing procedure within 24 months of starting Phase 2 • Complete step 3 of clearing procedure by end of Phase 3 • No rubbish in VMZ



TITLE : **FIGURE 10: VEGETATION MANAGEMENT ZONES**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): A A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 10 Vegetation Management Zones A A3 20200722.mxd

CLIENT: **PM NO 1 PTY LIMITED**

JOB REF: **PR130430**

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4.3 Management actions

Management actions, responsibilities, performance criteria, timing and corrective actions for this VMP are outlined in **Tables 10** to **16**. Management actions to be performed prior to construction works are outlined in **Table 10**.

Table 10: Management Actions: Site setup and pre-construction

Action	Responsibility	Performance Criteria	Timing	Corrective Actions
OH&S Hazard & risk assessment for vegetation management contractors and construction workers. Prepare Safe Work Method Statement. Conduct internal safety and environmental induction.	Project Ecologist	Safe Work Method Statement (or equivalent) submitted and approved	Phase 1 - Prior to clearing	Works cannot proceed until completion of task
Brief to all staff and contractors regarding the sensitive nature of the vegetation, of threatened species and of the vegetation clearing procedure	Project Ecologist	All staff informed of important ecological matters pertaining to this VMP	Phase 1 - Prior to clearing	Works cannot proceed until completion of task
Install koala fencing treatment as specified in the SIS (RPS 2020a)	Project Ecologist	Fencing to be installed along the boundary between Phase 3 and Conservation Area	Phase 1 – within first 6 months	Phase 2 cannot proceed until completion of task
Apply protective fencing or tree shielding to any trees in the Conservation Area that are deemed necessary for protection from construction works	Project Ecologist	All trees adjacent to APZ protected to the standard of Australian Standards 4970-2009 'Protection Of Trees On Development Sites'	Phase 1 - Prior to clearing	Works cannot proceed until completion of task
Install protection fencing for *Pterostylis chaetophora*	VMC	Installation of fluorescent tape forming a 10 m buffer around any individual *Pterostylis chaetophora*	Phase 1 - prior to clearing	Works cannot proceed until completion of task
Clearing limits must be identified and delineated by installing highly visible barrier or rape with 'No-Go' signage	Project Ecologist	Barriers and signage established	Check and verify limits 5 days prior to the commencement of clearing. Highly visible flagging tape or fencing that delineates vegetation to be retained will be maintained until the date of construction completion.	Works cannot proceed until completion of task
Identify nearby habitat suitable for the release of fauna that may be encountered during the pre-clearing process.	Project Ecologist	Area identified and documented	Within 7 days prior to clearing	Works cannot proceed until completion of task

Table 11: Management Actions: Construction

Action	Responsibility	Performance Criteria	Timing	Corrective Actions
Protection of surrounding vegetation	Project Ecologist	Evidence of presence during vegetation removal by supplying before and after photos of vegetation being cleared, fencing and tree protection measures, in accompaniment of a summary letter	Phase 1, 2 and 3 during vegetation clearing	If damage occurs to vegetation outside prescribed vegetation clearing areas, offset replanting will be required on a 1:1 ratio
Phytophthora cinnamomi spread prevention/control measures	Construction Contractors	Prior to heavy machinery entering and leaving site, clean down protocols must occur	Phase 1, 2 and 3 Before and after vegetation clearing	Machinery not to leave site until clean procedure conducted
Six monthly reports prepared	Project Ecologist	Six monthly reports to be submitted to Council and Certifying Authority verifying all works have been carried out in accordance with this VMP	Every six months until completion of the approved development	Immediate site visit to ensure VMP has been complied with, followed by report

Table 12: Management Actions: Primary Weed Control

Action	Responsibility	Performance Criteria	Timing	Corrective Actions
Removal of weeds, particularly WoNS/Priority weeds from all VMZs	VMC	Weed cover to be reduced by 25%	Phase 0 during periods of active growth	Continue primary weed control
Physical removal of *Eichhornia crassipes* (Water Hyacinth) from all VMZs	VMC	100% removal	Phase 0	Continue primary weed control

Table 13: Management Actions: Secondary Weed Control

Action	Responsibility	Performance Criteria	Timing	Corrective Actions
Consolidation of weed control for woody weeds for the VMZs	VMC	Weed cover to be reduced to 50%	Phase 1 during periods of active growth	Revert back to primary weed control measures
Consolidation of non-woody weed control from all VMZs	VMC	Weed cover to be reduced to 50%	Phase 1 during periods of active growth	Revert back to primary weed control measures

Table 14: Management Actions: Maintenance Weed Control

Action	Responsibility	Performance Criteria	Timing	Corrective Actions
Continually suppress weeds in all VMZs particularly Lantana, African Olive and Blackberry	VMC/ Landholder	Weed cover remains below 95% of baseline in all VMZs	Phase 3	Revert back to secondary weed control measures

Table 15: Management Actions: Revegetation

Action	Responsibility	Performance Criteria	Timing	Corrective Actions
Revegetation using locally sourced seeds and plant stock	VMC/Future Landholder	Revegetated areas composition, structure and size trending towards completion target using: • 'super feed trees' for koala habitat (i.e. Forest Redgum, Tallowwood, Grey Gum and Swamp Mahogany); • relevant PCTs using understorey plant species	Phase 1	Additional planting and maintenance to occur to ensure > 80% survival
	VMC	Survival of at least 95% of tubestock plantings	Within 1 year of plantings	Watering, mulching to occur as required or tree guards to be installed where appropriate. Replacement of the plants lost at a suitable time of year. Phase 2 cannot proceed until completion of task

Table 16: Management Actions: Monitoring

Action	Responsibility	Performance Criteria	Timing	Corrective Actions
Regular inspections of replanting areas to inspect performance of weed management and revegetation	Project Ecologist	Percent weed reported on and compared to baseline	Twice a year	As per report to VMC
	Landholder			
	Project Ecologist	Vegetation maintained within Bush Fire Protection Benchmarks	Twice a year for five years post planting	As per report to VMC
Site inspections to ensure compliance with VMP and to record progress of works. Feedback and contingency plans as required.	Project Ecologist	Inspection checklist completed and included in monitoring reports	Within 1-2 months of primary planting then twice yearly.	As per report to VMC
	Landholder		Annually until cessation	As per report to VMC
Prepare and submit Monitoring Report on implementation of VMP	Project Ecologist	Monitoring reports completed & submitted	Within 12 months of commencement of the VMP	As per report to VMC
Prepare and submit Annual Monitoring Report on implementation of VMP	Project Ecologist	Monitoring reports completed & submitted	Annually and one month before end of financial year	Ensure preparation for annual report is being undertaken.
	Landholder			

5 MANAGEMENT SPECIFICATIONS

5.1 Weed Management

Weed removal shall target any species likely to significantly invade bushland, prevent natural regeneration, or impede native seedling growth. During the initial primary weed control phase, priority shall be given to significant infestations where Weeds of National Significance (WoNS) and priority weeds occur. Weed removal techniques should be appropriate to the weed type, growth form, ecology, and to the existing VMZ conditions (refer to **Sections 5.1.1** and **5.1.2** for weed specific techniques). Wherever possible, weed removal should be carried out prior to annual seed set.

It is generally not possible to completely remove a weed species from a site on a single occasion, as many weeds have a persistent seed bank that can remain viable for long periods of time. Seeds will germinate rapidly after the parent plant has been removed due to increases in light and habitat availability. Therefore, a secondary consolidation phase of weed control will be undertaken which will involve control of minor infestations and revisiting the primary control phase sites for follow-up weeding, as cleared areas containing even moderately disturbed soil are highly conducive to weed invasion. This is likely to consist of spraying with herbicide (in areas not in the vicinity of a water body) or removal by hand, as any weeds present will be small and easily eradicated. At the completion of this stage, there should be minimal weeds remaining. Preventative measures and an ongoing maintenance phase control program will be undertaken to ensure this remains the case.

Minimising or active control of the spread of weeds as part of an integrated strategy will ameliorate the movement of weeds within the VMZs and surrounds. Weeds that bypass these strategies or naturally disperse into the VMZs will be controlled as part of the maintenance phase.

5.1.1 Focus

Quantitative baseline data will be collected during the first round of monitoring (refer to **Section 6**) and will be guided by weed mapping as prepared for the Species Impact Statement (SIS) (RPS 2020a). **Table 17** outlines the most prolific weed species and their presence in the respective VMZ.

Table 17: Exotic plant species incidence and respective VMZ

VMZ	Notable Exotic Plant Species	Comment
1	• *Lantana camara* (Lantana) • *Rubus fruticosus* species *aggregate* (Blackberry) • *Olea europaea* subsp. *cuspidata* (African Olive)	Significant infestations of African Olive to be addressed in this VMZ
2	• *Lantana camara* (Lantana) • *Olea europaea* subsp. *cuspidata* (African Olive)	-
3	• *Lantana camara* (Lantana) • *Rubus fruticosus* species *aggregate* (Blackberry)	-
4	• *Lantana camara* (Lantana) • *Rubus fruticosus* species *aggregate* (Blackberry) • *Olea europaea* subsp. *cuspidata* (African Olive)	Significant infestations of Lantana to be addressed in this VMZ
5	• *Lantana camara* (Lantana)	-

Additional weeds of concern that occur within the larger Conservation Area are *Ageratina adenophora* (Crofton Weed), *Asparagus aethiopicus* (Ground Asparagus), *Cinnamomum camphora* (Camphor Laurel), *Eichhornia crassipes* (Water Hyacinth), *Gomphocarpus fruticosus* (Narrow-leaved Cotton bush), *Ligustrum lucidum* (Large-leaved Privet), *Ligustrum sinense* (Small-leaved Privet), *Ochna serrulata* (Mickey Mouse Plant), *Opuntia stricta* (Prickly Pear) and *Solanum mauritianum* (Tobacco). *Lantana camara* (Lantana) was the most prevalent weed within the Conservation Area, with high percent cover in all VMZs.

5.1.2 Control Methods

Weed control requires an integrated approach and a single method of treatment should not be relied upon. Bush regeneration principles (Bradley 2006) designed for use in bushland settings, in combination with designated plantings should be employed. The systematic removal of weeds will allow native plants to establish themselves naturally (Buchanan 1989) in designated regeneration areas.

The Bradley Method of bush regeneration employs four basic principles:

1. Work outwards from good quality vegetation areas towards areas of weed;
2. Make minimal disturbance to the environment;
3. Weed control will involve primary, consolidation and long term maintenance; and
4. Do not over-clear; where possible let native plant regeneration dictate the rate of weed removal.

Manual removal of herbaceous weeds, regrowth and seedlings is preferred where possible, with minimal disturbance to soil stability and existing native species. Ecologically sensitive areas where weeds are removed manually should be stabilised or planted by the end of each working day. Removal work will be undertaken outside the seeding period of weeds, especially those weeds that produce large quantities of seed. If any work is undertaken within these periods, seed will be collected, bagged and disposed of off-site, ensuring that no seed remains.

5.1.3 Initial Weeding

Initial weeding includes the most intensive measures to reduce weeds from the subject VMZs. A combination of spot spraying and hand weeding should be implemented with a site-specific approach based on the type of weeds present. Spraying should occur in VMZs with large infestations of Lantana, African Olive and Blackberry, with consideration of the surrounding native environments. Cleared areas should also be sprayed prior to being seeded with native groundcover species. The remaining areas will undergo hand weeding or selective spot spraying due to their ecological sensitivity.

The aquatic weed Water Hyacinth (*Eichhornia crassipes*) is present in a dam in VMZ 1 to the south of the management area and further to the east. Classification of this species as a WoNs and a priority weed under the *Biosecurity Act* 2015, calls for its immediate removal. This weed obstructs waterways, reduces fish production, harbours mosquitoes and severely disrupts life in communities along rivers and lakes (DoE 2016). A single plant can develop into a patch covering 600 metres squared, and it grows rapidly, reducing the quality of the water it is in through deoxidization. Physical removal of this weed is the most efficient method.

5.1.4 Maintenance Weeding

Maintenance works should be undertaken every three months after primary and secondary weeding has been undertaken. This would commence at the start of Phase 1. Maintenance weeding should then be undertaken biannually for a period of 8+ years, and in perpetuity under the future landholder's responsibility.

A combination of spraying with herbicide and hand removal will be required for maintenance weeding, however, as weed presence will be reduced over time, hand removal should be prioritised to reduce the impacts on surrounding aquatic environments.

Monitoring of weed presence will be outlined in the Biodiversity Management Plan (RPS 2020b) which will be effective when this VMP is complete.

5.1.5 Herbicide Use

Chemical removal is only considered appropriate for larger weeds and areas of large infestation or in areas containing few natives. Strict controls for herbicide use apply to the control of weeds to prevent accidental damage sensitive aquatic environments, *Corybas dowlingii* and *Maundia triglochinoides*.

In regards to larger woody weed species and infestations, felling and digging up the roots can be dangerous, expensive, time consuming and could potentially increase erosion. Where practical the application of herbicides should only be carried out by qualified personnel and the use of chemicals should be kept to a minimum. Care should also be taken when implementing chemical spraying techniques near waterways and environmentally sensitive areas.

The use of more environmentally-friendly herbicides such as “Roundup Biactive ®” should be used when working within or adjacent to riparian areas (particularly towards the most western aspect of the site near the wetlands). Herbicides should not be applied immediately prior to rain occurring. This reduces the effectiveness of the herbicide and poses the risk that the herbicide could be transported by runoff into local creek lines and waterways.

Herbicide use can have the advantage of reduced management effort (i.e. cost) compared to physically removal, particularly for large infestations of weeds. In this respect, it is considered that the use of herbicides is warranted in the following circumstances:

- There are small areas of dense weeds with few or no native plants to protect;
- There are large areas of weeds;
- The weeds are growing too rapidly for physical removal; and
- The receiving environment is tolerant of herbicide applications with respect to indirect impacts on non-target species such as threatened plant species.

It is important to plan herbicide control of target species according to a weeding calendar that recognises the weed's life form and seasonality (i.e. flowering, fruiting and seed set).

Herbicide application shall be limited to the following techniques. Always remember to read the product label and any relevant permit before using any herbicide.

- Cut-stump and poison (cut and dab) (suitable for Lantana);
- Stem injection;
- Stem-scrape or frilling and poison;
- Basal bark painting; and
- Selective spot-spraying (suitable for herbaceous weeds, grasses and saplings of woody weeds).

5.1.6 Erosion Control and Stabilisation Works

Care should be taken when removing weeds and all bare soils should be covered using jute matting, seeded biodegradable sprayed cover material or mulch and replanted as soon as possible. This will assist in retention of the existing soil structure and lessen the likelihood of water and bank erosion. The matting will require planting of locally occurring species for long term bank stability.

5.2 Salvaged Habitat

5.2.1 Natural Hollows

Salvageable natural hollows are to be harvested from the impact area during Phase 1 clearing works. An estimated 1,000 natural hollows are to be salved from this area. The process is to be generally in accordance with the following process:

- Natural hollows are to be identified under the direction of the Project Ecologist and Project Arborist in Phase 0 as part of early pre-clearance works. Candidate trees are to be marked in the field with a tree number and recorded using GPS;

- Pre-clearance surveys and clearance supervision is to be performed under the direction of the Project Ecologist for identified trees. Fauna salvaged from these works are to be processed in accordance with procedure outlined in Appendix A of the BMP.
- Salvaged hollows will be inspected by the Project Ecologist and Project Arborist for suitability. Selected hollows are to be cut to size, sealed on the base and preserved with linseed oil and stored for installation works;
- Offcuts and hollow logs will also be preserved for ground logs; and
- Hollows will be attached to trees under the direction of the Project Ecologist and Project Arborist.

5.2.2 Fallen Logs

A total sawn log length of ~3,000 m is to be salvaged during Phase 1 works assuming ~1,000 m of log length is installed in the Conservation Area through selective thinning practices in Phase 0. Fallen logs will be identified and prepared by the Project Forester. The specifications for these logs are as follows:

- Minimum 100 mm diameter for the entire log length; and
- Minimum 1 m cut lengths with average log length being 2 – 5 m.

5.3 Revegetation

Revegetation is designed to strategically benefit tree canopy folivores such as the Koala and nectivorous Grey-headed Flying Fox. Additionally, understorey planting to encourage the vegetation to trend towards representative PCTs will also occur in VMZ 1. Plant species relevant to these habitat enrichment actions are outlined in **Section 5.3.1**.

Revegetation works are expected to generate high value habitat for the Koala and Grey-headed Flying Fox Supplementary benefits for Large Forest Owls are also expected where revegetation works are designed to benefit the Koala (i.e. high nutrient value foliage will also benefit preferred Powerful Owl prey species such as Brush-tailed Possum).

The revegetation prescription is to generally follow the principles outlined in *Silvicultural guidelines: Private Native Forestry Code of Practice* (DECC 2008), bearing in mind that the key revegetation objective is the rapid establishment of a tree canopy for foliage biomass production. This approach also reflects prescriptions that predicate the predicted minimum seven-year timeframe to ecological benefit as observed by Kavanagh and Stanton (2012).

Revegetation works will also enrich riparian areas and corridors, particularly in the western parts of the Conservation Area. Coastal Wetland 803 will be significantly enhanced by revegetation works, ultimately aiming to contribute to increased function and condition of the wetland.

5.3.1 Plant Species and densities

Table 18 outlines the relevant plant species required for enrichment of koala habitat and revegetation for PCT development throughout VMZ 1. Additionally, plant species recommended for use in landscape planting within the development footprint are contained in **Table 18**. **Figure 8** displays all areas subject to revegetation actions as required by this VMP.

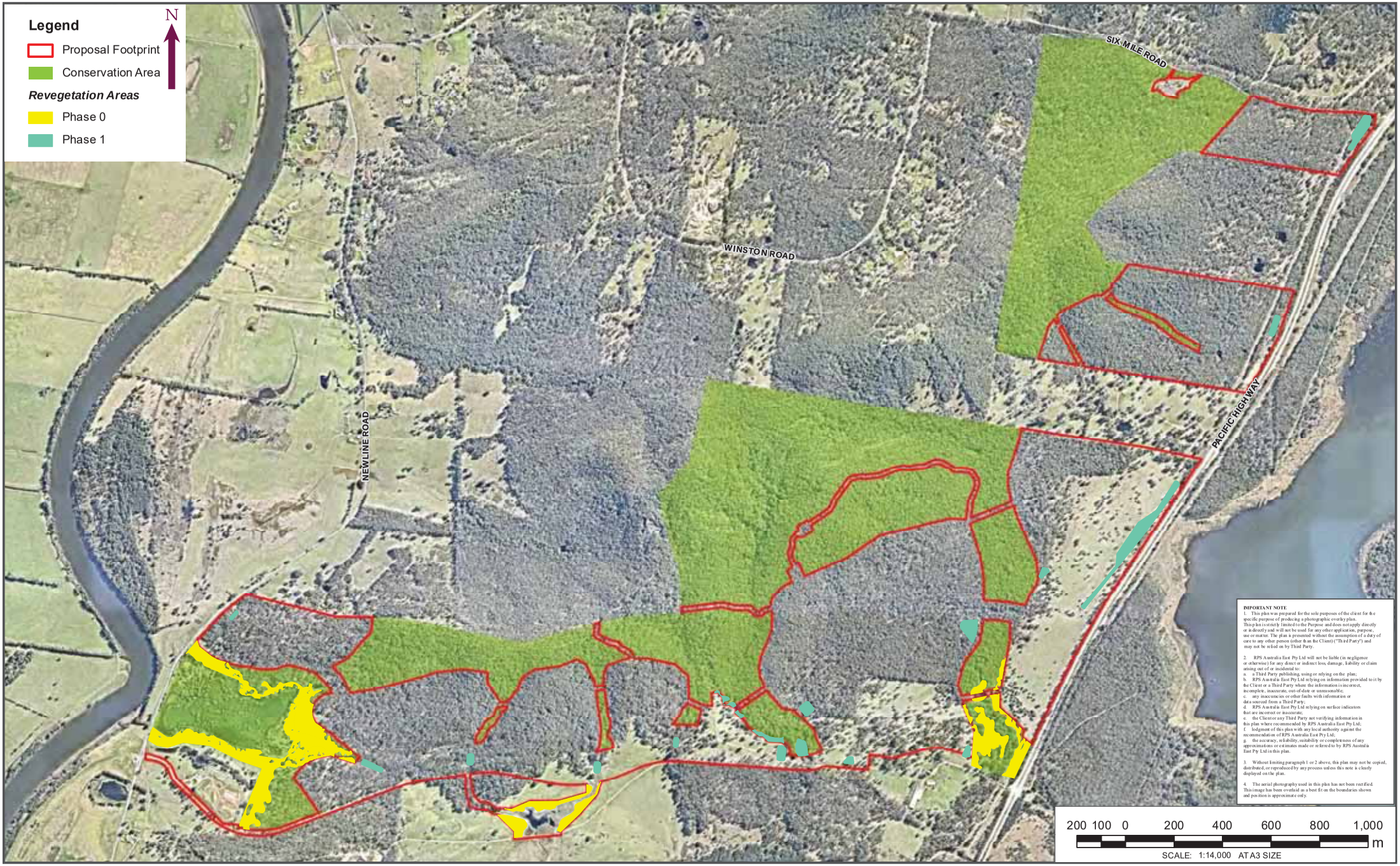
Table 18: Plant Species and Densities for Revegetation works

Plant species	Density
Eucalyptus microcorys (Tallowwood)	Tube stock 1,100 per hectare
Eucalyptus punctata (Grey Gum)	Tube stock 1,100 per hectare
Eucalyptus robusta (Swamp mahogany)	Tube stock 1,100 per hectare
Eucalyptus tereticornis (Forest Redgum)	Tube stock 1,100 per hectare
Shrubs	
Breynia oblongifolia	Tube stock 100 per hectare
Notelaea longifolia	Tube stock 100 per hectare
Leucopogon juniperinus	Tube stock 100 per hectare
Acacia irrorata	Tube stock 100 per hectare
Acacia ulicifolia	Tube stock 100 per hectare
Melaleuca linariifolia	Tube stock 50 per hectare
Glochidion ferdinandi	Tube stock 50 per hectare
Groundcover	
Dichondra repens	Tube stock 100 per hectare
Brunoniella australis	Tube stock 100 per hectare
Lomandra filiformis	Tube stock 100 per hectare
Glycine microphylla	Seed
Cymbopogon refractus	Seed
Microlaena stipoides	Seed
Echinopogon caespitosus	Seed
Gahnia aspera	Seed
Entolasia marginata	Seed
Oplismenus aemulus	Seed

5.3.2 Revegetation parameters

Important revegetation prescription parameters are listed below:

- Preferential use of direct seeding in treeless areas to encourage natural species patterns;
- Planting rate as specified in **Table 18**;
- Preferential use of Swamp Mahogany in landscapes supportive of ‘Swamp Sclerophyll Forests’;
- Preferential use of Forest Redgum and Tallowwood in areas directly adjoining/ fringing ‘Swamp Sclerophyll Forests’;
- Preferential use of Forest Redgum, Tallowwood and Grey Gum in drier terrestrial areas;
- Use of local provenance seed from trees with high measured foliage nutrient value and low plant secondary metabolites;
- Implement appropriate establishment and management measures to maximise revegetation success; and
- Use of appropriately timed thinning practices to maintain high biomass production in the tree crown (i.e. preventing adverse impacts from conspecific competition).



TITLE : **FIGURE 11: REVEGETATION AREAS**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): A A3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 11 Revegetation Areas A A3 20200722.mxd

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5.3.3 Plant Stock

Existing site-level forage quality information collected at Kings Hill (RPS 2020b) will be used to identify high-quality trees to source seed for revegetation. Seedlings grown from selected trees will form the foundations for the revegetation works proposed within VMZ 1.

5.3.4 Timing

Re-planting will be undertaken by a suitably experienced contractor who will be able to assess the site and develop a site-specific approach. The planting of additional vegetation will increase the coverage of the tree, and shrub layers within existing stands, enriching koala foraging and breeding habitat, and enhancing existing vegetation community structure to increase the resilience of the PCT as a whole. Where possible planting should occur in the cooler months (April to September) to allow for plants to become acclimatised to the site before drier conditions occur over summer.

5.3.5 Establishment

The most important factors for plant establishment are:

- The surrounding soil is moist at the time of planting. Mulch is a safe and effective way of ameliorating soil conditions. It helps control soil water loss, soil temperature fluctuations and weed invasion (Buchanan 1989);
- All plants are protected by bags (plastic sleeves) and bamboo stakes;
- Plants actively growing at the time of planting;
- Sufficient rain occurs and / or watering is provided in the following months; and
- The plants are free of weed competition. Weeds around planted vegetation shall be controlled during regular associated maintenance works.

Mulching will only be used if required in VMZ 1 primarily to act as a weed suppressant. It is not desirable to use mulch in areas where natural regeneration can occur as it will prevent native seedlings from regenerating. If mulching is required, weed free leaf and woodchip mulch will be used at the discretion of the regeneration contractor following site civil works and establishment / preparation.

All mulch shall be free of contaminants such as seeds and propagules of weeds. Avoid the use of pine mulch as the acidity level is not suitable for the native vegetation being used. Mulch will be established to a minimum depth of 75 mm prior to planting. Mulch has been shown to increase the survival rate of plants in soils with poor water holding ability (including the sandy soil that occurs on the site) however mulching will limit the likelihood of natural regeneration. It is recommended that once tubestock become established that mulching ceases to encourage seed germination of native plants. Where possible mulch should be sourced from local landscape centres

5.3.6 Fertilisers

Fertilisers are not to be used.

5.3.7 Tree Guards

In all parts of the site, tree protection measures for existing trees shall be implemented in accordance with Australian Standards 4970-2009 ‘Protection Of Trees On Development Sites’ before the commencement of site works, including driveways and services, filling, excavation or regrading. To aid in the protection of existing trees, at no time will there be stockpiling, storage, disposal or mixing of materials/liquids, parking of vehicles or machinery or positioning of sheds or offices within the drip lines of trees on site.

5.4 Maintenance

5.4.1 Plant Replacement

In areas where plants have been completely removed (i.e. as a result of vandalism or accidental damage) or where rehabilitation has failed, been damaged or is suffering from pests and/or disease, replanting should be undertaken in appropriate mild seasonal conditions.

Plants lost or damaged should be replaced to maintain a minimum of 95% survival rate of the original planted stock and recommended plant densities. Initial and careful consideration of the health of tube stock prior to its purchase should negate stock losses. Where weeds are removed, plantings should be undertaken at the VMC's (or other qualified persons) discretion. Plants should be replaced at the size originally specified and in accordance with all planting methods as previously described.

5.4.2 Irrigation

Watering of seedlings should be continued as required until all plants are established. Weather and site conditions will determine the frequency of watering for plants over the maintenance period to enhance establishment and survival rates. Moisture levels and plant health should be monitored weekly during drier periods.

Watering should be undertaken early morning or late afternoon to avoid the hottest part of the day and minimise water loss.

5.4.3 Pests and Diseases

All plants must be monitored for pests and disease during all other management actions on site for a period of 8+ years. Plants significantly affected by pests or disease must be removed, disposed of offsite and replaced. Particular vigilance must be used to detect Myrtle Rust. At the completion of monitoring for pests and disease prescribed by this VMP, further monitoring will be outlined in the BMP (RPS 2020b).

6 MONITORING AND REPORTING

The Project Ecologist and/ or Landholder are to perform regular monitoring and inspection work as part of the implementation of the VMP. Monitoring methods, frequency and timing are outlined in the following sections.

6.1 Methods

6.1.1 Weed Monitoring

The per cent cover of weed species is to be measured using the point intercept method for a 50 m long transect. The presence of a weed species is to be measured at every metre along the 50 m transect with the result multiplied by two to produce a score out of 100 (i.e. per cent). Data generated from annual monitoring events will be compared with baseline data (to be collected during Phase 0). Compliance with performance targets and completion criteria is to be determined from this comparison.

6.1.2 Photo Monitoring

The progressive photo monitoring will provide an indication of the success or failure of any areas of rehabilitation conducted in accordance with this VMP. They will enable contractors to adjust rehabilitation works accordingly to enhance the quality of retained vegetation further and provide required information for ongoing monitoring reports.

Photo monitoring will be performed by the VMC and supplied to the Project Ecologist for review during annual monitoring works performed by the Project Ecologist. Photos supplied are to be date stamped together with location (GPS) and bearing for central view in photo. Purpose of photo is to be provided (e.g. removal of Lantana). Photos taken by the Project Ecologist at nominated monitoring points are also required.

6.2 Locations

The location of these monitoring points is provided in **Figure 9**.

6.3 Frequency

A minimum of two monitoring events are to be performed annually (e.g. September and March) to inform management activities.

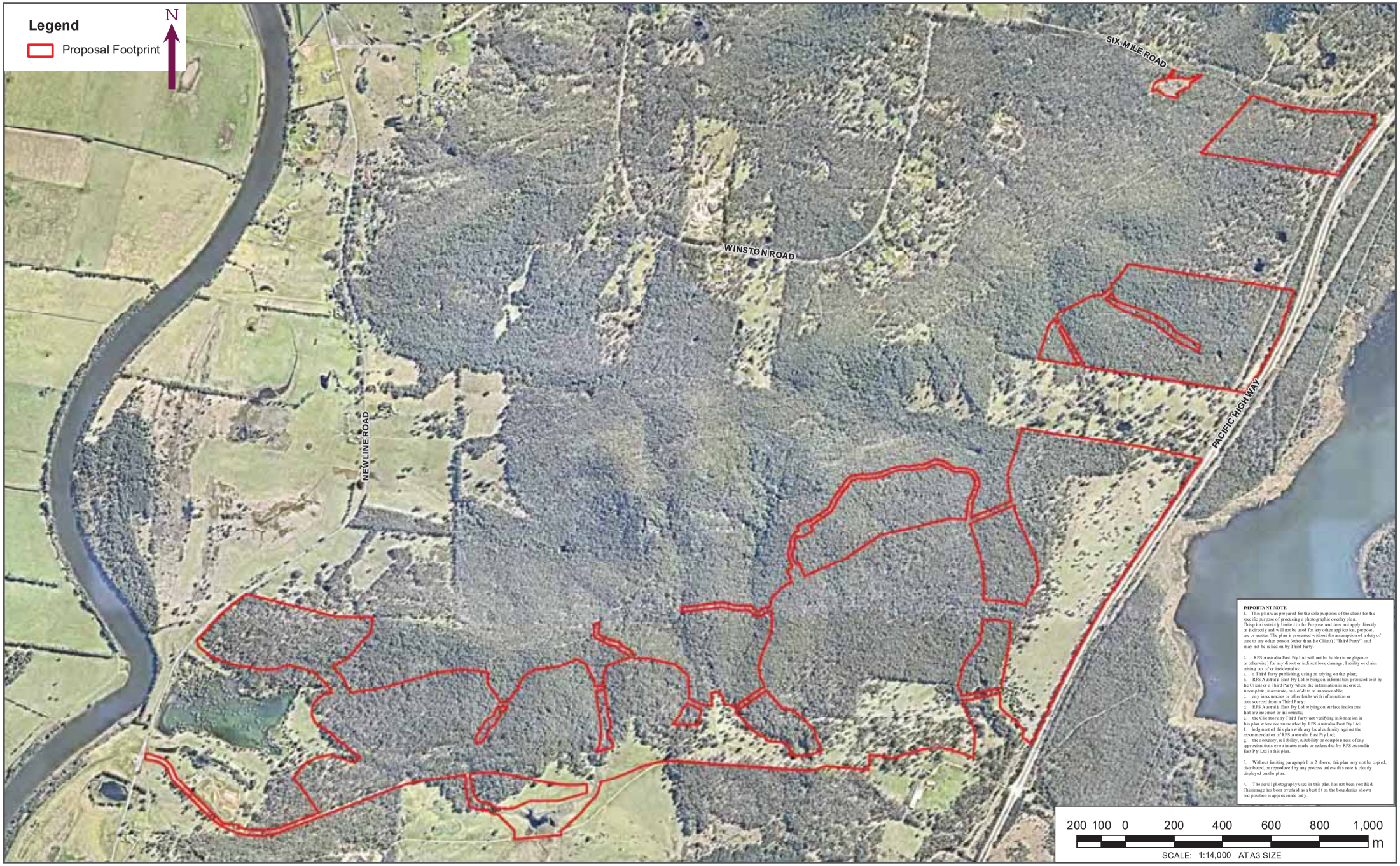
6.4 Reporting

An annual monitoring report issued at least one month before the end of any financial year is to be provided to Port Stephens Council to describe VMP performance for a period of 8+ years, from the issue of a Subdivision Works Certificate. The monitoring reports will:

- Report on the progress of the revegetation works;
- Success of weed management;
- Discuss any problems encountered in implementing the VMP; and
- Recommended adaptive management response for the forthcoming management period.

In relation to the revegetation areas, reporting will include:

- Estimates of weed cover / abundance;
- Documentation of plant death (from planted individuals) and measures for replacements; and
- Recommendations regarding timing and responsibility for corrective measures and/or vegetation management.



TITLE : **FIGURE 12: MONITORING AREAS**

LOCATION :**KINGS HILL**

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **22/07/2020**

PURPOSE: **ECOLOGY**

VERSION (PLAN BY): AA3 (Natalie.Wood)

PATH: J:\JOBS\130k\130430 Raymond Terrace\10 - Drafting\Arcgis Map Documents\Eco\Report\6. VMP\130430 Figure 12 Monitoring Areas AA3 20200722.mxd

CLIENT: **PM NO 1 PTY LIMITED**

JOB REF: **PR130430**

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
Unit 2A, 45 Fitzroy Street, Carrington, NSW, Australia, 2294 PO Box 120, Carrington, NSW, 2294
T: 02 4940 4200 F: 02 4940 4299 www.rpsgroup.com.au

MAKING COMPLEX EASY

7 ADAPTIVE MANAGEMENT

7.1 Framework

To account for uncertainties and to improve management response, all impacts to biodiversity will be adaptively managed using an Adaptive Management Framework. The adaptive management framework actions are detailed below noting this BMP represents steps 1 to 4, with any specifications for adaptive management to be determined through steps 5 to 7.

1. **Describe** - Undertake and complete comprehensive baseline biodiversity data collection.
2. **Model** – Model the biological environment and its response to certain management actions/decisions.
3. **Identify** – Set clear biodiversity management objectives.
4. **Do** – Implement the modelled biological management action.
5. **Learn** – Use the monitoring program to evaluate the biological response to management actions against objectives and performance targets. Where required, prepare draft adaptive management response and include in annual monitoring report.
6. **Consult** – Share draft adaptive management response with relevant stakeholders (i.e. Port Stephens Council). Seek approval to implement revised management actions.
7. **Adapt** – Implement revised and approved adaptive management actions.

Draft adaptive management responses are to be defined through Step 5, reported in the Annual Monitoring Report and approved as varied by Port Stephens Council prior to implementation.

8 PRE-CLEARANCE AND CLEARANCE ACTIVITIES

Pre-clearing surveys allow for the identification of any threatened flora or fauna species that may have moved into the development footprint since previous surveys. Pre-clearing surveys are to be undertaken by a qualified ecologist with experience in fauna handling.

The clearing procedure outlined in **Appendix B** explains the process and measures to be implemented prior to, during and after vegetation clearing for construction activities and identifies who is responsible for implementing each component.

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Appendix A

Staff Qualifications

Mark Aitkens

Principal Ecologist

Role at RPS
Principal Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Science (Environmental Biology), University of Technology Sydney (UTS)

Accredited Biodiversity Assessment Method Assessor under Section 6.10 of the *Biodiversity Conservation Act* 2016

Rail Industry Safety Induction - RISI

Memberships
Ecological Society of Australia

Why Mark for this role

Mark is a Principal Ecologist with over 24 years' experience in the delivery of terrestrial and aquatic ecology services to the private and public sectors. Mark is accredited to perform assessments in accordance with the Biodiversity Assessment Methodology (BAM) and has conducted a range of BBAM and BAM assessments for State Significant Infrastructure and State Significant Developments. Mark is also experienced in the application of the EPBC Act preparation of EPBC Act offset calculations.

He is experienced in all aspects of project delivery including design and implementation of seasonally based flora and fauna surveys, identification of terrestrial and aquatic species and ecological communities, impact assessments, and design and implementation of monitoring programs.

Mark has considerable experience in the preparation of biodiversity assessments under Part 5 of the *Environmental Planning Assessment Act* 1979 with demonstrated regional experience in the Hunter Valley and more broadly throughout NSW. Mark is highly experienced with linear infrastructure, small site assessments and large scale projects with complex inter-disciplinary interactions.

Relevant projects

Kings Hill Concept Plan, Kings Hill Developments, 2015-present

Prepared a Species Impact Statement for a 500 ha development site located within the Newcastle drinking water supply (Grahamstown Dam). Key affected species included the Koala, Brush-tailed Phascogale, woodland birds and threatened orchids. Impacts on coastal wetlands and swamp sclerophyll forest situated in mapped coastal wetlands (i.e. Irrawang Swamp) also prepared. Assessments were based on comprehensive seasonal surveys involving the project management of eight ecologists. Utilised innovative techniques to assess the projects impacts on the Koala (i.e. use of detection dogs and foliage nutrient analysis). Other commissions included the preparation of Biodiversity Management Plan for a dedicated Conservation Area, Vegetation Management Plan and Aquatic Impact Assessment (Key Fish Habitat).

Bulga to Broke Water Pipeline, Singleton Council, 2019

Biodiversity assessment for the installation of a water pipeline to supply potable water from Broke to Bulga. Works initially involved a routes selection process to determine the option with the least environmental impact. Detailed assessments were then performed for the preferred pipeline option, which included the mapping of site scale habitat to vegetation mapping including condition classes for critically endangered vegetation. Impact avoidance, minimisation and mitigation measures were provided within a Review of Environmental Factors assessment framework. State and Commonwealth assessments were performed for affected threatened species and ecological communities.

Relevant projects

Chaffey Dam, WaterNSW, 2020

Mark is currently involved in the reconfiguration of the approved 2015 biodiversity offset strategy for the endangered Booroolong Frog. Involvement includes the reconsideration of offset mechanisms and locations in light of implementation challenges associated with land tenure, impacts of drought and broader conservation needs for the species. Mark is working with a team of specialists to achieve an improved offsetting outcome for the species.

NSW Telco Authority (Visionstream), 2020

Preparation of biodiversity assessments for multiple existing and proposed telecommunication sites scattered throughout NSW involving a range of impacts including green field development (e.g. installation of lattice towers) to brownfield works (e.g. bush fire mitigation works). Assessments were performed in accordance with Part 5 of the EP&A Act (i.e. preparation of Test of Significance under Section 7.3 of the BC Act) to determine if the works are likely to have a significant impact on threatened species and ecological communities. Important measures for avoiding and minimising impacts on affected threatened species and ecological communities are provided to manage impacts.

Garfield Road West Upgrade, TfNSW, 2020

Mark prepared a specialist biodiversity assessment report prepared under Part 5 of the EP&A Act for inclusion in a Review of Environmental Factors for the reconstruction of Garfield West Road, Riverstone along a new alignment. Challenges successfully encountered included the management of roadside impacts on critically endangered ecological communities, threatened species habitat and key fish habitat (Eastern Creek).

NBN Build, Visionstream, 2018-2019

Preparation of biodiversity assessments for multiple greenfield NBN Towers from Mullumbimby to Tallong (five sites). Biodiversity constraints were identified and managed within tight assessment timeframes to meet NBN delivery objectives.

NBN Build, Tata Consulting, 2016-18

Preparation of biodiversity assessments for multiple greenfield NBN cabling installations from Tweed Heads to Merimbula and west to Braidwood (27 sites). Biodiversity constraints were identified and managed within tight assessment timeframes to meet NBN delivery objectives.

TAP3 Project, TfNSW, 2017-present

Mark is the project ecologist involved in the preparation of biodiversity assessment documentation for rail station upgrade for inclusion in Review of Environmental Factors. Assessments have included the identification and assessment of threatened species and ecological communities found within the rail corridor for multiple rail stations located within the greater Sydney metropolitan area.

Waterloo Road Upgrade, RMS, 2017

Mark prepared a specialist biodiversity assessment report as part of a Review of Environmental Factors for the Upgrade of Waterloo Road, North Ryde. Challenges successfully encountered included the management of roadside impacts on critically endangered ecological communities and threatened species habitat.

Wyong Hospital Enabling Works, Health Infrastructure NSW, 2016

Mark prepared a Flora and Fauna Assessment for the Wyong Hospital Enabling Works to inform a Review of Environmental Factors (REF). The approach adopted for field surveys for the Flora and Fauna Assessment was in accordance with the BioBanking Methodology (OEH 2014), enabling the surveys and results of the assessment to be transferrable to any BioBanking Assessments that may be required if the project became considered a Major Project (i.e. State Significant Infrastructure (SSI) or a State Significant Development (SSD)).

Bells Line of Road Upgrade, RMS, 2016-17

Mark prepared a specialist biodiversity assessment report as part of a Review of Environmental Factors for the Upgrade of Bells Line of Road from Lithgow to Bell. Challenges successfully encountered included the management of roadside impacts on endangered ecological communities and threatened species habitat. Investigations included assessments for terrestrial and aquatic matters.

Finley Solar Farm EIS, ESCO, 2017

Mark was involved in RPS' preparation of an Environmental Impact Statement (EIS) for the Finley Solar Farm Project. The Finley Solar Farm would produce 170MW over 500 hectares of land. Numerous RPS service lines worked together to prepare the document. To date RPS have successfully liaised with the NSW Department of Planning and Environment, as well as the client, to progress the project smoothly in line with the desired outcomes.

Rosewood Estate Tamworth, 2014-2015

Project managed and prepared Preliminary Documentation for a 'controlled action' declared under the EPBC Act. Assessment involved a detailed consideration of White Box Yellow Box Blakely's Redgum Grassy Woodland and Derived Native Grasslands, a critically endangered ecological community.

Mary's Mount Blue Metal Quarry, Gunnedah Quarry Products, 2013-2014

Project managed and prepared Preliminary Documentation for a 'controlled action' declared under the EPBC Act for a quarry project linked to the delivery of ballast needed for the inland rail project. Assessment involved the consideration of MNES impacted by the quarry including, but not restricted to Semi-evergreen Vine Thicket EEC and the Koala. Calculated and report biodiversity offset requirements in accordance with Commonwealth Offsets Policy and incorporated into a Biodiversity Offset Strategy.

Western Region Biodiversity Offset Strategy, Centennial Coal, 2018

Preparation of a biodiversity offset strategy for multiple approved coal mining operations in the NSW 'Western Coal Fields' near Lithgow. Involved a post hoc assessment of Project impacts and comparable offsets using the repealed Framework for Biodiversity Offsets (Major Projects) and Part 7A of the *Threatened Species Conservation Act* 1995. Demonstrated a suitable offset strategy for approved projects by gaining approval through the NSW Department of Planning and Environment and Office of Environment and Heritage.

Springvale Coal, Centennial Coal, 2018

Preparation and implementation of Biodiversity Management Plans (BMP) and Swamp Monitoring Programs (SMP) as subplans of Longwall Extractions Plans for the Springvale Coal Extension Project. BMPs and SMPs are reviewed by the Independent Monitoring Panel and State/ Commonwealth regulators prior to the approval of secondary coal extraction. Works involved the synthesis of a growing knowledge base on best practice monitoring and management of endangered upland peat swamps listed on State and Commonwealth legislation.

Albion Park, Tower Holdings, 2015-2016

Prepared Biodiversity Management Plans for the protection of State and Commonwealth listed endangered and critically endangered plant species (*Zieria granulata* and *Cynanchum elegans*) and ecological communities (Illawarra and South Coast Lowland Forest and Woodland). Management prescriptions centred on weed and fire management, with the latter linked to asset protection zones for the adjoining approved residential subdivision.

Holsworthy Base Training Facility Project, 2020

A new training facility proposed on Commonwealth land within the Holsworthy Military Base required detailed biodiversity investigations and assessment against the Significant impact guidelines 1.2 - Actions on, or impacting upon, Commonwealth land and Actions by Commonwealth Agencies. Matters of National Environmental Significance identified (i.e. threatened species and ecological communities) were mapped and used to identify an impact footprint with the least impact on these matters (i.e. avoid, minimise). Assessments were performed for the Koala, a range of threatened flora and two critically endangered ecological communities. Mitigation measures were recommended.

Water Quality Monitoring Program, Orchard Hills Defence Facility, 2012

Prepared a Water Quality Monitoring Program for a defence facility in western Sydney. Monitoring works included measures of abiotic and biotic indicators for a catchment containing defence activities imbedded within a highly sensitive natural setting containing the critically endangered Cumberland Plan Woodland and nationally listed threatened species. The program included the monitoring of groundwater dependant ecosystems.

Midal Cabling Project, Midal Cabling, 2011-2012

The approved Midal aluminium cabling plant is a heavy industrial development located adjacent to the Tomago aluminium smelter. Mark's role in the approvals process involved the preparation of State and Commonwealth assessments for impacts on lands adjacent to the Tomago sands beds (Newcastle water supply). Considered impacts on the threatened New Holland Mouse and Ramsar Wetlands. The EPBC Act Referral adequately demonstrated that Project was not a controlled action.

Maitland to Minimbah Third Track Project, 2011-2012

As part of the Hunter8 Alliance, Mark performed integral part of the approvals, post approvals and biodiversity offsetting components of a 30 km section of new rail track constructed adjacent to the existing rail corridor between Maitland and Minimbah, NSW. Prepared and, implemented management plans for microbat exclusion from culverts, pre-clearance surveys and reporting, vegetation clearing audits, biodiversity offset site identification, evaluation and assessment.

ELF Stage 2 Construction Biodiversity Assessment, Singleton Military Area, 2010

Prepared a Biodiversity Assessments for multiple defence training installations associated with the ELF program located within the Singleton Military Area. Included the assessment of development and operational impacts such as 'ballistic pruning' on threatened flora and fauna species including the Slaty Redgum (*Eucalyptus glaucina*) and habitat occupied by threatened woodland birds. Assessments adopted the 'good neighbour policy' (i.e. consideration of impacts on State listed threatened species and ecological communities).

Pacific Highway Upgrade: Oxley Highway to Kempsey, RMS, 2012-2014

Assisted in the procurement of approvals under State and Commonwealth legislation including participation in risk assessments, field surveys, reporting, project design and impact assessments (i.e. EPBC Act Preliminary Documentation). Performed monitoring surveys for the State listed *Maundia triglochinoides* and the State and Commonwealth listed Giant Barred Frog (*Mixophyes iteratus*) in accordance with a Before Impact Control After monitoring design. Analysed results and reported findings including an evaluation of Project impacts and performance of mitigation measures.

Reconstruction of the Limbri to Weabonga Road, Tamworth Regional Council, 2011

Performed biodiversity surveys and assessment for the reconstruction of the Limbri to Weabonga Road following flood damage from the adjacent Swamp Oak Creek. The endangered Booroolong Tree Frog (*Litoria booroolongensis*) and Eel-tailed Catfish (*Tandanus tandanus*) were detected adjacent to the construction area. Impact minimisation involving the establishment of exclusion zones and frog hygiene (Chytrid control) was successfully used to avoid a significant impact on the species. Works could proceed in accordance with an EPBC Act 'Particular Manner' decision notice.

Lauren Eather

Ecology Manager

Role at RPS
Ecology Manager

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Science (Biology), University of Newcastle, 2011

Planning for Bushfire Prone Areas, University of Technology Sydney, 2015

Memberships
Ecological Consultants Association

Why Lauren for this role

Lauren is a Biodiversity Assessment Method (BAM) accredited Senior Ecologist (and Ecology Manager) with over ten years' experience in terrestrial ecology, along with ecological assessment and management reporting in accordance with relevant State and Commonwealth government legislative frameworks.

Lauren's experience has included a variety of flora and fauna assessment disciplines as required by a wide range of public and private clients, along with significant Bushfire Management reporting. She has developed numerous Bushfire Threat Assessments informed by field surveys and desktop assessments.

Relevant projects

Harman Zone Substation Ecological Constraints Report, Department of Defence, 2018-2019

Lauren was involved in the development of an Ecological Constraints Report for the construction of a substation and associated easement at HMAS Harman, ACT, which is Commonwealth Land owned by the Department of Defence (DoD). Lauren helped prepare an Impact Assessment to determine the relevant constraints of the project.

Mandalong Substation Upgrade Project, Centennial Coal 2019

Lauren prepared a Biodiversity Development Assessment Report – Streamlined Assessment to determine the liability for this State Significant Project Modification. Preparation of this report involved some flora and fauna surveys to determine the extent of impact that this project could have on biodiversity values.

Various Biodiversity Management Plans, Centennial Coal 2017-2018

Lauren was the lead Ecological Consultant for the preparation and delivery of more than ten Biodiversity Management Plans for most of Centennial Coal's western and northern NSW mine sites. This involved extensive client engagement and stakeholder liaison.

Newcastle Light Rail, Downer and TfNSW, 2018

Lauren oversaw and was involved in pre-clearance surveys and the identification of tree species and fauna species within the Newcastle Light Rail alignment and immediate surrounds, to accommodate the Newcastle Light Rail.

Eleebana Shores Retirement Village, Coastplan Group, 2017

Production of a Biodiversity Assessment informed by flora and fauna field surveys involving vegetation mapping and flora and fauna identification.

Relevant projects

Nest Box Monitoring Program, Rose Group, 2012-2019

Conduct biannual monitoring of over 500 nest boxes to comply with Conditions of Consent for residential development at Gwandalan. Prepare annual compliance reports for various approvals.

Boatmans Creek Culvert Upgrade Vegetation Management Plan, Royal Haskoning, 2017

Site inspection and preparation of a Vegetation Management Plan that provided a practical approach to vegetation management for stream bank stability, erosion mitigation through revegetation, and native vegetation enhancement.

Bulga Mine Annual Fauna Monitoring, Glencore, 2013-2018

Lauren has been involved in an annual monitoring program that spans two operations and involves seasonal bird surveys, habitat assessments and the full spectrum of fauna monitoring methodologies targeting threatened species as well as comprising an overall species list, and providing technical input and annual report writing.

Angus Place Longwalls 900 and 910 Flora and Fauna Monitoring, Centennial Coal Angus Place, 2012-2014

Pre and postmining baseline surveys were undertaken by Lauren including flora and fauna species diversity surveys, vegetation condition assessments and nest box erection. Monitoring of multiple sites provides a comparable data set to display any notable changes as a result of longwall mining within this mining lease area. Swamp vegetation monitoring was a separate component of this project which required a memorandum to comment on overall swamp health and potential impacts as a result of surrounding mining activities.

Neubeck Open Cut Coal Mine, Centennial Coal, 2012-2014

Flora and fauna field surveys over a three year period and the production of the Flora and Fauna Assessment as part of an overriding Environmental Impact Statement were undertaken for the proposed Neubeck open cut coal mine. Surveys involved targeted threatened species surveys, vegetation mapping, flora and fauna identification and habitat mapping.

Airly Coal Mine Flora and Fauna Surveys, Centennial Airly, 2012-2014

A range of flora and fauna surveys were undertaken to inform both the Airly Baseline Survey Report and the Airly Flora and Fauna Report.

Airly Site Specific Biodiversity Management Plan, Centennial Airly, 2016

Baseline flora and fauna assessments primarily undertaken for the Airly Flora and Fauna Report informed the production of the Airly Biodiversity Management Plan, both of which Lauren was involved in. The BMP outlined areas of ecological importance and ecological issues on site with associated management actions and monitoring requirements in line with the Development Approval.

Wallarah House Bushfire Threat Assessment (BTA), Baudinet Group, 2015

Desktop assessments for the reconstruction of a dwelling that was substantially damaged during fires in October 2013. These assessments formed the production of the Bushfire Threat Assessment for the site.

Gunnedah Basin, Santos, 2013-2015

Conducted multiple projects over approximately two years. These projects included; ecological works for Santos within the Gunnedah Basin covering gas exploration and provision of infrastructure, including, gas pipelines and access tracks. Works included field survey, preparation of advice, impact assessments, EPBC referrals, preparation and implementation of well lease rehabilitation plans, liaison and negotiations with regulators and agencies.

Ringall Valley Housing Estate, Jewells, SNL Construction, 2014

RPS has been engaged as the Principal Consultant undertaking all project management responsibilities associated with delivering these 60 small lot housing developments. As part of the bushfire hazard assessment and management plan for this project, Lauren undertook the compilation of report and desktop assessments on slope and vegetation type.

Myall Lodge BTA, RSL Lifecare, 2013

Myall Lodge, or Peter Sinclair Gardens, in Hawkes Nest NSW offers medical / rehabilitative care, restorative care and dementia care. As the facility is surrounded by dense, bushfire prone reserve land, RPS was appointed to provide Ecology and Bushfire advice prior to construction. Lauren undertook site inspections, slope and vegetation assessments, and the construction of a Bushfire Threat Assessment.

Big Prawn Service Centre BTA, Westside Petroleum, 2014

The Big Prawn service station at Crangan Bay was completely damaged during the October 2013 bushfires. Field and desktop investigations allowed for the development of a Bushfire Threat Assessment that assessed the current hazards to the reconstruction of the service station and associated facilities on site.

Appendix B

Pre-Clearance and Clearance Procedures

Pre-clearing and clearance activities including clearly delineating clearing extents and implementing fauna habitat protection measures are detailed in **Table 19** and **20** below.

Table 19: Pre-clearance activities

Action	Timing	Responsibility
Mark all trees within the development footprint that could potentially be used by resident and migratory fauna as habitat (i.e. potential shelter sites, nest sites, hollows, termitaria, epiphytes, crevices, standing dead trees and large hollow logs). These habitat trees will be clearly demarcated with flagging tape or fluorescent paint, and clearly shown on plans, so that they are retained for the second stage of clearing or avoided by contractors where possible.	Prior to the commencement of clearing	Project Ecologist
Identify all non-habitat trees that are suitable for retention within the urban landscape. These trees will be clearly demarcated with flagging tape or fluorescent paint, and clearly shown on plans,	Prior to the commencement of clearing	Project Ecologist
Identify natural habitat features such as hollow logs, felled branches and bush rocks within the development footprint. Locations of habitat features will be recorded with a GPS and marked with flagging tape or fluorescent paint. Fauna microhabitat features will be removed from areas to be cleared and relocated to suitable nearby areas to be retained	Prior to the commencement of clearing	Project Ecologist
Identify nearby habitat suitable for the release of fauna that may be encountered during the pre-clearing process.	Within 7 days prior to the commencement of clearing	Project Ecologist

Table 20: Clearance activities

Action	Timing	Responsibility
All site personnel involved in construction activities must be inducted during Toolbox Talks on the requirements of this VMP prior to commencing work in the Management Area. Site personnel are to be: • Made aware of the clearing limits and how they are marked. • Informed that they are not to encroach on areas beyond the clearing limits. • Are to be informed of the 2 stage clearing process for habitat trees. • Made aware of the locations of trees that will be retained, measures required to protect them, and the consequences of damage to these areas. • Made aware of threatened and migratory species known or likely to occur in the Management Area and their habitat.	Immediately prior to the commencement of clearing	Foreman and Project Ecologist
Undertake a pre-start up check for sheltering native fauna of all infrastructure, plant and equipment and/or during relocation of stored construction materials. If fauna is identified, notify the Project Ecologist or WIRES so that they can relocate uninjured animals and manage injured animals.	Immediately prior to the commencement of daily clearing activities	Foreman and Project Ecologist
Undertake a two-stage approach to clearing:	During clearing activities	Project Ecologist, Contractors

Action	Timing	Responsibility
• Stage 1: under-scrubbing of the entire Management Area should be carried out by a 4 x 4 tractor with a slashing deck and a layer of mulch is to be left to aid in soil retention. Non-hollow-bearing tree and non-habitat trees will be cleared in a sequence that leaves trees that allow fauna to move to adjacent vegetation to be retained. • Stage 2: After a period of up to two weeks, clearing of hollow-bearing and habitat trees that are not being retained will commence. Trees not requiring arborist attention are to be knocked with an excavator bucket or other machinery to encourage fauna to evacuate the tree immediately prior to felling. Trees should be "soft-felled". Felled trees must be left for a short period of time on the ground to give any fauna trapped in the trees an opportunity to escape before further processing of the trees.		
Hollow-bearing trees felled within the subject site will be used as fauna habitat in the Conservation Area (see Table 16 and Table 17 of the KHD BMP for management objectives of this action).	Phase 1	Project Ecologist, Project Forester
Trees felled within the Management Area will be considered for use in the Conservation Area as fallen logs. Parameters for the logs are: • Minimum 100 mm diameter for the entire log length; and • Minimum 1 m cut lengths with average log length being 2 5 m; and • Logs are to be placed in designated locations.	Phase 1	Project Ecologist, Project Forester
If an animal (including shocked, juvenile animals or eggs) are discovered during clearing or other construction activities, STOP ALL WORK and handle fauna as per **Table 21** below.	During clearing activities	All site personnel

Animals identified within the construction footprint are to be handled in accordance with Table 21.

Table 21: Fauna Handing Procedures

Action	Timing	Responsibility
Animal Handling		
If an animal is located within the works area, stop all work in the vicinity of the animal and immediately notify the Environmental Manager. The Environmental Manager is to notify the Project Ecologist, who may nominate to contact a rescue agency (e.g. WIRES).	As soon as an animal is identified in the construction footprint	Contractors, Project Ecologist
Minimise stress to the animal and reduce the risk of further injury by: • Handling fauna with care and as little as possible. • Covering larger animals with a towel or blanket and placing in a large cardboard box. • Placing small animals in a cotton bag, tied at the top. • Keeping the animal in a quiet, warm, ventilated and dark place away from construction activities. This location is to be designated in advance of construction work.	As soon as possible after an animal is identified in the construction footprint	Project Ecologist

Action	Timing	Responsibility
Where handling of frogs is necessary, captured frogs must be handled in accordance with the Hygiene Protocol for the control of Disease in Frogs (DECC 2008), specifically: • A new pair of disposable gloves must be used between the handling of each frog. • Use one plastic bag per frog when transporting frogs. Do not reuse bags.	As soon as possible after a frog is identified in the construction footprint	Project Ecologist
Dangerous animals such as venomous reptiles must not be handled by inexperienced/unqualified personnel. The following actions must therefore be taken when a dangerous animal is identified within the construction footprint: • Exclude all personnel from the vicinity with fencing and/or signage. • Contact the Project Ecologist. The Project Ecologist may nominate to contact rescue agency (e.g. WIRES) or professional snake handler to assist. – WIRES 1300 094 737 • The Project Ecologist or other nominated personnel are, where practical, to keep the dangerous animal in sight where it remains within the construction site.	As soon as possible after a venomous snake or other dangerous animal is identified in the construction footprint	Project Ecologist and Wildlife rescue agency
If the fauna species is identified by the Project Ecologist, as a threatened species that was not identified and assessed in the Environmental Assessment or other Project documentation, then the Project Ecologist must inform the Environmental Manager, who must: • Immediately cease all work that may affect the threatened species. • Contact the Environmental Manager and advise them of the situation. • Contact relevant stakeholders. • Determine in consultation with stakeholders, corrective actions and additional safeguards to be undertaken. • Construction works may recommence only once the Environmental Manager in consultation with the Project Ecologist, has confirmed that all corrective actions and additional safeguards have been implemented.	As soon as possible after an additional threatened species is identified in the construction footprint	Project Ecologist
Release of Animals		
Release the animal, outside of the construction footprint, into similar habitat and as close as possible to the area where the animal was found.	As soon as practical after animal is caught, and only when animal is determined to be fit for release	Project Ecologist
Time the release of the animal to coincide with the active period of the species; i.e. nocturnal animals to be released at dusk.	As soon as practical after animal is caught, and only when animal is determined to be fit for release	Project Ecologist
Do not undertake fauna relocation during periods of heavy rainfall or extreme weather conditions (e.g. very high temperatures), unless the animal is too stressed to be held any longer.	As soon as practical after animal is caught, and only when animal is determined to be fit for release	Project Ecologist

Action	Timing	Responsibility
Injured Animals Management		
Contact the Project Ecologist if an injured animal is found on or in the vicinity of the construction site. The Project Ecologist will determine if the animal is seriously injured and requires attention. If the animal is injured, contact one of the following local wildlife rescue agencies and/or veterinary surgeries immediately: • WIRES 1300 094 737 • Raymond Terrace Veterinary Clinic (02) 4987 1111 • Irrawang Veterinary Hospital (02) 4987 1898	As soon as practical after injured animal is identified in the construction footprint	Project Ecologist
Contact the local wildlife rescue agency and/or veterinary surgeon if the Project Ecologist is not present or cannot immediately attend the site. Follow advice from the Project Ecologist, wildlife rescue agency and/or veterinary surgeon while waiting for any of the above parties to attend the site.	As soon as practical after injured animal is identified in the construction footprint	Project Ecologist
Once the rescue agency arrives at the site, they are responsible for the animal. Any decisions regarding the care of the animal will be made by the rescue agency.	Upon arrival of wildlife rescue agency	Wildlife Agency
In the event that the rescue agency and/or local veterinary service cannot be contacted, the Project Ecologist, or in their absence, the Environmental Manager, will deliver the injured animal to the agency/local veterinary service as soon as practically possible.	As soon as practical after injured animal is identified in the construction footprint	Environmental Manager
The Project Ecologist must record the following information about the animal, prior to the animal leaving the site: • Species. • Location of where animal was found (exact as possible, GPS co-ordinates). • Date. • Gender (if possible). • Photograph the animal (if possible).	Prior to injured animal leaving the site boundary	Project Ecologist
Contact the Environmental Manager immediately if a dead animal is found within the site. Carcasses must be buried to a depth that will prevent scavengers from reaching them and to minimise the risk of disease transmission. The Project Ecologist must record the following details: • Species. • Location of where animal was found (exact as possible, GPS co-ordinates). • Date. • Gender (if possible). Photograph the animal (if possible).	As soon as practical after a dead animal is found within the site	Project Ecologist
Reporting		
The Project Ecologist must prepare a report upon completion of clearing activities for submission to the Environmental Manager and council, that includes: • A description of the assessment of habitat trees undertaken prior to clearing. • How fauna was handled that was affected by clearing activities.	Within 30 days of the completion of clearing activities	Project Ecologist

Action	Timing	Responsibility
• Procedures that were adopted for the relocation of non-injured fauna from clearing areas and operations, including the identification of appropriate locations, timings and weather conditions for the relocation of non-injured fauna. • Procedures, dates, areas and fauna specialist(s) present during clearing and structures removal operations. • A description of any animals that were sighted, captured, released, injured or shocked. • Procedures that were adopted for handling injured fauna from clearing areas and operations, including details on liaison with wildlife rescue groups, veterinary surgeons and any other appropriate organisations or individuals. • A description of any dead animals that were found as a result of clearing of structures operations and fauna rescue. • A description of any tree that is used for breeding or roosting by fauna. Include tree species, location, size, height and depth of hollow. • A description of any bridge or culvert structure that is used for breeding or roosting by fauna. Include location, size, gap height and depth. • Photos (where possible) of rescued and dead fauna.		

Appendix E

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FINAL REPORT

Assessment of the Kings Hill development impacts on the hydrology and vegetation of Irrawang Swamp and Coastal Wetland 803

December 2019

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1 Executive summary

Kings Hill Developments Pty Ltd (KHD) is proposing to develop residential rezoned land in the Kings Hill Urban Release Area (Kings Hill) located north of Raymond Terrace. The land would be developed over multiple stages across a 10 to 15 year period for residential and other mixed use development. Kings Hill includes three main catchments that each currently drain to separate receiving environments. Kings Hill South drains to Irrawang Swamp (Coastal Wetland 804) which is located between New Line Road and the Pacific Highway. Kings Hill West drains to an unnamed wetland (Coastal Wetland 803) located adjacent to New Line Road to the north of Irrawang Swamp. Kings Hill East currently drains to Grahamstown Dam and runoff from this catchment is proposed to be diverted to Irrawang Swamp to protect water quality in the dam. Irrawang Swamp and Coastal Wetland 803 are both mapped coastal wetlands under SEPP (Coastal Management) 2018 (SEPP 2018).

Each wetland contains a number of species that are susceptible to impacts from altered hydrological regimes. The vegetation communities will be most susceptible to changes in the drying hydrology that typically occurs in the critical warmer September to March period. The dominant risks to the vegetation in the wetlands from hydrological changes include:

- extended periods of increased inundation depth; and
- reductions in seasonal drying patterns

If these are realised, retention of diversity in the Seasonal Swamp Meadow vegetation would be compromised within Irrawang Swamp and the ability for the woody plants to regenerate would be reduced. The hydrological analysis indicates that these risks are unlikely to occur for the reasons that are summarised below.

- Increased runoff from Kings Hill East during low flow periods is expected to flow efficiently and in a relatively linear manner along the proposed diversion drain through the original spillway channel to the Pennington Drain channel and discharge through the existing flood gates to the Williams River. It is expected that these diverted low flows would not impact on the northern Seasonal Swamp Meadow and Melaleuca Woodlands in Irrawang Swamp.
- Increased runoff diverted from Kings Hill East to Irrawang Swamp during high flow periods would typically coincide with periods where inflows to the swamp are already elevated resulting in wide-spread inundation across Irrawang Swamp. The estimated increase in high flows from Kings Hill East represents approximately 10% of the average annual spillway volume from Grahamstown Dam. These high flow events typically dissipate rapidly and would not cause long term ecological damage.
- Increased runoff volumes from King Hill South during low flow periods are estimated to be substantially lower than those from Kings Hill East. Increased runoff from Kings Hill South will disperse more readily through the wetland vegetation and it is estimated that the increase in water depth during the critical drying period will largely be contained within 5 ha area aligned with currently regularly wetted areas in the northern part of the swamp (refer Zone 1 in Figure 1-1). These additional flows will support the existing areas of open water and stands of *Typha orientalis.*
- Increased annual high flow volumes from King Hill South are estimated to be minor and would have an insignificant impact on increasing water levels in Irrawang Swamp during high flow periods.
- There will continue to be seasonal dry periods in the Swamp Oak and Melaleuca Woodlands and Seasonal Swamp Meadow areas and estimated changes in inundation depths are within the ecological tolerance range of the vegetation communities.
- Modelling results for Wetland 803 in Kings Hill West indicate that the WSUD strategy and partial catchment diversion outlined by Northrop Consulting Engineers (NCE, 2019) would result in water levels in the wetland increasing by less than 50mm across the critical drying period. The modelling results also indicate that wetting extents across the wetland would be similar during this period but may increase over existing conditions by up to 15% during short periods (days) during the drying period in response to small rainfall events in the Kings Hill West catchment.

- The Swamp Oak Woodland in Coastal Wetland 803 in Kings Hill West has been impacted due to increased water retention resulting from historical construction of a bund across its outlet and cattle grazing. Nonetheless a Swamp Oak (Casuarina) Woodland persists on the site with a mixture of fresh and saline understorey plants present. Controlling additional runoff to this wetland alone is unlikely to improve conditions for the remnant wetland vegetation. To maintain the condition of this wetland seasonal flow patterns are crucial for providing the conditions for the existing vegetation. This will ensure winter freshes lower the salinity for the less saline seasonal vegetation with lower summer water levels enabling regeneration to occur. The removal of stock may enable regeneration and healthy growth of the *Casuarina glauca* in the wetland and a woodland more representative of natural conditions to develop.

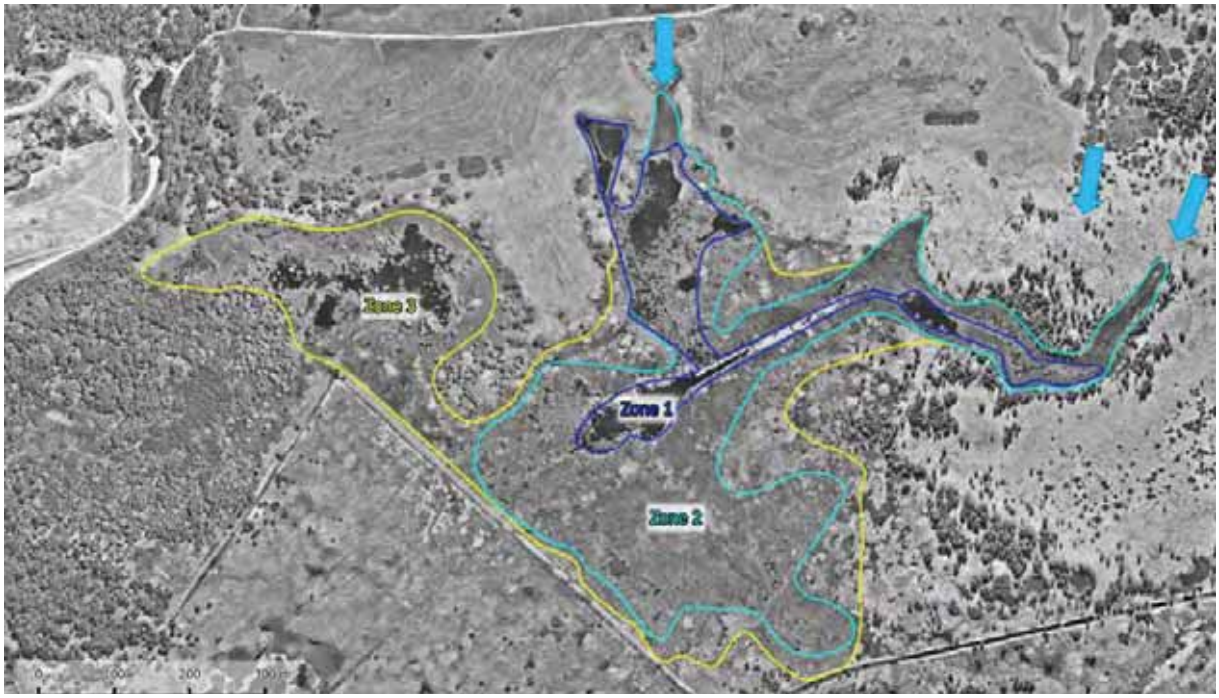

Figure 1-1 *Irrawang Swamp wetting zones showing key inflow locations from Kings Hill South*

2 Introduction

Irrawang Swamp (Coastal Wetland 804) is located just north of Raymond Terrace between New Line Road and the Pacific Highway (refer Figure 2-1), and is a protected Coastal Wetland under SEPP (Coastal Management) 2018 (SEPP 2018). The mapped extents of Irrawang Swamp comprise approximately 450 ha (SEPP 2018).

Kings Hill Developments Pty Ltd (KHD) is proposing to develop rezoned land within the northern catchments draining to the Irrawang Swamp for residential and mixed land uses. This land is referred to as Kings Hill South within this report. Additional land on the eastern side of Kings Hill that currently drains to Grahamstown Dam is also proposed to be developed for residential and mixed land uses. To avoid draining future urban runoff into Grahamstown Dam, a diversion channel is proposed on the eastern side of the Pacific Highway to divert all runoff up to the 0.2% AEP design storm event to the original spillway from Grahamstown Dam. This diverted runoff would be discharged into the eastern side of Irrawang Swamp. The land draining to the proposed diversion channel is referred to as Kings Hill East in this report. Additional development is proposed within the catchment of Coastal Wetland 803 located adjacent to New Line Road to the north of Irrawang Swamp. Development within the catchment of this wetland is referred to as Kings Hill West in this report.

Hunter Water Corporation (HWC) owns all the land within Irrawang Swamp and is currently actively managing the land in accordance with the Irrawang Swamp Plan of Management (Hunter Water, 2012a). Hunter Water previously lodged an application with OEH to register land they own within Irrawang Swamp as a biobanking/biodiversity stewardship site. We understand that HWC has now withdrawn this application and is not actively pursuing this outcome.

HWC's long term objective for Irrawang Swamp is to restore and maintain the environmental quality of the wetland, 'environmental quality' being defined as the range of environmental (predominantly ecological) services or functions provided by the wetland including:

- biodiversity conservation, including supporting habitat for threatened flora and fauna species;
- nursery and breeding grounds for various waterbirds, frogs and aquatic biota such as fish;
- improvement in water quality downstream by removing suspended matter, reducing numbers of faecal microorganisms and using dissolved nitrogen and phosphorus for plant growth;
- biological productivity and nutrient recycling;
- flood mitigation; and
- groundwater recharge.

To support these objectives Hunter Water has progressed a range of measures aimed at restoring the ecological function and integrity of Irrawang Swamp, including:

- Opening of the floodgates on Pennington Drain to reintroduce tidal inundation to the lower areas of the swamp;
- Tree planting;
- Cessation of grazing;
- Allowing drainage channels to naturally infill; and
- Weed control (primarily within the tree planting areas).

It will be important that effective management of stormwater quality and quantity is achieved in the future Kings Hill development areas to support achievement of the ecological protection criteria. HWC has advised that a detailed assessment of the impacts of stormwater discharge from the proposed Kings Hill development on the ecology of the swamp is to be completed before HWC can agree to any discharge into Irrawang Swamp.

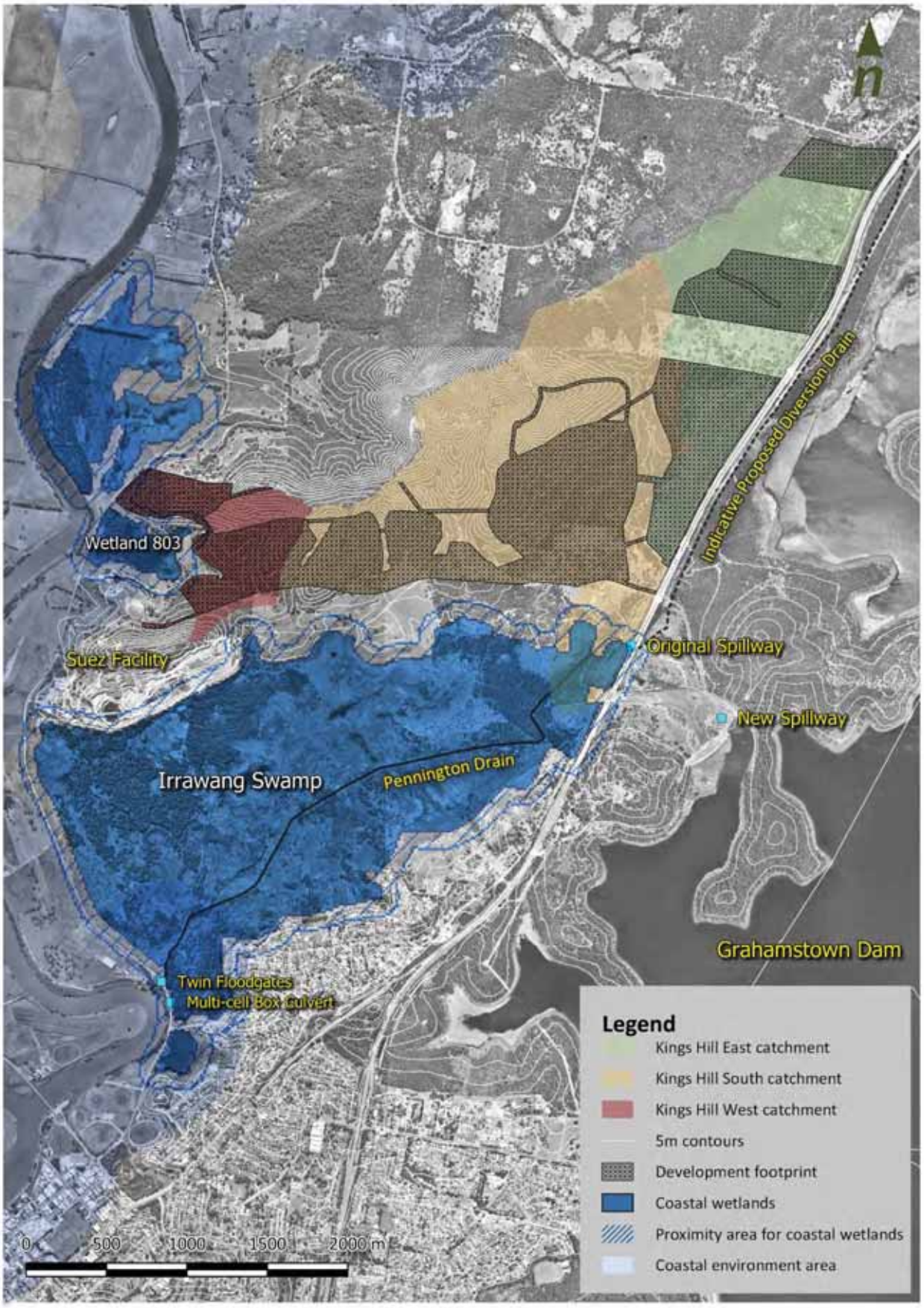

Figure 2-1 *Irrawang Swamp and Coastal Wetland 803 locality*

HWC outlined their concerns regarding the potential impacts of the Kings Hill development on Irrawang Swamp ecology in letter sent to Port Stephens Council dated 9 January 2018 (intended to be dated 9 January 2019) (Hunter Water, 2019). A summary of HWC's key concerns are outlined below:

- HWC has identified that increases in the volume, flow velocity and frequency of stormwater discharges associated with development have the potential to alter wetting/drying regimes in Irrawang Swamp and adversely impact on the composition and distribution of wetland communities.
- HWC has requested that the applicant closely consider the effects of stormwater discharge from the development including both the diverted Kings Hill East catchments and direct discharges from development in Kings Hill South. HWC has requested that consideration of changes to water quality and hydrology be assessed for both the diversion channel and direct discharge catchments.
- HWC has indicated that the applicant would need to demonstrate that the current wetting/drying regime of the receiving environment in Irrawang Swamp would not be adversely impacted by increased stormwater discharges. HWC refers to the "*Water Sensitive Urban Design Solutions for Catchments above Wetlands – Overview Report*" (McManus et al, 2007) prepared for HCCREMS. This guideline indicates that Water Sensitive Urban Design strategies associated with new development in catchments upstream of natural wetlands need to include methods to preserve the pre-development drying and/or flooding hydrology characteristics in order to protect wetland ecology.

This report focuses on potential changes to the Irrawang Swamp and Wetland 803 hydrology associated with the Kings Hill development. The report also includes an assessment of the potential impacts of hydrological changes on the ecology within each wetland. Our assessment is based on stormwater runoff estimates output from MUSIC models prepared by Northrop Consulting Engineers (NCE). We have assumed that the MUSIC modelling completed by NCE appropriately reflects the existing and developed hydrological conditions of the King Hill site and was completed in accordance with the relevant policies and guidelines. The details of NCE's modelling are not duplicated in this report, but are described in NCE, 2019.

The potential impacts on water quality in Irrawang Swamp and Wetland 803 associated with stormwater runoff from the Kings Hill development are also addressed in NCE, 2019.

This report is configured as follows:

- Section 3 summarises our understanding of the existing Irrawang Swamp and Wetland 803 hydrology.
- Section 4 summarises our understanding of the existing vegetation communities in Irrawang Swamp and Wetland 803 and historical changes that have occurred to the vegetation.
- Section 5 summarises the Kings Hill development impacts on catchment hydrology.
- Section 6 outlines the potential impacts of the changed catchment hydrology on the Irrawang Swamp and Wetland 803 hydrology and vegetation.
- Section 7 provides a summary of key points and our conclusions.

3 Existing hydrology

3.1 Irrawang Swamp (Wetland 804)

Overview
The hydrology of Irrawang Swamp has changed significantly from natural conditions due to historical land management practices associated with catchment development, land clearing, pasture irrigation, grazing and drainage channel construction. Under natural conditions, surface runoff from local catchments would have drained to a series of swamps including the Grahamstown Moors, Campvale Swamp and Irrawang Swamp. The hydrology of these swamps would have also been influenced by groundwater from the catchment. Although, clay soils are dominant in the local Irrawang Swamp catchment and it is expected that groundwater inflows to this swamp would be relatively low. The western extents of Irrawang Swamp were regularly inundated by tidal flows and it is envisaged that salt marsh and other salt tolerant species would have previously inhabited these areas.

Construction of the Grahamstown Dam wall across the natural outlet from the Grahamstown Moors resulted in Campvale Swamp and Irrawang Swamp being separated. The natural hydrology of Irrawang Swamp was significantly altered by the dam construction due to catchment flows now being stored in the dam and extracted for water supply. Diversion of river flows from the Williams River to the dam has also modified the Irrawang Swamp hydrology. Surface water flows from the east of the wetland are now limited to infrequent periods when the dam capacity is exceeded initiating spillway discharges to Irrawang Swamp. The dam construction has also modified groundwater flows.

Increasing residential development on the southern side of Irrawang Swamp has altered the hydrology for these catchments with the increased imperviousness in these catchments now contributing more regular pulses of stormwater runoff volume discharges into the southern area of Irrawang Swamp. In addition, the construction of rural dams and water holding dams associated with the waste recycling and recovery site on the northern side of the swamp has altered the hydrology in these areas.

Irrawang Swamp naturally would have received tidal inflows and been inundated during large overbank flooding events from the Williams River. Construction of the New Line Road embankment and flood gates on pipes under Newline Road has resulted in tidal inflows to the swamp and low flows from the swamp now being controlled through these gates. During large spillway events from Grahamstown Dam, water can rapidly fill Irrawang Swamp. To control flooding in these large events, a levee was constructed within the western extents of the swamp parallel to New Line Road to controls overflows from the swamp to the Williams River. A large multi-cell culvert was also constructed under New Line Road just south of the flood gates to convey spillway flows from Grahamstown Dam in a controlled manner to the Williams River.

A large open channel, Pennington Drain, was constructed centrally through Irrawang Swamp in the 1970's as a component of the initial Grahamstown Dam construction to efficiently convey spillway flows through the swamp to the Williams River. Pennington Drain was formed by excavating a trapezoidal-shaped channel from just downstream of the original spillway to the floodgates. A number of other minor interconnected lateral drains were also constructed in the wetland by landowners to enable efficient draining of the land for cattle grazing and to grow pasture grasses. Many of these drainage channels were connected to the Pennington Drain.

Further discussion on the key elements that influence hydrology in the Irrawang Swamp catchment is provided below.

Grahamstown Dam storage
Grahamstown Dam was originally formed by construction of an embankment across the outlet of a natural wetland area known as the Grahamstown Moors. Construction of the dam began in 1955 and was completed in 1965. Prior to completion, water was supplied from the dam in 1960 during a severe drought that extended from 1960 to 1963. Since 1965, the following main modifications to the dam have been completed (https://www.hunterwater.com.au):

- In 1973 a bentonite clay core was installed in the central section of the Grahamstown embankment to provide a watertight seal.
- In 1985 the Full Supply Level (FSL) was reduced from 11.1 metres to 10.6 metres as a temporary measure to reduce the risk of damage to the main embankment from major flooding.
- In 1994 Stage 1 augmentation works were completed to raise the level of the clay core to the road level along the full length of the embankment to enable the flood storage capacity to be increased. Rock armouring of the main embankment was also undertaken.
- In 2005 Stage 2 augmentation works were completed to increase the FSL from 10.6 to 12.8 metres. These works involve construction of a larger spillway and discharge channel under the Pacific Highway.

The Stage 2 augmentation works addressed two key objectives, improving the safety of the dam to bypass major flood events, and increasing the water storage capacity to improve regional drought security (Kinhill, 1993). The works resulted in the dam storage capacity increasing by 50%. Whilst the dam storage capacity increased, there was an associated reduction in temporary flood storage capacity. To reduce risks associated with this reduced temporary storage, the original dam spillway was replaced with a wider spillway.

The dam currently has a total storage volume of over 182 GL and covers an area of 28 km^2. The total catchment area for Grahamstown Dam is 115 km^2 (www.hunterwater.com.au). Additional catchment area is diverted to the dam from the Williams River through the Balickera Canal diversion that forms an off take from the Williams River at Seaham Weir.

Grahamstown Dam spillway

The original Grahamstown Dam spillway was constructed as a component of the Grahamstown Dam construction works between 1955 and 1965. Although the original spillway is no longer in operation, the spillway gates, outlet channel, weir and energy dissipator remain in place.

Figure 3-1 *Original Grahamstown Dam spillway gates*

A larger spillway was constructed as a component of the Stage 2 augmentation works in 2005 approximately 350m south of the original spillway. The current spillway is a labyrinth type spillway that provides more efficient flow discharges at lower depths. The current spillway was designed to have a capacity of 780 m^3/s which is significantly greater than the original spillway capacity of 60 m^3/s (Kinhill, 1993).

Figure 3-2 *New Grahamstown Dam labyrinth spillway (source: Port Stephens Examiner, 2008)*

The Stage 2 augmentation EIS identified that a major impact would be to increase the frequency of spillway discharges with associated increases in inundation frequency within parts of Irrawang Swamp (Kinhill, 1993). Whilst the water supply storage increased with the Stage 2 augmentation, the temporary flood storage reduced. It was identified that the reduction in temporary flood storage would result in the spillway being overtopped more frequently resulting in more frequent discharges to Irrawang Swamp.

It was estimated that Irrawang Swamp would be more frequently inundated for periods up to several days from flood flows from Grahamstown Dam and overbank flows from the Williams River. It was estimated that the new spillway would be overtopped on average once every two years (Kinhill, 1993). Review of spillway flow data provided by HWC indicates that flows have occurred in approximately 40% of the years since the current spillway was completed in 2005 and this aligns well with the EIS predicted spill frequency.

Irrawang Swamp drainage

Surface runoff currently drains into Irrawang Swamp from the surrounding catchment and additional flow is contributed from Grahamstown Dam during periods when the spillway level is exceeded. Surface runoff drains from the forested and pastured upper slopes of Kings Hill in a southerly direction along unnamed ephemeral watercourses into the northern section of Irrawang Swamp. Existing and future residential development in Raymond Terrace drains into the swamp from the south.

Pennington Drain was constructed centrally through Irrawang Swamp as a component of the initial Grahamstown Dam construction works to efficiently drain spillway flows through the swamp to the Williams River. This channel still functions to efficiently convey spillway flows through Irrawang Swamp, although the drain is increasingly becoming infilled and covered by vegetation due to cessation of drain maintenance. This infilling is being encouraged as a restoration action to reduce the drainage efficiency and enable more frequent spills from Pennington Drain into the adjacent wetland areas (Hunter Water, 2012a). This action supports the Irrawang Swamp plan of management objectives and Hunter Water expects this will assist to restore the natural hydrological regime and increase freshwater wetland vegetation (Hunter Water, 2012a).

Excavated soil from the Pennington Drain channel construction was deposited along the sides of the drain to form a levee. This levee functions to preferentially direct overbank flows from the drain into the northern areas of the wetland. In some locations, breaks in the channel banks and levee have been formed to facilitate past agricultural activities and potentially also to drain trapped areas.

A number of other minor interconnected lateral drains were previously constructed in the wetland to enable efficiently draining of the land for cattle grazing and other agricultural activities. Many of these drainage channels were connected to the Pennington Drain. These lateral drains are now not actively maintained and are being allowed to infill.

Newline Road drainage structures
Discharges from Irrawang Swamp to the Williams River can occur through the following mechanisms depending on the water level in Irrawang Swamp:

- Low flows from the swamp and tidal exchange can drain through open flood gates constructed at the end of Pennington Drain immediately downstream of New Line Road.
- High catchment runoff and spillway flows can result in water levels increasing rapidly across the swamp initiating flow through a multi-cell box culvert located just south of the flood gates when a levee in this area is breached.
- Very high flows exceeding the capacity of the multi-cell box culvert and minimum Newline Road crown level would weir flow across the road.

These drainage structures are discussed further below.

Flood gates
Floodgates were installed on the Pennington Drain outlet immediately downstream of Newline Road in the 1970's (Kleinfelder, 2018). We understand that the flood gates are installed on twin 900mm or 1050mm diameter pipe culverts (pers com. Holly Marlin, HWC). The flood gates are owned and operated by the NSW Department of Industry (Water). The gates originally functioned to prevent tidal inundation of the Irrawang Swamp and discharge of stormwater to the Williams River during periods when river water levels were elevated.

The flood gates currently remain open unless a Flood Watch is issued by the Bureau of Meteorology on either the Williams or Hunter Rivers. The flood gates are manually closed during a Flood Watch and re-opened when the flood risk has passed (Hunter Water, 2012b).

Figure 3-3 *Pennington Drain flood gates*

Over the 2010-11 period Hunter Water worked in partnership with the Department of Primary Industries (Fisheries) on the Irrawang SEPP 14 wetland rehabilitation project. The goal of this project was to reintroduce natural tidal flows to Irrawang Swamp through the flood gates. Two trial openings of the flood gates were undertaken and a draft Review of Environmental Factors (REF) prepared for the project (Hunter Water, 2011).

Over the 2011-12 period Hunter Water continued working with DPI (Fisheries) on the wetland rehabilitation project. Flood modelling identified the complexity of determining the impact of simultaneous spills from Grahamstown Dam and flooding from either the Hunter River or Williams River. Although not quantified, the completed modelling indicated that permanent opening of the flood gates could only increase the likelihood of residential impacts in the event of a simultaneous spill from Grahamstown Dam and flooding of either the Hunter River or Williams River. Further modelling was deemed unnecessary and it was decided that the flood gates would not be permanently opened (Hunter Water, 2012b).

New Line Road levee

In 2010, a new levee was constructed on the eastern side of Newline Road within Irrawang Swamp to protect private properties located between Irrawang Swamp and the Williams River during periods of high spillway discharges from Grahamstown Dam. This levee controls overflows from Irrawang Swamp across a section of New Line Road south of the existing flood gates. The construction of this levee was a condition of the Stage 2 augmentation consent (Kleinfelder, 2018).

Multi-cell culvert

HWC provided Alluvium with design details of a multi-cell culvert under Newline Road just north of the Newline Road and Beaton Avenue intersection. The design drawings (Hunter District Water Board, 1975) indicate that a six-cell reinforced concrete box culvert was proposed to be constructed at this location. Each cell was 3.3m (w) x 1.8 m (h). The culvert inverts were designed at 0.97 m AHD and the road crown level was designed at approximately 3.6m AHD.

The multi-cell culvert was constructed as part of the Irrawang Spillway works in 1975 in conjunction with roadworks in Newline Road. The culvert was funded by Hunter Water and constructed by Port Stephens Council, and is owned by Hunter Water (pers. com. Holly Marlin, HWC). The culvert is separated from the swamp by a high levee bank/weir (pers. com. Holly Marlin, HWC). The levee/weir was constructed with a crest at approximately 1.7m AHD (Hunter Water, 2012a). The constructed gabion weir at the entrance to the culvert is shown in Figure 3-4.

Figure 3-4 *Existing gabion supported bund upstream of multi-cell box culvert*

Based on the available data, when water levels in the Irrawang Swamp exceed 1.7m AHD, spills would be initiated over the levee bank/weir into the multi-cell culvert prior to discharge along a short section of channel to the Williams River. The level of the levee bank/weir effectively controls the maximum level for extended duration of water in Irrawang Swamp. Water levels in Irrawang Swamp would only exceed the levee bank/weir level for a relatively short period (days), as water above this level would discharge relatively efficiently through the multi-cell culvert. Water stored at levels below 1.7m AHD drains through the flood gates.

3.2 Wetland 803

The majority of the Kings Hill West development area drains to Wetland 803 located adjacent to New Line Road. The total catchment area draining to Wetland 803 is approximately 97 ha and the wetland covers approximately 14 ha of the catchment. The catchment is primarily forested in the upper reaches with cleared grazing areas observed around the lower reaches and the wetland perimeter. The existing wetland includes a number of distinct shallow cells that receive inflows from separate sub-catchments. The maximum water depth in the wetland prior to overflow through the outlet occurring is estimated to be approximately 0.25m. The shallow cells can be observed partially filled in Figure 3-5.

Figure 3-5 *Wetland 803 partially full*

Water level/electrical conductivity data available for the 210452 Raymond Terrace water level recorder over the 2013 to 2019 period indicates that exchange of saline inflows from the Williams River with the stored water in the wetland will occur (WaterNSW, 2019). Based on a recent survey of the wetland outlet (deWitt Consulting, 2019) it appears that tides can flow into the wetland when water levels in the Williams River exceed approximately 0.65m AHD (the minimum outlet/spill level in the north-western corner of the wetland). This level is estimated to be between the mean high water (MHW) and mean high water springs (MHWS) levels at this location (MHL, 2012).

The hydrology of Wetland 803 is influenced by catchment inflows and tidal inflows from the Williams River. Surface water can drain from the wetland when water levels exceed the outlet level. Surface water drains through a shallow trapezoidal channel located adjacent to the north-western extents of the wetland. The channel connects to a narrow drain located in the Newline Road reserve that conveys surface water through a twin 600mm diameter culvert under New Line Road to the Williams River. In addition to surface flows from the catchment, tidal inflows to the wetland can also occur when the tide level exceeds the outlet level.

During seasonally high rainfall periods, water levels in the wetland will typically be elevated and close to the outlet level for extended periods. During these periods, tidal exchange with the Williams River will occur with saline/brackish water flowing into the wetland when tidal flood flow levels exceed the outlet level. It is expected that tidal flood flows will partially mix with stored water in the wetland close to the outlet location, prior to draining from the wetland during the ebb tide.

During low rainfall and warmer periods, evapotranspiration across the wetland will reduce the water levels below the outlet level. During these periods, catchment inflows will typically be low and water levels primarily influenced by tidal flood flows into the wetland and evapotranspiration. It is envisaged that during these low catchment inflow periods, the water stored in the wetland will become increasingly saline under the dominant influence of tidal flows. During these drier periods, incoming flows during some high tides would be retained in the wetland on the ebb tide, with following high tides also functioning to gradually increase water levels until the outlet level is reached or high tide levels fall below the outlet level.

4 Existing wetland vegetation

4.1 Irrawang Swamp

Historical management practises impacting wetland vegetation
The vegetation in Irrawang Swamp is a mosaic of wetland marsh and woodland communities. These occupy areas of the swamp which experience different hydrological regimes (wetting/drying cycles and depth of inundation). These have developed depending upon the elevation and drainage patterns in the different areas of the Swamp.

The Irrawang Swamp vegetation was significantly modified after the 1950s to enable agricultural uses. This involved the cutting of drains through the central areas of the swamp and the clearing of some of the Swamp Oak (*Casuarina glauca*) woodland areas to enable pasture management. The Irrawang Swamp Plan of Management (Hunter Water, 2012a) outlines the following historical changes:

Irrawang Swamp has been subjected to a range of anthropogenic disturbances, all aimed at improving the area for agricultural activities, particularly grazing. This disturbance history has resulted in a degraded wetland system with a highly altered hydrological regime affecting inundation frequency, duration and extent, as well as salinity.

In addition to the hydrological changes outlined in Section 3, past land management practices that have altered the natural vegetation include:

- Clearing of native vegetation;
- Livestock grazing; and
- Introduction of exotic pasture species.

The 1954 aerial image of the Swamp (Figure 4-1) shows minimal constructed drainage. This contrasts with the 1977 and 2018 images (Figure 4-2 & Figure 4-3 respectively) which show development and constructed drainage through the central areas of the swamp.

The main historical changes in vegetation communities through the swamp were:

- Reduction in Swamp Oak and Paperbark Woodland areas.
- Reduction in Perennial Swamp meadow (Tall marsh) wetland vegetation
- Increase in Seasonal and Transient Swamp Meadow and pasture.

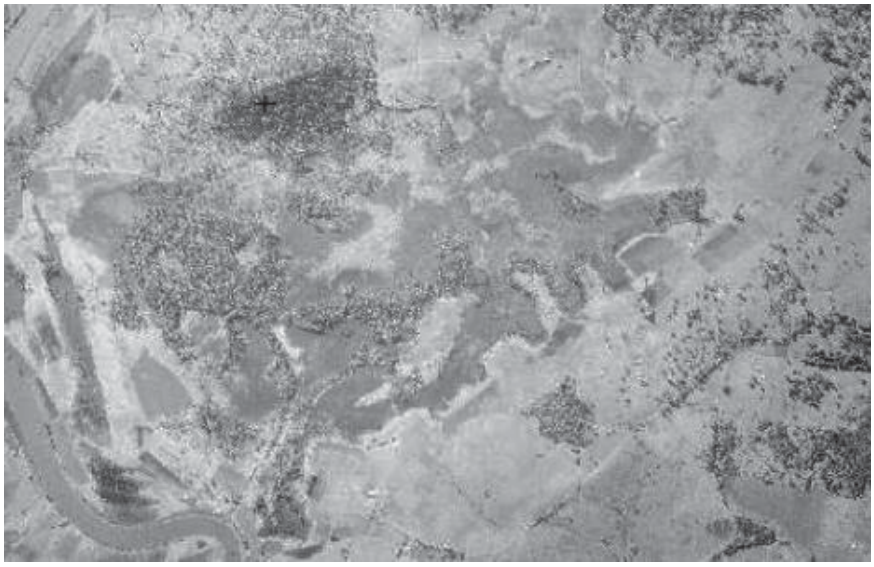

Figure 4-1 *1954 aerial image of Irrawang Swamp*

Figure 4-2 1977 Aerial image of Irrawang Swamp

Figure 4-3 2018 Aerial image of Irrawang Swamp

The swamp vegetation is adjusting to the current flow regime which includes maintenance practices that are allowing the drainage channels to infill reducing their hydraulic efficiency. This will see water retained in the central areas of the swamp for longer periods and increased inundation for tolerant plant species.

Changes in the flows to Irrawang Swamp will alter the current hydrological regime with different areas more likely to be impacted than others.

Previous studies

The vegetation of Irrawang Swamp has most recently been mapped within the *Grahamstown Dam Stage 2 Augmentation Phase 3 – Flora Monitoring of Irrawang Swamp* monitoring report prepared by Kleinfelder (2018).

Alluvium has not undertaken a detailed flora survey, but has used the Kleinfelder (2018) report as a baseline for viewing the current vegetation community extents. An initial site visit was undertaken by Alluvium on 24 April 2019 to observe the vegetation communities outlined in the Kleinfelder report. A second site visit was undertaken on 16 October 2019 to observe the Melaleuca Swamp Sclerophyll Forest in the north-west area and Seasonal Swamp Meadow in the north-central area of the swamp.

The swamp vegetation mapped by Kleinfelder (2018) has been assigned to different communities (Figure 4-4) depending on the vegetation structure and hydrological regime. For the purposes of this assessment, Table 4-2 shows the alignment with the *Coastal Wetlands Classification* following McManus et al (2007). These communities occupy portions of the study area potentially impacted by changes in catchment runoff. Other more terrestrial areas have not been considered.

No individual flora species listed as threatened or endangered were observed during the site inspections.

Eight flora species listed as vulnerable or endangered species (under NSW and/or federal legislation) are recorded in the NSW BioNet Atlas database for the Irrawang Swamp and surrounding area. Suitable habitat to support four of these species is present within the Irrawang Swamp. One of these (*Maundia triglochinoides*) was recently observed in a dam adjacent to Wetland 803 (Mark Aitkens, pers com), although was not observed during the Alluvium site visits.

Table 4-1 *BioNet records for vulnerable or endangered flora species*

Data from the BioNet BioNet Atlas website.
Report generated on 12/11/2019 3:46 PM

Scientific Name	Common Name	NSW status	Comm. status	Records	Last record	Habitat present within Irrawang Swamp	Habitat likely to exist post development
Maundia triglochinoides	Maundia	V		3	2017	Yes	Yes
Commersonia prostrata	Dwarf Kerrawang	E1	E	1		No	
Eucalyptus camfieldii	Camfield's Stringybark	V	V	79		No	
Eucalyptus parramattensis subsp. decadens	Earp's Gum	V	V	35	2006	No	
Rhodamnia rubescens	Scrub Turpentine	E4A		1	1934	Possible	Possible
^Pterostylis chaetophora	Taree rustyhood	V,P,2		1	2017	No	
Persicaria elatior	Tall Knotweed	V	V	2	2010	Yes	Yes
Asperula asthenes	Trailing Woodruff	V	V	1	2009	Yes	Yes

Twenty-two fauna species (listed as vulnerable or endangered fauna species under NSW and/or federal legislation) which are likely to utilise Irrawang Swamp habitats for foraging or shelter are recorded in the NSW BioNet Atlas database for the Irrawang Swamp and surrounding area. Further consideration of impacts on fauna is provided in RPS (2019).

Table 4-2 *Vegetation community classification*

	Ecological community	Conservation status	Coastal Wetland classification
Woodland	Swamp Oak Woodland (Swamp Oak Floodplain Forest)	EPBC - listed as endangered vegetation community	Forest Swamp Ephemeral
Swamp Meadow Complex	Perennial Swamp-meadow (Freshwater Wetlands on Coastal Floodplains)		Deep Marsh (Tall Marsh)
	Seasonal Swamp-meadow (Freshwater Wetlands on Coastal Floodplains)		Shallow Marsh (wet)
	Transilient Swamp-meadow (Freshwater Wetlands on Coastal Floodplains)		Shallow Marsh (dry)
Woodland	Paperbark Woodland (Swamp Sclerophyll Forest on Coastal Floodplains)	EPBC - listed as endangered vegetation community	Forest Swamp Ephemeral

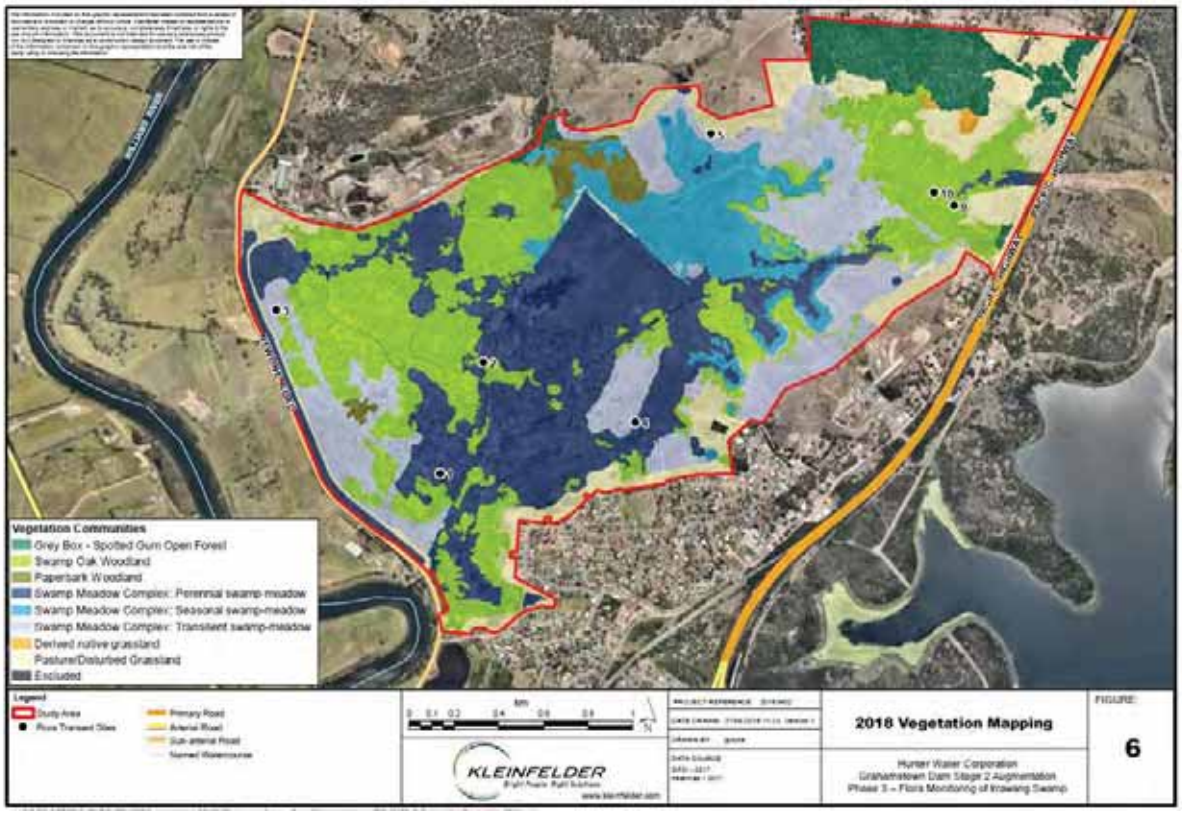

Figure 4-4 *Vegetation mapping by Kleinfelder 2018*

Figure 4-5 *Vegetation mapping by Umwelt 2011*

The Kleinfelder (2018) survey identified the vegetation communities in the wetland to be broadly similar to earlier vegetation assessments undertaken by Umwelt in 2011. Kleinfelder (2018) describes how the extent of the different vegetation communities had changed since the earlier studies in the following way:

> *the key differences are a general increase in the extent of Swamp Oak Woodland vegetation due to significant regeneration of Casuarina glauca (Swamp Oak); and an increase in the extent of swamp-meadow sub-units over the wet meadow sub-unit. In particular, the floristic monitoring shows that increases in the abundances of Bolboschoenus caldwellii, Typha orientalis (Broadleaf Cumbungi) and Casuarina glauca (Swamp Oak), and decreases in the abundance of Cynodon dactylon (Common Couch) over time have made the highest contributions to the overall changes in the vegetation between 2002 and 2018.*

The historic changes in the woodland vegetation can be seen by comparing the estimated Swamp Oak Woodland and Melaleuca Woodland extents from the 1954 image shown in Figure 4-6 with the 2018 extents in Figure 4-4. Due to the clarity of the images, distinctions between the two woodland types cannot be made and therefore they have been combined on the image.

The combined Swamp Woodlands extent in 1954 is estimated to be 174 Ha with the 2018 extent recorded by Kleinfelder (2018) to be 149 Ha. This shows a historic decline in the Swamp Woodlands of approximately 25 Ha (14% of the 1954 extent).

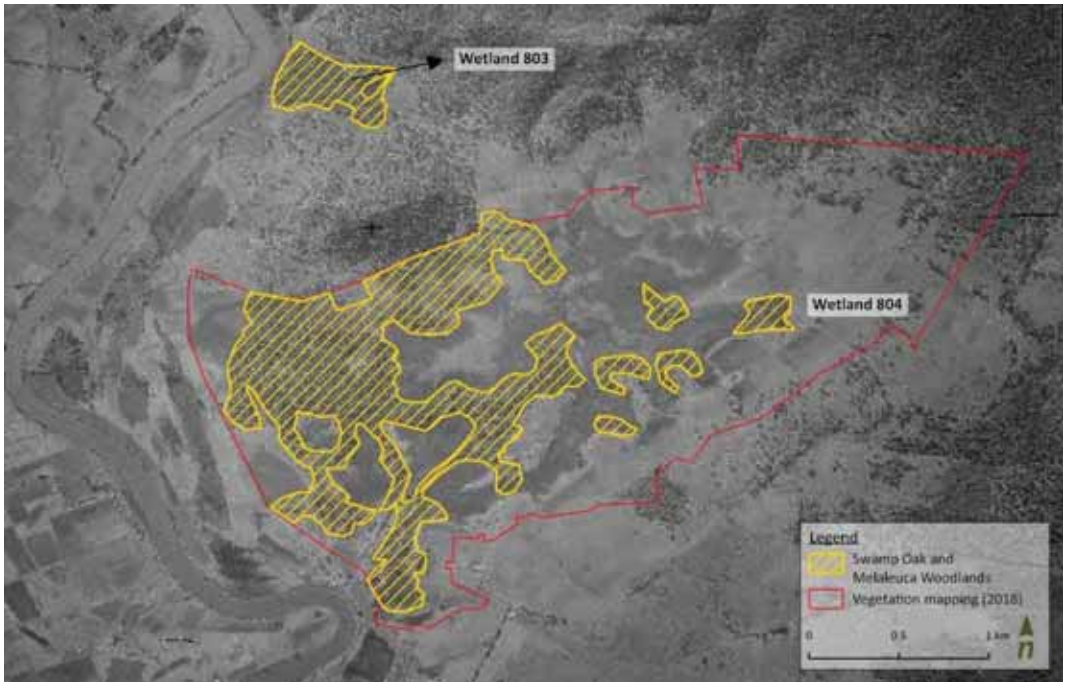

Figure 4-6 *1954 extent of Swamp Oak and Melaleuca Woodlands*

The historic change in Swamp Oak woodland is more pronounced for Wetland 803 which will receive Kings Hill West catchment flows. The Swamp Oak Woodland in this wetland has reduced in extent and density by up to 30%.

Figure 4-7 *1954 and 2019 extents of Swamp Oak Woodland in Wetland 803*

These recent trends of increasing areas of some vegetation communities and species in Irrawang Swamp noted by Kleinfelder (2018) may be a result of a few significant changes that have occurred in the swamp post 2000 including:

- Removal of the cattle and grazing pressure that has:
    - Enabled regeneration of woodland species *Casuarina glauca* and *Melaleuca* sp; and
    - Enabled regeneration of seasonal wetland vegetation such as *Bolboschoenus caldwellii, Carex appressa, Juncus* species.
- Reduction of drainage efficiency to retain water within the swamp that has:
    - Increased perennial marsh *Typha orientalis* and *Phragmites australis*

- Reducing *Cynodon dactylon* (Common Couch) and replacement with more inundation tolerant species such as *Bolboschoenus caldwellii*, *Phragmites australis* and *Typha orientalis*.

4.2 Wetland 803

Wetland 803 is a *Casuarina glauca* Swamp Oak Woodland with areas of submerged vegetation and open water. The wetland is a shallow water body, with a small volume relative to its catchment, which fills readily from the catchment and tidal inflows. Livestock have had historic access to the wetland.

The mature *Casuarina glauca* (Swamp Oak) are growing on pedestals of their own roots (see Figure 4-8) indicating that they have been growing under elevated water levels for a significant period of time. The healthiest *Casuarina glauca* are seen in the north-western corner - which is a shallower area on the wetland and less "pedestaling" is seen in this area. The extent and density of the Casuarina has changed over time with a historic reduction of up to 30% between 1954 and 2019 (see Figure 4-9).

Figure 4-8: *Casuarina glauca growing on a root pedestal within Wetland 803*

Figure 4-9 *1954 and 2019 extents of Swamp Oak Woodland in Wetland 803*

The shallow gradient banks of Wetland 803 have a mixture of herbs, grasses and sedges including: *Paspalum distichum* (Water Couch), *Cotula coronopifolia* (Water Buttons), *Samolus repens* (Creeping Brookweed), *Triglochin* sp (Water Ribbons, Juncus sp, *Bolboschoenus caldwellii* (Marsh Club Rush). In some areas the bank has a sharply stepped bank (at the high water level) reducing the shallow bank vegetation extent.

Extensive emergent macrophytes stands, as seen in Irrawang Swamp, are not present. However, emergent species such as: *Carex appressa* (Tall Sedge), *Eleocharis equisetina* (Spike Sedge), *Bolboschoenus caldwellii* (Sea Club-rush), *Juncus continuus* (Rush), *Ranunculus inundata* (River Buttercup) and Ludwigia peploides (Water Primrose) are present at low cover abundance. This may reflect the hydrology which draws down and then rapidly refills possibly drowning any new emergent macrophyte species. Historic grazing by cattle will have impacted on the emergent vegetation with grazing by water-fowl expected to have some ongoing impact. The lack of *Typha orientalis* indicates that the site periodically dries out.

Areas of submerged vegetation dominated by *Thyridia repens* (Syn *Mimulus repens* - Monkey face) were present during the site visit. This species often occupies areas of sub-saline seasonal mudflats indicating the wetland water level varies through a cycle of complete drying in most years. Other seasonal aquatic species are present including *Callitriche stagnalis* (Common Star-wort), *Potamogeton sulcatus* and *Triglochin* sp. (Water-ribbons).

Wetland 803 has a number of saline tolerant species including *Cotula coronopifolia, Mimulus repens* and *Samolus repens*. Their presence is an indicator of saline influence in the wetland. They are particularly abundant in the areas near the outlet where frequent inflow of saline water occurs. The banks which undergo frequent wetting and drying (which will accumulate salts) are also dominated by these species. However, other non-saline tolerant aquatic plants such as *Callitriche stagnalis* and *Potamogeton sulcatus* were present during the site visit. The presence of these varying tolerance species indicates that inflow from the estuary occurs and that seasonal winter inflow must lower the salinity level significantly. Maintaining these conditions will enable the diversity of flora in the wetland to persist.

4.3 Significant weeds

Two aquatic weeds of national significance (WONS) were identified in vegetation surveys. These are Alligator Weed (*Alternanthera philoxeroides*) and Water Hyacinth (*Eichhornia crassipes*). Both these weeds pose a significant threat to the biodiversity of the wetland and will need to be managed to prevent their spread through the system.

Other WONS recorded or observed on the site are:

- Blackberry (*Rubus fruticosus* species aggregate)
- Lantana (*Lantana camara)*
- *Willows (Salix sp)*

During the April 2019 site visit Alligator Weed was observed adjacent to the north-western boundary of Irrawang Swamp. During the October 2019 site visit a wider area was accessed and Alligator Weed was observed across large areas of Irrawang Swamp. The infestation occupied large areas of the inundated zones and extended into the drier more terrestrial boundary of the swamp. Figure 4-10 shows the spreading infestation smothering over Seasonal Meadow and into the Melaleuca Woodland. A systematic survey of the infestation was not undertaken with Figure 4-11 showing locations where Alligator Weed was observed.

Figure 4-10: *Alligator Weed infestation at North Western corner of Irrawang Swamp*

Figure 4-11: *Observed locations of Alligator Weed October 2019*

The infestation in October 2019 is estimated to cover 2 to 5 Ha and is actively expanding. There is an associated infestation of Water Hyacinth which is more restricted to frequently inundated areas and is estimated to cover 1 to 2 Ha within Irrawang Swamp.

Weed control programs need to be implemented and ongoing to ensure these weeds are kept to an acceptable low level throughout the wetland.

4.4 Site visits

A site visit was undertaken on 24 April 2019 to observe the vegetation communities outlined in the Kleinfelder (2018) report. A second site visit was undertaken on 16 October 2019 to review the north-west portion of Irrawang Swamp focussing on the Melaleuca Woodland and Seasonal Meadow north of the central

bund/channel. Hydraulic structures were also accessed to further understand their impact on flows through the reserve. The site visits did not include a detailed flora survey, but the Kleinfelder (2018) report was used as a baseline for the current vegetation community extents. Vegetation communities within Wetland 803 were also noted during this site visit.

The site visit was able to confirm the floristic makeup of the different vegetation communities described in Kleinfelder (2018). The relative position of the vegetation communities within the swamp areas and inundation profile was also observed. This has enabled cross checking to historic mapping and LiDAR to determine estimates of the inundation frequency and depths of the vegetation communities.

4.5 Wetland typologies

The vegetation communities in Irrawang Swamp and Wetland 803 occupy different areas depending upon the hydrology of those areas. The hydrological regimes for the different communities described below are shown in Table 4-3. Hydrology risks to these vegetation communities are shown in Table 4-4.

Swamp Meadow Complex

This vegetation community is a mosaic of grasses, sedges and herbs with occasional trees (e.g. Casuarina and Melaleuca) occupying areas of varying inundation. Kleinfelder (2018) mapped this vegetation into three floristic communities shown below. These are stable assemblages of plants but will vary in their composition and extent in response to micro-topography across the site, seasonal water availability and land management practices.

Perennial Swamp Meadow – areas of frequently deep (0.5 to 0.8m deep) and prolonged inundation including during summer. This is found in the lower sections where the Pennington Drain spills frequently and dominates the former agricultural pasture area centrally within the swamp. The vegetation is dominated by monospecific stands of *Typha orientalis* (Broadleaf Cumbungi) and/or *Phragmites australis* (Common Reed). Diversity in these areas is low. Serious weeds such as *Eichhornia crassipes* (Water Hyacinth) and *Alternanthera philoxeroides* (Alligator Weed) have been observed in this zone. Areas of open water occur in within this zone where the water depth prevents tall marsh plants from growing.

This vegetation community is equivalent to the Deep Marsh wetland vegetation in McManus et al (2007). Present in Irrawang Swamp.

Figure 4-12 *Perennial Swamp Meadow on the former agricultural pasture area that is dominated by Typha orientalis.*

Seasonal Swamp Meadow – areas of seasonal inundation (0.2 to 0.5m deep) with an annual drying period of 3 to 6 months. The vegetation of this community can be dominated by *Paspalum distichum* (Water Couch) but shows more diversity in plant species than the Perennial Swamp Meadow areas. Plants observed in this community include *Eleocharis equisetina* (Spike Sedge), *Bolboschoenus caldwellii* (Sea Club-rush), *Juncus continuus* (Rush), *Ranunculus inundata* (River Buttercup), Ludwigia peploides (Water Primrose), *Carex appressa* (Tall Sedge), *Triglochin* sp (Water-ribbons) and *Persicaria decipiens* (Slender Knotweed). Serious weeds such as *Alternanthera philoxeroides* (Alligator Weed) and *Eichhornia crassipes* (Water Hyacinth) have been observed in this zone with *Xanthium occidentale* (Noogoora Burr) also common.

This vegetation community is equivalent to the Shallow Marsh wetland vegetation type in McManus et al (2007). Present in Irrawang Swamp and Wetland 803.

Figure 4-13: *Seasonal Swamp Meadow vegetation with Eleocharis, Triglochin and Paspalum sp.*

Figure 4-14: *Seasonal Swamp Meadow showing variations in vegetation.*

Transient Swamp Meadow – areas that are flooded for short periods after significant rain events. The vegetation is dominated by *Cynodon dactylon* (Common Couch) with *Juncus continuus* and *Carex appressa* commonly seen. Herbaceous weeds such as *Xanthium occidentale* (Noogoora Burr) are also common in this area. Alligator Weed can also invade this zone with this weed invading areas of Transient Swamp Meadow in the NW corner of Irrawang Swamp.

This vegetation community is equivalent to the Shallow Marsh wetland vegetation type in McManus et al (2007). Present in Irrawang Swamp and Wetland 803.

Figure 4-15: *Transient Swamp Meadow dominated by Couch and Tall Sedge (Seasonal Swamp Meadow in lower left corner).*

Swamp Oak Woodland

Swamp Oak Woodland is a floodplain vegetation dominated by *Casuarina glauca* (Swamp Oak) with a variable understorey depending upon the inundation frequency and density of the canopy. Melaleuca species can form part of the canopy structure. This is the most widespread woodland community within Irrawang Swamp. The mapping by Kleinfelder (2018) shows most of the Swamp Oak woodland to be consistent with the community definition under the EPBC Act.

The Swamp Oak Woodlands occupy saturated soils which have a seasonal drying cycle. They periodically flood for short periods (up to 1 month) following large runoff events which recedes rapidly from these areas.

The Swamp Oak Woodland has expanded since the 1970s recolonising areas previously drained and grazed. This is a response to the removal of the cattle and increased soil moisture through the previously drained areas.

This vegetation community is equivalent to the Forest Swamp Ephemeral wetland vegetation type in McManus et al (2007). Present in Irrawang Swamp and Wetland 803.

Figure 4-16 *Swamp Oak Woodland showing recruitment with juvenile plants present.*

Paperbark Woodland

This is an alluvial plain woodland community dominated by Melaleuca species including *Melaleuca linariifoli*a (Snow in Summer), *Melaleuca styphelioide*s (Prickly Paperbark) and *Melaleuca ericifolia* (Swamp Paperbark). This is a seasonally inundated vegetation community with water up to 0.5m deep. It occupies areas at a slightly lower (100-200mm) elevation than the Swamp Oak with longer inundation periods.

Kleinfelder (2018) have mapped it at two main locations. One in the northern boundary of Irrawang Swamp where a drainage line enters and the other near the western boundary.

The northern Paperbark Woodland (Melaleuca Swamp) is susceptible to impacts from increased summer flows as this area is a natural depression and increased summer flows may prevent this area from drying out.

This vegetation community is equivalent to the Forest Swamp Ephemeral wetland vegetation type in McManus et al (2007). Present in Irrawang Swamp.

Figure 4-17 *Melaleuca Woodland with Triglochin dominated understorey*.

Table 4-3 *Vegetation community hydrological regimes*

	Ecological community	Wetland classification	Dominant species	Hydrological conditions							
				Soil water conditions	Inundation frequency	Inundation depth	Inundation duration	Inundation regularity	Drying period	Drying frequency	Water quality
Woodland	Swamp Oak Woodland (Swamp Oak Floodplain Forest)	Forest Swamp Ephemeral	*Casuarina glauca*	Water logged	Espisodic	0 to 0.4m (RL 0.6 to 1)	<3 days	4-6 times per year	4-8 months	Annually	Fresh to brackish
Swamp Meadow Complex	Perennial Swamp-meadow Freshwater Wetlands on Coastal Floodplains	Deep Marsh (Tall Marsh)	*Typha orientlis/Phragmites australis*	Saturated	Seasonal to permanent	0.5 to 0.8m (RL 0.2 to .5)	6 months to perennial	Annual	1 - 4 months	1.5 - 3 years	Fresh to brackish
	Seasonal Swamp-meadow Freshwater Wetlands on Coastal Floodplains	Shallow Marsh (wet)	*Paspalum distichum* (Water Couch), *Bolboschoenus caldwellii, Ludwigia pleboides, Carex appressa. Juncus* sp	Water logged	Seasonal to episodic	0.2 to 0.5m (RL 0.4 to 0.8)	1-2 months	2-3 times per year	3 - 6 months	Annually	Fresh
	Transilient Swamp-meadow Freshwater Wetlands on Coastal Floodplains	Shallow Marsh (dry)	*Cynodon dactylon* (Common Couch), *Juncus sp, Carex appressa*	Water logged	Episodic	0 to 0.4m (RL 0.6 to 1)	1 month	2-3 times per year	8 - 12+ months	Annually	Fresh
Woodland	Paperbark Woodland Swamp Sclerophyll Forest on Coastal Floodplains	Forest Swamp Ephemeral	*Melaleuca styphelioides, Melaleuca linariifolia, Melaleuca ericifolia*	Water logged	Seasonal (Spring)	0 to 0.5m (RL 0.5 to 0.9)	2 to 3 months	Annual	3-6 months	Annually	Fresh to brackish
				Water logged	Episodic	0.2 to 0.4m (RL 0.6 to 0.8)	1 month	2-3 times per year			

Table 4-4 *Vegetation community hydrology risks*

	Ecological community	Wetland classification	Dominant species	Hydrology risk		
				Current trajectory	Increase in depth and duration	Reduced depth and duration
Woodland	Swamp Oak Woodland (Swamp Oak Floodplain Forest)	Forest Swamp Ephemeral	*Casuarina glauca*	Increase in extent. Unclear ff this is due to hydrology or reduced grazing pressure.	>200mm of drawdown depth for more than 1 month duration. Drowning of Swamp Oak, reduced extent.	Increase in Swamp Oak if reduction is low and waterlogged soils are retained.
Swamp Meadow Complex	Perennial Swamp-meadow Freshwater Wetlands on Coastal Floodplains	Deep Marsh (Tall Marsh)	*Typha orientlis/Phragmites australis*	Increase in extent	Further spread especially if summer inundation increses	Reduction in perrennial to Season Swamp-meadow
	Seasonal Swamp-meadow Freshwater Wetlands on Coastal Floodplains	Shallow Marsh (wet)	*Paspalum distichum* (Water Couch), *Bolboschoenus caldwellii, Ludwigia pleboides, Carex appressa. Juncus* sp	Reducing	Reduction with increase in Perennial Swamp-meadow	Potential increase
	Transilient Swamp-meadow Freshwater Wetlands on Coastal Floodplains	Shallow Marsh (dry)	*Cynodon dactylon* (Common Couch), *Juncus sp, Carex appressa*	Reducing with Swamp Oak Woodland colonising into this area.	Reduction with increase in Perennial Swamp-meadow	Potential increase
Woodland	Paperbark Woodland Swamp Sclerophyll Forest on Coastal Floodplains	Forest Swamp Ephemeral	*Melaleuca styphelioides, Melaleuca linariifolia, Melaleuca ericifolia*	Stable with some increase	>200mm of drawdown depth for more than 1 month duration. Reduction with increase in Perennial Swamp-meadow	Potential increase

5 Development impacts on catchment hydrology

5.1 Hydrological model development

MUSIC models were prepared by Northrop Consulting Engineers (NCE) to evaluate runoff quality from the development site for existing, developed (untreated) and developed (with treatment) scenarios.

The five-year modelling period adopted by NCE for stormwater quality modelling was considered insufficient for the purpose of completing flow regime analysis. Alluvium assisted NCE with extending the modelling period to reflect an appropriately representative period for the hydrology analysis. A representative continuous 20-year rainfall period with good quality and complete 6-minute time step data was selected from the nearby Williamtown RAAF rainfall station. The period from 1989 to 2008 provided good quality data with a mean annual rainfall consistent with the long-term average.

Alluvium sourced appropriate daily potential evapotranspiration data from the SILO database covering the rainfall data period. Daily estimates of Mortons PET (wet) were adopted as being most appropriate for hydrologic modelling.

A MUSIC template was prepared utilising the above data and supplied to NCE. NCE modified their MUSIC models to incorporate the new template and provided updated daily flow estimates for 3 scenarios; existing, developed (untreated) and developed (with treatment).

NCE provided daily flow outputs from their models for Alluvium's hydrological analysis. In completing this analysis, Alluvium has assumed that the models developed by NCE appropriately reflect the site characteristics and conditions for each development scenario. We understand that the process followed to develop the MUSIC models is outlined in a separate report prepared by NCE (NCE, 2019).

Northrop provide flow outputs at three separate locations relevant to the assessment:

- Kings Hill South includes the future development and remaining forest areas that drain into the northern side of Irrawang Swamp through ephemeral gullies.
- Kings Hill East includes areas draining to a location where the original spillway channel joins the eastern side of Irrawang Swamp. For the existing scenario, the sub-catchments only include areas draining to an ephemeral creek located between the Pacific Highway and the Riding for the Disabled site. For the developed (treated) scenario the catchment draining to this location will increase significantly due to construction of a diversion channel required to prevent the discharge of runoff from development in Kings Hill East into Grahamstown Dam.
- Kings Hill West includes areas draining to a small coastal wetland previously listed as Coastal Wetland 803 under repealed SEPP 14 legislation.

5.2 Mean annual runoff volume

Changes in mean annual runoff volume provide a coarse indicator of the catchment hydrology changes associated with the Kings Hill development. Table 5-1 summarises the estimated changes to mean annual runoff volumes draining to Irrawang Swamp and Wetland 803 that are associated with the Kings Hill development.

The Kings Hill East sub-catchment includes all future development areas (and forested areas draining through these areas) that will drain to the original Grahamstown Dam spillway outlet into Irrawang Swamp. The estimated mean annual runoff volumes for the developed and developed (with treatment) scenarios are based on a 0.2% AEP capacity diversion drain being constructed on the eastern side of the Pacific Highway in Hunter Water owned land. This drain would divert runoff that currently drains directly to Grahamstown Dam to the original spillway.

The Kings Hill East sub-catchment also includes an existing ephemeral creek between the existing Riding for the Disabled site and the Pacific Highway. This creek transitions to a section of concrete channel parallel to the original Grahamstown Dam. The creek discharges into Irrawang Swamp at the same location as the original spillway.

The Kings Hill South sub-catchment includes all future development areas (and forested areas draining through these areas) that drain through three existing ephemeral gullies into the northern side of Irrawang Swamp.

The sub-catchment extents for Kings Hill East, Kings Hill South and Kings Hill West are shown on Figure 2-1.

Table 5-1 *Estimated mean annual runoff volumes (1989 to 2008 modelling period)*

Sub-catchment	Scenario	Catchment runoff discharge location				
		Northern Irrawang Swamp	**Original spillway outlet channel**	**Grahamstown Dam**	**Wetland 803**	**Williams River**
Kings Hill East	Existing	0	625	925	0	0
	Developed	0	2300	0	0	0
	Developed (treated)	0	2120	0	0	0
	Change		+1495 (+240%)	-925 (-100%)		
Kings Hill South	Existing	470	0	0	0	0
	Developed	700	0	0	0	0
	Developed (treated)	575	0	0	0	0
	Change	+105 (+22%)				
King Hill West	Existing	0	0	0	427	0
	Developed	0	0	0	529	0
	Developed (treated)	0	0	0	458	31
	Change				+31 (+7%)	+31

The estimated mean annual runoff volumes summarised in Table 5-1 indicate that:

- The average annual runoff discharged to Grahamstown Dam from the Kings Hill East sub-catchments is estimated to decrease by approximately 925 ML/yr following construction of the diversion drain. Excluding infiltration and evapotranspiration losses along the diversion drain, most of this runoff would discharge to the original spillway channel and then to Pennington Drain.
- The average annual runoff discharged from the local Kings Hill sub-catchments to the original spillway channel is expected to increase by up to approximately 1500 ML/year following development. This increased volume includes the parts of Kings Hill East currently draining to Grahamstown Dam that will be diverted to the original spillway, and the increased runoff from the other parts of Kings Hill East that continue to drain to the original spillway.
- An increase in mean annual runoff of 105 ML is estimated from the Kings Hill South sub-catchments draining into the ephemeral gullies located to the north of Irrawang Swamp.
- The increase in runoff from Kings Hill West to Wetland 803 will be limited 31 ML/yr (7% increase).

As a proportion of the existing runoff, the increase in runoff discharged into the eastern extents of Irrawang Swamp is significantly greater than the increase from the northern catchments. Whilst the total volume of runoff will increase across the full range of small to large storm events, changes in the flow regime during drier low flow periods are expected to be more critical for the vegetation communities within Irrawang Swamp. How runoff characteristics are estimated to change with development for small and large rainfall events is discussed in Section 5.3.

5.3 Cumulative runoff

A plot of daily rainfall totals and associated cumulative runoff volumes for Kings Hill South is provided in Figure 5-1. Figure 5-1 is based on MUSIC model flow outputs from the 20-year models prepared by NCE for the existing and developed scenarios. The trends shown in the hydrologic modelling results presented in Figure 5-1 would also be representative of other areas of the Kings Hill development.

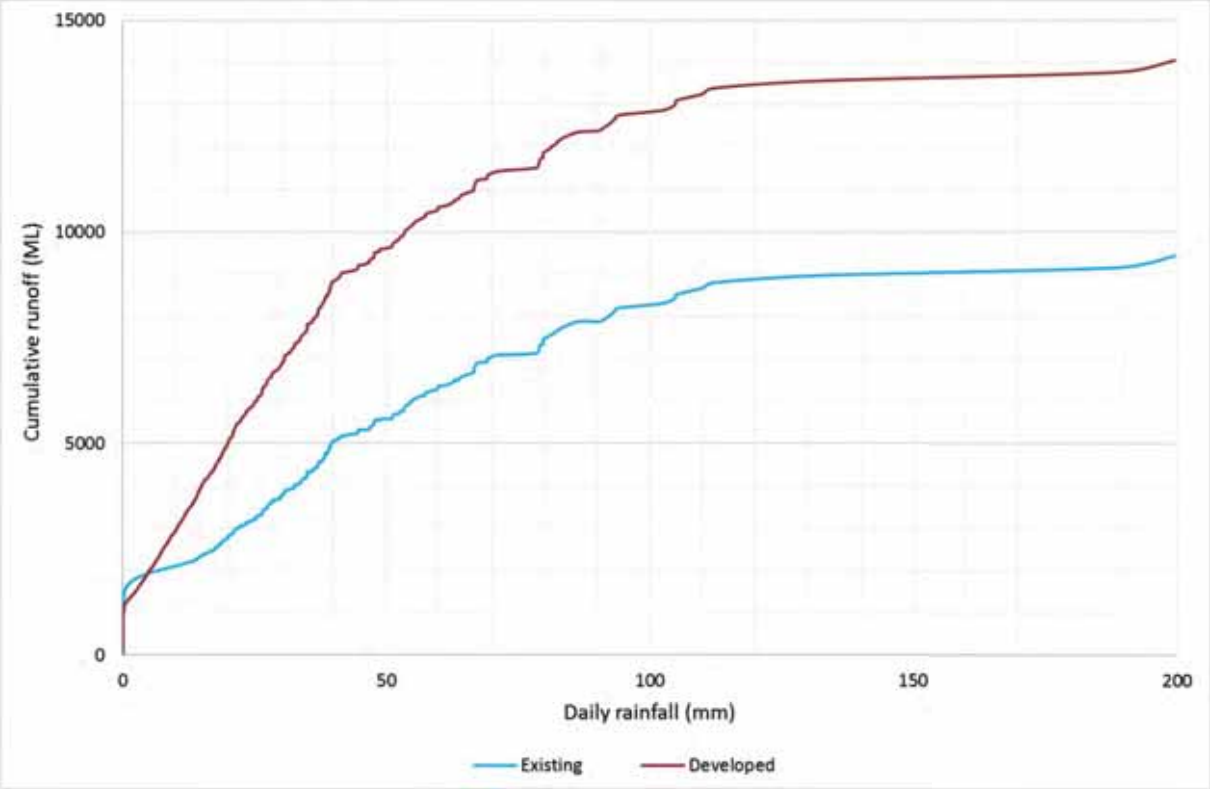

Figure 5-1 *Plot of daily rainfall and estimated cumulative runoff for Kings Hill South catchment (1989 to 2008)*

Figure 5-1 indicates that the most significant differences in runoff volumes between the existing and developed scenarios are likely to occur for days where the daily rainfall is less than 50mm. For daily rainfall totals between 50mm and 100mm there is a small difference, and above daily rainfall totals of 100mm the volume of runoff from the existing and developed site is expected to be similar. The reasons for these differences are discussed below.

For daily rainfall totals less than 50mm, a high proportion of rainfall within the existing forested and pasture areas will be retained in the upper soil layers with some intercepted rainfall draining slowly as either interflow or base flow to creeks in the days immediately following rainfall. Rainfall absorbed by the soil will typically evaporate or be transpired by plants in the days following a storm event. In a developed site, impervious roof and road surfaces only intercept a very small rainfall depth (typically less than 2mm) with any additional rainfall causing stormwater runoff to occur from these surfaces. This results in more frequent runoff from developed catchments during much smaller rainfall events and this cumulatively adds up to a significant volume.

For daily rainfall totals exceeding 50mm, it is likely that soils will become close to saturation in the early stages of a rainfall event, resulting in a high proportion of additional rainfall being converted to runoff. In this manner, pervious surfaces would tend to generate similar runoff volumes as developed impervious surfaces in larger rainfall events and this is why only a marginal increase in estimated runoff volume occurs above a daily rainfall total of 50mm in Figure 5-1.

Figure 5-1 indicates that cumulative changes in hydrology from developing catchments are likely to be more pronounced for days where the daily rainfall is less than 50mm. Mitigation strategies aiming to replicate pre-development hydrology conditions therefore need to focus on reducing changes in runoff volumes for days where the daily rainfall is less than 50mm. This requires a change in approach from conventional drainage and flooding studies where much larger storm events are the focus. It also requires a change from a focus on discrete peak stormwater flow rates to management of stormwater runoff volumes.

5.4 Legislation context

The *NSW Coastal Management Act 2016* replaced the *Coastal Protection Act 1979* and established a new strategic framework and objectives for managing coastal issues in NSW. This act includes *State Environmental Planning Policy (Coastal Management) 2018.* ('the SEPP'). The SEPP identifies areas of interest that are delineated on the *Coastal Wetlands and Littoral Rainforest areas map*. This map highlights the coastal wetlands and a proximity buffer area which the SEPP applies to.

The study area contains two Coastal Wetlands (803 & 804) listed in SEPP 2018 and these are shown on Figure 2-1. Whilst the proposed Kings Hill development extents lie outside the mapped Coastal Wetlands and the Proximity Area for Coastal Wetlands, the development has the potential to impact within the areas of interest to the SEPP.

SEPP Clauses 10 and 11 provide guidance on the threats that need to be considered to determine if an impact will occur (see relevant sections of the SEPP outlined below). The key threatening processes posed by the development are identified in other legislation that is also outlined below.

Clause 10: Development on certain land within coastal wetlands and littoral rainforests area

(1) The following may be carried out on land identified as "coastal wetlands" or "littoral rainforest" on the Coastal Wetlands and Littoral Rainforests Area Map only with development consent:

> *(a) the clearing of native vegetation within the meaning of Part 5A of the Local Land Services Act 2013,*
>
> *(b) the harm of marine vegetation within the meaning of Division 4 of Part 7 of the Fisheries Management Act 1994,*
>
> *(c) the carrying out of any of the following:*
>
> > *(i) earthworks (including the depositing of material on land),*
> >
> > *(ii) constructing a levee,*
> >
> > *(iii) draining the land,*
> >
> > *(iv) environmental protection works,*
> >
> > *(d) any other development.*

Clause 11: Development on land in proximity to coastal wetlands or littoral rainforest

The Coastal Wetlands and Littoral Rainforests Area Map identifies certain land that is inside the coastal wetlands and littoral rainforests area as "proximity area for coastal wetlands" or "proximity area for littoral rainforest" or both.

(1) Development consent must not be granted to development on land identified as "proximity area for coastal wetlands" or "proximity area for littoral rainforest" on the Coastal Wetlands and Littoral Rainforests Area Map unless the consent authority is satisfied that the proposed development will not significantly impact on:

(a) the biophysical, hydrological or ecological integrity of the adjacent coastal wetland or littoral rainforest, or

(b) the quantity and quality of surface and ground water flows to and from the adjacent coastal wetland or littoral rainforest.

This report documents the potential changes to the surface water flows and the estimated impacts of those changes if the Kings Hill development proceeds. If direct impacts on the values in the wetland are not likely to occur then SEPP 2018 Clause 10 is not active.

NSW Biodiversity Conservation Act 2016 **(BC Act), Threatened Species Conservation Act 1995 and the** *Environment Protection and Biodiversity Conservation Act 1999* **(EPBC Act)**

These Acts provide protection to individual species and vegetation communities throughout NSW. If listed species or vegetation communities are identified in project areas or areas to be impacted as a consequence of development, these Acts must be referred to for assessment and response requirements.

Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is listed as a 'key threatening process' in Schedule 3 of the Threatened Species Conservation Act 1995 [31 May 2002]. Understanding the potential for this threatening process to impact on the values within Irrawang Swamp is a key objective of this assessment. This threatening process aligns to the requirements in SEPP 2018 to protect coastal wetlands.

Eight flora species listed as vulnerable or endangered species (under NSW and/or federal legislation) are recorded in the NSW BioNet Atlas database for the Irrawang Swamp and surrounding area. Conditions suitable to support four of these species occur within the Irrawang Swamp. See Table 4-1 for details on these species. No flora species listed as threatened or endangered were observed during the site visits.

Three vegetation communities listed as vulnerable or endangered in the BC Act or EPBC Act (shown in Table 5-2) have been recorded and observed in the site.

Table 5-2 *Vegetation communities of interest within Irrawang Swamp*

Vegetation community	NSW Biodiversity Conservation Act 2016 (BC Act)	Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
Swamp Meadow Complex	Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions **Endangered**	
Swamp Oak Woodland	Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions **Endangered**	Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland **Endangered**
Paperbark Woodland (Melaleuca Swamp)	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions **Endangered**	

The listing of a vegetation community under these Acts requires the protection of the area occupied by them from the key threatening processes listed in the Acts.

Activities which can lead to changes to natural drainage regimes, such as the diversion of water, affecting the ecological community can require a referral under the Acts if they will have an impact on the listed species or communities. With the presence of listed species and vegetation communities in the wetland evidence needs to be provided to ensure that they will not be impacted.

This assessment investigates the potential for the changes in flows from the catchment following development to have an impact on the Irrawang Swamp values.

5.5 Kings Hill East and Kings Hill South flow regimes (Irrawang Swamp)

HWC has requested that an assessment of the effects of changes to stormwater discharges to Irrawang Swamp be completed to address biodiversity values and ecological integrity. HWC has indicated it expects that the Kings Hill development proponent demonstrate that the current wetting / drying regime of the Irrawang Swamp would not be adversely impacted by stormwater discharges from the diversion channel and direct discharges from other catchments areas.

HWC has referred to the approach outlined in the guideline document *Water Sensitive Urban Design Solutions for Catchments above Wetlands – Overview Report* (McManus et al, 2007) which indicates that WSUD strategies associated with new developments in the catchments upstream of natural wetlands need to include measures to preserve the pre-development drying and flooding hydrology characteristics in order to protect the wetland ecology.

McManus et al (2007) outlines drying and flooding hydrology management targets for a range of wetland categories and these are summarised in Table 5-3. Wetland categories identified in Section 4.5 that would be relevant to Irrawang Swamp include Shallow Marsh, Deep Marsh and Forest Swamp - Ephemeral.

Table 5-3 *Hydrologic management targets for natural wetlands (McManus et al, 2007)*

Wetland Category	Flooding Hydrology	Drying Hydrology		Reference Duration
	High Flow Duration Frequency Curve	Low Flow Duration Frequency Curve	Low Flow Spell Frequency	
1. Coastal Flats	✓			7 days
2. Inland Flats	✓	Isolate wetland from upstream catchment		30 to 60 days
3. Bogs	✓	✓	✓	30 to 60 days
4. Deep Marsh		✓	✓	30 to 60 days
5. Fen	✓	✓	✓	30 to 60 days
6. Shallow Marsh		✓	✓	60 days
7. Salt Marsh	✓	✓	✓	7 days
8. Seagrass Beds	✓			7 days
9. Deep Salt Pans	✓	Isolate wetland from upstream catchment		30 to 60 days
10. Deep Open Water	No hydrologic management objectives required			
11. Shallow Open Water		✓	✓	60 days
12. Wet Heath		✓	✓	60 days
13. Mangrove	✓			7 days
14. Scrub Swamp	✓	✓*	✓*	60 days
15. Forest Swamp – Wet		✓	✓	60 days
16. Forest Swamp – Ephemeral		✓	✓	60 days
17. Forest Swamp – Dry	✓	✓*	✓*	60 days

Considering the targets outlined in Table 5-3 for the identified relevant wetland categories within Irrawang Swamp, flow regime analysis was completed focusing on the drying hydrology. Inflows to Irrawang Swamp were analysed to derive dry spells curves (low flow spells) and low flow duration frequency curves for 30 and 60-day reference durations. Additional analysis of 7-day duration high flows was also completed to evaluate the impact of diverting runoff from Kings Hill East to Irrawang Swamp. The completed analysis covers the range of wetland vegetation communities currently observed in the swamp. The approach followed to derive the flow regime curves is described in the following sections.

Critical drying period

The critical drying period for Irrawang Swamp is from September to March when average monthly potential evapotranspiration typically exceeds average monthly rainfall at this location (refer Figure 5-2). It is during this period that rainfall and associated runoff to the wetland would be lower enabling soils to partially dry in areas of a wetland to support new plant growth. Minimising changes to hydrology during this drying period are particularly important for the Shallow Marsh, Deep Marsh and Forest Swamp - Ephemeral communities within Irrawang Swamp.

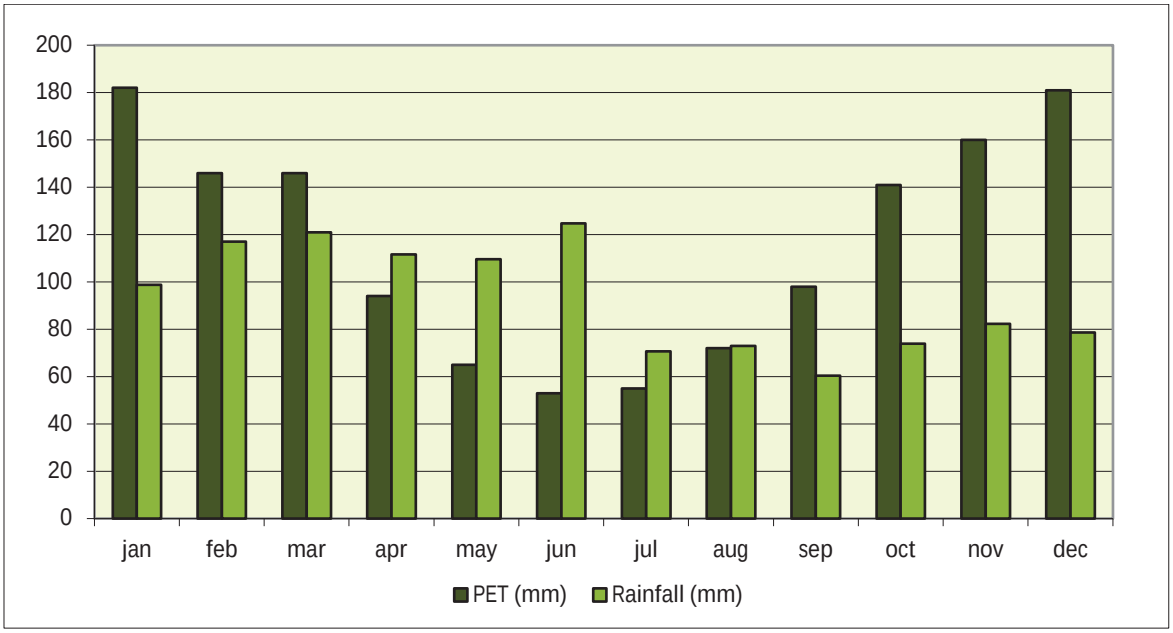

Figure 5-2 *Average monthly potential evapotranspiration and rainfall depths for Irrawang Swamp (BoM Climate Atlas of Australia)*

Dry spells curves

The MUSIC models prepared by NCE to evaluate runoff quality for Kings Hill were adopted for developing the dry spells curves. The approach outlined in McManus et al (2007) was applied to develop the dry spells curves. This approach involves completing annual flow frequency analysis considering the critical drying period for the swamp. As outlined above, for Irrawang Swamp this period was assessed to be from September to March. For each of modelled years, the longest continuous period where estimated daily runoff was lower than the long-term median flow was calculated within the critical drying period. Flow frequency analysis was then completed using the flows estimated by NCE for the existing, developed (untreated) and developed (treated) scenarios and the results plotted. The dry spell curves derived for the Kings Hill South and Kings Hill East sub-catchments are show on Figure 5-3 and Figure 5-4 respectively.

An example of how these curves may be interpreted is indicated by the dashed green line shown on Figure 5-3. This line indicates that there is a 10% chance in any year that the maximum dry spell will exceed 32 days for developed conditions and 190 days for the existing conditions. Typically, a 10% AEP dry spell would be representative of that occurring in a dry year, whilst a 90% AEP dry spell would occur within a wet year. A 50% AEP dry spell is considered to be that occurring in a typical year.

The dry spells curves indicate that the length of the maximum annual dry spell is expected to reduce following development for the full range of dry to wet years. The stormwater management strategy proposed by NCE would partially mitigate reductions in dry spells through the provision of 5 kL rainwater tanks, biofiltration systems and urban lakes throughout the development.

Figure 5-3 *Kings Hill South – Dry Spells Curves*

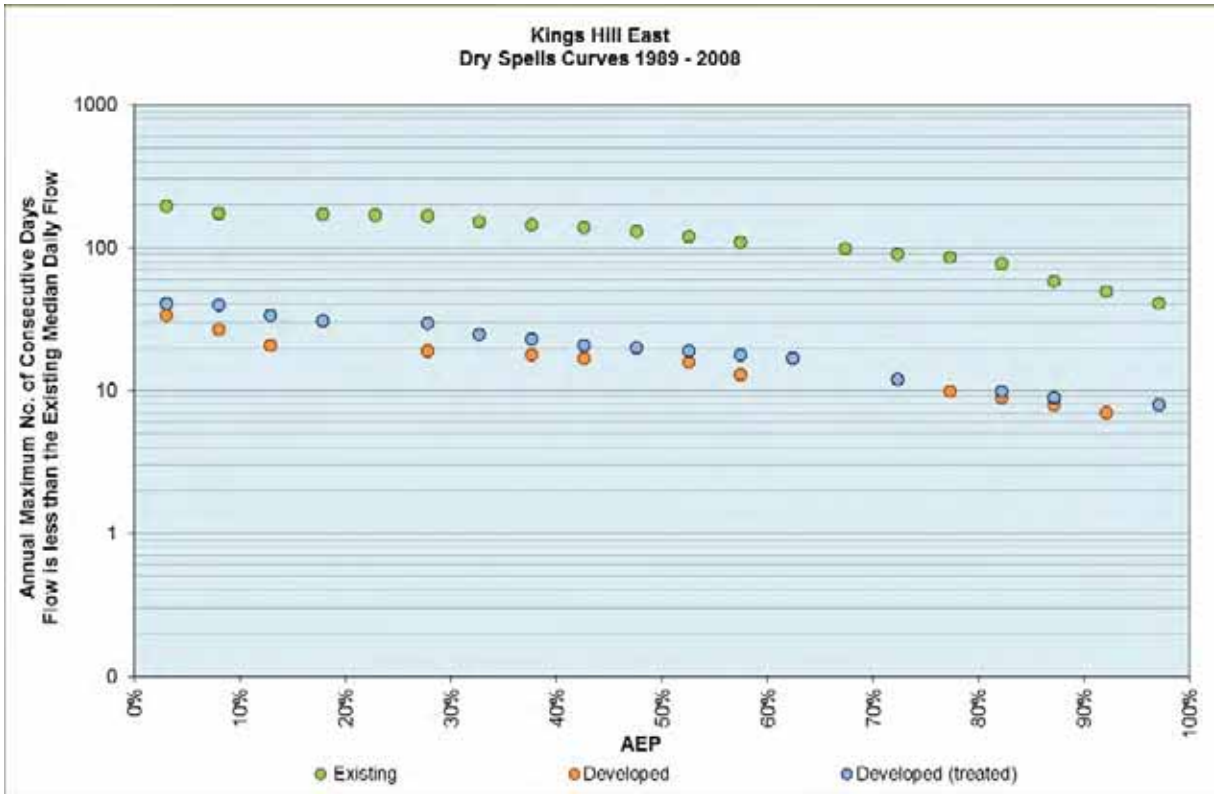

Figure 5-4 *Kings Hill East – Dry Spells Curves*

Low flow duration frequency curves

Similar to the dry spells analysis, the approach outlined in McManus et al (2007) was adopted to develop low flow duration frequency curves. This approach also involves completing annual flow frequency analysis considering the critical drying period for the swamp. A continuous moving average (30 days and 60 days) of the mean daily flow was calculated over the entire modelled period. For each of the modelled years, the maximum average daily 30 and 60-day flows within the critical drying period for each year were calculated. Flow frequency analysis was then completed on the averages for the existing, developed (untreated) and developed (treated) scenarios and the results plotted. The low flow curves derived for the Kings Hill South and Kings Hill East sub-catchments are show on Figure 5-5, Figure 5-6, Figure 5-7 and Figure 5-8.

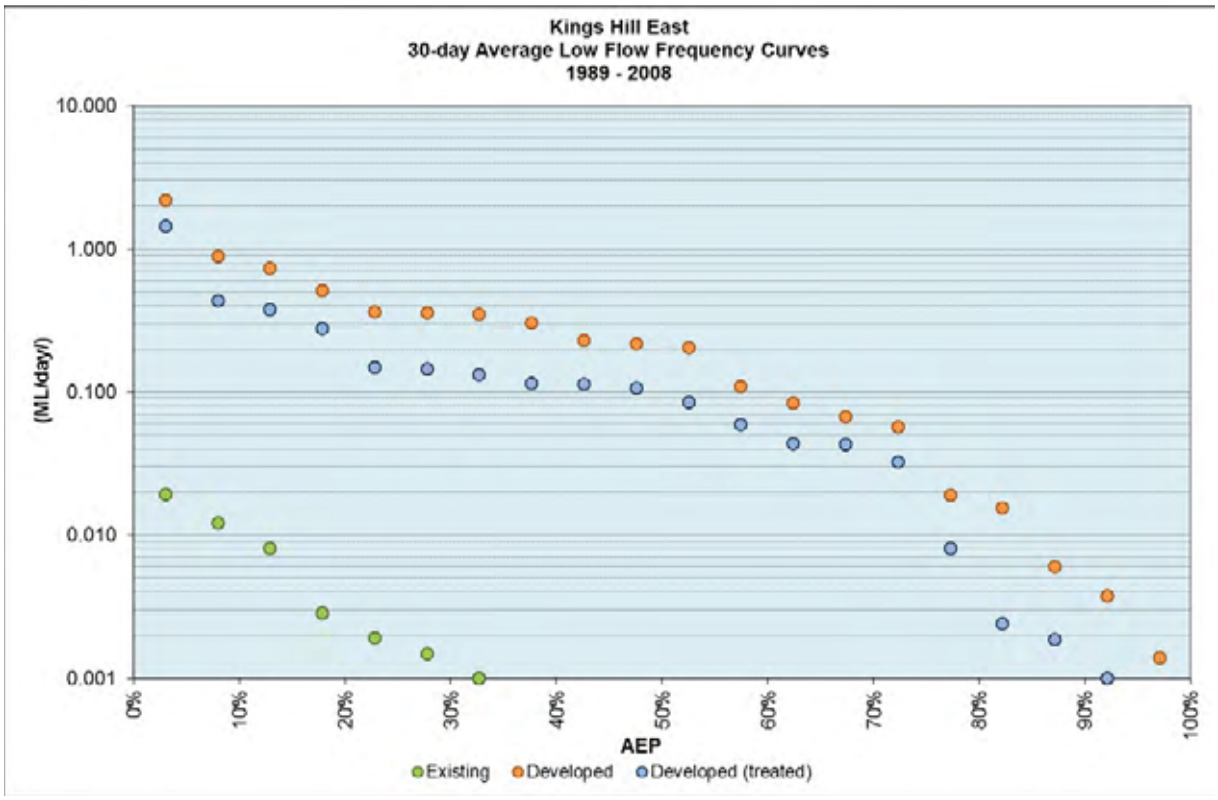

Figure 5-5 *Kings Hill East – 30-day average low flow frequency curves*

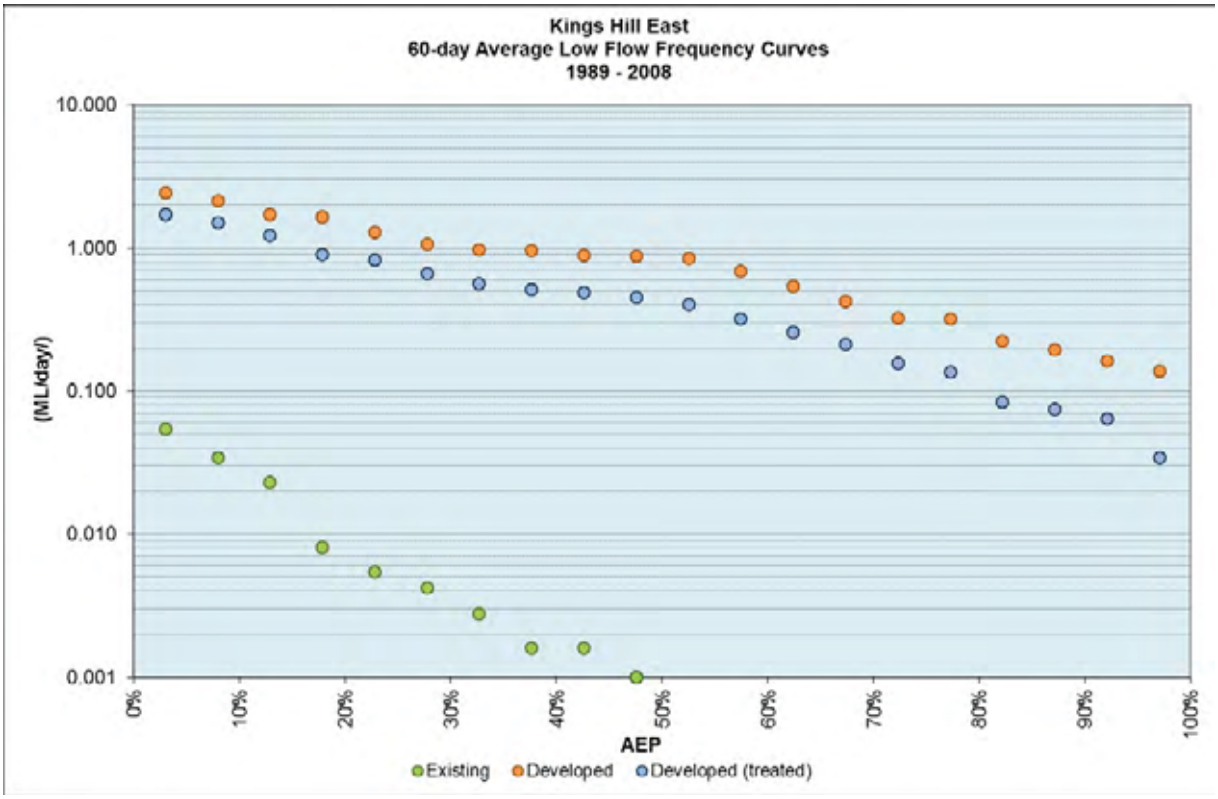

Figure 5-6 *Kings Hill East – 60 day average low flow frequency curves*

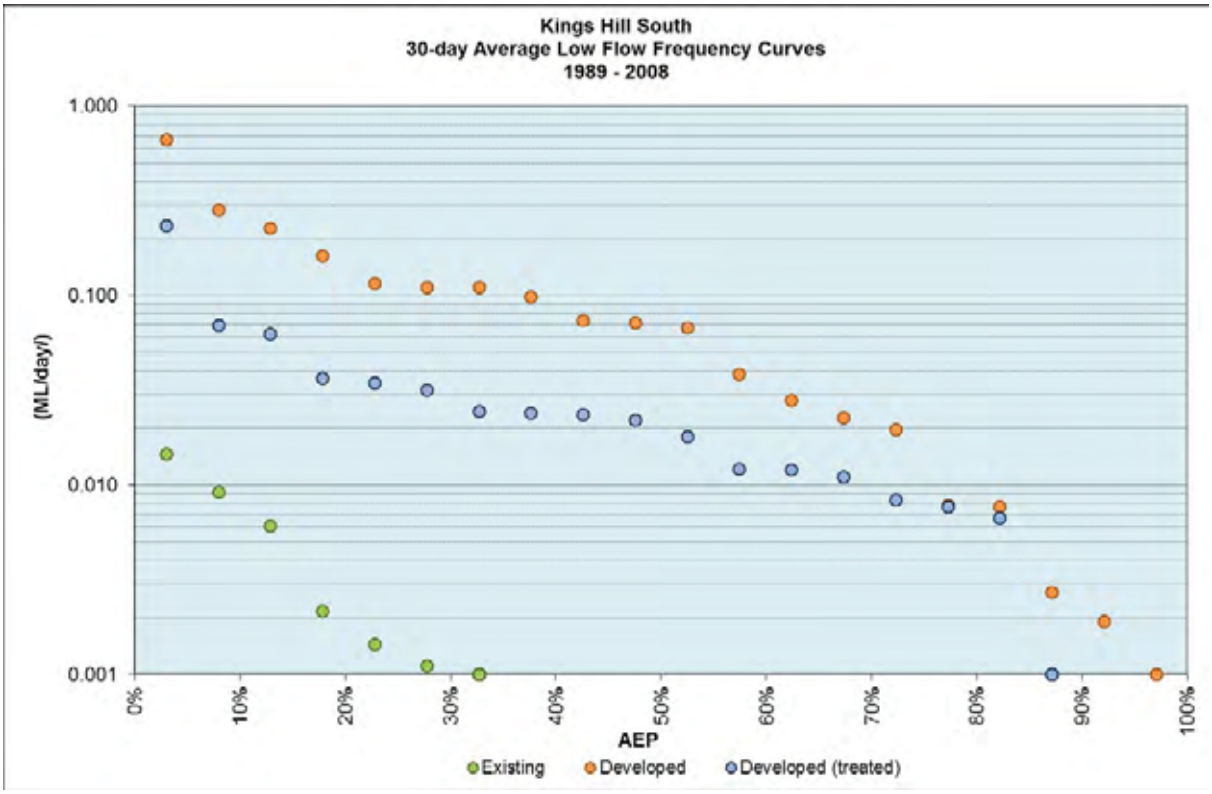

Figure 5-7 *Kings Hill South – 30-day average low flow frequency curves*

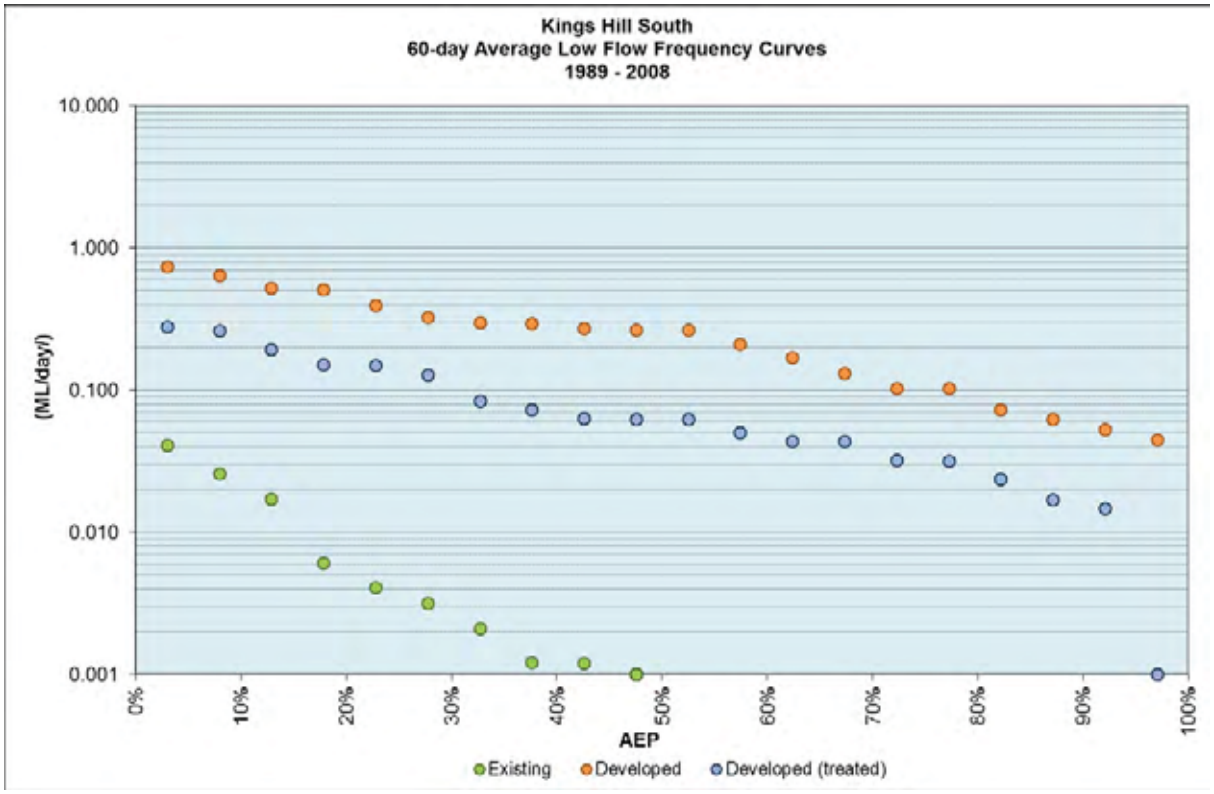

Figure 5-8 *Kings Hill South – 60-day average low flow frequency curves*

The low flow frequency curves indicate that the average daily flow during the 30 and 60-day low flow periods is expected to increase following development for the full range of dry to wet rainfall years. The stormwater management strategy proposed by NCE partially mitigates increased low flows through the provision of 5 kL rainwater tanks, biofiltration systems and urban lakes throughout the development.

The low flow frequency curves indicate that under existing conditions, there is a 50% chance in any year that the average daily flow volume during the critical drying period will be approximately zero. For developed conditions, it is estimated that for all but very dry years, runoff will discharge into Irrawang Swamp from the developed catchments during the critical drying period. Whilst low flow discharges are likely to occur, the magnitude of the increased low flows and associated impacts on wetland vegetation inundation are expected to be low. These impacts are discussed further below.

High flow duration frequency curves

Potential impacts on the wetland vegetation from Kings Hill runoff are expected to be largely related to changes in increased frequency of runoff from impervious surfaces within the development during natural low flow periods. Irrawang Swamp is currently already exposed to high discharges associated with spillway releases from Grahamstown Dam that differ significantly to natural conditions.

It is expected that the runoff volumes from Kings Hill South and Kings Hill West during high flow periods will not change significantly from existing conditions as these would generally align with periods where soils would be saturated or close to saturation for extended periods (refer to Section 5.1 for further discussion on this) and this is demonstrated in Figure 5-9 for Kings Hill South.

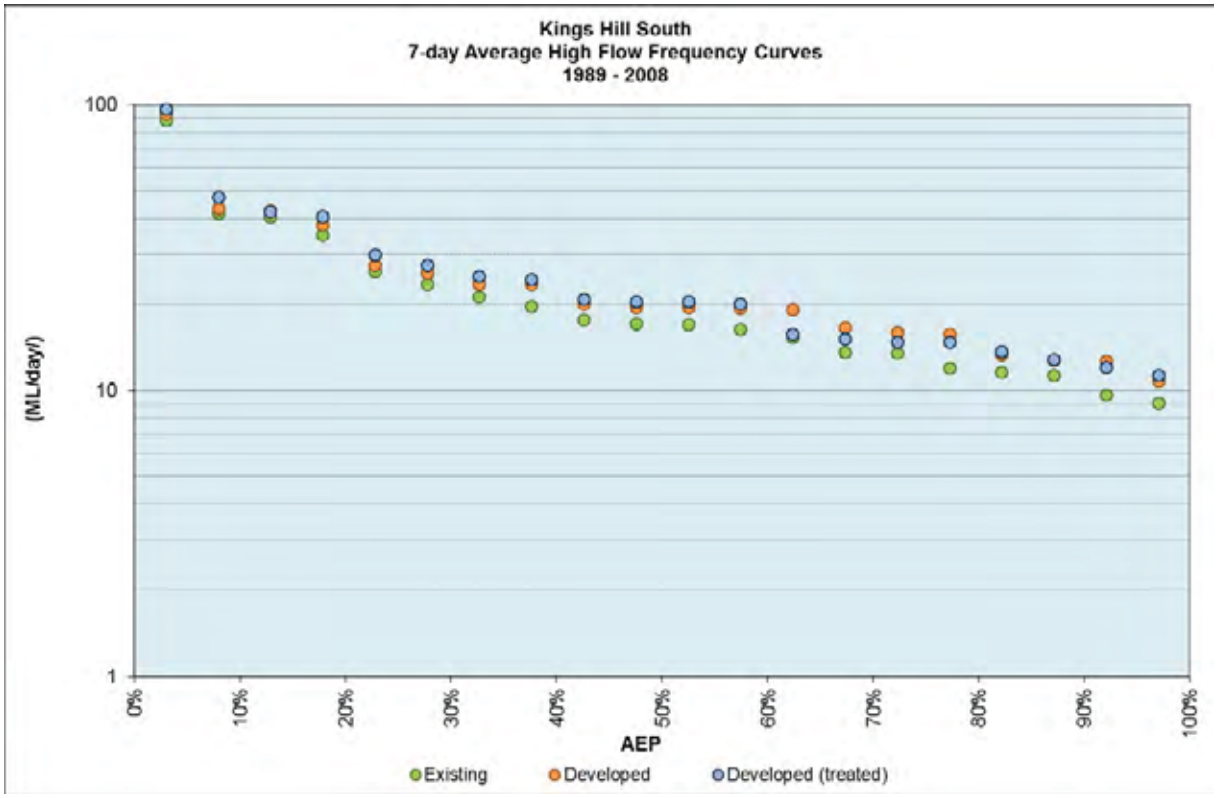

Figure 5-9 *Kings Hill South – 7-day average high flow frequency curves*

The main change from developed conditions would be that increased high flows from Kings Hill East will be directed to Irrawang Swamp along the diversion channel. Under existing conditions, high flows from Kings Hill East discharge directly into Grahamstown Dam. Although, during periods when dam storage levels in Grahamstown Dam are close to the spillway level, existing high flow discharges from Kings Hill East to Grahamstown Dam may indirectly discharge to Irrawang Swamp through the spillway.

Figure 5-10 summarises the estimated high flow discharges from Kings Hill East under existing and developed conditions. The existing high flows are for the portion of the Kings Hill East catchment that drains south of the proposed interchange along an existing ephemeral creek through the Riding for the Disabled site to a concrete channel that joins Irrawang Swamp at the same location as the original Grahamstown Dam spillway. The developed high flows for Kings Hill East include contributions from the catchment described above and the remaining part of the Kings Hill East catchment directed to the proposed diversion channel.

Figure 5-10 indicates that for a high rainfall year (10% AEP), the Kings Hill East development is estimated to increase average 7-day high flows by approximately 85 ML/day (600 ML over the 7 day period). For a typical rainfall year (50% AEP), the model results indicate that the Kings Hill East development and diversion drain would increase average 7-day high flows by approximately 40 ML/day (280 ML over the 7-day period) from Kings Hill East.

Figure 5-10 also indicates that the stormwater management measures proposed by NCE are unlikely to have any significant impact on reducing high flow discharges. This is expected as the magnitude of the high flows would require the provision of an excessively large volume of additional retention storage similar in size to the estimated increase to have any significant influence on reducing the high flow volumes.

The impact of this increase in high flow discharge is discussed and compared with current Grahamstown Dam discharges below.

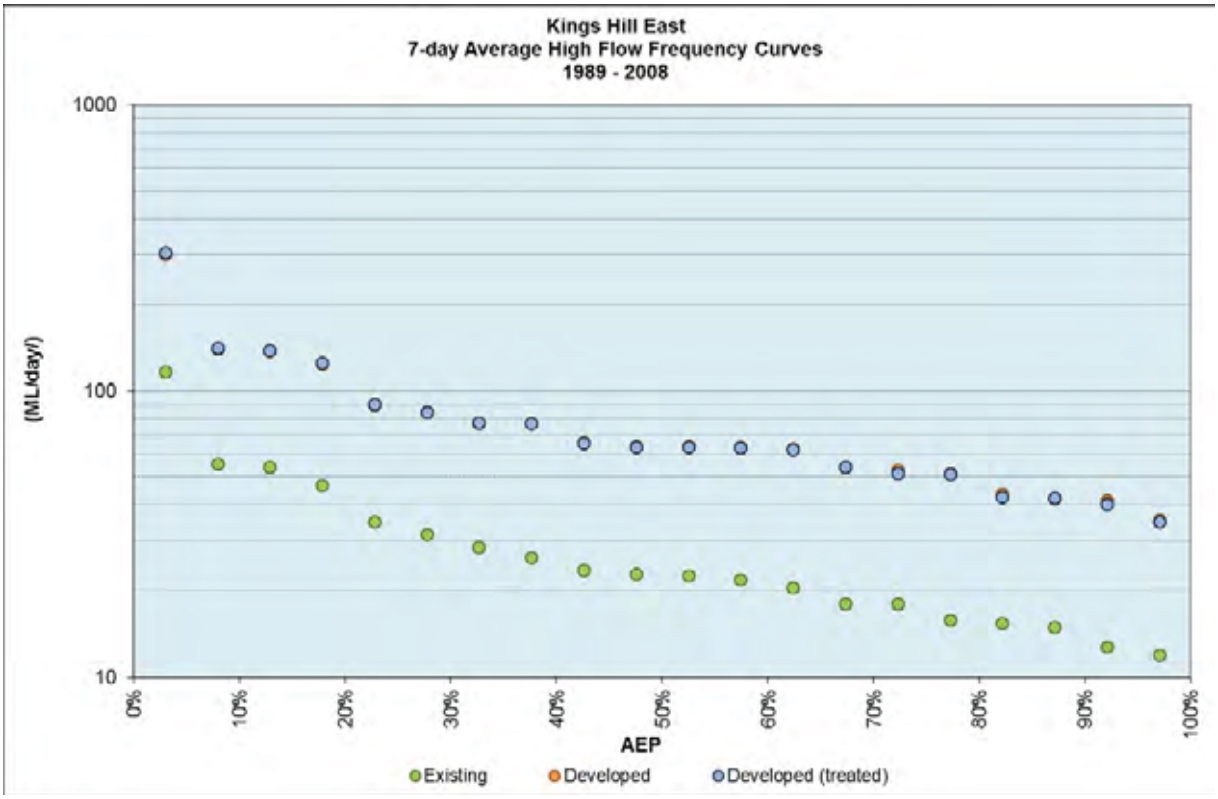

Figure 5-10 *Kings Hill East – 7-day average high flow frequency curves*

Grahamstown Dam spillway discharges

HWC provided Alluvium with estimates of Grahamstown Dam spillway discharges for the period 1974 to 2019. A summary of the recorded spillway discharges is provided in Table 5-4. The data indicates that between 1974 and 1989 no spillway discharges were observed from Grahamstown Dam to Irrawang Swamp. Between 1990 and 2005 (prior to the new spillway being constructed), spillway discharges were recorded in four separate years (1990, 1998, 1999 and 2001). Between 2006 and 2018 (after the new spillway construction), spillway discharges were recorded in five separate years (2008, 2011, 2013, 2015 and 2016).

Table 5-4 *Grahamstown Dam spillway flows (source: Hunter Water Corporation, 2019)*

Years with releases	Total annual discharge (ML/yr)	No. discharge days	Discharge months (No. Days)
1990	18850	13	Aug (13)
1998	9750	15	Aug (7), Nov (8)
1999	24050	37	Apr (6), Jun (12), Jul (17), Aug (2)
2001	10150	7	May (7)
Mean 1990 to 2005	**3925**	**5**	
Mean in overflow years	**15700**	**18**	
2008	9355	25	Apr (8), Jun (12), Sep (5)
2011	4159	8	Jul (6), Oct (2)
2013	484	3	Mar (3)
2015	5539	8	Apr (4), May (4)
2016	15096	17	Jan (17)
Mean 2006 to 2018	**2664**	**5**	
Mean in overflow years	**6927**	**12**	

The average annual spillway flow since the Stage 2 augmentation was completed in 2005 is approximately 2,700 ML/yr, and spills have occurred in 40% of the years and on average for 5 days a year. The increase in average annual 7 day high flow discharge from Kings Hill East to Irrawang Swamp during a typical year (50% AEP) following development is estimated to be 280 ML (refer Figure 5-10).

An increase in flow volume of 280 ML over 7 days represents an average depth of approximately 65mm across the total area of the swamp (estimated to be 450 ha from the SEPP 2018 mapping). This increased flow as a proportion of the average annual spillway flow from Grahamstown Dam to Irrawang Swamp is approximately 10%. This increase in flow is considered a conservative estimate, as it assumes that high flows from Kings Hill East that current drain to Grahamstown Dam do not contribute to existing spillway flows. During high rainfall years (10% AEP), runoff volumes diverted from Kings Hill East would be higher, although it is considered likely that spillway flows during these wetter years would similarly be elevated resulting in the overall proportional increase being similar.

Most spills from Grahamstown Dam to Irrawang Swamp have occurred during the wetter April to August period. Increased high flow discharges from Kings Hill East are likely to coincide with this period when inflows from direct rainfall on the swamp and other local catchment inflows are also elevated resulting in wide-spread inundation across Irrawang Swamp.

The critical drying period for Irrawang Swamp is from September to March (refer to Figure 5-2). Approximately 25% of days where spillway discharges have occurred fall within this critical drying period. The records indicate that spillway discharges to Irrawang Swamp have occurred only once during summer over the entire 1974 to 2019 period. Based on the available data, it appears that spillway discharges are unlikely to have a significant impact on drying hydrology in Irrawang Swamp.

5.6 Kings Hill West flow regimes (Wetland 803)

A different approach to Kings Hill South and Kings Hill East flow regime analysis was adopted for the Kings Hill West development. The entire Kings Hill West catchment drains to Wetland 803 located adjacent to New Line Road. As discussed in Section 3.2, the hydrology of Wetland 803 is currently influenced by catchment inflows from the Kings Hill West catchment and tidal inflows from the Williams River. Whilst catchment inflows are estimated to change following development, there is no proposal to modify the existing outlet/spill level from the wetland to the Williams River that would change the periods where tidal interactions between the river and wetland could occur. The following analysis is based upon changes to catchment inflows only. Discussion is provided in Section 6.4 on how mixing with tidal flows may change with modified catchment inflows.

MUSIC models of the entire Wetland 803 catchment including future developed areas and undeveloped areas were prepared by Northrop Consulting Engineers (NCE) and provided to Alluvium. The MUSIC models included existing, developed and developed (with treatment) scenarios. In addition to including the sub-catchment areas draining to Wetland 803, the models included allowance for direct rainfall within the extents of the wetland. The surface area of this wetland represents approximately 15% of the total catchment area.

NCE also provided estimates of stage / storage within Wetland 803 based on available LiDAR data. The LiDAR data were reviewed closely and assessed to be providing inaccurate wetland bathymetry levels below approximately 0.65m AHD. A level of 0.65m AHD corresponds with the spill level for the wetland adjacent to New Line Road. The LiDAR survey was completed during winter and it is suspected that elevated water levels in the wetland at that stage prevented the gathering of accurate bathymetry levels across inundated areas. Additional survey cross sections were gathered by a surveyor on site to supplement the LiDAR data. The additional survey data were compared with inundation extents shown in historical aerial imagery (refer Figure 5-11) to assist with estimating storage volumes at various stages below the wetland spill level.

Survey detail were also gathered by de Witt Consulting from the wetland overflow location and New Line Road reserve along an existing drainage channel. Culvert dimensions and inverts were confirmed in addition to cross sections of bed and bank levels along the drainage channel leading to the culvert. Surveyed cross sections were also taken of a narrow shallow trapezoidal channel within the wetland leading to the wetland outlet. The above survey data was utilised to develop a one-dimensional hydraulic model of the wetland outlet to assist with developing a stage / discharge relationship for the wetland.

The MUSIC flow estimates and derived stage / storage and stage / discharge relationships were applied to develop a temporal water balance model for Wetland 803. The model outputs were utilised as the basis for the flow regime analysis for this wetland.

Figure 5-11 *Historical aerial images of Wetland 803 showing varying wetting extents*

The results of the temporal water balance modelling over the 1989 to 2008 modelling period are shown in Figure 5-12 and Figure 5-13. Figure 5-12 provides estimates of the proportion of time in the modelling period (during the September to March drying period) that particular water levels (m AHD) would be exceeded.

The results indicate that for around 50% of the time, water levels in the wetland would be elevated and similar for existing and developed conditions. This period would coincide with the early spring period where initial water levels would be high in the wetland from winter rainfall and evapotranspiration is lower.

In the 50% to 95% range shown in Figure 5-12, there is an apparent divergence in water levels between the modelled existing and developed conditions, with modelled water levels being up to 50mm higher following development. The reason for this divergence is associated with more regular pulses of stormwater during small rainfall events that would flow into the wetland from roof and road surfaces during warmer periods from

future development. Under existing conditions during warmer months, a high proportion of the smaller rainfall events would be adsorbed by the soil and evaporate with minimal runoff occurring. The developed condition runoff has the effect of providing regular top ups to the water levels in the wetland.

Above the 95% range shown in Figure 5-12, existing and developed condition water levels would be similar as this range would represent a period closer to the end of summer where runoff from development areas would be low and evapotranspiration rates high.

The developed (with treatment) results shown in Figure 5-12 indicate that the proposed WSUD strategy would reduce impacts on water levels. This reduction is achieved through the application of rainwater tanks that will be effective at harvesting a high proportion of roof runoff during the critical drying period. In addition, the proposed bioretention measures would also absorb a high proportion of additional runoff during the drier periods. The treatment strategy also incorporates a proposal to divert over 5% of the Kings Hill West catchment (modelled developed sub-catchment C02 refer NCE, 2019) around the wetland.

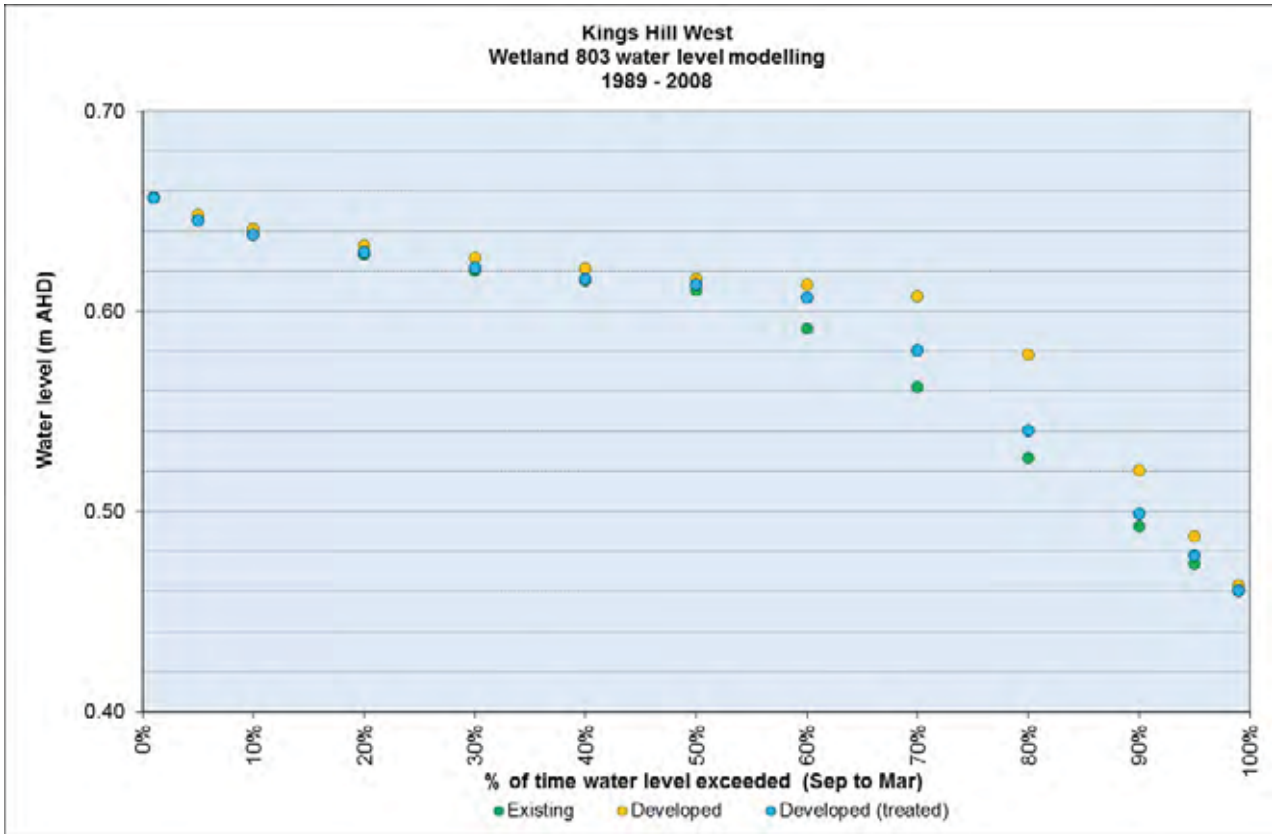

Figure 5-12 *Kings Hill West – Wetland 803 water level modelling results*

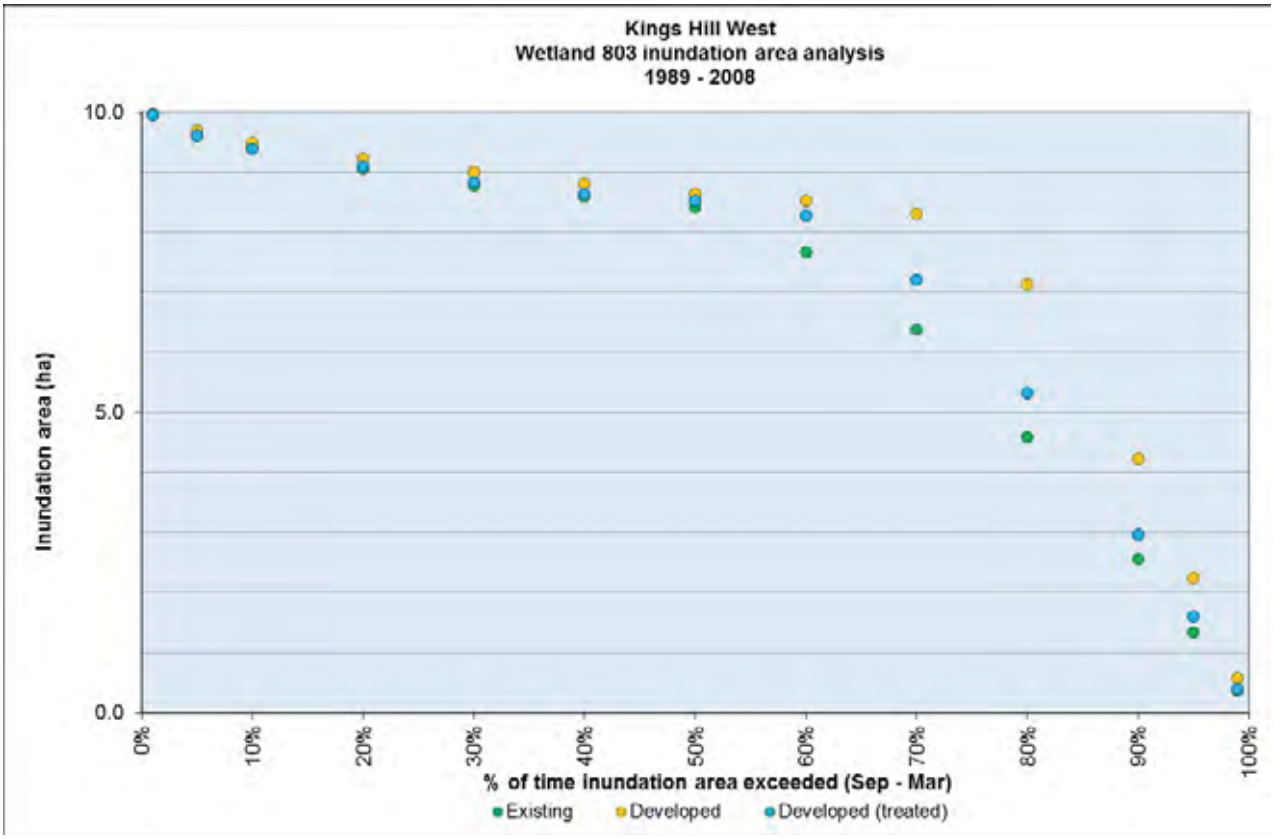

Figure 5-13 *Kings Hill West – Wetland 803 inundation modelling results*

6 Development impacts on wetland hydrology and ecology

6.1 Overview

Section 5 outlines the estimated impacts of future development in Kings Hill on catchment hydrology. This section of the report focuses on the impacts of the development modified catchment hydrology on the wetland hydrology and ecology.

The vegetation communities within Irrawang Swamp and Wetland 803 occupy the sites in a dynamic manner evolving in their extent in response to management practices. The hydrological regimes shown in Table 4-3 detail the inundation depths and drying periods required for the persistence of the different vegetation communities.

The critical hydrological items for the vegetation in the swamp is the presence of waterlogged soils, seasonal inundation and seasonal drying periods for all the communities except for the Perennial Swamp Meadow.

The key concern is the potential change in inundation extents across Irrawang Swamp associated with increased low flows following development.

Wet season flows

It is estimated that the runoff volumes from Kings Hill South and Kings Hill West during high flow periods will not change significantly from existing conditions as these generally occur during periods where soils would be saturated or close to saturation for extended periods. In these conditions pervious areas will generate similar runoff volumes as equivalent impervious areas.

Diversion of the Kings Hill East catchment to Irrawang Swamp is estimated to increase typical high flows (50% AEP) by 280 ML over 7 days. This represents an average water depth of approximately 65mm across the entire area of the swamp (estimated to be 450 ha from the SEPP 2018 mapping). This increased flow as a proportion of the average annual spillway flow from Grahamstown Dam to Irrawang Swamp is approximately 10%.

Increased high flow discharges from Kings Hill East are likely to coincide with periods where direct rainfall on the swamp, other local catchment inflows and dam spillway flows are also elevated resulting in wide-spread inundation across Irrawang Swamp. The increase in high flows will predominately coincide with the wet season flows when the wetland vegetation is seasonally inundated or growing on saturated soils.

The estimated increase in water depth of 65mm over the site for the 7-day high flow duration event is considered insignificant and is only temporary (<5 days). Infrequent wet season inundation events are not a serious concern ecologically as their impact is temporary and doesn't change the long-term seasonal wetting and drying patterns required by the vegetation communities.

Increased high flows are not considered a significant threat to the vegetation within the wetland.

6.2 Kings Hill South

Available LiDAR data and observed inundation extents interpreted from historical aerial imagery were reviewed to predict where additional inflows would drain to and be stored within the wetland during the critical drying period. Considering the available data, three zones were mapped indicating areas of the wetland that would progressively be wetted by inflows from Kings Hill South during dry periods. These three zones are mapped on Figure 6-1 with the three key locations where stormwater runoff from the future development in Kings Hill South would discharge into the wetland along existing gullies**Error! Reference source not found.**. Zone 1 covers a total area of approximately 5 ha, Zone 2 approximately 15 ha and Zone 3 approximately 35 ha.

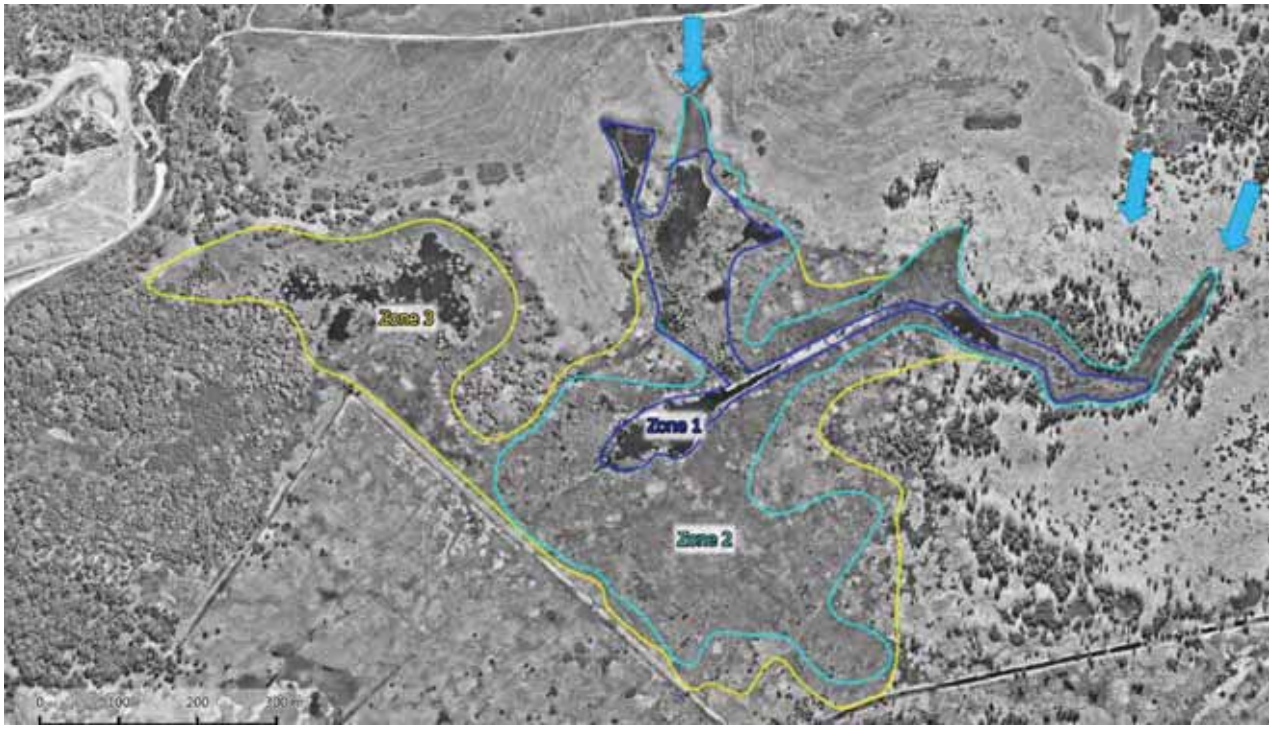

Figure 6-1 *Estimated critical drying period wetting zones in Irrawang Swamp receiving Kings Hill South inflows*

Dry season hydrology impacts

Low flows from Kings Hill South drain along the existing gullies that discharge into the northern extents of Irrawang Swamp. Concentrated flow along these natural gullies naturally spreads out into the wetland where the lower hill slopes meet the wetland floodplain areas. Natural drainage of this area was restricted after 1954 when a channel and elevated bund was constructed in a north-west to south-east alignment across the wetland to enable controlled irrigation of pasture areas south-west of the bund. The channel is connected to Pennington drain enabling irrigation from and drainage to Pennington Drain. It appears that an opening was cut through the bund to enable water to flow from the north-east for distribution along channels for irrigation of the pasture areas. Recent observation of this cut by Alluvium indicates that following cessation of irrigated pasture activities, the cut has partially infilled with sediment and dense growth of *Typha orientalis* (Cumbungi) has established. This has reduced the drainage connectivity between wetland areas on either side of the bund.

Review of historical aerial imagery covering the northern extents of Irrawang Swamp highlighted areas that would be more regularly inundated by stormwater runoff from future development in Kings Hill South. The observed inundation patterns indicate that surface runoff would initially fill areas aligned with the central part of the wetland mapped as Zone 1 on Figure 6-1. It is estimated that the majority of runoff during the critical drying period would be retained within Zone 1.

As inflows from the King Hill South sub-catchments increase, inundation is estimated to increase laterally from Zone 1 into Zone 2 (refer Figure 6-1). Review of historical aerial imagery and LiDAR data indicates that a spur of higher ground extending out into the wetland separates Zone 2 from the Melaleuca Swamp. The Melaleuca Swamp receives direct inflows from a local catchment adjacent to the existing Suez Waste Recycling and Recovery facility. This local catchment does not include any proposed future development in the Kings Hill South.

As inflows from the King Hill South sub-catchments increase further, inundation would increase laterally from Zone 2 into Zone 3 (refer Figure 6-1). At this stage, it is estimated that inflows to the wetland from Kings Hill South would increase water levels in the wetland sufficiently to interact with the Melaleuca Swamp and Pennington Drain.

Table 6-1 *Irrawang Swamp conditions (October 2019)*

Spur separating the Melaleuca Swamp from other wetland areas	Seasonal Swamp Meadow infested by Xanthium occidentale (Noogoora Burr).
Swamp Oak Forest showing minimal inundation.	
Central channel/bund with Perennial Swamp Meadow on the SW side.	Central drain from the channel/bund leading to the frequently inundated zone in the northern section of the swamp.
Perennial Swamp Meadow with Bolboschoenus fluvilatus and Typha orientalis	Seasonal Swamp Meadow transitioning to Transient Swamp Meadow

Frequently inundated zone (Zone 1) that receives flow from Kings Hill South.

View into Irrawang Swamp from Kings Hill South boundary looking towards Zone 1.

The Kings Hill South 30 and 60 day average low flow frequency curves presented in Figure 5-7 and Figure 5-8 provide estimates of increased flow volumes draining to Irrawang Swamp following development. The estimated increases in flow volumes formed the basis for evaluating changes to inundation extents in areas of the wetland receiving these inflows.

Table 6-2 summarises the estimated increase in average water depths across the potential wetting zones. For example, in a typical 50% AEP year the 60 day inflow volume to Irrawang Swamp from the Kings Hill South development area is estimated to increase by 3.6 ML. If this additional volume is retained within Zone 1, this will result in the average water depth over this area increasing by 1.2 mm/day during the 60 day period.

Table 6-2 *Estimated average increase in wetland water depth during low flow periods from Kings Hill South*

Frequency	Period (days)	Increase in flow volume (ML)	Estimated increase in average water depths (mm/day)		
			Zone 1 (5 ha)	Zone 2 (20 ha)	Zone 3 (35 ha)
10% AEP	30	1.8	1.2	0.3	0.2
(wet year)	60	12.6	4.2	1.1	0.6
50% AEP	30	0.6	0.4	0.1	0.1
(typical year)	60	3.6	1.2	0.3	0.2
90% AEP	30	0.0	0.0	0.0	0.0
(dry year)	60	1.2	0.4	0.1	0.1

The estimated increases in water depth conservatively assumes that none of the additional flow volume infiltrates, evaporates, transpires or drains from each zone. The results indicate that for the flow frequency and periods evaluated, the average increase in water depth over the zones considered is below the typical average potential evapotranspiration rate of 5mm/day over the critical drying period. In most of the scenarios considered, the estimated increase in average water depth is less than 1mm/day and this water is likely to readily evaporate during these hot and dry periods.

The increase in average water depths outlined in Table 6-2 are approximate only as they are based on a number of simplifying assumptions. The estimated water depths assume that low flows spread out evenly across each of the mapped zones. This is unlikely to occur as subtle variations in terrain across the northern extents of the swamp will result in inundation depths varying. The water depths indicated are based on daily average inflows, and temporally are likely to vary across the relevant period with inflows during some days being higher, and others lower.

It is envisaged that any noticeable change in wetting of wetland areas from development in King Hill South during dry periods will be observed in the areas immediately downslope of the three stormwater outlets into the wetland. It is these locations that will be exposed to more regular stormwater discharges during the critical drying period. It is expected that the increased stormwater volumes during the critical drying period would primarily be intercepted in the existing constructed dams and shallow ponded areas within Zone 1. It is estimated that these dams and shallow ponded areas may experience a localised small increase in water depth, inundation extents and inundation period following development. Whilst additional Zone 2 and Zone 3 areas have been mapped on , it is considered unlikely any significant increased inundation of these zones would occur during the critical drying period following development.

Dry season vegetation impacts
It is expected that low flows from Kings Hill South would interact mostly with the existing swamp meadow vegetation communities located north of the Pennington Drain. It is estimated that increased low flows from Kings Hill South would tend to spread out across northern parts of the swamp and gravitate towards the existing large area of Perennial Swamp Meadow in this area.

A vegetation response to such inflows is already observed with an area of Perennial Swamp Meadow (*Typha* orientalis) below the existing dam on an existing gully from Kings Hill South. The lower areas and depressions in Zone 1 will continue to refill regularly supporting the growth of permanent water tolerant species such as *Typha orientalis in water 300-500mm depth*. Areas of open water in deep holes (>1.5m deep) will continue to be present.

The impact of the flows from Kings Hill South will be to increase the inundation depth in the northern sections of the swamp (Seasonal Swamp Meadow) by less than 10mm during winter and spring. This will not be an equal depth change with the micro-topography of the site that collecting flows into deeper areas resulting in a mosaic of vegetation response.

The increase in inundation depth is within the ecological depth tolerance of the vegetation. Seasonal drying in the Seasonal and Transient Swamp Meadow zones will still occur in most years, although the duration of drying may reduce. The impact of this may be localised changes in extent of the Seasonal Swamp Meadow with potential expansion into the Transient Swamp Meadow. Perennial Swamp Meadow is unlikely to expand into the Seasonal Swamp Meadow as seasonal drying will still occur reducing the spread of *Typha orientalis.*

The area of Paperbark Woodland in the north-west of the swamp may see increased inundation duration compared to the recent hydrology but not a significant increase in depth. If there was a change in permanent inundation of the *Melaleuca* species of >200mm there would be a negative impact. This impact would predominately be on the ability of the *Melaleuca* species to regenerate from seed. Inundation of >200mm over new seedlings for >3months will kill the new germinates reducing the capability of the woodland to regenerate. However, the analysis shows that the inundation depth increase is less than 50mm and drying periods are expected at least 1 in 3 years. This indicates that this vegetation will not be significantly impacted by increased flows from Kings Hill South.

Changes in water retention within Irrawang Swamp are expected to occur with reduced maintenance of the old agricultural drains by Hunter Water to align with actions in the management plan for the swamp. The reduction in the drainage efficiency of the old agricultural drains will see water retained in the areas south of the east-west channel/bund. The vegetation in these areas will adjust over time with consolidation of the perennial marsh in the central agricultural area and potential increase in Swamp Oak in the southern areas. The areas south of the east-west channel/bund are disconnected from the areas impacted by flows from Kings Hill South and the primary driver of their hydrology is the performance of the internal drainage south of the east-west channel/bund.

6.3 Kings Hill East

Dry season hydrology impacts
It is expected that additional low flow discharges would largely be conveyed within the Pennington Drain and if overflows from this drain occur during the critical drying period (September to March) these low flows would

largely be contained in areas on both sides of drain where vegetation currently tolerant of extended inundation during low flow periods is located. As an example, considering the low flow curves in Figure 5-6, for a typical 50% AEP low flow, the increase in average daily low flow discharged to Irrawang Swamp is estimated to be less than 0.5 ML/day (i.e. average flow of 5 litres/s). It is envisaged that this additional flow would readily be conveyed along Pennington Drain without spilling into the adjacent wetland areas prior to discharge through the open flood gates.

Dry season vegetation impacts
The dry season flows from Kings Hill East will mostly be contained in the Pennington drain or spill to the Perennial Swamp Meadow areas. Both outcomes will not result in a negative ecological change to the vegetation.

6.4 Kings Hill West

Dry season hydrology impacts
The water balance modelling results for Wetland 803 outlined in Section 5.6 indicate that the WSUD strategy and partial catchment diversion proposed by NCE would result in water levels in the wetland increasing by less than 50mm across the critical drying period. The modelling results also indicate that wetting extents across the wetland would be similar during this period but may increase over existing conditions by up to 15% during short periods (days) during the drying period in response to small rainfall events in the Kings Hill West catchment.

The results in Figure 5-12 and Figure 5-13 show the estimated relative changes to water levels and inundation in Wetland 803 considering inflows, evapotranspiration and outlet flows associated with catchment runoff. The water levels in the wetland will also be influenced by tidal inflows that (excluding future sea level rise) are expected to be similar in magnitude to existing conditions. The main impact is estimated to be a small reduction in salinity in the wetland during drying periods due to the slight increase in catchment inflows. However, with predicted sea level rise the increased freshwater runoff from the catchment during drying periods may offset the increased saline inflows during the same period.

Dry season vegetation impacts
The vegetation within the wetland is currently adapted to the existing hydrological regime. The treated development flows are quite similar to the existing conditions with a slight (<50mm) increase in depth during the driest times and possible lowering of salinity in high runoff periods. The extent of the wetland surface area inundation will potentially increase for a period over the summer which may support the perimeter vegetation, enabling the more establishment of rushes and sedges.

Submerged plants within the wetland will be able to tolerate an increase in depth through summer and are tolerant of periodic drying if that occurs. Minor changes in the salinity profile can be tolerated due to the presence of species with a range of salinity tolerance.

Maintenance of periodic drawdown will advantage the site as this can stimulate germination of the *Casuarina* and emergent macrophytes in the damp mud. Increased salinity in the deeper sections of the wetland as the water recedes will control the incursion of *Typha* sp into these areas.

Overall the changes indicated for the treated development flows will support the existing vegetation with potential to increase the density and extent of marginal emergent rushes and sedges.

Figure 6-2 *Typical Casuarina glauca 'pedestal' observed in Wetland 803*

7 Summary and conclusions

Irrawang Swamp and Wetland 803 contain a number of vegetation species that are susceptible to impacts from altered hydrological regimes. McManus et al (2007) outlines drying and flooding hydrology management targets for a range of wetland categories represented in Irrawang Swamp include Shallow Marsh, Deep Marsh and Forest Swamp - Ephemeral. These key vegetation communities will be most susceptible to changes in the drying hydrology over the critical September to March period.

Flow regime analysis was completed focusing on drying hydrology in accordance with McManus et al (2007). Inflows to Irrawang Swamp were analysed to derive dry spells curves (low flow spells) and low flow duration frequency curves for 30 and 60-day reference durations. Additional analysis of 7-day duration high flows was also completed to evaluate the impact of diverting runoff from Kings Hill East to Irrawang Swamp. The completed analysis covers the key wetland vegetation communities currently observed in the swamp.

The dominant risks to the vegetation in Irrawang Swamp and Wetland 803 from hydrological changes include:

- increases in periods of increased inundation depth; and
- reductions in seasonal drying patterns

If these are realised, retention of diversity in the Seasonal Swamp Meadow vegetation in Irrawang Swamp would be compromised and the ability for the wood plants to regenerate would be reduced. The hydrological analysis indicates that these risks are unlikely to occur for a range of reasons that are summarised below.

Whilst the total runoff volume from Kings Hill East will increase, a high proportion of the increased runoff volume is expected to flow efficiently in a relatively linear manner along the proposed diversion drain through the original spillway channel to the Pennington Drain channel and discharge through the existing flood gates to the Williams River. During critical drying periods, low flows from Kings Hill East would be significantly lower than the Pennington Drain capacity. It is expected that even with consideration of infilling of the channel over time, increased low flows from Kings Hill East will continue to drain in a relatively linear manner through Irrawang Swamp to the flood gates. It is expected that these diverted low flows would not impact on the northern Seasonal Swamp Meadow and Melaleuca Woodlands.

During typical annual high flow periods, it is estimated that high flows from Kings Hill East would spill outside the Pennington Drain banks into the adjacent vegetated areas. Considering a representative 7-day high flow period, the increased flow from Kings Hill East represents an estimated increase in water depth of 65 mm over Irrawang Swamp. Although high flows would increase, the increase is estimated to be a maximum of 10% of the average annual spillway flow from Grahamstown Dam. It is expected that many of the high flow periods would coincide with periods where inflows from direct rainfall on the swamp, other local catchment inflows and spillway flows would also be elevated resulting in wide-spread inundation across Irrawang Swamp. These high flow events typically dissipate rapidly and would not cause long term ecological damage.

Increased runoff volumes from King Hill South are estimated to be much lower than those from Kings Hill East. Increased runoff from Kings Hill South will disperse more readily through the wetland vegetation. Based on a review of available LiDAR data and historical imagery, it is estimated that the increase in water depth during the critical drying period will largely be contained within a mapped 5 ha area (Zone 1) aligned with currently regularly wetted areas in the northern part of the swamp. These additional flows will support the existing areas of open water and stands of *Typha orientalis.* Localised increases in water depth are likely to occur due to subtle variations in the terrain leading to support of localised pockets of perennial swamp meadow. Some localised impacts on vegetation in Zone 1 are expected along the gullies leading into Irrawang Swamp from Kings Hill South as these areas will be most exposed to more frequent pulses of stormwater.

Increased annual high flow volumes from King Hill South are estimated to be minor and would have an insignificant impact on increasing water levels in Irrawang Swamp during high flow periods.

There will continue to be seasonal dry periods in the Swamp Oak and Melaleuca Woodlands and Seasonal Swamp Meadow areas and estimated changes in inundation depths are within the ecological tolerance range of the vegetation communities.

The Swamp Oak Woodland in Coastal Wetland 803 in Kings Hill West reduced in extent and density by approximately 30% between 1954 and 2019. It is clear that the condition of this wetland has been impacted due to increased water retention resulting from construction of a bund across its outlet and cattle grazing. Controlling additional runoff to this wetland alone is unlikely to improve conditions for the remnant wetland vegetation. To improve conditions for this wetland, ensuring seasonal flow patterns and lowering of the existing outlet weir would be crucial for controlling seasonal water levels to reflect more natural levels. This would enable regeneration and healthy growth of the Casuarina glauca in the wetland that is more representative of natural conditions. Without removal of the cattle and lowering of the current water levels restoring the wetland to a more natural ecological condition is unlikely to be feasible.

It is envisaged that increased runoff volumes could potentially create opportunities that support the management objectives for Irrawang Swamp including:

- Increased flows support the ongoing management actions in Irrawang Swamp which aim to reduce the drainage efficiency of the wetland and increase retention of water in the landscape to assist the wetland to transition back to a more natural state.
- Increased runoff volumes could potentially be diverted from urban lakes and other stormwater storages in the Kings Hill development to irrigate additional habitat and biobanking areas on the fringes of Irrawang Swamp. Harvested stormwater during summer would assist with irrigating young plants and further reduce low flows closer to existing conditions.
- Increase availability of water within the wetland would provide opportunities for increased resilience during extended period of drought and as predicted climate change impacts occur.
- The flows replicate the existing conditions to seasonally saturate the soils in the Swamp Oak and Paperbark Woodland areas of Irrawang Swamp, providing the soil conditions for these vegetation communities ensuring their survival.

Incorporation of effective water sensitive urban design (WSUD) into all stages of the Kings Hill development will be very important for managing water quantity and quality from development areas. Water quantity management strategies should focus on reducing stormwater runoff during frequent smaller rainfall events. Measures including disconnecting impervious areas, oversized BASIX rainwater tanks, infiltrating biofiltration systems, stormwater retention and harvesting systems would all have a role to play at appropriate locations within the development. Ensuring that the majority of future runoff passes through appropriately sized stormwater retention/detention measures will be important for protecting ephemeral watercourses from erosion.

Management of stormwater runoff quality will also be important for preventing coarse sediment, dissolved nutrients, fine sediment and other diffuse source stormwater pollutants from impacting on the wetland ecology. This includes effective measures (including regular inspections) in the subdivision construction, building construction and post development phases.

Proposed monitoring protocols for hydrology and vegetation with Irrawang Swamp and Wetland 803 prior to and following development are outlined in RPS (2019).

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Appendix F

Cumberland Ecology (2019)

KINGS HILL DEVELOPMENT

Ecological Survey Summary Report

For:

APP Corporation Pty Limited

August 2019

Final

PO Box 2474
Carlingford Court 2118

Report No. 16140RP2

The preparation of this report has been in accordance with the brief provided by the Client and has relied upon the data and results collected at or under the times and conditions specified in the report. All findings, conclusions or recommendations contained within the report are based only on the aforementioned circumstances. The report has been prepared for use by the Client and no responsibility for its use by other parties is accepted by Cumberland Ecology.

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001	15/02/2019	MF, KW	Draft
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Approved by: Dr David Robertson

Position: Director

Signed: David Robertson

Date: *21 August, 2019*

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Chapter 1

Introduction

1.1 Purpose

Cumberland Ecology has been commissioned by APP Corporation on behalf of Kings Hill Development Pty Ltd (KHD) to prepare an ecological survey summary report to document the work undertaken by Cumberland Ecology for the proposed residential development at 3221 Pacific Highway, Kings Hill NSW, located in the Port Stephens Council Local Government Area (LGA).

KHD is the majority land owner of the two Lots (Lot 41 DP1037411 and Lot 4821 DP 852073), which are known as the Kings Hill Urban Release Area (URA). KHD proposes a residential subdivision development within the two lots. Field surveys by Cumberland Ecology were undertaken the entirety of the two lots as well as a 120m buffer across the northern portion of Lot 3 DP 1098770 and Lot 113 DP 733181, hereafter referred to as the study area.

Cumberland Ecology carried out field surveys between March 2014 and August 2018 targeting numerous threatened species, populations and communities within the study area. This report documents the type of surveys undertaken, location, timing and personnel involved on each survey. Additionally, the findings of each survey are presented.

1.2 Background

1.2.1 Location

The study area includes two lots, (Lot 41 DP1037411 and Lot 4821 DP 852073) which are located at 3221 and 4821 Pacific Highway, Kings Hill (**Figure 1.1**) and an additional 120m buffer across the northern portion of Lot 3 DP 1098770 and Lot 113 DP 733181. The study area is approximately 547 ha in size.

The study area is located approximately 25km north of the Newcastle city centre, 6km north of Raymond Terrace, 28km west of Port Stephens and 21km east of Maitland. The study area is bounded by the Pacific Highway to the east and Newline Road to the west. The northern boundary of Lot 4821 is along Mile Road. Williams River, a tributary of the Hunter River, flows in a southerly direction within close proximity to the western boundary of Lot 41.

The Irrawang quarry and the Raymond Terrace Resource Recovery Centre are south-west of the study area and Hunter Water Corporation lands are to the south. Irrawang swamp is to the south, directly adjacent to the southern boundary of the study area. The Irrawang Spillway, which connects Grahamstown Lake to the east with the Hunter Water lands to the south and Williams River to the west, is located less than one kilometre south-east of the study area.

1.3 Relevant NSW Legislation

Legislation relevant to this report includes:

- The NSW Environmental Planning and Assessment Act 1979 (EP&A Act);
- The NSW Threatened Species Conservation Act 1995 (TSC Act); and
- The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

1.3.1 Environmental Planning and Assessment Act 1979

The EP&A Act is the principal planning legislation for NSW, providing a framework for the overall environmental planning and assessment of development proposals. Various legislation and instruments, such as the TSC Act, are integrated with the EP&A Act and have been reviewed separately.

1.3.2 Threatened Species Conservation Act 1995

The TSC Act is the key piece of legislation in NSW relating to the protection and management of biodiversity and threatened species. The TSC Act aims to protect and encourage the recovery of threatened species, populations and communities that are listed under the Act through threat abatement and species recovery programs.

Schedule 1 of the TSC Act lists threatened species, populations and ecological communities that are endangered or presumed extinct. Schedule 2 lists vulnerable species and Schedule 3 lists key threatening processes. The TSC Act is administered by OEH, which has issued guidelines for the assessment of threatened flora and fauna.

The recent NSW Land Management and Biodiversity Conservation reform includes legislative changes and a suite of new regulations, guidelines and tools. In November 2016 the NSW Parliament passed the following two Acts, which commenced on 25 August 2017:

- The Biodiversity Conservation Act 2016 (BC Act), which replaces the Threatened Species Conservation Act 1995 (TSC Act), the Nature Conservation Trust Act 2001 and parts of the National Parks and Wildlife Act 1974; and
- The Local Land Services Amendment Act 2016, which replaces the Native Vegetation Act 2003 and the Native Vegetation Regulation 2005.

Although survey work undertaken on this project was carried out under the TSC Act, references to threatened species, populations and communities are made under the current BC Act.

1.3.3 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is the Australian Government's key piece of environmental legislation which commenced 16 July 2000. The EPBC Act enables the Australian Government to join with the states and territories in providing a truly national scheme of environment and heritage protection and biodiversity conservation. The EPBC Act focuses Australian Government interests on the protection of matters of national environmental significance, with the states and territories having responsibility for matters of state and local significance.

Figure 1.1. Location of the study area

Chapter 2

Methodology

2.1 Flora Surveys

2.1.1 Vegetation Mapping

The study area was visited on a number of occasions between March 2014 and January 2018 by botanists, senior ecologists and ecologists. Previous broad scale vegetation mapping was ground-truthed by Cumberland Ecology in March 2014 and further refined over subsequent surveys. The survey tracks from March 2014 to January 2018 are shown in **Figure 2.1.** Vegetation mapping also included consideration of previous detailed surveys of the study area by other consultancies (EcoBiological, 2009{PEA Consulting, 2012 #5551; PEA Consulting, 2014)

Vegetation communities were classified into BVTs and PCTs and conducted as per BBAM 2014 and OEH VIS database (OEH, 2017).

2.1.2 Flora Survey

A total of eighty-two (82) flora plots and transects were conducted between 2014 and 2018, thirty-one (31) of which were done under the 2009 BioBanking Assessment Methodology (BBAM) (DECC, 2009) and fifty-one (51) using the 2014 BBAM (OEH, 2014). Plots and transects were carried out within each of the vegetation communities identified by Cumberland Ecology within the study area. Each vegetation community was sampled using the minimum number of plots required under 2014 BBAM, with additional plots undertaken to capture environmental variation or to assist in the classification of vegetation communities. Locations of all flora plot and transects are shown in **Figure 2.1**.

The following data was collected for each plot and transect:

- Ground-truthing of existing vegetation maps and establishment of boundaries of the extent of BVTs and PCTs within the study area;
- Native species richness recorded within each stratum of a 20 m x 20 m plot;
- Native over-storey projected foliage cover recorded at 10 points along a 50 m transect;
- Native mid-storey projected foliage cover recorded at 10 points along a 50 m transect;

- Native groundcover projected foliage cover recorded at 10 points along a 50 m transect for three life forms (shrubs, grasses and other);
- Weed species projective foliage cover expressed as a percentage of over-storey, mid-storey and ground cover along a 50 m transect;
- Number of trees with hollows where entrance width is over 5 cm and hollow is at least 1 m above ground within the 20 m x 50 m plot;
- The percentage of regenerating canopy species within the vegetation zone; and
- The total length in metres of fallen logs over 10 cm in diameter within the 20 m x 50 m plot.

Furthermore native plant species richness within a 20 m x 20 m plot and full floristic data was also collected to enable classification of each vegetation zone to the best-fit Biometric Vegetation Type (BVT)/Plant Community Type (PCT).

Due to the data collection taking place over many years, the collection methods for floristic data changed. Cover-abundance estimates for 2009 BBAM plots (plots 1 to 31) were according to the following adapted version of the Braun-blanquet scale:

1 is <5% - Rare (usually just 1 plant in the plot)

2 is <5% - uncommon (a couple of plants in the plot)

3 is <5% - Common

4 is <5% - Very Common

5 is 5-25% coverage

6 is 26-50% coverage

7 is 51-75% coverage

8 is 76-100% coverage

Cover estimates for 2014 BBAM plots (plots 32 to 76) were undertaken in accordance with the BAM, where cover is an estimated percentage recorded from 1–5% and then to the nearest 5%. Abundance estimates for these plots were a measure of the number of individuals of a species within the plot.

2.1.3 Targeted Threatened Flora Surveys

Targeted surveys for threatened flora species were conducted in January 2017, October 2017 and August 2018 via random meander transects. These surveys targeted the spring and summer flowering subject species.

The targeted orchid species include:

- *Corybas dowlingii* (Red Helmet Orchid);
- *Cymbidium canaliculatum* (Tiger Orchid);
- *Dendrobium melaleucaphilum* (Spider Orchid);
- *Diuris pedunculata* (Small Snake Orchid);
- *Diuris praecox* (Rough Doubletail);
- *Genoplesium baueri* (Bauer's Midge Orchid); and
- *Pterostylis chaetophora*.

Surveys were completed by two botanists who conducted a 30 minute random meander transect within a stratification unit (habitat type). The survey design considered both the Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities Working Draft (DEC (NSW), 2004) and the NSW Guide to Surveying Threatened Plants (NSW Government, 2016).

A total of 22 random meander searches were completed within the stratification units identified within the study area and recorded using a hand held GPS unit in January 2017. Stratification units were delineated based on the Keith formation (Keith, 2004) of each PCT within the study area and included woodland, forest and wetland areas. For each random meander transect, two observers walked approximately 5m apart for the duration of the 30 minute search and any threatened plants identified were recorded.

During the random meander survey in October 2017 and August 2018, threatened orchids as well as other threatened flora were targeted. One random meander transect was completed in October 2017 and two random meander transects were completed in August 2018. During these surveys two observers walked approximately 5m apart for the duration of the search and any threatened plants identified were recorded. Additionally, in the patch where threatened orchids were identified in 2018, a total of 20 random 2m x 1m plots were surveyed to estimate the species abundance.

The location of the random meander transects and random survey plots undertaken for threatened species are shown in **Figure 2.1**.

2.2 Fauna Survey

Cumberland Ecology conducted fauna surveys within the study area in January 2017. Fauna surveys were conducted, where appropriate, in accordance with the *Threatened Biodiversity Survey and Assessment* (DEC (NSW), 2004). The following surveys were conducted, methods of which are discussed in detail for each:

- Habitat assessment;
- Ground and arboreal mammal surveys;

- Infra-red cameras;
- Spot Assessment Technique (SAT) surveys for Koalas;
- Diurnal bird census;
- Microchiropteran bat surveys;
- Nocturnal surveys; and
- Amphibian surveys;
- Incidental fauna observations.

2.2.1 Habitat Assessment

Habitat assessments for threatened and native fauna included consideration of important indicators of habitat condition and complexity including the occurrence of microhabitats such as tree hollows, fallen logs, bushrock, caves and crevices, manmade structures, riparian areas, wetlands, soaks and water bodies. General observations were made of these indicators to inform the survey design.

2.2.2 Ground and Arboreal Mammal Surveys

Trap lines, each consisting of 10 arboreal Elliot B traps and 10 terrestrial hair tubes, were set up to detect arboreal and terrestrial fauna occurring within the study area. In order to minimise disturbance to fauna, hair tubes were used instead of Elliot A traps. A total of four trap lines were established for four nights from 9 to 13 January 2017. The hair tubes were left out for an additional 11 nights and were collected on 25 January 2017.

The arboreal and terrestrial traps were set approximately 10 m apart depending on available habitat. Arboreal traps were placed on platforms attached to habitat trees at a height of approximately two metres. Terrestrial hair tubes were placed in association with the arboreal traps, in areas with suitable habitat cover (under logs, shrubs and close to bush rock) and hammered into place with tent pegs. Both arboreal and terrestrial traps were baited with a mixture of peanut butter, honey and rolled oats. Arboreal traps were checked each morning, within two hours of sunrise. Any fauna captured were identified and then released, and the bait replaced.

An additional six hair tube only transects were set up over 15 nights in January 2017. Within five of these six transects, twenty hair tubes were set up at each transect, 10 arboreal and 10 terrestrial, spaced approximately 10 m apart. The fifth hair tube transect was set up with only 10 arboreal hair tubes (hair tube line H6), spaced approximately 10 m apart. Arboreal hair tubes were attached to suitable habitat trees at a height of approximately two metres. Terrestrial hair tubes were placed on the ground in areas providing some habitat cover, such as under logs, shrubs and rocks. All hair tubes were baited with a mixture of peanut butter, honey and rolled oats. Subsequent hair analysis was undertaken by Georgeanna Story of Scats About.

The locations of the trap lines and hair tube transects are shown on **Figure 2.2**.

2.2.3 Infra-red Cameras

Fourteen infra-red (IR) cameras were set up in areas near likely foraging areas over 15 nights in January 2017. One camera was placed at each of the trap lines, four cameras were arboreal and the remaining six IR cameras were terrestrial and placed across the study area in areas of suitable habitat. The four IR cameras placed at the trap lines and six terrestrial IR cameras were placed on trees near suitable habitat and angled towards the ground, where bait (consisting of a mixture of peanut butter, honey and rolled oats) was buried to attract fauna species. The arboreal IR cameras were placed in suitable habitat trees, at a height of approximately two metres, and at a distance of at least one metre from a bait station. The bait station consisted of a hamster feeder attached to the tree at a height of approximately two metres and filled with a mixture of honey and water.

The locations of IR cameras within the study area are shown in **Figure 2.2**.

2.2.4 Spot Assessment Technique Surveys

The SAT methodology was carried out as outlined in Phillips and Callaghan (2011). A 500 m sampling grid was established over the study area with a total of 21 SAT survey sites across the study area.

Field assessments carried out at each SAT survey site included:

- Selection and sampling of a central mature Koala feed tree (or another species if no feed trees are present);
- Subsequent sampling of up to 29 of the trees closest to this central tree, i.e. a total of 30 trees sampled at each SAT site;
- At each SAT survey site, a maximum of two person minutes was spent searching for faecal pellets (scats) within a one metre radius of the base of each selected tree. Searching ceased if a Koala faecal pellet was located before the two minutes expired;
- Searching for faecal pellets involved an initial inspection of the ground surface followed by a robust disturbance, i.e. raking of the leaf litter if necessary to search for faecal pellets; and
- The species of each tree searched was recorded along with presence/absence of Koala faecal pellets. Notes were made on whether the scats were fresh or old and a photograph and/or sample was taken.

Area searches for the Koala were also undertaken at each of the SAT survey site, irrespective of result of the faecal pellet searches. At each of the SAT survey sites, a five minute visual inspection of trees was conducted within a 25 m radius of the central tree. Any individual Koalas present during this inspection were recorded.

Where scats were encountered they were collected for analysis. All scat analysis was undertaken by Georgeanna Story of Scats About.

2.2.5 Diurnal Bird Census

A total of 21 diurnal bird census surveys were undertaken during the January 2017 survey period. Surveys were undertaken at each SAT survey site by two ecologists for 30 minutes. Any bird species that were observed or heard calling were recorded and listed in the total species list for the study area. Locations of each bird census point location are shown in **Figure 2.2**. The complete list of bird species recorded during surveys is detailed in **Appendix C**.

2.2.6 Microbat Survey

One ANABAT detector and two SM2BAT Songmeters were set up at six locations, between 9 and 13 January 2017. Each unit was left for two nights at one location, and then moved to a second location. A further two SM2BAT Songmeters were set up for two nights of survey between 23 and 25 January 2017, resulting in a total of eight locations. Units were placed in areas of suitable habitat. Each unit was recording for 12 hours, from dusk to dawn. All call identification was undertaken by Greg Ford of Balance Environmental.

Four harp traps were also set up at each mammal trap line in January 2017 in a suitable flyway. Each harp trap was left for two nights and checked each morning at dawn.

The locations of microbat surveys are shown in **Figure 2.2**.

2.2.7 Nocturnal Surveys

Spotlighting surveys were undertaken over six nights in January 2017, with two ecologists using a high powered torch to search for evidence of nocturnal mammals. A spotlighting transect was completed at each of the trap lines by two ecologists for 30 minutes each. Random meanders were also undertaken throughout the remainder of the study area. The location of spotlighting surveys is shown in **Figure 2.2**.

Call playback was also undertaken during spotlighting surveys and targeted the following species:

- Powerful Owl;
- Barking Owl;
- Masked Owl;
- Sooty Owl;
- Bush-stone Curlew;
- Squirrel Glider;

- Yellow-bellied Glider;
- Spotted-tailed Quoll; and
- Koala.

2.2.8 Amphibian Surveys

Spotlighting surveys were undertaken over four nights in January 2017 by two ecologists using a high powered torch to search for evidence of the Wallum Froglet and Green and Golden Bell Frog. Surveys were conducted for 30 minutes each at four wetland and dam locations, along the bank and in fringing vegetation. Call playback was undertaken for both species. All frog species observed and heard were recorded and are listed in **Appendix D**.

2.2.9 Incidental Observations

Any incidental fauna species that were observed, heard calling, or otherwise detected during the survey periods were recorded and listed in the total species list for the study area.

2.3 Survey Effort

2.3.1 Flora Survey Effort

The flora surveys conducted by Cumberland Ecology between March 2014 and August 2018 within the study area are summarised in **Table 2.1** and shown in **Figure 2.1**. The total survey effort for flora is 283 person-hours.

Table 2.1 Flora survey dates and effort

Survey Type	Date	Number of plots	Person hours
20x50 Floristic BioBanking Plot/Vegetation mapping	3-5 March 2014	31	48
20x50 Floristic BioBanking Plot/Vegetation mapping	11-14 October 2016	15	72
Vegetation mapping	20 October 2016	n/a	16
Random Meander/Targeted Threatened Flora Search	23-25 January 2017	n/a	21
20x50 Floristic BioBanking Plot/Vegetation mapping	29 May 2017	7	16
20x50 Floristic BioBanking Plot/Vegetation mapping	2 June 2017	8	16
20x50 Floristic BioBanking Plot/Vegetation mapping	8 June 2017	2	16
20x50 Floristic BioBanking Plot/Vegetation mapping	14 June 2017	5	16
20x50 Floristic BioBanking Plot/Vegetation mapping	16 June 2017	8	16
Target Orchid Search	27 October 2017	n/a	16
Target survey of subject site and Koala food trees	16 January 2018	n/a	10
20x50 Floristic BioBanking Plot/Vegetation mapping	23 January 2018	6	20

Table 2.1 Flora survey dates and effort

Survey Type	Date	Number of plots	Person hours
Target Orchid Survey	16-17 August 2018	20	32
Target Orchid Survey	23-24 August 2018	n/a	32

2.3.2 Fauna Survey Effort

Fauna survey methods and survey effort for the study area in January 2017 are summarised in **Table 2.2** and **Figure 2.2**.

Table 2.2 Fauna survey dates and effort

Survey Type	Date	Days/Nights	Units	Total
General habitat assessment	9/01/2017, 10/01/2017, 11/01/2017, 12/01/2017, 23/01/2017, 24/01/2017	40 hours	2 people	80 person hours
Elliot B traps	9/01/2017, 10/01/2017, 11/01/2017, 12/01/2017	4 nights	40 traps	160 trap nights
Hair tubes	9/01/2017 - 25/01/2017	15 nights	150 traps	2,250 trap nights
IR Cameras	9/01/2017 - 25/01/2017	15 nights	14 cameras	210 trap nights
SAT surveys	10/01/2017, 11/01/2017, 12/01/2017, 13/01/2017, 23/01/2017, 24/01/2017, 25/01/2017	30 mins/site	2 people/ 21 sites	1,260 person hours
Diurnal Bird Census	10/01/2017, 11/01/2017, 12/01/2017, 13/01/2017, 23/01/2017, 24/01/2017, 25/01/2017	30 mins/site	21 sites	630 person hours
Bat Echolocation Detection	9/01/2017, 10/01/2017, 11/01/2017, 12/01/2017, 23/01/2017, 24/01/2017	6 nights	8 sites	36 trap nights
Harp Trapping	9/01/2017, 10/01/2017, 11/01/2017, 12/01/2017	2 nights/site	4 sites	8 trap nights
Spotlighting and call playback	9/01/2017, 10/01/2017, 11/01/2017, 12/01/2017, 23/01/2017, 24/01/2017	6 nights	2 people/ 3 hours	36 person hours
Amphibian surveys	9/01/2017, 10/01/2017, 11/01/2017, 12/01/2017	4 nights	2 people/ 4 sites	16 person hours
Assessment of Koala Habitat within subject site	16/01/2018	5 hours	2 people	10 hours

Table 2.2 Fauna survey dates and effort

Survey Type	Date	Days/Nights	Units	Total
Incidental observations	throughout survey periods			

2.4 Weather Conditions

Weather data was obtained from Station 61078 - Williamtown RAAF base (Bureau of Meteorology, 2018). The lunar phases are obtained from Tidal Predictions by the Bureau of Meteorology. The phases are indicated in the number of days before (-) or after (+) a half-moon (HM), new moon (NM) or full moon (FM).

Weather conditions during flora and fauna surveys were generally appropriate for detection of a variety of flora and fauna. Surveys were undertaken over all four seasons. A summary of weather conditions in the wider locality of the study area during the flora and fauna survey periods is provided in **Table 2.3** below.

It is important to note that the Hunter area experienced the lowest soil moisture on record between September 2017 and January 2018. During the survey in October 2017 no threatened flora species were discovered.

Table 2.3 Weather Conditions During Surveys

Date	Temp. Min (°C)	Temp. Max (°C)	Rainfall (mm)	Max. Wind Gust Speed (km/h)	Max. Wind Gust Direction	Cloud Cover 9am (oktas)	Lunar Phase
3/03/2014	18.7	25.1	4.6	31	ESE	6	NM+2
4/03/2014	18.8	26.2	0	35	SE	4	NM+3
5/03/2014	13.4	30.5	0	54	SW	6	NM+4
11/10/2016	10.7	21.7	8.4	54	WSW		FM-6
12/10/2016	7.0	22.0	0	37	NW		FM-5
13/10/2016	11.8	16.0	8.8	48	SSW	8	FM-4
14/10/2016	9.9	18.9	1.4	28	ESE		FM-3
20/10/2016	14.1	22.4	0	52	ENE	4	FM+4
9/01/2017	16.9	34.6	0	35	ENE		FM-3
10/01/2017	19.6	35.5	0	31	SSE	5	FM-2
11/01/2017	23.2	42.0	0	61	WNW	6	FM-1
12/01/2017	23.2	27.9	0	50	SSW		FM

Table 2.3 Weather Conditions During Surveys

Date	Temp. Min (°C)	Temp. Max (°C)	Rainfall (mm)	Max. Wind Gust Speed (km/h)	Max. Wind Gust Direction	Cloud Cover 9am (oktas)	Lunar Phase
13/01/2017	23.2	37.9	0	37	ENE	1	FM+1
23/01/2017	20.1	34.7	0	0	-		NM-5
24/01/2017	21.0	41.4	0	63	WNW	5	NM-4
25/01/2017	19.4	23.4	16.0	44	S	8	NM-3
29/05/2017	9.4	18.8	0	46	W		NM+3
2/06/2017	6.7	18.3	0	43	SSW		HM+1
8/06/2017	10.5	17.6	49.2	39	SE	8	FM-1
14/06/2017	12.9	19.3	13.2	24	SW	7	HM-3
16/06/2017	11.3	18.8	0	26	SW	8	HM-1
27/10/2017	13.1	24.0	38.8	76	WNW	7	HM-1
16/01/2018	18.3	24.0	0	67	S	2	NM-1
23/01/2018	18.3	33.5	0	37	SSE	6	HM-2
16/08/2018	13.1	25.1	0	48	NW	8	HM-2
17/08/2018	5.8	19.1	0	41	WNW		HM-2
23/08/2018	5.6	18.2	0	35	S		FM-3
24/08/2018	4.3	21.1	0	39	ENE	3	FM-2

2.4.1 Survey Personnel

The details of survey personnel are provided in **Table 2.4** below.

Table 2.4 Survey Personnel

Survey Personnel	Role
Dr David Robertson	Project Director/Botanist
Michelle Frolich	Project Manager/GIS Specialist
Dr Gitanjali Katrak	Senior Ecologist/Reviewer
Ariane Weiss	BioBanking/GIS Specialist
Bryan Furchert	Botanist
Cecilia Phu	Botanist
Alex Pursche	Ecologist
Mikael Peck	Ecologist

Table 2.4 Survey Personnel

Survey Personnel	Role
Matt Freeman	Ecologist
Emily Cave	Ecologist
Eleanor Saxon	Ecologist

2.4.2 Survey Limitations

The flora and fauna of the study area have been subject to a series of surveys over several years. Consequently, the ecology of the study area and subject site, as well as the flora and fauna of the locality is well known.

i. Flora

The weather conditions at the time of the flora surveys were generally favourable for plant growth and production of features required for identification of most species. Shrubs, grasses, herbs and creepers were readily identifiable in most instances. The targeted orchid surveys however, were undertaken at the end of the acceptable survey period, which resulted in an orchid species not being able to be identified to species level. There is potential that this orchid is a threatened species listed under the BC Act.

The Hunter area experienced its lowest soil moisture on record between September 2017 and January 2018. It is, however, unlikely that survey results are impacted by these dry conditions, except for the targeted surveys conducted in October 2017.

It is expected that not all flora species present would have been recorded during surveys. Despite this, it is considered that sufficient information has been collected to assess issues including conservation significance of the flora, condition and viability of vegetation and likely impact on native vegetation.

ii. Fauna

Targeted fauna surveys were only undertaken within a single survey season; however the results of the fauna surveys were supplemented by data from previous studies. The combination of surveys conducted by Cumberland Ecology and previous studies provide a sufficient detail of the faunal activity of the study area. It is possible that not all fauna species were detected due to climatic conditions, low detectability, large home range of the species and/or low occurrence rates.

Multiple bat echolocation devices were used during surveys in January 2017, however one of these devices malfunctioned and as a result no data was recorded by this device. Although no calls were recorded, the remaining echolocation devices collected data across the study area. The data collected from these devices is considered to provide an adequate

amount of data in order to determine the species of microchiropteran bats likely to occur within the study area.

A full bird survey of migratory wetland species has not been conducted within the study area.

Figure 2.1. Flora survey locations within the study area

Figure 2.2. Fauna survey locations within the study area

Chapter 3

Results

3.1 Vegetation Communities

Whilst Cumberland Ecology undertook vegetation mapping within the study area, this mapping was subsequently refined and vegetation communities reclassified by RPS. Therefore vegetation community descriptions and mapping are not contained within this report.

3.2 Flora

3.2.1 General Species

The majority of the study area consists of woodland and forest associated species, comprising over 400 flora species. The overall abundance of native and exotic species varies across the study area; however, in general, native species predominate. Over 100 exotic species were recorded during the surveys. **Appendix A** provides the list of flora species recorded within the study area. It is to be noted that this flora species list comprises all species identified within the flora plots and target searches. It is not a list of all flora species within the study area.

The flora plot data is provided in **Appendix A** and the floristic plot data is in **Appendix B**.

3.2.2 Threatened Species

One threatened flora species was confirmed as occurring within the study area. *Maundia triglochinoides*, was recorded within the study area in January 2017. Several individuals were identified within a small patch within a highly disturbed dam to the north east of the large wetland in the west of the study area. This species has also previously been recorded within the study area during surveys by PEA (2012).

A second threatened flora species was assessed as potentially present within the study area. A total of 210 individual Corybas sp. were recorded within the 2x1m random plots in August 2018. Although this species was recorded post-flowering, diagnostic features suggested that it was Corybas dowlingii (Red Helmet Orchid). The abundance and distribution of the species was mapped, with all individuals occurring within a patch in the northern portion of Lot 41.

The location of *Maundia triglochinoides* and the *Corybas sp.* recorded within the study area are shown in **Figure 3.1**.

No other targeted threatened flora species were found during surveys.

3.3 Fauna

3.3.1 Fauna Habitat

Within the study area fauna habitat comprises three broad habitat types: Open Forest, Grassland and Water bodies. These habitat types are discussed below.

i. Open Forest

Over 85% of the study area is covered in native woody vegetation, dominated by different variations of Spotted Gum shrubby open forest. The canopy is dominated by Eucalypt species, with a sub-canopy of younger individuals of the same species. Due to historical logging, mature trees with large tree hollows are under-represented. Vegetation along the ephemeral drainage lines is generally denser including *Allocasuarina torulosa*, *Clerodendrum tomentosum*, and *Melaleuca nodosa* in lower-lying, wetter areas. Shrub layers vary from very few to dense thickets of *Lantana camara*, which is common in many areas. Current grazing prevents natural regrowth of many native species. The ground cover includes many native and exotic grasses, as well as forbs and climbers.

Most of the open forest habitat has been historically cleared and is used for grazing, especially in the lower lying areas. The forest is dominated by young trees is lacking in old growth, mature trees. The habitat for species requiring large tree hollows is therefore limited. Nevertheless, the open forest provides good foraging, roosting, resting and nesting habitat for a range of species, including threatened species. Most importantly, it provides habitat for Koalas, Brush-tailed Phascogales, large forest owls, arboreal mammals, as well as many other birds, reptiles, mammals.

ii. Grassland

Grasslands are present over 13% of the study area and are dominated by exotic grazing land. The majority of grassland areas are dominated by exotic species, such as *Cenchrus clandestinum* (Kikuyu), *Paspalum dilatatum*, *Cynodon dactylon* (Couch), and *Axonopus fissifolius*. The dominant native species include native grasses such as *Microlaena stipoides*, *Sporobolus creber* (Rat's Tail Grass), *Chloris truncata* (Windmill Grass), and *Dichelachne micrantha*.

Grassland, including scattered trees, primarily provide potential foraging habitat for macropods and birds of prey. They can also provide suitable foraging habitat for microchiropteran bats along the edge of the open forest. Due to historic and current land uses in the locality, large areas of exotic and native grassland are present on surrounding properties. Such areas have the potential to be utilised by a number of fauna species, including threatened species.

iii. Waterbodies

Waterbodies include a 15 ha wetland in the western extremity of the study area, several farm dams and ephemeral drainage lines. The wetland and some of the farm dams have fringing vegetation dominated by species such as *Typha orientalis* and tall sedges, such as *Schoenoplectus validus.* This fringing vegetation provides basking habitat for frogs and shelter for water birds. Banks are generally soft and muddy, which provide less sheltering sites compared to banks with rocks or snags. Free floating aquatic flora such as *Azolla* spp. and *Spirodela* spp. provide shade and hiding spots for aquatic species.

The wetland is fringed by a scattered canopy of *Casuarina glauca* (Swamp Oak) and *Melaleuca styphelioides* (Prickly-leaved Tea Tree). These species also occur as small islands when the wetland is fully flooded. The trees and islands provide a stepping stone habitat for predominantly arboreal species such as Koalas.

The farm dams are accessed by grazing stock and therefore have limited fringing vegetation, often dominated by exotic species such as the weeds *Alternanthera philoxeroides* (Alligator Weed) and *Eichhornia crassipes* (Water Hyacinth). They nevertheless provide potential habitat for aquatic and semi-aquatic fauna, including reptiles and amphibians, especially after periods of rain. During wet periods, the wetland provides habitat for migrating and local wetland birds. It also provides permanent habitat for many birds, mammals, reptiles, fish and amphibians, including threatened species. Koalas are also known to access preferred feed trees in wetlands.

3.3.2 General Species

A total of seventy-three (73) fauna species were recorded within the study area during the field surveys between 2014 and 2018, including forty-six (46) birds, six (6) frogs, eighteen (18) mammals and three (3) reptiles. Seven of these fauna species are non-native including cows, horses and goats.

A full list of fauna species can be found in **Appendix C**, including the survey method by which it was detected. This species list includes all species identified during surveys; however, it does not provide a comprehensive list of all species potentially using the study area. It is possible that fauna species were not detected due to climatic conditions, low detectability, large home range of the species and/or low occurrence rates.

3.3.3 Threatened Species

Nine threatened species were definitively recorded during surveys by Cumberland Ecology within the study area. They include the following:

- Koala (*Phascolarctos cinereus*) – three Koalas seen during spotlighting;
- Brush-tailed Phascogale (*Phascogale tapoatafa*) – two in Elliot traps and one on IR Camera;

- White-bellied Sea Eagle (*Haliaeetus leucogaster*) – seen flying near wetland and two nests found in study area;
- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*) – observed in social groups;
- Powerful Owl (*Ninox strenua*) - observed foraging;
- Grey-headed Flying Fox (*Pteropus poliocephalus*) – observed flying overhead and feeding in trees;
- Eastern Freetail-bat (*Mormopterus norfolkensis*) – Bat detector;
- Little Bentwing-bat (*Miniopterus australis*) – Bat detector;
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) – Bat detector;

Four additional threatened microchiropteran bat species may potentially occur within the study area. These species however are only considered as potentially occurring as many of the calls could not be reliably identified due to the similarities in call characteristics between a number of species that may occur in the region. The threatened microchiropteran bat species that are potentially occurring include:

- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) – Bat detector;
- Greater Broad-nosed Bat (*Scoteanax rueppellii*) – Bat detector;
- Southern Myotis (*Myotis macropus*) – Bat detector; and
- Eastern Cave Bat (*Vespadelus troughtoni*) – Bat detector.

The location of threatened fauna definitively recorded within the study area is shown in **Figure 3.2**. A full fauna species list is in **Appendix C.**

Figure 3.1. Locations of threatened flora recorded within the study area

Figure 3.2. Locations of threatened fauna species recorded within the study area

Chapter 4

Conclusion

Cumberland Ecology conducted numerous flora and fauna surveys across the study area between March 2014 and August 2018. Flora surveys included vegetation mapping, 2009 BBAM plots, 2014 BBAM plots, and targeted searches for threatened flora via random meander transects. Threatened fauna surveys undertaken included habitat assessments, IR camera surveys, diurnal bird surveys, ground and arboreal mammal surveys, SAT surveys for Koalas, microchiropteran bat surveys, nocturnal surveys and amphibian surveys. The results of surveys indicate a diversity of native species occupy the habitats within the study area.

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Appendix A

Flora Species List and Plot Data

Appendix A Flora Species List and Plot Data

Family	*	Scientific Name	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		33		34		35		36		37		38		39		40		41		42		43		44		45		46	
																																			C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
Tree																																																																
Casuarinaceae		*Casuarina glauca*	Swamp Oak		5	5							5	5																																				5	3														
Cunoniaceae		*Ceratopetalum apetalum*	Coachwood																	5																																												
Malvaceae		*Brachychiton populneus*	Kurrajong													5																																																
Myrtaceae		*Angophora costata*	Sydney Red Gum																					5	X				6										15	2																							
Myrtaceae		*Backhousia myrtifolia*	Grey Myrtle																	6	6																																											
Myrtaceae		*Corymbia gummifera*	Red Bloodwood																		5			X	1																																								
Myrtaceae		*Corymbia maculata*	Spotted Gum						6	5		5				5	5	6	6			6	5			6	5	5		5	5	5	5	5							10	1	17	2	15	2	15	9			10	3					7	2	10	3			10	2
Myrtaceae		*Eucalyptus acmenoides*	White Mahogany									5					5	5	5	5	5	5	5	5	5	5		6	5	5	X		1	5											10	3	25	7															5	1
Myrtaceae		*Eucalyptus canaliculata*	Grey Gum																																																													
Myrtaceae		*Eucalyptus crebra*	Narrow-leaved Ironbark												6																										10	1									15	2												
Myrtaceae		*Eucalyptus fibrosa*	Red Ironbark															5									5				2	5	5	5									3	1														7	2	7	2				
Myrtaceae		*Eucalyptus globoidea*	White Stringybark						5	5						5	3	5					1	5	5					5				5					15	2													7	1										
Myrtaceae		*Eucalyptus moluccana*	Grey Box																						1						1																																	
Myrtaceae		*Eucalyptus pilularis*	Blackbutt																						5																																							
Myrtaceae		*Eucalyptus propinqua*	Small-fruited Grey Gum						X	5		6						5							1	1	5																10	1	X	X																		
Myrtaceae		*Eucalyptus punctata*	Grey Gum																											5																X	X	5	2																
Myrtaceae		*Eucalyptus siderophloia*	Grey Ironbark							X		5				5		X			5	5	5			1		5																	5	1											6	2	3	1			5	1
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum						X	5	1					5	6					X	X					X			1	5	5	5																			15	13									5	1
Myrtaceae		*Melaleuca styphelioides*	Prickly-leaved Tea Tree		5									5					6	5																												5	3														
Myrtaceae		*Syncarpia glomulifera*	Turpentine																																									15	3																		
Rhamnaceae		*Alphitonia excelsa*	Red Ash																																															10	1												
Small Tree																																																																
Casuarinaceae		*Allocasuarina torulosa*	Forest Oak																										1			1															1	1																
Casuarinaceae		*Casuarina glauca*	Swamp Oak			6	6						6																																				1	1														
Cunoniaceae		*Ceratopetalum gummiferum*	Christmas Bush																		5																																											
Elaeocarpaceae		*Elaeocarpus obovatus*	Hard Quandong																	X																																												
Flacourtiaceae		*Scolopia braunii*	Flintwood																																																												
Lamiaceae		*Clerodendrum tomentosum*	Hairy Clerodendrum													1																																															
Malvaceae		*Brachychiton populneus*	Kurrajong																																																												
Malvaceae		*Hibiscus heterophyllus subsp. heterophyllus*	Native Rosella																6	5																																											
Moraceae		*Ficus coronata*	Sandpaper Fig																	5																																											
Myrtaceae		*Angophora costata*	Sydney Red Gum																						1																																							
Myrtaceae		*Backhousia myrtifolia*	Grey Myrtle																	5	6																							2	1																		
Myrtaceae		*Callistemon salignus*	Willow Bottlebrush																																																												
Myrtaceae		*Corymbia gummifera*	Red Bloodwood									5														5																																					
Myrtaceae		*Corymbia maculata*	Spotted Gum						5	5	X						5	5					5				5	5	3	4	5		1								25	8	5	3	1	1	5	4			2	1					3	1					2	1
Myrtaceae		*Eucalyptus acmenoides*	White Mahogany									5				1						5	5		5	5		5		5									3	1			20	10			3	2															4	1
Myrtaceae		*Eucalyptus canaliculata*	Grey Gum																																																												
Myrtaceae		*Eucalyptus crebra*	Narrow-leaved Ironbark												5																																			1	2												
Myrtaceae		*Eucalyptus fibrosa*	Red Ironbark																										1	1				3																						5	2	2	1				
Myrtaceae		*Eucalyptus globoidea*	White Stringybark							5						5	5	5						1										2																		5	2					1	1				
Myrtaceae		*Eucalyptus moluccana*	Grey Box																																						2	1																						
Myrtaceae		*Eucalyptus propinqua*	Small-fruited Grey Gum																1																																												
Myrtaceae		*Eucalyptus punctata*	Grey Gum								X																																																				
Myrtaceae		*Eucalyptus siderophloia*	Grey Ironbark						5	5							4					5	5																							1	1											5	3				
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum																																						3	1											5	3										
Myrtaceae		*Melaleuca nodosa*	Prickly-leaved Paperbark									5													5																																							
Myrtaceae		*Melaleuca styphelioides*	Prickly-leaved Tea Tree				6				6		X	5					5							5	1	5																2	2	5	3	4	2														2	1
Myrtaceae		*Syncarpia glomulifera*	Turpentine																																									3	3																		
Oleaceae	*	*Olea europaea subsp. cuspidata*	African Olive																																																												
Phyllanthaceae		*Glochidion ferdinandi*	Cheese Tree								6																																	2	1																	60	16
Pittosporaceae		*Hymenosporum flavum*	Native Frangipani																																																										5	3
Pittosporaceae		*Pittosporum undulatum*	Native Daphne																																															5	1												
Shrubs																																																																
Myrtaceae		*Eucalyptus moluccana*	Grey Box																																		<1	1			1	15																						
Myrtaceae		*Eucalyptus propinqua*	Small-fruited Grey Gum																																								4	6																				
Myrtaceae		*Eucalyptus punctata*	Grey Gum																																											1	4																
Myrtaceae		*Eucalyptus siderophloia*	Grey Ironbark																																																												
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum																																																X	X										
Myrtaceae		*Eucalyptus umbra*	Broad-leaved White Mahogany																																											<1	1																
Myrtaceae		*Leptospermum polygalifolium*	Tantoon																																								1	2																				
Myrtaceae		*Leptospermum polygalifolium subsp. cismontanum*	Tantoon																																																												
Myrtaceae		*Melaleuca nodosa*																							5						5																<1	1									40	50	15	20				
Myrtaceae		*Melaleuca styphelioides*	Prickly-leaved Tea Tree										2	1												5	6	5															<1	1	1	5																
Myrtaceae		*Rhodamnia rubescens*	Scrub Turpentine																		1																								1	20																		
Ochnaceae	*	*Ochna serrulata*	Mickey Mouse Plant									1																																																	<1	1
Oleaceae		*Jasminum volubile*	Stiff Jasmine																																																<1	1									1	5
Oleaceae		*Notelaea longifolia*	Large Mock-olive						3	4	3	4			X	5	3		3	4	5	4	5	3	1	4	2	3	3	3		1	1	2					<1	2			1	7	1	4	<1	5					1	3			1	5	<1	1			5	70
Oleaceae	*	*Olea europaea subsp. cuspidata*	African Olive						3							1	1																																		<1	1									<1	2
Phyllanthaceae		*Breynia oblongifolia*	Coffee Bush						3	3	X	X			1	3	3	X	4	3	3		3		2	2	2	3	2	3	2	2	2	2					<1	2	<1	1	<1	2	1	20	1	10			1	5	1	5			1	10						
Phyllanthaceae		*Glochidion ferdinandi*	Cheese Tree								5								5							2	1				2		1						<1	1			1	2																1	4			5	20
Phyllanthaceae		*Phyllanthus gunnii*	Scrubby Spurge																											X																																	
Phyllanthaceae		*Phyllanthus hirtellus*																																					<1	3			<1	5																				
Pittosporaceae		*Bursaria spinosa*	Blackthorn						1																					4				2											<1	2	5	50									5	20						
Pittosporaceae		*Hymenosporum flavum*	Native Frangipani																																																										1	3
Pittosporaceae		*Pittosporum multiflorum*	Orange Thorn								2					4			4	5	6	5	4			5		5																2	50																	25	100
Pittosporaceae		*Pittosporum revolutum*	Rough Fruit Pittosporum													1													2																																	
Pittosporaceae		*Pittosporum undulatum*	Sweet Pittosporum						2	4						5		3					1																						<1	1					<1	2	<1	1										
Proteaceae		*Persoonia linearis*	Narrow-leaved Geebung																										2	5	2			X										1	3																		
Rhamnaceae		*Alphitonia excelsa*	Red Ash							X						1	1																																		<1	2												
Rhamnaceae		*Pomaderris discolor*																																																												
Rosaceae	*	*Rosa rubiginosa*	Sweet Briar																																																												
Rutaceae		*Boronia polygalifolia*	Dwarf Boronia																																				<1	2																								
Rutaceae		*Zieria pilosa*	Pilose-leafed Zieria																											X																																	
Rutaceae		*Zieria smithii*																									1																																				
Santalaceae		*Exocarpos cupressiformis*	Cherry Ballart									X																		1																																	
Sapindaceae		*Cupaniopsis anacardioides*	Tuckeroo																																															1	1												
Sapindaceae		*Dodonaea triquetra*	Large-leaf Hop-bush																						3																		<1	1																				
Solanaceae		*Duboisia myoporoides*	Corkwood																	5	3																																										
Solanaceae	*	*Solanum mauritianum*	Wild Tobacco Bush																																																												
Solanaceae		*Solanum stelligerum*	Devil's Needles																																																												
Verbenaceae	*	*Lantana camara*	Lantana						6	6	5	3			5	7	6	5	5	5	5	5	5		3	6	1	6	3	5	1		2	3									<1	1	<1	2	2	10			15	20	7	20			1	3					5	10
Violaceae		*Melicytus dentatus*	Tree Violet																																									X	X																		
Herbs - Ferns and Allies																																																																
Adiantaceae		*Cheilanthes sieberi*						X	3	4		2			3		3						3		X		2		X	3	3	4	4	4									<1	5			<1	20			<1	50					0.5	500	<1	50				
Aspleniaceae	P	*Asplenium australasicum*	Bird's Nest Fern																																																										<1	1
Blechnaceae		*Blechnum indicum*	Swamp Water Fern			X																																																									
Blechnaceae		*Doodia aspera*	Prickly Rasp Fern																3	5	6																							40	4000																	<1	10
Dennstaedtiaceae		*Pteridium esculentum*	Bracken																					X	3				2										3	20																							
Gleicheniaceae	P	*Sticherus flabellatus*	Shiny Fan Fern																																																										<1	2
Myrtaceae		*Eucalyptus siderophloia*	Northern Grey Ironbark																																																<1	2										

Family	*	Scientific Name	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		33		34		35		36		37		38		39		40		41		42		43		44		45		46	
																																			C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
Pteridaceae		*Adiantum aethiopicum*	Common Maidenhair								3								X		4																								10	1000							1	200									2	100
Pteridaceae		*Adiantum hispidulum*	Rough Maidenhair Fern													2			X	2																																												
Pteridaceae		*Pellaea falcata*	Sickle Fern								3					3			3	3	5																																										1	50
Pteridaceae		*Pellaea paradoxa*																	2	2	4																																											
Herbs - Dicots																																																																
Acanthaceae		*Brunoniella australis*	Blue Trumpet						4	4	3					3	4	3	3			2	3	3	3	3	3		4	3	3	3	4	3					<1	5	<1	10			<1	10	<1	20			<1	20	<1	10			<1	100	<1	20				
Acanthaceae		*Brunoniella pumilio*	Dwarf Brunoniella																																								<1	2																				
Acanthaceae		*Pseuderanthemum variabile*	Pastel Flower																																										<1	4																		
Amaranthaceae		*Alternanthera denticulata*	Lesser Joyweed								2		2																																																			
Amaranthaceae	*	*Alternanthera philoxeroides*	Alligator Weed																																														4	50														
Amaranthaceae	*	*Gomphrena celosioides*	Gomphrena Weed					3																																																								
Apiaceae		*Centella asiatica*	Indian Pennywort		4			2			X		4																			2	2												<1	5					<1	10											<1	20
Apiaceae	*	*Cyclospermum leptophyllum*	Slender Celery																																<1	10	<1	20											<1	10											<1	10		
Apiaceae		*Daucus glochidiatus*	Native Carrot																																																<1	20	<1	20										
Araliaceae	*	*Ageratina adenophora*	Crofton Weed																																																													
Araliaceae		*Hydrocotyle laxiflora*	Stinking Pennywort																																																													
Araliaceae		*Hydrocotyle tripartita*	Pennywort																																																												<1	2
Asteraceae	*	*Aster subulatus*	Wild Aster		3	1	1						3	2																																																		
Asteraceae	*	*Bidens pilosa*	Cobbler's Pegs												1																																				<1	10												
Asteraceae		*Brachyscome microcarpa*	Forest Daisy																					2																																								
Asteraceae		*Calotis dentex*																																																														
Asteraceae		*Centipeda minima*	Spreading Sneezeweed																																																										<1	20		
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting																													2																																
Asteraceae	*	*Cirsium vulgare*	Spear Thistle										2																												<1	1															1	20					<1	1		
Asteraceae	*	*Conyza bonariensis*	Flaxleaf Fleabane																																																													
Asteraceae	*	*Conyza sumatrensis*	Tall Fleabane		2								2																								<1	5	<1	1													<1	2	<1	20					<1	10		
Asteraceae		*Cotula australis*	Common Cotula																																																													
Asteraceae	*	*Cotula coronopifolia*	Water Buttons																																														5	500														
Asteraceae		*Enydra woollsii*				1								2																																															<1	20		
Asteraceae		*Epaltes australis*	Spreading Nut-heads																																																													
Asteraceae		*Euchiton involucratus*	Star Cudweed																																																													
Asteraceae		*Euchiton sphaericus*																							1							2																																
Asteraceae	*	*Facelis retusa*	Annual trampweed																																																		<1	10								
Asteraceae	*	*Gamochaeta americana*	Cudweed																																																													
Asteraceae	*	*Gamochaeta purpurea*	Purple Cudweed	2				2																											<1	10	<1	10																	1	300								
Asteraceae	*	*Hypochaeris microcephala*	White Flatweed										2																						<1	50	<1	20																							<1	10		
Asteraceae	*	*Hypochaeris radicata*	Catsear	4	3			3							4									2	1		1		3						<1	100	<1	100	<1	5	<1	20									<1	10	<1	50	<1	100								
Asteraceae	*	*Lactuca saligna*	Willow-leaved Lettuce																																		<1	1																										
Asteraceae		*Lagenophora stipitata*	Blue Bottle-daisy																																										<1	1	<1	5					<1	5			<1	20	<1	50				
Asteraceae		*Pseudognaphalium luteoalbum*	Jersey Cudweed																																												<1	10					<1	20			<1	10						
Asteraceae	*	*Senecio madagascariensis*	Fireweed	3	3	2	2	4					3	2	3																						1	100	<1	3	<1	10			<1	2			<1	10			<1	20	3	500	<1	5			<1	10	<1	3
Asteraceae		*Sigesbeckia orientalis*											2				2																																		<1	1												
Asteraceae		*Solenogyne bellioides*							2									X																																														
Asteraceae		*Soliva anthemifolia*	Button Burweed																																																										<1	10		
Asteraceae	*	*Soliva sessilis*	Bindyi																																		<1	100																	<1	200					<1	5		
Asteraceae	*	*Sonchus asper*	Prickly Sowthistle																																														<1	3														
Asteraceae	*	*Sonchus oleraceus*	Common Sowthistle																																																		<1	1										
Asteraceae	*	*Taraxacum officinale*	Dandelion																																<1	10																												
Asteraceae		*Vernonia cinerea*							3	3		3					2	X				2	2	1	2		2	2	3		2	2		2					<1	10	<1	5	<1	5			<1	5																
Asteraceae	*	*Xanthium occidentale*	Noogoora Burr			2							2																																																			
Brassicaceae	*	*Cardamine hirsuta*	Common Bittercress																																																													
Callitrichaceae	*	*Callitriche stagnalis*	Common Starwort																																														1	100														
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell																																																													
Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell														2																						<1	10							<1	2																
Campanulaceae		*Wahlenbergia stricta*	Australian Bluebell																																												<1	5			<1	2	<1	5										
Caryophyllaceae	*	*Cerastium glomeratum*	Mouse-ear Chickweed																																<1	10	<1	20																	<1	50					<1	10		
Caryophyllaceae	*	*Petrorhagia dubia*																																			<1	20																										
Caryophyllaceae		*Stellaria flaccida*																	X		2																																										5	500
Caryophyllaceae	*	*Stellaria media*	Common Chickweed																																														<1	2														
Chenopodiaceae	*	*Atriplex prostrata*					3						3	3																																			<1	1														
Convolvulaceae		*Dichondra repens*	Kidney Weed						4	4	4	4			4	4	4	X	3	3		3	4	4	4	4	4	4	3	4	2	4	3	4	<1	20			1	200	1	200	<1	100	<1	100	<1	200			1	500	<1	100	<1	200	1	500	<1	200				
Crassulaceae		*Crassula sieberiana*	Australian Stonecrop																																																													
Droseraceae		*Drosera peltata*																																																									<1	1				
Euphorbiaceae		*Chamaesyce drummondii*	Caustic Weed					2																																																								
Fabaceae (Faboideae)		*Bossiaea prostrata*								2								X																																												
Fabaceae (Faboideae)		*Chorizema parviflorum*	Eastern Flame Pea																																																													
Fabaceae (Faboideae)	*	*Lotus uliginosus*	Birds-foot Trefoil			1								2																																							<1	200								
Fabaceae (Faboideae)	*	*Medicago polymorpha*	Burr Medic																																<1	50	<1	50																							<1	5		
Fabaceae (Faboideae)	*	*Trifolium campestre*	Hop Clover																																		<1	50																										
Fabaceae (Faboideae)	*	*Trifolium repens*	White Clover																																																				1	500								
Gentianaceae		*Centaurium tenuiflorum*																																																														
Geraniaceae		*Geranium homeanum*																																																													<1	10
Geraniaceae		*Geranium solanderi*	Native Geranium								3																								<1	5	<1	5			<1	10									<1	1			<1	10								
Goodeniaceae		*Goodenia hederacea*	Ivy Goodenia							X																																																						
Goodeniaceae		*Goodenia heterophylla*																																																														
Goodeniaceae		*Goodenia heterophylla subsp. eglandulosa*										4					2	4							3		3		3										1	100			<1	50																				
Goodeniaceae		*Goodenia paniculata*																													3																										<1	200				
Haloragaceae		*Gonocarpus tetragynus*																																1					<1	10			1	50																				
Haloragaceae		*Gonocarpus teucrioides*	Raspwort																						2																																							
Hypericaceae		*Hypericum gramineum*	Small St John's Wort																												2				<1	5	<1	10																										
Hypericaceae		*Hypericum japonicum*																																																												<1	10
Hypericaceae	*	*Hypericum perforatum*	St. Johns Wort																																																													
Lamiaceae		*Ajuga australis*	Austral Bugle																			3	1																												<1	5												
Lamiaceae		*Mentha satureioides*	Creeping Mint																				2																																									
Lamiaceae		*Plectranthus parviflorus*	Cockspur Flower						2										2			2	2			2		1																			<1	1															<1	2
Lamiaceae		*Scutellaria humilis*	Dwarf Skullcap																					2																																								
Lamiaceae	*	*Stachys arvensis*	Stagger Weed																																																													
Linaceae	*	*Linum trigynum*	French Flax																																<1	50	<1	200																										
Lobeliaceae		*Pratia concolor*	Poison Pratia																																																													
Lobeliaceae		*Pratia purpurascens*	Whiteroot	3					2	3	3	3				4	3	3	X			3	X		3	3	2		4	4							<1	5	<1	50			<1	20	<1	5	<1	50			<1	100	1	500	<1	100	<1	100	<1	100				
Malvaceae	*	*Modiola caroliniana*	Red-flowered Mallow										3																						<1	10																												
Malvaceae	*	*Pavonia hastata*							4																																												<1	10										
Malvaceae	*	*Sida rhombifolia*	Paddy's Lucerne	2				2			2		3		2		3																								<1	20													<1	10					<1	20		
Myrsinaceae	*	*Lysimachia arvensis*	Scarlet Pimpernel																																		<1	20			<1	10							<1	10														
Oleaceae	*	*Olea europaea subsp. cuspidata*	African Olive (seedling)						1																																						<1	1																
Onagraceae		*Ludwigia peploides subsp. montevidensis*	Water Primrose		5	4	5						2	6																																													5	200		
Orobanchaceae	*	*Parentucellia latifolia*	Red Batisia																																		<1	50																										
Oxalidaceae	*	*Oxalis corniculata*																																																														
Oxalidaceae		*Oxalis perennans*							2				2		3		X						1	X	X							1	3	2	<1	10					<1	3									<1	10	<1	10	<1	50	<1	20	<1	10				
Phyllanthaceae		*Phyllanthus hirtellus*	Thyme Spurge																											2	3																																	
Phyllanthaceae		*Phyllanthus similis*																																											<1	50																	<1	1
Phyllanthaceae		*Phyllanthus virgatus*						3	2						3		2																				<1	10																										
Phyllanthaceae		*Poranthera microphylla*																																													<1	1																
Phytolaccaceae	*	*Phytolacca octandra*	Inkweed																																																													
Plantaginaceae		*Plantago debilis*							2																																																							
Plantaginaceae		*Plantago gaudichaudii*	Narrow Plantain																																<1	5	X	X																			<1	10						

Family	*	Scientific Name	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		33		34		35		36		37		38		39		40		41		42		43		44		45		46	
																																			C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
Plantaginaceae	*	*Plantago lanceolata*	Lamb's Tongues	3	2			3					3		4		2								2		1								<1	100	1	200	<1	5	<1	20							<1	20	<1	20	<1	50							<1	10		
Plantaginaceae	*	*Plantago major*	Large Plantain				2																																																										
Plantaginaceae		*Plantago myosuros*																																			<1	50																										
Plantaginaceae	*	*Veronica arvensis*	Wall Speedwell																																																				<1	20								
Plantaginaceae		*Veronica plebeia*	Trailing Speedwell																																										<1	1									<1	3								
Polygalaceae		*Polygala japonica*	Dwarf Milkwort																																																													
Polygonaceae		*Persicaria decipiens*	Slender Knotweed																																																										15	1500		
Polygonaceae		*Persicaria hydropiper*	Water Pepper			2	3				3																																																					
Polygonaceae		*Persicaria strigosa*	Spotted Knotweed			1																																																							5	500		
Polygonaceae	*	*Polygonum aviculare*	Wireweed																																														<1	10														
Polygonaceae		*Rumex brownii*	Swamp Dock								1																																																						
Polygonaceae	*	*Rumex crispus*	Curled Dock																																														<1	1														
Pontederiaceae	*	*Eichhornia crassipes*	Water Hyacinth		5	5								3																																															<1	2		
Portulacaceae		*Calandrinia pickeringii*													X																																																	
Portulacaceae		*Portulaca oleracea*	Pigweed					3																																																									
Proteaceae		*Persoonia linearis*	Narrow-leaved Geebung (seedling)																																																														
Ranunculaceae		*Ranunculus inundatus*	River Buttercup			2																																											<1	10													10	500		
Ranunculaceae		*Ranunculus lappaceus*	Common Buttercup								1																								<1	20	<1	1																										
Ranunculaceae		*Ranunculus plebeius*	Forest Buttercup																																																		<1	1										
Ranunculaceae	*	*Ranunculus sceleratus*	Celery Buttercup																																														<1	1														
Ranunculaceae		*Ranunculus sessiliflorus*	Small-flowered Buttercup																																		<1	20																										
Rhamnaceae		*Alphitonia excelsa*	Red Ash																			1																																										
Rosaceae		*Acaena echinata*								X																																																							
Rubiaceae		*Asperula conferta*	Common Woodruff																																1	200																												
Rubiaceae		*Galium binifolium*																						2															<1	20							<1	5					<1	10									<1	3
Rubiaceae		*Opercularia diphylla*							2	X		2				2	2	2						2	3			2	2	3		2	3	2					<1	5			<1	3			<1	10					<1	20			<1	50	<1	50				
Rubiaceae		*Pomax umbellata*																											X	1													<1	5																				
Rubiaceae	*	*Richardia brasiliensis*	White Eye																																																								<1	3				
Rubiaceae	*	*Richardia stellaris*													2																		2																															
Rutaceae		*Boronia polygalifolia*	Dwarf Boronia																																																														
Scrophulariaceae		*Eremophila debilis*	Winter Apple						1			1										2	X	1																	<1	1					<1	1																
Solanaceae	*	*Solanum americanum*																																																														
Solanaceae		*Solanum brownii*	Violet Nightshade																		1	3	2					2		2																																		
Solanaceae	*	*Solanum mauritianum*	Wild Tobacco Bush										2																																																			
Solanaceae	*	*Solanum nigrum*	Black-berry Nightshade			1							2																																																		<1	1
Solanaceae		*Solanum prinophyllum*	Forest Nightshade							2												2																																										
Stackhousiaceae		*Stackhousia viminea*	Slender Stackhousia																													1	2	1							<1	5																						
Stylidiaceae		*Stylidium graminifolium*	Grass Trigger-plant																																																													
Verbenaceae	*	*Verbena bonariensis*	Purpletop	2				2			3		3		3																				1	50	1	100																	<1	5							<1	1
Verbenaceae	*	*Verbena officinalis*	Common Verbena																																																													
Verbenaceae	*	*Verbena rigida*	Veined Verbena																													2			<1	20					1	50											<1	20										
Violaceae		*Hybanthus monopetalus*	Slender Violet-bush																					2															<1	3																								
Violaceae		*Hybanthus stellarioides*															3					2	3	2				2		1	1			2																	<1	2	<1	1										
Violaceae		*Viola hederacea*	Ivy-leaved Violet																																										<1	20																	<1	10
Herbs - Climbers																																																																
Apocynaceae		*Marsdenia flavescens*	Hairy Milk Vine																	X	3																																											
Apocynaceae		*Marsdenia suaveolens*	Scented Marsdenia																																														<1	4														
Apocynaceae		*Parsonsia straminea*	Common Silkpod		1	2			2				2		1	3				2						3		2																							1	1	<1	1			<1	2	1	10			<1	5
Apocynaceae		*Tylophora barbata*	Bearded Tylophora																	1						4	1	3																																			<1	10
Bignoniaceae		*Pandorea pandorana*	Wonga Wonga Vine						2	X						3			2	3	4	3	3	2	X	2		X		2				1											<1	1	<1	2					<1	3									<1	10
Convolvulaceae		*Convolvulus erubescens*	Blushing Bindweed																			1							2				1						<1	20																			<1	2				
Convolvulaceae		*Polymeria calycina*																		2	3							3																																				
Dilleniaceae		*Hibbertia scandens*	Climbing Guinea Flower								3																																																					<1	1
Dioscoreaceae		*Dioscorea transversa*	Native Yam																																										X	X																	<1	2
Fabaceae (Faboideae)		*Desmodium brachypodum*	Large Tick-trefoil						3								2					4	4							2											<1	1																								
Fabaceae (Faboideae)		*Desmodium gunnii*	Slender Tick Trefoil																																				<1	5	<1	5			<1	50	<1	100			<1	10	<1	10			<1	20						
Fabaceae (Faboideae)		*Desmodium rhytidophyllum*																3	2			1	3	2	3	X	X	1	2	3			X	2									<1	5			<1	1					<1	2										
Fabaceae (Faboideae)		*Desmodium varians*	Slender Tick-trefoil						2	3	2	2					3	X	2			X	X		2	2	2					X	2	2							<1	20									<1	20	<1	20			<1	5						
Fabaceae (Faboideae)		*Glycine clandestina*							2	3	2	2					2						1	2	X		3				4	2	2						<1	1							<1	1			<1	1	<1	5			<1	20	<1	5				
Fabaceae (Faboideae)		*Glycine microphylla*	Small-leaf Glycine																			2																	<1	10			<1	10	<1	3	<1	10			<1	10	<1	20			<1	10	<1	20			<1	10
Fabaceae (Faboideae)		*Glycine tabacina*													2	2	3			2	2		2		2		2	2	2				3	2	<1	10	<1	20			<1	10					<1	2			<1	20					<1	10						
Fabaceae (Faboideae)		*Hardenbergia violacea*	False Sarsaparilla									1										2		2	3	X	2	1	2										<1	10			<1	20			<1	20																
Fabaceae (Faboideae)		*Kennedia rubicunda*	Dusky Coral Pea							4		2				2	2	X								2																	<1	1																				
Fabaceae (Faboideae)		*Podolobium scandens*	Netted Shaggy Pea																						3														<1	20			<1	10																				
Fabaceae (Faboideae)		*Zornia dyctiocarpa*	Zornia						2																							2																																
Loranthaceae		*Amyema congener subsp. congener*	Variable Mistletoe																																														<1	6														
Luzuriagaceae		*Eustrephus latifolius*	Wombat Berry						3	X		3				3	2	3	3			2	2	3	2	2	2	2	3	2	2		2	3					<1	20			<1	10	<1	5	<1	20					<1	10									<1	2
Luzuriagaceae		*Geitonoplesium cymosum*	Scrambling Lily						3	3	2	2			2	3	2	3	3	3	3	2	2	4		3	3			2				2					<1	5	<1	2	<1	10	<1	20	<1	50			<1	20	<1	20			<1	5	<1	10			<1	20
Menispermaceae		*Sarcopetalum harveyanum*	Pearl Vine																2			1																																									<1	1
Menispermaceae		*Stephania japonica*	Snake Vine																2	3								1																	X	X																	<1	10
Oleaceae		*Jasminum volubile*	Stiff Jasmine																																																<1	2												
Pittosporaceae		*Billardiera scandens*	Hairy Apple Berry							2		2				2	2	X						2	3				2				X						<1	50			<1	20	<1	10																		
Ranunculaceae		*Clematis aristata*	Old Man's Beard													4			2									3											<1	1																			<1	1				
Ranunculaceae		*Clematis glycinoides*	Headache Vine								X															2			2	2																																		
Rosaceae	*	*Rubus fruticosus sp. aggregate*	Blackberry								3																																																					<1	2
Rosaceae		*Rubus parvifolius*	Native Raspberry							1						2	X		2																																1	50											<1	1
Rubiaceae		*Morinda jasminoides*	Sweet Morinda								4								2	4	4					2																			1	10																	20	500
Smilacaceae		*Smilax australis*	Lawyer Vine																2			2																																										
Smilacaceae		*Smilax glyciphylla*	Sweet Sarsaparilla																																																														
Vitaceae		*Cayratia clematidea*	Native Grape							3		2				3				X	3	4	3			3		3																																			<1	1
Vitaceae		*Cissus antarctica*	Kangaroo Vine																2	2	3							2																	1	2																	10	50
Vitaceae		*Clematicissus opaca*	Pepper Vine													2	2	X		2		2	2	2	1			3		3																	<1	10																
Vitaceae		*Tetrastigma nitens*														X																																																
Herbs - Monocots (Grasses)																																																																
Poaceae	*	*Andropogon virginicus*	Whisky Grass																																<1	5																												
Poaceae	*	*Anthoxanthum odoratum*	Sweet Vernal Grass																																<1	5																			<1	20								
Poaceae		*Aristida ramosa*	Purple Wiregrass												2								3						4						<1	5															<1	20												
Poaceae		*Aristida sp.*																														2																																
Poaceae		*Aristida vagans*	Threeawn Speargrass							2		5						4					2	4	5		3				6	5	5	4					5	500	5	500	2	100			5	500									<1	20	5	500				
Poaceae	*	*Axonopus fissifolius*	Narrow-leafed Carpet Grass	5				5	2		5		4		5										3				3		2	4	4	4	40	4000	50	5000													<1	20	<1	10	15	1500					<1	20		
Poaceae		*Bothriochloa decipiens*	Red Grass																																																														
Poaceae		*Bothriochloa macra*	Red Grass																																5	1000	5	500															<1	5										
Poaceae	*	*Briza maxima*	Shaking Grass																																																		<1	50										
Poaceae	*	*Briza minor*	Shivery Grass																																<1	50	5	500											<1	5			<1	20	1	100					<1	20		
Poaceae	*	*Briza subaristata*																																	<1	20	<1	20			<1	50																						
Poaceae	*	*Bromus catharticus*	Prairie Grass																																																														
Poaceae	*	*Bromus hordeaceus*	Soft Brome																																																				<1	20								
Poaceae	*	*Chloris gayana*	Rhodes Grass																																																														
Poaceae		*Chloris truncata*	Windmill Grass																																		<1	10																										
Poaceae		*Cymbopogon refractus*	Barbed Wire Grass					X	4	2		2			4			X					5	X	4		3		4	?	4	5	5	5	<1	20			5	500	15	1500					20	1500			10	1000	15	1500			25	2000	20	2000				
Poaceae		*Cynodon dactylon*	Couch	7	7	7	5	6			5		7	6	6																				5	500	5	500			5	500							60	4000					10	1000					10	1000		
Poaceae	*	*Dactylis glomerata*	Cocksfoot																																																													
Poaceae		*Dichelachne micrantha*	Shorthair Plumegrass					X		3		2												X			3								<1	20	1	100	<1	10	<1	10					<1	5			<1	5	<1	20	<1	5								
Poaceae		*Dichelachne rara*																																									<1	3									<1	5										
Poaceae		*Digitaria diffusa*	Open Summer-grass																																																						<1	20	<1	10				
Poaceae		*Digitaria parviflora*	Small-flowered Finger Grass							2																							2						2	200							<1	20																
Poaceae	*	*Digitaria sanguinalis*	Crab Grass					3																																																								
Poaceae		*Echinopogon caespitosus*	Bushy Hedgehog-grass						4	3					1		3						3	4	4				4		2	3	4	3					<1	20							<1	100			<1	5	<1	5			<1	10	5	500				
Poaceae		*Echinopogon ovatus*	Forest Hedgehog Grass						2															?																	<1	20									<1	20	<1	50									<1	10
Poaceae	*	*Ehrharta erecta*	Panic Veldtgrass																																																<1	2												

Family	*	Scientific Name	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		33		34		35		36		37		38		39		40		41		42		43		44		45		46	
																																			C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
Poaceae		*Entolasia marginata*	Bordered Panic						4	5	5					4	2	4	4			2				3		3				2	2						<1	1					<1	3	<1	3					<1	10			<1	10					<1	10
Poaceae		*Entolasia stricta*	Wiry Panic						2			4						6	5					4	4	5	6	3	6	?	5	4							5	500			15	1500	<1	10	10	1000									1	100	5	500			2	5
Poaceae		*Eragrostis brownii*	Brown's Lovegrass	3				3	3						4			3									2						4	3									<1	5			<1	5					<1	5					<1	50				
Poaceae	*	*Eragrostis curvula*	African Lovegrass												5																																								<1	5								
Poaceae		*Eragrostis leptostachya*	Drooping Lovegrass							2		3			4												1					3									<1	5											<1	10										
Poaceae	*	*Hyparrhenia hirta*	Coolatai Grass																																		<1	1																										
Poaceae		*Imperata cylindrica*	Blady Grass							4	6	6				5		5	3			6		4	5	4	5	4	5	5	5			5					35	3500			40	4000	<1	10	30	3000									<1	100	5	1000				
Poaceae		*Lachnagrostis aemula*	Blown Grass																																<1	20	<1	20	<1	1	<1	10											<1	20										
Poaceae		*Lachnagrostis filiformis*																																															<1	20														
Poaceae	*	*Lolium perenne*	Perennial Ryegrass																																						1	100							<1	20														
Poaceae		*Microlaena stipoides*	Weeping Grass						5			X	4		5	5	5	5					4		5	4	4	5	5		5	4	5	5					5	500	5	500	5	500	1	100	5	500			40	4000	40	4000	20	2000	40	4000					10	1000
Poaceae		*Oplismenus aemulus*							4	5	5	X			3	4	5	4	5			4	4	3	X	4				3		2	2	X							<1	5					<1	50					<1	100			1	100					15	1500
Poaceae		*Oplismenus imbecillis*								3						6	2	3	5	6	5	2				5		5		3															<1	20	<1	50																
Poaceae		*Panicum effusum*	Hairy Panic						4	2					2		3						3								4	3	4	3					<1	20							<1	2									<1	5						
Poaceae		*Panicum simile*	Two-colour Panic																																								<1	10													<1	10	<1	20				
Poaceae		*Paspalidium distans*							2	2		3											2				X	3											<1	5			<1	10									<1	10			<1	50	1	50				
Poaceae	*	*Paspalum dilatatum*	Paspalum	6	2	3	2	5	3		4		4	3	4		2																		25	2500	20	2000	<1	5	5	500											<1	20	20	2000								
Poaceae		*Paspalum distichum*	Water Couch		4	5	6						4	5																																			20	2000														
Poaceae	*	*Pennisetum clandestinum*	Kikuyu Grass																																																				20	2000								
Poaceae	*	*Phalaris minor*	Lesser Canary Grass																																																													
Poaceae		*Poa affinis*																	5																										1	100	<1	50															<1	10
Poaceae	*	*Poa annua*	Winter Grass																																		<1	20																	1	500								
Poaceae		*Poa labillardierei*	Tussock						5	5							5					4	5	?		3	5				5	5	5	3																														
Poaceae		*Poa sieberiana*																																	10	1000	<1	20			40	1000					<1	20			10	1000	30	3000			10	100						
Poaceae	*	*Polypogon monspeliensis*	Bearded Grass																																														<1	5														
Poaceae		*Rytidosperma caespitosum*	Ringed Wallaby Grass																																																													
Poaceae		*Rytidosperma fulvum*	Wallaby Grass																																																													
Poaceae		*Rytidosperma racemosum*																																							<1	10																						
Poaceae		*Rytidosperma sp.*																																4																														
Poaceae		*Rytidosperma tenuis*										2																															<1	10			<1	1																
Poaceae		*Sacciolepis indica*	Indian Cupscale Grass																																																													
Poaceae	*	*Setaria parviflora*		2																																																												
Poaceae	*	*Setaria sphacelata*	South African Pigeon Grass																																																													
Poaceae	*	*Sporobolus africanus*	Parramatta Grass	4				4																											<1	100																			<1	20								
Poaceae		*Sporobolus creber*	Western Rat-tail Grass																																5	500	5	500			<1	20					<1	1							2	200	<1	10						
Poaceae		*Sporobolus elongatus*	Slender Rat's Tail Grass																														1																								<1	5						
Poaceae		*Themeda triandra*	Kangaroo Grass					X		3							5						6		3		3				5	6	4						10	500	5	200					10	1000			10	1000							10	1000				
Poaceae	*	*Vulpia bromoides*	Squirrel Tail Fescue																																		1	500																	<1	20								
Herbs - Monocots (Other)																																																																
Anthericaceae		*Arthropodium milleflorum*	Pale Vanilla-lily																														1								<1	5	<1	4	<1	1	<1	5									<1	2						
Anthericaceae		*Arthropodium minus*							X																																												<1	10										
Anthericaceae		*Arthropodium sp. B*																																																														
Anthericaceae		*Caesia parviflora*	Pale Grass-lily												1		?	X				2	2	2			1		4		1	1																																
Anthericaceae		*Dichopogon fimbriatus*	Nodding Chocolate Lily																																																						<1	4						
Anthericaceae		*Dichopogon strictus*	Chocolate Lily																																																						<1	5						
Anthericaceae		*Laxmannia gracilis*	Slender Wire Lily																												1																										<1	5	<1	5				
Anthericaceae		*Tricoryne elatior*	Yellow Autumn-lily									2																		1	2	2	2								<1	1					<1	1			X	X	<1	10					<1	1				
Araceae		*Gymnostachys anceps*	Settlers' Twine																	2																																												
Colchicaceae		*Wurmbea dioica*	Early Nancy																																																<1	1	<1	3			<1	5						
Commelinaceae		*Commelina cyanea*					2		3	3	3		3		2	3		X	3				3					3																																			<1	5
Commelinaceae		*Murdannia graminea*	Grass Lily																																																														
Cyperaceae		*Carex appressa*	Tall Sedge			2					5		X																																																<1	1	<1	20
Cyperaceae		*Carex inversa*								2	2																								<1	50	<1	5	<1	20	<1	20					<1	100			1	200			<1	20	<1	50			<1	2		
Cyperaceae		*Carex longebrachiata*																	2	5														1	2	200			<1	10	1	50			3	100					<1	10					1	20					10	100
Cyperaceae	*	*Cyperus brevifolius*	Mullumbimby Couch																																																													
Cyperaceae		*Cyperus difformis*																		X																																												
Cyperaceae	*	*Cyperus eragrostis*	Umbrella Sedge																																																														
Cyperaceae		*Cyperus gracilis*	Slender Flat-sedge																																														<1	5												
Cyperaceae		*Cyperus laevis*																																																															
Cyperaceae		*Cyperus polystachyos*				X																																																											
Cyperaceae	*	*Cyperus sesquiflorus*																																																															
Cyperaceae		*Cyperus sp.*															?		2				2				2																																					
Cyperaceae		*Eleocharis cylindrostachys*																																																															
Cyperaceae		*Fimbristylis dichotoma*	Common Fringe-sedge	4				3	3						3		X										2					3	2						<1	2							<1	1									<1	10						
Cyperaceae		*Isolepis cernua*	Nodding Club-rush																																														<1	50														
Cyperaceae	*	*Isolepis levynsiana*				2										3			4	3						2											<1	10																										
Cyperaceae		*Isolepis producta*																																																													<1	1
Cyperaceae	*	*Isolepis prolifera*																																																											40	4000		
Cyperaceae		*Lepidosperma laterale*																									2	2	4	X	3						1	50			<1	10			1	100									2	200	10	1000				
Cyperaceae		*Lepidosperma neesii*																																																									1	100				
Cyperaceae		*Ptilothrix deusta*																																					<1	20																								
Cyperaceae		*Schoenoplectus validus*																																																													15	2000		
Cyperaceae		*Schoenus apogon*	Common Bog-rush																																<1	20	<1	1													<1	10	<1	10					<1	10				
Cyperaceae		*Scleria mackaviensis*																																																															
Hypoxidaceae		*Hypoxis hygrometrica*	Golden Weather-grass												X																																																	
Iridaceae	*	*Herbertia lahue*																																																																
Iridaceae	*	*Herbertia lahue subsp. caerulea*																																																															
Iridaceae		*Patersonia longifolia*	Purple Flag																																				<1	1																								
Iridaceae	*	*Romulea rosea*	Onion Grass																																<1	500	<1	50			<1	200									<1	10	<1	5	1	500								
Iridaceae	*	*Sisyrinchium rosulatum*	Scourweed																																<1	100	<1	50			<1	20													<1	100								
Juncaceae	*	*Juncus acutiflorus*			1									5																																																		
Juncaceae	*	*Juncus acutus*	Sharp Rush			1	4																																																									
Juncaceae		*Juncus bufonius*	Toad Rush											2																							<1	10																							<1	1		
Juncaceae	*	*Juncus cognatus*																																																															
Juncaceae		*Juncus homalocaulis*																																																															
Juncaceae		*Juncus planifolius*																																																	<1	20										
Juncaceae		*Juncus sp.*																							2																																							
Juncaceae		*Juncus usitatus*		3	4	5	5	3			4		?	5	3																	1					1	50									<1	20	5	200	<1	3	<1	5							<1	20		
Juncaginaceae		*Triglochin procera*	Water Ribbons																																														<1	10														
Lomandraceae		*Lomandra confertifolia*	Mat-rush																			3		2						5																																		
Lomandraceae		*Lomandra filiformis*	Wattle Mat-rush									5			3							X	4	4	4	2			3	5	3																																	
Lomandraceae		*Lomandra*																																	<1	1																												
Lomandraceae		*Lomandra*	Wattle Mat-rush																																				<1	50	10	1000	<1	20			1	200			1	200	1	200			<1	100						
Lomandraceae		*Lomandra glauca*	Pale Mat-rush																																																								1	200				
Lomandraceae		*Lomandra longifolia*	Spiny-headed Mat-rush						1	X									3			X											1						1	10			<1	5	3	3																		
Lomandraceae		*Lomandra multiflora*	Many-flowered Mat-rush							X		4				1		X				4		3	3		X		3	3		2	3	3					<1	20	<1	3	<1	10			<1	20			1	50	<1	50			<1	50	1	50				
Lomandraceae		*Lomandra obliqua*																						3	3														<1	50																								
Orchidaceae		*Acianthus fornicatus*	Pixie Caps																																																														
Orchidaceae		*Chiloglottis reflexa*																																																															
Orchidaceae		*Corybas pruinosus*	Toothed Helmet Orchid																																																														
Orchidaceae		*Microtis parviflora*	Slender Onion Orchid																																												<1	1											<1	1				
Orchidaceae		*Microtis unifolia*																																																	<1	5										
Phormiaceae		*Dianella caerulea var. caerulea*	Blue Flax-lily							3						1	X	1					2		X		2		2	2				2									<1	10	<1	2	<1	10									<1	3	<1	2				
Phormiaceae		*Dianella caerulea var. producta*																																																															
Phormiaceae		*Dianella longifolia*																																																																
Phormiaceae		*Dianella longifolia var. longifolia*	Blueberry Lily																								1												<1	3	<1	3					<1	1											<1	5				
Phormiaceae		*Dianella revoluta*	Blueberry Lily																			1									4	2		1																														
Typhaceae		*Typha orientalis*	Broadleaf Cumbungi																																																												40	1000		
Xanthorrhoeaceae		*Xanthorrhoea latifolia subsp.*																						1						4	3																																	
Xanthorrhoeaceae		*Xanthorrhoea macronema*																																																															

Key:

Family	*	Scientific Name	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		33		34		35		36		37		38		39		40		41		42		43		44		45		46	
																																				C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A

1 is <5% - Rare (usually just 1 plant in the plot)
2 is <5% - uncommon (a couple of plants in the plot)
3 is <5% - Common
4 is <5% - Very Common (lots of plants but below 5% coverage)
5 is 5-25% coverage
6 is 26-50% coverage
7 is 51-75% coverage
8 is 76-100% coverage

cumberland ecology

Appendix A Flora Species List and Plot Data

Family	*	Scientific Name	Common Name	47		48		49		50		51		52		53		54		55		56		57		58		59		60		61		62		63		64		65		66		67		68		69		70		71		72		73		74		75		76		77	
				C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
Tree																																																													
Casuarinaceae		*Casuarina glauca*	Swamp Oak																																																											
Cunoniaceae		*Ceratopetalum apetalum*	Coachwood																																																										
Malvaceae		*Brachychiton populneus*	Kurrajong																																																										
Myrtaceae		*Angophora costata*	Sydney Red Gum																																							10	5																				
Myrtaceae		*Backhousia myrtifolia*	Grey Myrtle																																																										
Myrtaceae		*Corymbia gummifera*	Red Bloodwood																																																										
Myrtaceae		*Corymbia maculata*	Spotted Gum													15	6	15	3	35	10							4	1			20	8	15	6			5	3	10	3			5	3	3	1	0.5	1			25	4	20	3	15	3	10	2	10	2			10	1
Myrtaceae		*Eucalyptus acmenoides*	White Mahogany																													10	5					10	2	5	2	5	3	4	2									10	3	18	11				
Myrtaceae		*Eucalyptus canaliculata*	Grey Gum																																																										
Myrtaceae		*Eucalyptus crebra*	Narrow-leaved Ironbark													20	1																																												
Myrtaceae		*Eucalyptus fibrosa*	Red Ironbark																																			5	2																				
Myrtaceae		*Eucalyptus globoidea*	White Stringybark																																			10	4							18	9			15	4										
Myrtaceae		*Eucalyptus moluccana*	Grey Box											30	3													2	1																																
Myrtaceae		*Eucalyptus pilularis*	Blackbutt																																																										
Myrtaceae		*Eucalyptus propinqua*	Small-fruited Grey Gum															20	3	5	2																																								
Myrtaceae		*Eucalyptus punctata*	Grey Gum																															3	1	4	1			1	2	5	1											5	1	5	1	2	1				
Myrtaceae		*Eucalyptus siderophloia*	Grey Ironbark																											10	1	3	1			5	4	10	2			10	3							4	1	5	1	10	1			5	1
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum																																	16	5									15	5											5	2			15	3
Myrtaceae		*Melaleuca styphelioides*	Prickly-leaved Tea Tree																																																										
Myrtaceae		*Syncarpia glomulifera*	Turpentine																																																										
Rhamnaceae		*Alphitonia excelsa*	Red Ash																																																										
Small Tree																																																												
Casuarinaceae		*Allocasuarina torulosa*	Forest Oak																													2	3			1	3	8	6	20	18																				
Casuarinaceae		*Casuarina glauca*	Swamp Oak																																																									
Cunoniaceae		*Ceratopetalum gunnifierum*	Christmas Bush																																																									
Elaeocarpaceae		*Elaeocarpus obovatus*	Hard Quandong																																																									
Flacourtiaceae		*Scolopia braunii*	Flintwood																																																									
Lamiaceae		*Clerodendrum tomentosum*	Hairy Clerodendrum																																																								
Malvaceae		*Brachychiton populneus*	Kurrajong																													0.5	1																												
Malvaceae		*Hibiscus heterophyllus subsp. heterophyllus*	Native Rosella																																																								
Moraceae		*Ficus coronata*	Sandpaper Fig																																																									
Myrtaceae		*Angophora costata*	Sydney Red Gum																																			1	1			3	2																		
Myrtaceae		*Backhousia myrtifolia*	Grey Myrtle																																																								40	26
Myrtaceae		*Callistemon salignus*	Willow Bottlebrush																																	7	3									1	1														
Myrtaceae		*Corymbia gummifera*	Red Bloodwood																																																							0.25	1
Myrtaceae		*Corymbia maculata*	Spotted Gum											adj.	adj.	10	3	7	2	11	6							2	1			30	19	25	16	4	2	3	2	10	10			15	15	4	5	1	1			2	2	10	3	1	1	3	3	4	6				
Myrtaceae		*Eucalyptus acmenoides*	White Mahogany															10	4	10	12													5	7					5	2	5	3	10	10	1	2									10	5	5	4				
Myrtaceae		*Eucalyptus canaliculata*	Grey Gum																																																										
Myrtaceae		*Eucalyptus crebra*	Narrow-leaved Ironbark																																																									
Myrtaceae		*Eucalyptus fibrosa*	Red Ironbark																													0.5	1					0.5	1							10	8									5	2				
Myrtaceae		*Eucalyptus globoidea*	White Stringybark																																	5	4									0.5	1							2	1	8	5				
Myrtaceae		*Eucalyptus moluccana*	Grey Box															2	1									5	2									0.5	1																				
Myrtaceae		*Eucalyptus propinqua*	Small-fruited Grey Gum																	5	4																																								
Myrtaceae		*Eucalyptus punctata*	Grey Gum																																	2	1			1	1															3	2				
Myrtaceae		*Eucalyptus siderophloia*	Grey Ironbark															10	5	4	3													2	2			10	5	2	3			2	2							10	10					1	1	3	1
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum																			10	1					adj.	adj.					10	4									0.5	1			1	1			5	2	6	5	1	1	5	1
Myrtaceae		*Melaleuca nodosa*	Prickly-leaved Paperbark																											3	2											3	4	2	1									5	3	1	1	10	12				
Myrtaceae		*Melaleuca styphelioides*	Prickly-leaved Tea Tree															2	2			3	2	2	1																																				
Myrtaceae		*Syncarpia glomulifera*	Turpentine																																																									
Oleaceae	*	*Olea europaea subsp. cuspidata*	African Olive																																																						5	10				
Phyllanthaceae		*Glochidion ferdinandi*	Cheese Tree																																																								
Pittosporaceae		*Hymenosporum flavum*	Native Frangipani																																																								
Pittosporaceae		*Pittosporum undulatum*	Native Daphne																																																					2	1				
Shrubs																																																											
Myrtaceae		*Eucalyptus moluccana*	Grey Box											1	3													2	10																																
Myrtaceae		*Eucalyptus propinqua*	Small-fruited Grey Gum																																																									
Myrtaceae		*Eucalyptus punctata*	Grey Gum							0.25	1																									0.5	2																				
Myrtaceae		*Eucalyptus siderophloia*	Grey Ironbark																																																				0.5	3				
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum																			1	7			0.25	1			0.25	1			1	5																								
Myrtaceae		*Eucalyptus umbra*	Broad-leaved White Mahogany																																																								
Myrtaceae		*Leptospermum polygalifolium*	Tantoon																																																								
Myrtaceae		*Leptospermum polygalifolium subsp. cismontanum*	Tantoon																																	5	20																				
Myrtaceae		*Melaleuca nodosa*																0.25	1	0.5	2											5	6											2	5	2	1					10	20	2	3	20	50				
Myrtaceae		*Melaleuca styphelioides*	Prickly-leaved Tea Tree															25	50	3	7																																							
Myrtaceae		*Rhodamnia rubescens*	Scrub Turpentine																																																									
Ochnaceae	*	*Ochna serrulata*	Mickey Mouse Plant																																																								
Oleaceae		*Jasminum volubile*	Stiff Jasmine																																																								
Oleaceae		*Notelaea longifolia*	Large Mock-olive			<0.25	1	<0.25	1									0.5	3	0.25	1											0.25	1	1	5	0.25	1			5	10	0.5	3	0.5	2							0.25	2	8	20	10	50				
Oleaceae	*	*Olea europaea subsp. cuspidata*	African Olive											<0.25	1													<0.25	1																											10	50				
Phyllanthaceae		*Breynia oblongifolia*	Coffee Bush					<0.25	1											0.25	3											2	10	0.5	5	<0.25	1	0.25	2	0.25	3					<0.25	2			<0.25	1			0.25	3	5	20	1	10				
Phyllanthaceae		*Glochidion ferdinandi*	Cheese Tree															0.25	1			<0.25	1			<0.25	1																																
Phyllanthaceae		*Phyllanthus gunnii*	Scrubby Spurge																																																									
Phyllanthaceae		*Phyllanthus hirtellus*																																																									
Pittosporaceae		*Bursaria spinosa*	Blackthorn							0.25	4																					2	10	1	5			2	10													0.5	3				
Pittosporaceae		*Hymenosporum flavum*	Native Frangipani																																																								
Pittosporaceae		*Pittosporum multiflorum*	Orange Thorn																	0.25	3																																			0.5	5			0.25	3
Pittosporaceae		*Pittosporum revolutum*	Rough Fruit Pittosporum																	0.25	2																			0.5	3													0.5	5	0.25	3	0.1	3
Pittosporaceae		*Pittosporum undulatum*	Sweet Pittosporum															0.5	1																																			<0.25	3	1	3	0.25	3	0.1	1
Proteaceae		*Persoonia linearis*	Narrow-leaved Geebung																													0.5	3					1	5	0.25	1			<0.25	1														
Rhamnaceae		*Alphitonia excelsa*	Red Ash																																																						0.25	1	0.25	1		
Rhamnaceae		*Ponaderris discolor*																																																						0.5	3				
Rosaceae	*	*Rosa rubiginosa*	Sweet Briar													0.25	3											0.5	1																														
Rutaceae		*Boronia polygalifolia*	Dwarf Boronia																																																									
Rutaceae		*Zieria pilosa*	Pilose-leafed Zieria																																																									
Rutaceae		*Zieria smithii*																													0.25	1									0.25	1	0.25	2													5	20				
Santalaceae		*Exocarpos cupressiformis*	Cherry Ballart																																																									
Sapindaceae		*Cupaniopsis anacardioides*	Tuckeroo																																																									
Sapindaceae		*Dodonaea triquetra*	Large-leaf Hop-bush																																																									
Solanaceae	*	*Duboisia myoporoides*	Corkwood																																																									
Solanaceae	*	*Solanum mauritianum*	Wild Tobacco Bush																																																					0.25	2				
Solanaceae		*Solanum stelligerum*	Devil's Needles																	<0.25	3											0.5	20																												
Verbenaceae	*	*Lantana camara*	Lantana															1	3	3	3	0.25	1	0.25	1					15	20	1	2	4	5			1	3	3	3					0.5	20			30	50	5	20	3	5	15	20	3	5			10	10
Violaceae		*Melicytus dentatus*	Tree Violet																																																									
Herbs - Ferns and Allies																																																										
Adiantaceae		*Cheilanthes sieberi*								<0.25	20							<0.25	20	<0.25	5									<0.25	10			0.25	100	0.25	100	0.25	20			<0.25	20	0.25	50	0.5	200			<0.25	50	<0.25	20	1	1	0.25	50	<0.25	10		
Aspleniaceae	P	*Asplenium australasicum*	Bird's Nest Fern																																																								
Blechnaceae		*Blechnum indicum*	Swamp Water Fern																																																								
Blechnaceae		*Doodia aspera*	Prickly Rasp Fern																																																								
Dennstaedtiaceae		*Pteridium esculentum*	Bracken																																					4	100																		
Gleicheniaceae	P	*Stiicherus flabellatus*	Shiny Fan Fern																																																							
Myrtaceae		*Eucalyptus siderophloia*	Northern Grey Ironbark																											0.5	2	0.5	2			0.5	3	2	5			1	3							2	5	0.25	3						

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Family	*	Scientific Name	Common Name	47		48		49		50		51		52		53		54		55		56		57		58		59		60		61		62		63		64		65		66		67		68		69		70		71		72		73		74		75		76		77	
				C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
Pteridaceae		*Adiantum aethiopicum*	Common Maidenhair																													15	1500							0.5	50															10	1000					0.1	1
Pteridaceae		*Adiantum hispidulum*	Rough Maidenhair Fern																																																										
Pteridaceae		*Pellaea falcata*	Sickle Fern																							<0.25	10																													0.25	20			0.1	5
Pteridaceae		*Pellaea paradoxa*																																																										
Herbs - Dicots																																																											
Acanthaceae		*Brunoniella australis*	Blue Trumpet					<0.25	20					0.25	100			<0.25	50									<0.25	10			<0.25	50	0.25	50	<0.25	50	<0.25	50	0.25	50					<0.25	20	0.25	100	<0.25	50	0.25	50			0.1	2
Acanthaceae		*Brunoniella pumilio*	Dwarf Brunoniella																																																								
Acanthaceae		*Pseuderanthemum variabile*	Pastel Flower																																																						0.2	20
Amaranthaceae		*Alternanthera denticulata*	Lesser Joyweed																											<0.25	1																														
Amaranthaceae	*	*Alternanthera philoxeroides*	Alligator Weed																																																							
Amaranthaceae	*	*Gomphrena celosioides*	Gomphrena Weed																																																							
Apiaceae		*Centella asiatica*	Indian Pennywort			<0.25	20	<0.25	50	<0.25	20	0.25	100	<0.25	10	<0.25	10					<0.25	10	<0.25	50	<0.25	50	<0.25	10			<0.25	100			0.25	200	<0.25	4	<0.25	20					<0.25	20	0.25	200	<0.25	20			<0.25	20	<0.25	10			<0.25	50		
Apiaceae	*	*Cyclospermum leptophyllum*	Slender Celery					<0.25	20																	<0.25	20					<0.25	50	<0.25	5									<0.25	20	<0.25	100												
Apiaceae		*Daucus glochidiatus*	Native Carrot													<0.25	10																																												
Araliaceae	*	*Ageratina adenophora*	Crofton Weed																																																								
Araliaceae		*Hydrocotyle laxiflora*	Stinking Pennywort																																																							
Araliaceae		*Hydrocotyle tripartita*	Pennywort																																																							
Asteraceae	*	*Aster subulatus*	Wild Aster									<0.25	5			<0.25	2									<0.25	10	<0.25	10	<0.25	20																									0.25	50		
Asteraceae	*	*Bidens pilosa*	Cobbler's Pegs							<0.25	4																			<0.25	5															<0.25	2												
Asteraceae		*Brachyscome microcarpa*	Forest Daisy																																																							
Asteraceae		*Calotis dentex*																<0.25	5																																								
Asteraceae		*Centipeda minima*	Spreading Sneezeweed																																																							
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting																																																						
Asteraceae	*	*Cirsium vulgare*	Spear Thistle									<0.25	2	<0.25	1	<0.25	2							<0.25	2							<0.25	3													<0.25	2	0.25	20			<0.25	2							0.1	1
Asteraceae	*	*Conyza bonariensis*	Flaxleaf Fleabane					<0.25	1																			<0.25	2																														
Asteraceae	*	*Conyza sumatrensis*	Tall Fleabane					<0.25	2			<0.25	5																	<0.25	2															<0.25	2	<0.25	20	<0.25	4								
Asteraceae	*	*Cotula australis*	Common Cotula																											<0.25	50															0.25	100							<0.25	100				
Asteraceae	*	*Cotula coronopifolia*	Water Buttons																																																						
Asteraceae		*Enydra woollsii*																																																						
Asteraceae		*Epaltes australis*	Spreading Nut-heads																											<0.25	1																							<0.25	10				
Asteraceae		*Euchiton involucratus*	Star Cudweed	<0.25	20	<0.25	100					<0.25	5									<0.25	1	<0.25	3																																			
Asteraceae		*Euchiton sphaericus*						<0.25	20																	<0.25	1			<0.25	2															<0.25	1												
Asteraceae	*	*Facelis retusa*	Annual trampweed																					<0.25	10																					0.25	50			<0.25	5			<0.25	2				
Asteraceae	*	*Gamochaeta americana*	Cudweed	0.25	200	<0.25	200																																																			
Asteraceae	*	*Gamochaeta purpurea*	Purple Cudweed																			0.25	100	0.25	200			<0.25	20	<0.25	50															<0.25	20											0.25	200	
Asteraceae	*	*Hypochaeris microcephala*	White Flatweed													<0.25	20											<0.25	5			<0.25	10																							<0.25	20	
Asteraceae	*	*Hypochaeris radicata*	Catsear	0.25	200	0.25	200	<0.25	50	0.5	200	0.5	200	<0.25	50	0.25	50					0.5	200	0.5	200	0.5	200	<0.25	100	1	200	<0.25	50			1	500							<0.25	10			0.5	200					<0.25	2			0.5	500	
Asteraceae	*	*Lactuca saligna*	Willow-leaved Lettuce																																																						
Asteraceae		*Lagenophora stipitata*	Blue Bottle-daisy											<0.25	5	<0.25	5	<0.25	100	<0.25	20											<0.25	50			0.5	200	<0.25	100	0.25	200	<0.25	20	<0.25	50	<0.25	50	<0.25	20			<0.25	20	<0.25	10	<0.25	50		
Asteraceae		*Pseudognaphalium luteoalbum*	Jersey Cudweed																																																					
Asteraceae	*	*Senecio madagascariensis*	Fireweed	1	100	1	100	0.25	20	1	100	1	100	0.25	20			<0.25	10			0.5	50	0.5	50	0.5	50	0.25	20	0.25	50	<0.25	20									<0.25	1	1	100	2	100	0.25	10	0.25	10			<0.25	2	0.25	20		
Asteraceae		*Sigesbeckia orientalis*						<0.25	20									<0.25	10													<0.25	3											<0.25	4			<0.25	10			<0.25	3				
Asteraceae		*Solenogyne bellioides*												<0.25	4																																									
Asteraceae		*Soliva anthemifolia*	Button Burweed																																																					
Asteraceae		*Soliva sessilis*	Bindy																																																				
Asteraceae	*	*Sonchus asper*	Prickly Sowthistle																																																				
Asteraceae	*	*Sonchus oleraceus*	Common Sowthistle																	<0.25	1																									<0.25	5												
Asteraceae	*	*Taraxacum officinale*	Dandelion											<0.25	20	<0.25	20																																							<0.25	10		
Asteraceae		*Vernonia cinerea*												<0.25	5			0.25	50			<0.25	10							0.25	50	<0.25	20	<0.25	20	<0.25	10	<0.25	20	<0.25	3	<0.25	10	<0.25	20	0.25	50			<0.25	20	<0.25	10	<0.25	20		
Asteraceae	*	*Xanthium occidentale*	Noogoora Burr																																																					
Brassicaceae	*	*Cardamine hirsuta*	Common Bittercress																											<0.25	10																												
Callitrichaceae		*Callitriche stagnalis*	Common Starwort																																																						
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell					<0.25	2					<0.25	2	<0.25	3															0.25	50																			<0.25	5						
Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell					<0.25	10					<0.25	10			<0.25	20	<0.25	10			<0.25	50			<0.25	10																											<0.25	20		
Campanulaceae		*Wahlenbergia stricta*	Australian Bluebell																																																					
Caryophyllaceae	*	*Cerastium glomeratum*	Mouse-ear Chickweed																					<0.25	20			<0.25	10			<0.25	50													0.25	50												
Caryophyllaceae	*	*Petrorhagia dubia*																																																				
Caryophyllaceae	*	*Stellaria flaccida*																																																				
Caryophyllaceae	*	*Stellaria media*	Common Chickweed																																																			
Chenopodiaceae	*	*Atriplex prostrata*																																																			
Convolvulaceae		*Dichondra repens*	Kidney Weed					<0.25	100					<0.25	20	0.25	200	0.25	100	<0.25	50							<0.25	100					0.5	200	<0.25	200			<0.25	100	<0.25	50	<0.25	50			2	500	<0.25	50	0.25	100			0.25	200	<0.25	100	2	500		
Crassulaceae		*Crassula sieberiana*	Australian Stonecrop																																																					
Droseraceae		*Drosera peltata*																																		<0.25	1							<0.25	50							<0.25	20				
Euphorbiaceae		*Chamaesyce drummondii*	Caustic Weed																																																				
Fabaceae (Faboideae)		*Bossiaea prostrata*																																																		
Fabaceae (Faboideae)		*Chorizema parviflorum*	Eastern Flame Pea																																																		<0.25	1				
Fabaceae (Faboideae)	*	*Lotus uliginosus*	Birds-foot Trefoil			<0.25	20															<0.25	50							<0.25	10															<0.25	50			<0.25	3						
Fabaceae (Faboideae)	*	*Medicago polymorpha*	Burr Medic	<0.25	20	<0.25	10							<0.25	2									<0.25	20	<0.25	10	0.25	50	0.25	100																										
Fabaceae (Faboideae)	*	*Trifolium campestre*	Hop Clover																																																					
Fabaceae (Faboideae)	*	*Trifolium repens*	White Clover																							<0.25	20																																
Gentianaceae		*Centaurium tenuiflorum*																																																					
Geraniaceae		*Geranium homeanum*																														<1	1																								
Geraniaceae		*Geranium solanderi*	Native Geranium					<0.25	5							<0.25	5									<0.25	3			<0.25	2															<0.25	5							<0.25	4				
Goodeniaceae		*Goodenia hederacea*	Ivy Goodenia																																																				<0.25	3				
Goodeniaceae		*Goodenia heterophylla*																<0.25	10																			<0.25	20	<0.25	20	<0.25	3	<0.25	20					<0.25	20				
Goodeniaceae		*Goodenia heterophylla subsp. eglandulosa*																																																					
Goodeniaceae		*Goodenia paniculata*		0.5	500																	<0.25	20											0.25	100	<0.25	10			0.25	100	<0.25	20												
Haloragacaceae		*Gonocarpus tetragynus*										<0.25	20																							<0.25	20	0.25	50					0.5	200												
Haloragacaceae		*Gonocarpus teucrioides*	Raspwort																																	<0.25	2																				
Hypericaceae		*Hypericum gramineum*	Small St John's Wort	0.25	200	<0.25	50			<0.25	50	0.25	200	<0.25	50	<0.25	20	<0.25	10			0.25	200	0.25	100	<0.25	50	<0.25	20	<0.25	50																									0.25	200		
Hypericaceae		*Hypericum japonicum*																																																					
Hypericaceae	*	*Hypericum perforatum*	St. Johns Wort	<0.25	20																																																			
Lamiaceae		*Ajuga australis*	Austral Bugle											adj.	adj.																																										
Lamiaceae		*Mentha satureioides*	Creeping Mint													<0.25	10																					<0.25	10																
Lamiaceae		*Plectranthus parviflorus*	Cockspur Flower															<0.25	2											<0.25	4																									0.1	10
Lamiaceae		*Scutellaria humilis*	Dwarf Skullcap																																																				
Lamiaceae	*	*Stachys arvensis*	Stagger Weed					<0.25	20																																															
Linaceae	*	*Linum trigynum*	French Flax																																																				
Lobeliaceae		*Pratia concolor*	Poison Pratia																																																			
Lobeliaceae		*Pratia purpurascens*	Whiteroot	<0.25	10			<0.25	100			<0.25	20	<0.25	50	<0.25	50	0.5	500	0.25	100	<0.25	20			<0.25	20	<0.25	20			0.5	200	0.25	100	1	100	0.25	200	0.5	200	1	500	2	1000	0.25	100	5	500	<0.25	5	0.5	200	0.25	100	1	100	1	200	2	500		0.1	5
Malvaceae	*	*Modiola caroliniana*	Red-flowered Mallow													<0.25	20																																						
Malvaceae	*	*Pavonia hastata*																																																					
Malvaceae	*	*Sida rhombifolia*	Paddy's Lucerne	<0.25	20					<0.25	3					<0.25	20													<0.25	3																									0.1	5
Myrsinaceae	*	*Lysimachia arvensis*	Scarlet Pimpernel					<0.25	20									<0.25	20					0.25	100	<0.25	50			0.25	100															0.25	100	<0.25	50										
Oleaceae	*	*Olea europaea subsp. cuspidata*	African Olive (seedling)																																																				
Onagraceae		*Ludwigia peploides subsp. montevidensis*	Water Primrose																																																				
Orobanchaceae	*	*Parentucellia latifolia*	Red Batisia																																																			
Oxalidaceae	*	*Oxalis comiculata*														<0.25	10																																							
Oxalidaceae		*Oxalis perennans*						<0.25	1					<0.25	2	<0.25	3	<0.25	20	<0.25	10							<0.25	20					<0.25	2	<0.25	20	<0.25	3	<0.25	2					<0.25	2	<0.25	100	<0.25	5	<0.25	20			<0.25	5			<0.25	1		
Phyllanthaceae		*Phyllanthus hirtellus*	Thyme Spurge																																																				
Phyllanthaceae		*Phyllanthus similis*																																																			
Phyllanthaceae		*Phyllanthus virgatus*																																																		
Phyllanthaceae		*Poranthera microphylla*																																																		
Phytolaccaceae	*	*Phytolacca octandra*	Inkweed																																																		
Plantaginaceae		*Plantago debilis*																																																			
Plantaginaceae		*Plantago gaudichaudii*	Narrow Plantain					<0.25	10					0.25	200													<0.25	20	0.25	50																										

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Family	*	Scientific Name	Common Name	47		48		49		50		51		52		53		54		55		56		57		58		59		60		61		62		63		64		65		66		67		68		69		70		71		72		73		74		75		76		77	
				C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
Plantaginaceae	*	*Plantago lanceolata*	Lamb's Tongues			<0.25	10	<0.25	20	<0.25	20	<0.25	50	<0.25	50	0.25	100					<0.25	20	<0.25	50	<0.25	50	<0.25	50	<0.25	50	0.25	100			1	500											2	500	<0.25	50	<0.25	10							0.25	200				
Plantaginaceae	*	*Plantago major*	Large Plantain																																																										
Plantaginaceae		*Plantago myosuros*																																																									
Plantaginaceae	*	*Veronica arvensis*	Wall Speedwell																																																								
Plantaginaceae		*Veronica plebeia*	Trailing Speedwell					<0.25	2									<0.25	20													<0.25	20													<0.25	20							<0.25	5	0.25	50				
Polygalaceae		*Polygala japonica*	Dwarf Milkwort																									<0.25	1																																
Polygonaceae		*Persicaria decipiens*	Slender Knotweed																																																								
Polygonaceae		*Persicaria hydropiper*	Water Pepper																																																								
Polygonaceae		*Persicaria strigosa*	Spotted Knotweed																																																								
Polygonaceae	*	*Polygonum aviculare*	Wireweed																																																								
Polygonaceae		*Rumex brownii*	Swamp Dock																																																								
Polygonaceae	*	*Rumex crispus*	Curled Dock																																																								
Pontederiaceae	*	*Eichhornia crassipes*	Water Hyacinth																																																								
Portulacaceae		*Calandrinia pickeringii*																																																								
Portulacaceae		*Portulaca oleracea*	Pigweed																																																								
Proteaceae		*Persoonia linearis*	Narrow-leaved Geebung (seedling)																																																								
Ranunculaceae		*Ranunculus inundatus*	River Buttercup																					<0.25	20	<0.25	20					<0.25	20															1	500																
Ranunculaceae		*Ranunculus lappaceus*	Common Buttercup					<0.25	50	<0.25	20	<0.25	20	<0.25	5															<0.25	1																									<0.25	2			<0.25	10		
Ranunculaceae		*Ranunculus plebeius*	Forest Buttercup																																																								
Ranunculaceae	*	*Ranunculus sceleratus*	Celery Buttercup																																																								
Ranunculaceae		*Ranunculus sessiliflorus*	Small-flowered Buttercup			<0.25	20	<0.25	2																																																			
Rhamnaceae		*Alphitonia excelsa*	Red Ash																																																								
Rosaceae		*Acaena echinata*																																																								
Rubiaceae		*Asperula conferta*	Common Woodruff											<0.25	10	<0.25	10													<0.25	10																														
Rubiaceae		*Galium binifolium*																<0.25	5															<0.25	5													<0.25	10							<0.25	2	<0.25	5				
Rubiaceae		*Opercularia diphylla*						<0.25	10	<0.25	3							0.25	100	<0.25	20											<0.25	50			0.25	100	0.25	100	0.25	50	<0.25	20	<0.25	20	0.25	50	<0.25	10			<0.25	20	<0.25	20	<0.25	20	<0.25	20				
Rubiaceae		*Ponax umbellata*																																																									
Rubiaceae	*	*Richardia brasiliensis*	White Eye							<0.25	2																	<0.25	5																													<0.25	10		
Rubiaceae	*	*Richardia stellaris*																																																								
Rutaceae		*Boronia polygalifolia*	Dwarf Boronia																																			<0.25	1	<0.25	2					<0.25	1												
Scrophulariaceae		*Eremophila debilis*	Winter Apple																																																							
Solanaceae	*	*Solanum americanum*																<0.25	1																																							
Solanaceae		*Solanum brownii*	Violet Nightshade																																																							
Solanaceae	*	*Solanum mauritianum*	Wild Tobacco Bush																																																							
Solanaceae	*	*Solanum nigrum*	Black-berry Nightshade																																																							
Solanaceae		*Solanum prinophyllum*	Forest Nightshade																																																							
Stackhousiaceae		*Stackhousia viminea*	Slender Stackhousia																																																							
Stylidiaceae		*Stylidium graminifolium*	Grass Trigger-plant																																			<0.25	1																			
Verbenaceae	*	*Verbena bonariensis*	Purpletop			1	50			<0.25	3					<0.25	5					<0.25	2			<0.25	3	<0.25	2																			<0.25	10									0.25	20		
Verbenaceae	*	*Verbena officinalis*	Common Verbena	<0.25	20			1	50	3	100	1	100	0.25	10	0.5	20					<0.25	10	0.25	20			0.25	20	1	50																	<0.25	10			0.25	5					0.25	20		
Verbenaceae	*	*Verbena rigida*	Veined Verbena	<0.25	5			0.25	20	<0.25	10			0.25	20									<0.25	10	<0.25	10			<0.25	10																											<0.25	10		
Violaceae		*Hybanthus monopetalus*	Slender Violet-bush																																																						
Violaceae		*Hybanthus stellaroides*																																																						
Violaceae		*Viola hederacea*	Ivy-leaved Violet																													<0.25	20																										
Herbs - Climbers																																																								
Apocynaceae		*Marsdenia flavescens*	Hairy Milk Vine																																																						
Apocynaceae		*Marsdenia suaveolens*	Scented Marsdenia																																																						
Apocynaceae		*Parsonsia straminea*	Common Silkpod											<0.25	1															<0.25	3					1	10									<0.25	1			<0.25	1	<0.25	2			1	10			0.4	10
Apocynaceae		*Tylophora barbata*	Bearded Tylophora															0.25	10	0.25	20																																						
Bignoniaceae		*Pandorea pandorana*	Wonga Wonga Vine																	<0.25	3											0.5	50					1	50	<0.25	5											0.25	20	1	20				
Convolvulaceae		*Convolvulus erubescens*	Blushing Bindweed					<0.25	2																											<0.25	2																				
Convolvulaceae		*Polymeria calycina*																<0.25	5																					<0.25	10																		
Dilleniaceae		*Hibbertia scandens*	Climbing Guinea Flower																																																						
Dioscoreaceae		*Dioscorea transversa*	Native Yam																																																						
Fabaceae (Faboideae)		*Desmodium brachypodum*	Large Tick-trefoil																																																						
Fabaceae (Faboideae)		*Desmodium gunnii*	Slender Tick Trefoil											<0.25	5					<0.25	5			<0.25	10							0.5	200							<0.25	20											<0.25	5	0.25	200				
Fabaceae (Faboideae)		*Desmodium rhytidophyllum*																<0.25	5	<0.25	2											<0.25	20																			<0.25	3				
Fabaceae (Faboideae)		*Desmodium varians*	Slender Tick-trefoil			<0.25	5											<0.25	10									<0.25	5																										
Fabaceae (Faboideae)		*Glycine clandestina*																<0.25	1	<0.25	2																			<0.25	5	<0.25	3	<0.25	5							<0.25	5	<0.25	2	<0.25	2	<0.25	5		
Fabaceae (Faboideae)		*Glycine microphylla*	Small-leaf Glycine			<0.25	50	0.25	50					<0.25	20	<0.25	50	<0.25	50	<0.25	5					<0.25	2	<0.25	10	-	-	<0.25	50	0.25	100	<0.25	50	0.25	50	0.25	100	<0.25	20	<0.25	20	<0.25	50	<0.25	50			<0.25	20	<0.25	20	<0.25	15	<0.25	50	<0.25	20		
Fabaceae (Faboideae)		*Glycine tabacina*												0.25	100	0.25	200									<0.25	50	-	-	<0.25	20							<0.25	20											<0.25	10			<0.25	1			<0.25	20		
Fabaceae (Faboideae)		*Hardenbergia violacea*	False Sarsaparilla			<0.25	2	<0.25	3									0.5	50	<0.25	5											<0.25	2							1	20			<0.25	1	0.25	3												
Fabaceae (Faboideae)		*Kennedia rubicunda*	Dusky Coral Pea																	0.25	5																																						
Fabaceae (Faboideae)		*Podolobium scandens*	Netted Shaggy Pea																																																					
Fabaceae (Faboideae)		*Zornia dyctiocarpa*	Zornia																																																					
Loranthaceae		*Amyema congener subsp. congener*	Variable Mistletoe																																																				
Luzuriagaceae		*Eustrephus latifolius*	Wombat Berry			<0.25	10	0.25	20									0.5	50	0.25	20											0.25	20	1	100			<0.25	10	0.5	20	<0.25	20	0.25	20			<0.25	5			1	50	0.25	10	0.25	10	2	100	0.5	50			0.3	10
Luzuriagaceae		*Geitonoplesium cymosum*	Scrambling Lily															<0.25	10	<0.25	10			<0.25	1							0.5	20	0.5	50	0.25	10			0.25	20							0.25	20			0.25	20	<0.25	5	0.25	20	0.25	20	0.5	50			0.1	5
Menispermaceae		*Sarcopetalum harveyanum*	Pearl Vine																																																						
Menispermaceae		*Stephania japonica*	Snake Vine																																																					
Oleaceae		*Jasminum volubile*	Stiff Jasmine																											<0.25	1																							0.25	1		2	3				
Pittosporaceae		*Billardiera scandens*	Hairy Apple Berry					<0.25	1																							<0.25	5	<0.25	3			0.25	20	<0.25	10					<0.25	3			<0.25	2					<0.25	10	<0.25	4				
Ranunculaceae		*Clematis aristata*	Old Man's Beard											<0.25	1	<0.25	1															0.25	20					<0.25	3													0.25	2				
Ranunculaceae		*Clematis glycinoides*	Headache Vine																																																					
Rosaceae	*	*Rubus fruticosus sp. aggregate*	Blackberry																							10	20	0.5	3																			1	1												
Rosaceae		*Rubus parvifolius*	Native Raspberry																																																				
Rubiaceae		*Morinda jasminoides*	Sweet Morinda															<0.25	5																																						
Smilacaceae		*Smilax australis*	Lawyer Vine																																																			
Smilacaceae		*Smilax glyciphylla*	Sweet Sarsaparilla																																							<0.25	3														
Vitaceae		*Cayratia clematidea*	Native Grape																											<0.25	5																							<0.25	10		
Vitaceae		*Cissus antarctica*	Kangaroo Vine																	<0.25	2																																			0.25	2		
Vitaceae		*Clematicissus opaca*	Pepper Vine															<0.25	3	0.25	10											<0.25	5																					<0.25	2		
Vitaceae		*Tetrastigma nitens*																																																						
Herbs - Monocots (Grasses)																																																								
Poaceae	*	*Andropogon virginicus*	Whisky Grass	20	2000	30	3000	15	1500	15	1500	30	3000	<0.25	10							20	####	10	1000	20	1000	<0.25	10	<0.25	10					0.25	20			<0.25	2											<0.25	2								
Poaceae	*	*Anthoxanthum odoratum*	Sweet Vernal Grass																																																							
Poaceae		*Aristida ramosa*	Purple Wiregrass											<0.25	20	1	100													3	300																			0.25	20	<0.25	5					0.5	20		
Poaceae		*Aristida sp.*																																																							
Poaceae		*Aristida vagans*	Threeawn Speargrass							0.5	50							10	1000											2	200	0.25	20	1	100	20	2000	10	1000	5	500	20	1500	15	1500	15	1500			10	100	10	500	5	500	1	50				
Poaceae	*	*Axonopus fissifolius*	Narrow-leafed Carpet Grass	55	5500	50	5000	5	500	3	300	55	5500	4	500	2	200					42	5000	45	4500	45	4500	35	3000	40	4000	5	500			5	500	<0.25	20							5	500	30	3000	2	200	5	500					35	3500	0.25	20
Poaceae		*Bothriochloa decipiens*	Red Grass							<0.25	5	0.25	50	<0.25	20											<0.25	2	<0.25	20	1	100																									<0.25	10		
Poaceae		*Bothriochloa macra*	Red Grass					<0.25	5					<0.25	20	2	200	<0.25	1									1	100																							<0.25	2						
Poaceae	*	*Briza maxima*	Shaking Grass																																																						
Poaceae	*	*Briza minor*	Shivery Grass																																																						
Poaceae	*	*Briza subaristata*						1	100	5	500	2	200													5	500																																
Poaceae	*	*Bromus catharticus*	Prairie Grass	0.25	50																													<0.25	10													<1	20	<0.25	20								
Poaceae	*	*Bromus hordeaceus*	Soft Brome																																																					
Poaceae	*	*Chloris gayana*	Rhodes Grass					1	20	1	50											0.25	10																															<0.25	2			<0.25	5		
Poaceae		*Chloris truncata*	Windmill Grass											<0.25	5																																										
Poaceae		*Cymbopogon refractus*	Barbed Wire Grass					5	500	5	500	<0.25	20	40	4000	3	3500	1	100	<0.25	5			<0.25	20			20	2000	15	1000	5	500	1	100	40	4000	5	500	5	500	5	500	5	500	5	500	5	500			5	500	10	500	10	1000	10	1000	0.5	50	3	300	1	100
Poaceae		*Cynodon dactylon*	Couch	5	500	2	200					5	500	3	500	1	100					1	100	5	500	5	500	5	500	1	100					1	100													5	500							5	500	0.1	5
Poaceae	*	*Dactylis glomerata*	Cocksfoot																											<0.25	2																										
Poaceae		*Dichelachne micrantha*	Shorthair Plumegrass									<0.25	20																											<0.25	5											0.25	5				
Poaceae		*Dichelachne rara*						<0.25	2																																					<0.25	5			<0.25	2						
Poaceae		*Digitaria diffusa*	Open Summer-grass																																																					
Poaceae		*Digitaria parviflora*	Small-flowered Finger Grass					2	200	1	10																			0.25	5	0.25	20																	<0.25	5	<0.25	2			0.25	20		
Poaceae	*	*Digitaria sanguinalis*	Crab Grass																																																					
Poaceae		*Echinopogon caespitosus*	Bushy Hedgehog-grass					<0.25	5	<0.25	5					<0.25	2	<0.25	20											0.25	20	<0.25	5	<0.25	20			0.25	20			<0.25	10					3	300			0.25	50	<0.25	20	0.25	20	<0.25	20			0.1	10
Poaceae		*Echinopogon ovatus*	Forest Hedgehog Grass																																																					
Poaceae	*	*Ehrharta erecta*	Panic Veldtgrass																																																				

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Family	*	Scientific Name	Common Name	47		48		49		50		51		52		53		54		55		56		57		58		59		60		61		62		63		64		65		66		67		68		69		70		71		72		73		74		75		76		77	
				C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
Poaceae		*Entolasia marginata*	Bordered Panic					<0.25	10									1	100	1	50											10	1000			5	500			1	100	0.25	20							2	200	10	1000	10	1000	5	500	2	200			10	1000
Poaceae		*Entolasia stricta*	Wiry Panic					<0.25	10	0.5	50							<0.25	20	0.25	20											0.25	50	<0.25	50			15	1500	5	500	2	200	5	500	10	1000	<0.25	20			<0.25	5	<0.25	10	<0.25	4						
Poaceae		*Eragrostis brownii*	Brown's Lovegrass	5	500	5	500	0.5	100	1	100	2	200	1	100			<0.25	20			3	300	2	200	3	300	1	100	0.5	150	0.5	50			5	500	1	100			2	200	1	100	5	500			1	100	5	500	1	100					1	100		
Poaceae	*	*Eragrostis curvula*	African Lovegrass																							<0.25	3																																				
Poaceae		*Eragrostis leptostachya*	Drooping Lovegrass											<0.25	5	<0.25	5															<0.25	10							<0.25	10			<0.25	20	10	1	100			1	100	<0.25	20			<0.25	10						
Poaceae	*	*Hyparrhenia hirta*	Coolatai Grass																																																										
Poaceae		*Imperata cylindrica*	Blady Grass			1	50	60	6000	60	6000	1	100					<0.25	10	3	200			2	200									1	100					20	2000	40	4000											35	3500	1	100				
Poaceae		*Lachnagrostis aemula*	Blown Grass																																																										
Poaceae		*Lachnagrostis filiformis*																																																										
Poaceae	*	*Lolium perenne*	Perennial Ryegrass																																																										
Poaceae		*Microlaena stipoides*	Weeping Grass					0.25	50							1	100	40	4000	6	600	1	100	2	200					2	200	60	6000	10	1000	10	1000	20	2000	25	2500	10	1000	30	3000	15	1500	40	4000	1	100	50	5000	30	3000	10	1000	25	2500	15	1500			30	3000
Poaceae		*Oplismenus aemulus*														0.5	100	<0.25	20											1	100			1	100					<0.25	20	1	100					5	500			<0.25	50			<0.25	10	<0.25	20	10	1000			1	100
Poaceae		*Oplismenus imbecillis*																<0.25	20	1	100													5	500																					<0.25	20	2	200				
Poaceae		*Panicum effusum*	Hairy Panic							<0.25	5			<0.25	20													<0.25	20			<0.25	5			0.25	20															<0.25	5					<0.25	5				
Poaceae		*Panicum simile*	Two-colour Panic							<0.25	2																													<0.25	5			<0.25	20	<0.25	20	<0.25	20					<0.25	5			<0.25	1				
Poaceae		*Paspalidium distans*								<0.25	20			<0.25	20			0.5	100	<0.25	20	<0.25	20													5	500	3	300	1	100			0.25	50	5	500	1	100			1	100	5	500	5	500	0.25	100				
Poaceae	*	*Paspalum dilatatum*	Paspalum	5	500	10	1000	3	300	2	200	5	500	10	1000	20	2000					25	1000	20	2000	15	1500	15	1500	25	2500	<0.25	20			1	100					<0.25	3							45	4500	<0.25	20	3	300	<0.25	5					35	3500		
Poaceae		*Paspalum distichum*	Water Couch																																																										
Poaceae	*	*Pennisetum clandestinum*	Kikuyu Grass																																																									
Poaceae	*	*Phalaris minor*	Lesser Canary Grass																																																							<0.25	2			
Poaceae		*Poa affinis*																																																										
Poaceae	*	*Poa annua*	Winter Grass									<0.25	50									<0.25	50	<0.25	100	<0.25	100																																							
Poaceae		*Poa labillardierei*	Tussock																																																									
Poaceae		*Poa sieberiana*												4	400	20	1000											5	200	0.25	20															1	20	2	50							1	50	2	100				
Poaceae	*	*Polypogon monspeliensis*	Bearded Grass																																																									
Poaceae		*Rytidosperma caespitosum*	Ringed Wallaby Grass																																																									
Poaceae		*Rytidosperma fulvum*	Wallaby Grass											<0.25	3													<0.25	5																																
Poaceae		*Rytidosperma racemosum*												<0.25	20	0.25	50																																												
Poaceae		*Rytidosperma sp.*																																																									
Poaceae		*Rytidosperma tenuis*																1	100																																										
Poaceae		*Sacciolepis indica*	Indian Cupscale Grass																																								<0.25	1																		
Poaceae	*	*Setaria parviflora*																										<0.25	20																					0.25	50			<0.25	3						
Poaceae	*	*Setaria sphacelata*	South African Pigeon Grass			<0.25	1																																																						
Poaceae	*	*Sporobolus africanus*	Parramatta Grass																																																									
Poaceae		*Sporobolus creber*	Western Rat-tail Grass	1	50	1	100	0.5	100	1	100	0.5	50	2	200	1	100	<0.25	1			0.25	20	3	300	0.25	50	5	500	5	500	<0.25	20													<0.25	3					<0.25	1					15	1500		
Poaceae		*Sporobolus elongatus*	Slender Rat's Tail Grass																									<0.25	5																																
Poaceae		*Themeda triandra*	Kangaroo Grass							1	100			10	1000															10	1000							<0.25	10					10	1000									1	100				
Poaceae	*	*Vulpia bromoides*	Squirrel Tail Fescue																																																									
Herbs - Monocots (Other)																																																										
Anthericaceae		*Arthropodium milleflorum*	Pale Vanilla-lily															<0.25	50																																									
Anthericaceae		*Arthropodium minus*																														<0.25	20																											
Anthericaceae		*Arthropodium sp. B*												0.25	100					<0.25	50											<0.25	50							<0.25	20									<0.25	50	<0.25	20	0.25	100	0.25	100	<0.25	50		
Anthericaceae		*Caesia parviflora*	Pale Grass-lily																																							<0.25	3																		
Anthericaceae		*Dichopogon fimbriatus*	Nodding Chocolate Lily																																																									
Anthericaceae		*Dichopogon strictus*	Chocolate Lily																																																									
Anthericaceae		*Laxmannia gracilis*	Slender Wire Lily																																																									
Anthericaceae		*Tricoryne elatior*	Yellow Autumn-lily							<0.25	20							<0.25	2																			<0.25	2					<0.25	1	<0.25	2					<0.25	3	<0.25	1						
Araceae		*Gymnostachys anceps*	Settlers' Twine																																																									
Colchicaceae		*Wurmbea dioica*	Early Nancy																																																									
Commelinaceae		*Commelina cyanea*																								<0.25	5			<0.25	20																			<0.25	2									1	20
Commelinaceae		*Murdannia graminea*	Grass Lily															<0.25	10											0.25	100			<0.25	20							<0.25	10					<0.25	20	<0.25	10	<0.25	10	<0.25	20				
Cyperaceae		*Carex appressa*	Tall Sedge																																																									
Cyperaceae		*Carex inversa*												0.25	100	0.25	100											0.25	100	<0.25	20	<0.25	10			<0.25	20																								
Cyperaceae		*Carex longebrachiata*												0.25	10	<0.25	2											3	100																																
Cyperaceae	*	*Cyperus brevifolius*	Mullumbimby Couch					<0.25	20																	0.25	50	<0.25	5																														
Cyperaceae		*Cyperus difformis*																						<0.25	5																																			
Cyperaceae	*	*Cyperus eragrostis*	Umbrella Sedge																																																									
Cyperaceae		*Cyperus gracilis*	Slender Flat-sedge											0.25	200	0.25	200																																												
Cyperaceae		*Cyperus laevis*																<0.25	5													<0.25	2																											
Cyperaceae		*Cyperus polystachyos*																																																									
Cyperaceae	*	*Cyperus sesquiflorus*		<0.25	20	0.25	100					<0.25	10									<0.25	20	0.5	100	1	200	0.5	50			<0.25	5																											
Cyperaceae		*Cyperus sp.*																																																								
Cyperaceae		*Eleocharis cylindrostachys*																																																								
Cyperaceae		*Fimbristylis dichotoma*	Common Fringe-sedge	<0.25	20	<0.25	50	<0.25	20	<0.25	20	<0.25	50	<0.25	10							0.5	500	<0.25	100	<0.25	100	<0.25	50	0.25	100	<0.25	50													0.25	200					<0.25	5	0.25	100					<0.25	100		
Cyperaceae		*Isolepis cernua*	Nodding Club-rush																																																									
Cyperaceae	*	*Isolepis levynsiana*																																																									
Cyperaceae		*Isolepis producta*																																																									
Cyperaceae	*	*Isolepis prolifera*																																																									
Cyperaceae		*Lepidosperma laterale*																<0.25	2																			<0.25	2	0.25	10	0.25	20	0.25	10	<0.25	5	1	100							<0.25	2				
Cyperaceae		*Lepidosperma neesii*																																																									
Cyperaceae		*Pillothrix deusta*						<0.25	10																																																				
Cyperaceae		*Schoenoplectus validus*																																																									
Cyperaceae		*Schoenus apogon*	Common Bog-rush																			<0.25	10																																							
Cyperaceae		*Scleria mackaviensis*																										<0.25	2																			<0.25	5										
Hypoxidaceae		*Hypoxis hygrometrica*	Golden Weather-grass			<0.25	10											<0.25	2			<0.25	5					<0.25	5			<0.25	5			<0.25	10																						
Iridaceae	*	*Herbertia lahue*																						<0.25	10			5	500	<0.25	50															<0.25	10									0.25	200		
Iridaceae	*	*Herbertia lahue subsp. caerulea*														10	2000																																												
Iridaceae		*Patersonia longifolia*	Purple Flag																																																									
Iridaceae	*	*Romulea rosea*	Onion Grass	<0.25	100			<0.25	100			0.25	500											0.5	1000			<0.25	20	<0.25	50																			1	1000									1	2000		
Iridaceae	*	*Sisyrinchium rosulatum*	Sourweed																																																									
Juncaceae	*	*Juncus acutiflorus*																																																									
Juncaceae	*	*Juncus acutus*	Sharp Rush																																																									
Juncaceae		*Juncus bufonius*	Toad Rush																																																									
Juncaceae	*	*Juncus cognatus*				<0.25	5															<0.25	5	0.25	5	0.25	20																			1	20															
Juncaceae		*Juncus homalocaulis*																														<0.25	10																											
Juncaceae		*Juncus planifolius*																																																									
Juncaceae		*Juncus sp.*																																																									
Juncaceae		*Juncus usitatus*												<0.25	2			<0.25	2									<0.25	2			<0.25	10															<0.25	1	2	50	<0.25	4	<0.25	5					1	50
Juncaginaceae		*Triglochin procera*	Water Ribbons																																																									
Lomandraceae		*Lomandra confertifolia*	Mat-rush																																					15	1500															3	300	1	100				
Lomandraceae		*Lomandra filiformis*	Wattle Mat-rush															<0.25	100													<0.25	20	40	4000	0.5	200	0.25	50	<0.25	20							0.25	100	1	200	0.25	100						
Lomandraceae		*Lomandra*												<0.25	20																																													
Lomandraceae		*Lomandra*	Wattle Mat-rush							0.25	50																																			1	200									<0.25	20				
Lomandraceae		*Lomandra glauca*	Pale Mat-rush																																																									
Lomandraceae		*Lomandra longifolia*	Spiny-headed Mat-rush																																																									
Lomandraceae		*Lomandra multiflora*	Many-flowered Mat-rush							<0.25	10							0.25	20	<0.25	5													<0.25	2	<0.25	20	1	100	0.25	10	<0.25	5	<0.25	5	0.5	50	<0.25	3			0.5	50	<0.25	10	1	50	0.25	20	<0.25	10		
Lomandraceae		*Lomandra obliqua*																																																									
Orchidaceae		*Acianthus fornicatus*	Pixie Caps															<0.25	10	<0.25	50													0.25	200					<0.25	10	<0.25	50													0.25	200		
Orchidaceae		*Chiloglottis reflexa*																<0.25	20	<0.25	50													<0.25	10					0.25	100					<0.25	20					0.25	100	<0.25	50	<0.25	20		
Orchidaceae		*Corybas pruinosus*	Toothed Helmet Orchid																																																									
Orchidaceae		*Microtis parviflora*	Slender Onion Orchid																																																									
Orchidaceae		*Microtis unifolia*																																																									
Phormiaceae		*Dianella caerulea var. caerulea*	Blue Flax-lily																																																									
Phormiaceae		*Dianella caerulea var. producta*																0.25	20															0.25	10	<0.25	1	0.25	10	<0.25	4	0.25	10	0.25	10							0.25	5	0.25	20	<0.25	1		
Phormiaceae		*Dianella longifolia*												<0.25	1			<0.25	5			<0.25	2					<0.25	2																											<0.25	5	<0.25	2				
Phormiaceae		*Dianella longifolia var. longifolia*	Blueberry Lily																																																									
Phormiaceae		*Dianella revoluta*	Blueberry Lily																																																									
Typhaceae		*Typha orientalis*	Broadleaf Cumbungi																																																									
Xanthorrhoeaceae		*Xanthorrhoea latifolia subsp.*																																																									
Xanthorrhoeaceae		*Xanthorrhoea macronema*																														0.5	4																											

Key:

Family	*	Scientific Name	Common Name	47		48		49		50		51		52		53		54		55		56		57		58		59		60		61		62		63		64		65		66		67		68		69		70		71		72		73		74		75		76		77	
				C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A

1 is <5% - Rare (usually just 1 plant in the plot)
2 is <5% - uncommon (a couple of plants in the plot)
3 is <5% - Common
4 is <5% - Very Common (lots of plants but below 5% coverage)
5 is 5-25% coverage
6 is 26-50% coverage
7 is 51-75% coverage
8 is 76-100% coverage

Appendix A Flora Species List and Plot Data

Family	*	Scientific Name	Common Name	78		79		80		81		82	
				C	A	C	A	C	A	C	A	C	A
Tree													
Casuarinaceae		*Casuarina glauca*	Swamp Oak										
Cunoniaceae		*Ceratopetalum apetalum*	Coachwood										
Malvaceae		*Brachychiton populneus*	Kurrajong										
Myrtaceae		*Angophora costata*	Sydney Red Gum										
Myrtaceae		*Backhousia myrtifolia*	Grey Myrtle										
Myrtaceae		*Corymbia gummifera*	Red Bloodwood										
Myrtaceae		*Corymbia maculata*	Spotted Gum	20	3			7	1	4	1	10	2
Myrtaceae		*Eucalyptus acmenoides*	White Mahogany					15	5	15	6	20	8
Myrtaceae		*Eucalyptus canaliculata*	Grey Gum									2	1
Myrtaceae		*Eucalyptus crebra*	Narrow-leaved Ironbark										
Myrtaceae		*Eucalyptus fibrosa*	Red Ironbark										
Myrtaceae		*Eucalyptus globoidea*	White Stringybark										
Myrtaceae		*Eucalyptus moluccana*	Grey Box										
Myrtaceae		*Eucalyptus pilularis*	Blackbutt										
Myrtaceae		*Eucalyptus propinqua*	Small-fruited Grey Gum										
Myrtaceae		*Eucalyptus punctata*	Grey Gum	10	1			10	2	5	1		
Myrtaceae		*Eucalyptus siderophloia*	Grey Ironbark	3	1							5	1
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum	4	1			7	2	10	5		
Myrtaceae		*Melaleuca styphelioides*	Prickly-leaved Tea Tree										
Myrtaceae		*Syncarpia glomulifera*	Turpentine										
Rhamnaceae		*Alphitonia excelsa*	Red Ash										
Small Tree													
Casuarinaceae		*Allocasuarina torulosa*	Forest Oak										
Casuarinaceae		*Casuarina glauca*	Swamp Oak										
Cunoniaceae		*Ceratopetalum gunnifierum*	Christmas Bush										
Elaeocarpaceae		*Elaeocarpus obovatus*	Hard Quandong										
Flacourtiaceae		*Scolopia braunii*	Flintwood										
Lamiaceae		*Clerodendrum tomentosum*	Hairy Clerodendrum										
Malvaceae		*Brachychiton populneus*	Kurrajong										
Malvaceae		*Hibiscus heterophyllus subsp. heterophyllus*	Native Rosella										
Moraceae		*Ficus coronata*	Sandpaper Fig										
Myrtaceae		*Angophora costata*	Sydney Red Gum										
Myrtaceae		*Backhousia myrtifolia*	Grey Myrtle										
Myrtaceae		*Callistemon salignus*	Willow Bottlebrush										
Myrtaceae		*Corymbia gummifera*	Red Bloodwood					2	1				
Myrtaceae		*Corymbia maculata*	Spotted Gum	1	1					2	3	5	4
Myrtaceae		*Eucalyptus acmenoides*	White Mahogany					5	4	10	6	15	9
Myrtaceae		*Eucalyptus canaliculata*	Grey Gum									5	2
Myrtaceae		*Eucalyptus crebra*	Narrow-leaved Ironbark										
Myrtaceae		*Eucalyptus fibrosa*	Red Ironbark										
Myrtaceae		*Eucalyptus globoidea*	White Stringybark										
Myrtaceae		*Eucalyptus moluccana*	Grey Box										
Myrtaceae		*Eucalyptus propinqua*	Small-fruited Grey Gum										
Myrtaceae		*Eucalyptus punctata*	Grey Gum							1	1		
Myrtaceae		*Eucalyptus siderophloia*	Grey Ironbark									1	2
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum	10	3			2	1	2	1		
Myrtaceae		*Melaleuca nodosa*	Prickly-leaved Paperbark										
Myrtaceae		*Melaleuca styphelioides*	Prickly-leaved Tea Tree										
Myrtaceae		*Syncarpia glomulifera*	Turpentine										
Oleaceae	*	*Olea europaea subsp. cuspidata*	African Olive	1	1			30	20				
Phyllanthaceae		*Glochidion ferdinandi*	Cheese Tree										
Pittosporaceae		*Hymenosporum flavum*	Native Frangipani										
Pittosporaceae		*Pittosporum undulatum*	Native Daphne										
Shrubs													
Myrtaceae		*Eucalyptus moluccana*	Grey Box										
Myrtaceae		*Eucalyptus propinqua*	Small-fruited Grey Gum										
Myrtaceae		*Eucalyptus punctata*	Grey Gum										
Myrtaceae		*Eucalyptus siderophloia*	Grey Ironbark										
Myrtaceae		*Eucalyptus tereticornis*	Forest Red Gum			0.75	4						
Myrtaceae		*Eucalyptus umbra*	Broad-leaved White Mahogany										
Myrtaceae		*Leptospermum polygalifolium*	Tantoon										
Myrtaceae		*Leptospermum polygalifolium subsp. cismontanum*	Tantoon										
Myrtaceae		*Melaleuca nodosa*											
Myrtaceae		*Melaleuca styphelioides*	Prickly-leaved Tea Tree										
Myrtaceae		*Rhodamnia rubescens*	Scrub Turpentine										
Ochnaceae	*	*Ochna serrulata*	Mickey Mouse Plant										
Oleaceae		*Jasminum volubile*	Stiff Jasmine										
Oleaceae		*Notelaea longifolia*	Large Mock-olive	1	4			5	20	10	20	2	5
Oleaceae	*	*Olea europaea subsp. cuspidata*	African Olive	0.25	1			35	100	0.5	3	1	5
Phyllanthaceae		*Breynia oblongifolia*	Coffee Bush					0.75	5			2	10
Phyllanthaceae		*Glochidion ferdinandi*	Cheese Tree										
Phyllanthaceae		*Phyllanthus gunnii*	Scrubby Spurge										
Phyllanthaceae		*Phyllanthus hirtellus*											
Pittosporaceae		*Bursaria spinosa*	Blackthorn										
Pittosporaceae		*Hymenosporum flavum*	Native Frangipani										
Pittosporaceae		*Pittosporum multiflorum*	Orange Thorn					1	10	30	100	35	100
Pittosporaceae		*Pittosporum revolutum*	Rough Fruit Pittosporum							0.25	3		
Pittosporaceae		*Pittosporum undulatum*	Sweet Pittosporum	0.25	3			0.25	2	0.25	1	0.25	1
Proteaceae		*Persoonia linearis*	Narrow-leaved Geebung										
Rhamnaceae		*Alphitonia excelsa*	Red Ash										
Rhamnaceae		*Pomaderris discolor*											
Rosaceae	*	*Rosa rubiginosa*	Sweet Briar										
Rutaceae		*Boronia polygalifolia*	Dwarf Boronia										
Rutaceae		*Zieria pilosa*	Pilose-leafed Zieria										
Rutaceae		*Zieria smithii*											
Santalaceae		*Exocarpos cupressiformis*	Cherry Ballart										
Sapindaceae		*Cupaniopsis anacardioides*	Tuckeroo										
Sapindaceae		*Dodonaea triquetra*	Large-leaf Hop-bush										
Solanaceae		*Duboisia myoporoides*	Corkwood										
Solanaceae	*	*Solanum mauritianum*	Wild Tobacco Bush										
Solanaceae		*Solanum stelligerum*	Devil's Needles										
Verbenaceae	*	*Lantana camara*	Lantana	10	20			1	5	2	5	1	2
Violaceae		*Melicytus dentatus*	Tree Violet										
Herbs - Ferns and Allies													
Adiantaceae		*Cheilanthes sieberi*		0.1	10								
Aspleniaceae	P	*Asplenium australasicum*	Bird's Nest Fern										
Blechnaceae		*Blechnum indicum*	Swamp Water Fern										
Blechnaceae		*Doodia aspera*	Prickly Rasp Fern										
Dennstaedtiaceae		*Pteridium esculentum*	Bracken										
Gleicheniaceae	P	*Sticherus flabellatus*	Shiny Fan Fern										
Myrtaceae		*Eucalyptus siderophloia*	Northern Grey Ironbark										

Family	*	Scientific Name	Common Name	78		79		80		81		82	
				C	A	C	A	C	A	C	A	C	A
Pteridaceae		*Adiantum aethiopicum*	Common Maidenhair										
Pteridaceae		*Adiantum hispidulum*	Rough Maidenhair Fern										
Pteridaceae		*Pellaea falcata*	Sickle Fern									0.1	3
Pteridaceae		*Pellaea paradoxa*											
Herbs - Dicots													
Acanthaceae		*Brunoniella australis*	Blue Trumpet					0.1	20	0.1	20	0.1	3
Acanthaceae		*Brunoniella pumilio*	Dwarf Brunoniella										
Acanthaceae		*Pseuderanthemum variabile*	Pastel Flower										
Amaranthaceae		*Alternanthera denticulata*	Lesser Joyweed	0.1	5								
Amaranthaceae	*	*Alternanthera philoxeroides*	Alligator Weed										
Amaranthaceae	*	*Gomphrena celosioides*	Gomphrena Weed										
Apiaceae		*Centella asiatica*	Indian Pennywort	0.1	20								
Apiaceae	*	*Cyclospermum leptophyllum*	Slender Celery										
Apiaceae		*Daucus glochidiatus*	Native Carrot										
Araliaceae	*	*Ageratina adenophora*	Crofton Weed										
Araliaceae		*Hydrocotyle laxiflora*	Stinking Pennywort										
Araliaceae		*Hydrocotyle tripartita*	Pennywort										
Asteraceae	*	*Aster subulatus*	Wild Aster										
Asteraceae	*	*Bidens pilosa*	Cobbler's Pegs										
Asteraceae		*Brachyscome microcarpa*	Forest Daisy									0.1	1
Asteraceae		*Calotis dentex*											
Asteraceae		*Centipeda minima*	Spreading Sneezeweed										
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting										
Asteraceae	*	*Cirsium vulgare*	Spear Thistle										
Asteraceae	*	*Conyza bonariensis*	Flaxleaf Fleabane										
Asteraceae	*	*Conyza sumatrensis*	Tall Fleabane					0.1	1				
Asteraceae		*Cotula australis*	Common Cotula										
Asteraceae	*	*Cotula coronopifolia*	Water Buttons										
Asteraceae		*Enydra woollsii*											
Asteraceae		*Epaltes australis*	Spreading Nut-heads										
Asteraceae		*Euchiton involucratus*	Star Cudweed										
Asteraceae		*Euchiton sphaericus*											
Asteraceae	*	*Facelis retusa*	Annual trampweed										
Asteraceae	*	*Gamochaeta americana*	Cudweed			0.2	100						
Asteraceae	*	*Gamochaeta purpurea*	Purple Cudweed										
Asteraceae	*	*Hypochaeris microcephala*	White Flatweed										
Asteraceae	*	*Hypochaeris radicata*	Catsear			0.1	20						
Asteraceae	*	*Lactuca saligna*	Willow-leaved Lettuce										
Asteraceae		*Lagenophora stipitata*	Blue Bottle-daisy										
Asteraceae		*Pseudognaphalium luteoalbum*	Jersey Cudweed										
Asteraceae	*	*Senecio madagascariensis*	Fireweed	0.1	5	0.3	50						
Asteraceae		*Sigesbeckia orientalis*											
Asteraceae		*Solenogyne bellioides*											
Asteraceae	*	*Soliva anthemifolia*	Button Burweed										
Asteraceae	*	*Soliva sessilis*	Bindyi										
Asteraceae	*	*Sonchus asper*	Prickly Sowthistle										
Asteraceae	*	*Sonchus oleraceus*	Common Sowthistle										
Asteraceae	*	*Taraxacum officinale*	Dandelion			0.1	10						
Asteraceae		*Vernonia cinerea*											
Asteraceae	*	*Xanthium occidentale*	Noogoora Burr										
Brassicaceae	*	*Cardamine hirsuta*	Common Bittercress										
Callitrichaceae	*	*Callitriche stagnalis*	Common Starwort										
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell										
Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell										
Campanulaceae		*Wahlenbergia stricta*	Australian Bluebell										
Caryophyllaceae	*	*Cerastium glomeratum*	Mouse-ear Chickweed										
Caryophyllaceae	*	*Petrorhagia dubia*											
Caryophyllaceae		*Stellaria flaccida*											
Caryophyllaceae	*	*Stellaria media*	Common Chickweed										
Chenopodiaceae	*	*Atriplex prostrata*											
Convolvulaceae		*Dichondra repens*	Kidney Weed										
Crassulaceae		*Crassula sieberiana*	Australian Stonecrop										
Droseraceae		*Drosera peltata*											
Euphorbiaceae		*Chamaesyce drummondii*	Caustic Weed										
Fabaceae (Faboideae)		*Bossiaea prostrata*											
Fabaceae (Faboideae)		*Chorizema parviflorum*	Eastern Flame Pea										
Fabaceae (Faboideae)	*	*Lotus uliginosus*	Birds-foot Trefoil										
Fabaceae (Faboideae)	*	*Medicago polymorpha*	Burr Medic										
Fabaceae (Faboideae)	*	*Trifolium campestre*	Hop Clover										
Fabaceae (Faboideae)	*	*Trifolium repens*	White Clover										
Gentianaceae		*Centaurium tenuiflorum*				0.2	50						
Geraniaceae		*Geranium homeanum*											
Geraniaceae		*Geranium solanderi*	Native Geranium										
Goodeniaceae		*Goodenia hederacea*	Ivy Goodenia										
Goodeniaceae		*Goodenia heterophylla*								0.1	2		
Goodeniaceae		*Goodenia heterophylla subsp. eglandulosa*											
Goodeniaceae		*Goodenia paniculata*											
Haloragaceae		*Gonocarpus tetragynus*											
Haloragaceae		*Gonocarpus teucrioides*	Raspwort										
Hypericaceae		*Hypericum gramineum*	Small St John's Wort			0.1	1						
Hypericaceae		*Hypericum japonicum*											
Hypericaceae	*	*Hypericum perforatum*	St. Johns Wort										
Lamiaceae		*Ajuga australis*	Austral Bugle										
Lamiaceae		*Mentha satureioides*	Creeping Mint										
Lamiaceae		*Plectranthus parviflorus*	Cockspur Flower	0.1	2							0.1	2
Lamiaceae		*Scutellaria humilis*	Dwarf Skullcap										
Lamiaceae	*	*Stachys arvensis*	Stagger Weed										
Linaceae	*	*Linum trigynum*	French Flax										
Lobeliaceae		*Pratia concolor*	Poison Pratia										
Lobeliaceae		*Pratia purpurascens*	Whiteroot	0.1	2								
Malvaceae	*	*Modiola caroliniana*	Red-flowered Mallow										
Malvaceae	*	*Pavonia hastata*											
Malvaceae	*	*Sida rhombifolia*	Paddy's Lucerne										
Myrsinaceae	*	*Lysimachia arvensis*	Scarlet Pimpernel										
Oleaceae	*	*Olea europaea subsp. cuspidata*	African Olive (seedling)					5	5000				
Onagraceae		*Ludwigia peploides subsp. montevidensis*	Water Primrose										
Orobanchaceae	*	*Parentucellia latifolia*	Red Batisia										
Oxalidaceae	*	*Oxalis comiculata*											
Oxalidaceae		*Oxalis perennans*											
Phyllanthaceae		*Phyllanthus hirtellus*	Thyme Spurge										
Phyllanthaceae		*Phyllanthus similis*											
Phyllanthaceae		*Phyllanthus virgatus*											
Phyllanthaceae		*Poranthera microphylla*											
Phytolaccaceae	*	*Phytolacca octandra*	Inkweed										
Plantaginaceae		*Plantago debilis*				0.1	10						
Plantaginaceae		*Plantago gaudichaudii*	Narrow Plantain										

Family	*	Scientific Name	Common Name	78		79		80		81		82	
				C	A	C	A	C	A	C	A	C	A
Plantaginaceae	*	*Plantago lanceolata*	Lamb's Tongues			0.1	20						
Plantaginaceae	*	*Plantago major*	Large Plantain										
Plantaginaceae		*Plantago myosuros*											
Plantaginaceae	*	*Veronica arvensis*	Wall Speedwell										
Plantaginaceae		*Veronica plebeia*	Trailing Speedwell									0.1	1
Polygalaceae		*Polygala japonica*	Dwarf Milkwort										
Polygonaceae		*Persicaria decipiens*	Slender Knotweed	0.1	2								
Polygonaceae		*Persicaria hydropiper*	Water Pepper										
Polygonaceae		*Persicaria strigosa*	Spotted Knotweed										
Polygonaceae	*	*Polygonum aviculare*	Wireweed										
Polygonaceae		*Rumex brownii*	Swamp Dock										
Polygonaceae	*	*Rumex crispus*	Curled Dock										
Pontederiaceae	*	*Eichhornia crassipes*	Water Hyacinth										
Portulacaceae		*Calandrinia pickeringii*											
Portulacaceae		*Portulaca oleracea*	Pigweed										
Proteaceae		*Persoonia linearis*	Narrow-leaved Geebung (seedling)			0.1	1						
Ranunculaceae		*Ranunculus inundatus*	River Buttercup										
Ranunculaceae		*Ranunculus lappaceus*	Common Buttercup										
Ranunculaceae		*Ranunculus plebeius*	Forest Buttercup										
Ranunculaceae	*	*Ranunculus sceleratus*	Celery Buttercup										
Ranunculaceae		*Ranunculus sessiliflous*	Small-flowered Buttercup										
Rhamnaceae		*Alphitonia excelsa*	Red Ash										
Rosaceae		*Acaena echinata*											
Rubiaceae		*Asperula conferta*	Common Woodruff										
Rubiaceae		*Galium binifolium*											
Rubiaceae		*Opercularia diphylla*											
Rubiaceae		*Pomax umbellata*											
Rubiaceae	*	*Richardia brasiliensis*	White Eye										
Rubiaceae	*	*Richardia stellaris*											
Rutaceae		*Boronia polygalifolia*	Dwarf Boronia										
Scrophulariaceae		*Eremophila debilis*	Winter Apple										
Solanaceae	*	*Solanum americanum*											
Solanaceae		*Solanum brownii*	Violet Nightshade										
Solanaceae	*	*Solanum mauritianum*	Wild Tobacco Bush										
Solanaceae	*	*Solanum nigrum*	Black-berry Nightshade										
Solanaceae		*Solanum prinophyllum*	Forest Nightshade										
Stackhousiaceae		*Stackhousia viminea*	Slender Stackhousia										
Stylidiaceae		*Stylidium graminifolium*	Grass Trigger-plant										
Verbenaceae	*	*Verbena bonariensis*	Purpletop	0.3	5								
Verbenaceae	*	*Verbena officinalis*	Common Verbena			0.4	20						
Verbenaceae	*	*Verbena rigida*	Veined Verbena										
Violaceae		*Hybanthus monopetalus*	Slender Violet-bush										
Violaceae		*Hybanthus stellaroides*		0.1	1								
Violaceae		*Viola hederacea*	Ivy-leaved Violet										
Herbs - Climbers													
Apocynaceae		*Marsdenia flavescens*	Hairy Milk Vine										
Apocynaceae		*Marsdenia suaveolens*	Scented Marsdenia										
Apocynaceae		*Parsonsia straminea*	Common Silkpod	0.3	2					1	20		
Apocynaceae		*Tylophora barbata*	Bearded Tylophora										
Bignoniaceae		*Pandorea pandorana*	Wonga Wonga Vine					0.1	2	0.1	10		
Convolvulaceae		*Convolvulus erubescens*	Blushing Bindweed										
Convolvulaceae		*Polymeria calycina*											
Dilleniaceae		*Hibbertia scandens*	Climbing Guinea Flower										
Dioscoreaceae		*Dioscorea transversa*	Native Yam										
Fabaceae (Faboideae)		*Desmodium brachypodum*	Large Tick-trefoil										
Fabaceae (Faboideae)		*Desmodium gunnii*	Slender Tick Trefoil							0.1	5	0.1	1
Fabaceae (Faboideae)		*Desmodium rhytidophyllum*										0.1	1
Fabaceae (Faboideae)		*Desmodium varians*	Slender Tick-trefoil										
Fabaceae (Faboideae)		*Glycine clandestina*											
Fabaceae (Faboideae)		*Glycine microphylla*	Small-leaf Glycine	0.1	5					0.1	10	0.1	2
Fabaceae (Faboideae)		*Glycine tabacina*		0.2	50								
Fabaceae (Faboideae)		*Hardenbergia violacea*	False Sarsaparilla										
Fabaceae (Faboideae)		*Kennedia rubicunda*	Dusky Coral Pea										
Fabaceae (Faboideae)		*Podolobium scandens*	Netted Shaggy Pea										
Fabaceae (Faboideae)		*Zornia dyctiocarpa*	Zornia										
Loranthaceae		*Amyema congener subsp. congener*	Variable Mistletoe										
Luzuriagaceae		*Eustrephus latifolius*	Wombat Berry	0.3	10			0.5	20	0.3	10	0.2	10
Luzuriagaceae		*Geitonoplesium cymosum*	Scrambling Lily	0.5	10			0.2	10	0.3	10	0.2	10
Menispermaceae		*Sarcopetalum harveyanum*	Pearl Vine										
Menispermaceae		*Stephania japonica*	Snake Vine										
Oleaceae		*Jasminum volubile*	Stiff Jasmine	0.1	1			0.4	5	1	20	2	20
Pittosporaceae		*Billardiera scandens*	Hairy Apple Berry	0.2	10							0.1	5
Ranunculaceae		*Clematis aristata*	Old Man's Beard							0.2	1		
Ranunculaceae		*Clematis glycinoides*	Headache Vine									0.25	1
Rosaceae	*	*Rubus fruticosus sp. aggregate*	Blackberry										
Rosaceae		*Rubus parvifolius*	Native Raspberry	0.1	1					0.1	2	0.1	1
Rubiaceae		*Morinda jasminoides*	Sweet Morinda										
Smilacaceae		*Smilax australis*	Lawyer Vine										
Smilacaceae		*Smilax glyciphylla*	Sweet Sarsaparilla										
Vitaceae		*Cayratia clematidea*	Native Grape					0.1	5	0.25	20	0.1	1
Vitaceae		*Cissus antarctica*	Kangaroo Vine									0.5	1
Vitaceae		*Clematicissus opaca*	Pepper Vine					0.2	10	0.1	10	0.1	5
Vitaceae		*Tetrastigma nitens*											
Herbs - Monocots (Grasses)													
Poaceae	*	*Andropogon virginicus*	Whisky Grass			0.3	20						
Poaceae	*	*Anthoxanthum odoratum*	Sweet Vernal Grass										
Poaceae		*Aristida ramosa*	Purple Wiregrass			0.1	5						
Poaceae		*Aristida sp.*											
Poaceae		*Aristida vagans*	Threeawn Speargrass	1	100								
Poaceae	*	*Axonopus fissifolius*	Narrow-leafed Carpet Grass	0.1	10	35	3000						
Poaceae		*Bothriochloa decipiens*	Red Grass										
Poaceae		*Bothriochloa macra*	Red Grass										
Poaceae	*	*Briza maxima*	Shaking Grass										
Poaceae	*	*Briza minor*	Shivery Grass			0.1	10						
Poaceae	*	*Briza subaristata*				1	100						
Poaceae	*	*Bromus catharticus*	Prairie Grass										
Poaceae	*	*Bromus hordeaceus*	Soft Brome										
Poaceae	*	*Chloris gayana*	Rhodes Grass										
Poaceae		*Chloris truncata*	Windmill Grass										
Poaceae		*Cymbopogon refractus*	Barbed Wire Grass	2	100					5	500	5	500
Poaceae		*Cynodon dactylon*	Couch	5	500	30	3500						
Poaceae	*	*Dactylis glomerata*	Cocksfoot										
Poaceae		*Dichelachne micrantha*	Shorthair Plumegrass	0.1	10	0.1	10					0.1	20
Poaceae		*Dichelachne rara*											
Poaceae		*Digitaria diffusa*	Open Summer-grass										
Poaceae		*Digitaria parviflora*	Small-flowered Finger Grass										
Poaceae	*	*Digitaria sanguinalis*	Crab Grass										
Poaceae		*Echinopogon caespitosus*	Bushy Hedgehog-grass	0.1	5								
Poaceae		*Echinopogon ovatus*	Forest Hedgehog Grass	5	500					0.1	10		
Poaceae	*	*Ehrharta erecta*	Panic Veldtgrass										

cumberland ecology

Family	*	Scientific Name	Common Name	78		79		80		81		82	
				C	A	C	A	C	A	C	A	C	A
Poaceae		*Entolasia marginata*	Bordered Panic	2	200								
Poaceae		*Entolasia stricta*	Wiry Panic	0.2	20					1	100	0.1	10
Poaceae		*Eragrostis brownii*	Brown's Lovegrass										
Poaceae	*	*Eragrostis curvula*	African Lovegrass										
Poaceae		*Eragrostis leptostachya*	Drooping Lovegrass			0.1	10						
Poaceae	*	*Hyparrhenia hirta*	Coolatai Grass										
Poaceae		*Imperata cylindrica*	Blady Grass	1	100			0.5	50	5	500	5	100
Poaceae		*Lachnagrostis aemula*	Blown Grass										
Poaceae		*Lachnagrostis filiformis*											
Poaceae	*	*Lolium perenne*	Perennial Ryegrass										
Poaceae		*Microlaena stipoides*	Weeping Grass			30	300						
Poaceae		*Oplismenus aemulus*		1	100					0.5	100	0.1	1
Poaceae		*Oplismenus imbecillis*						5	500				
Poaceae		*Panicum effusum*	Hairy Panic										
Poaceae		*Panicum simile*	Two-colour Panic										
Poaceae		*Paspalidium distans*											
Poaceae	*	*Paspalum dilatatum*	Paspalum	0.1	2								
Poaceae		*Paspalum distichum*	Water Couch										
Poaceae	*	*Pennisetum clandestinum*	Kikuyu Grass										
Poaceae	*	*Phalaris minor*	Lesser Canary Grass										
Poaceae		*Poa affinis*											
Poaceae	*	*Poa annua*	Winter Grass										
Poaceae		*Poa labillardierei*	Tussock										
Poaceae		*Poa sieberiana*		1	100	2	100			10	500	5	500
Poaceae	*	*Polypogon monspeliensis*	Bearded Grass										
Poaceae		*Rytidosperma caespitosum*	Ringed Wallaby Grass										
Poaceae		*Rytidosperma fulvum*	Wallaby Grass										
Poaceae		*Rytidosperma racemosum*											
Poaceae		*Rytidosperma sp.*											
Poaceae		*Rytidosperma tenuis*		5	500								
Poaceae		*Sacciolepis indica*	Indian Cupscale Grass										
Poaceae	*	*Setaria parviflora*		0.1	10								
Poaceae	*	*Setaria sphacelata*	South African Pigeon Grass										
Poaceae	*	*Sporobolus africanus*	Parramatta Grass										
Poaceae		*Sporobolus creber*	Western Rat-tail Grass			1	100						
Poaceae		*Sporobolus elongatus*	Slender Rat's Tail Grass										
Poaceae		*Themeda triandra*	Kangaroo Grass										
Poaceae	*	*Vulpia bromoides*	Squirrel Tail Fescue										
Herbs - Monocots (Other)													
Anthericaceae		*Arthropodium milleflorum*	Pale Vanilla-lily										
Anthericaceae		*Arthropodium minus*											
Anthericaceae		*Arthropodium sp. B*		0.1	4							0.1	1
Anthericaceae		*Caesia parviflora*	Pale Grass-lily										
Anthericaceae		*Dichopogon fimbriatus*	Nodding Chocolate Lily										
Anthericaceae		*Dichopogon strictus*	Chocolate Lily										
Anthericaceae		*Laxmannia gracilis*	Slender Wire Lily										
Anthericaceae		*Tricoryne elatior*	Yellow Autumn-lily										
Araceae		*Gymnostachys anceps*	Settlers' Twine									0.25	1
Colchicaceae		*Wurmbea dioica*	Early Nancy										
Commelinaceae		*Commelina cyanea*		0.5	20					0.1	2	0.1	1
Commelinaceae		*Murdannia graminea*	Grass Lily										
Cyperaceae		*Carex appressa*	Tall Sedge	5	200								
Cyperaceae		*Carex inversa*		0.1	20								
Cyperaceae		*Carex longebrachiata*											
Cyperaceae	*	*Cyperus brevifolius*	Mullumbimby Couch										
Cyperaceae		*Cyperus difformis*											
Cyperaceae	*	*Cyperus eragrostis*	Umbrella Sedge	0.1	1								
Cyperaceae		*Cyperus gracilis*	Slender Flat-sedge										
Cyperaceae		*Cyperus laevis*		0.1	2								
Cyperaceae		*Cyperus polystachyos*											
Cyperaceae	*	*Cyperus sesquiflorus*											
Cyperaceae		*Cyperus sp.*											
Cyperaceae		*Eleocharis cylindrostachys*		0.2	20								
Cyperaceae		*Fimbristylis dichotoma*	Common Fringe-sedge										
Cyperaceae		*Isolepis cernua*	Nodding Club-rush										
Cyperaceae	*	*Isolepis levynsiana*											
Cyperaceae	*	*Isolepis producta*											
Cyperaceae	*	*Isolepis prolifera*											
Cyperaceae		*Lepidosperma laterale*											
Cyperaceae		*Lepidosperma neesii*											
Cyperaceae		*Pillothrix deusta*											
Cyperaceae		*Schoenoplectus validus*											
Cyperaceae		*Schoenus apogon*	Common Bog-rush										
Cyperaceae		*Scleria mackaviensis*											
Hypoxidaceae		*Hypoxis hygrometrica*	Golden Weather-grass										
Iridaceae	*	*Herbertia lahue*											
Iridaceae	*	*Herbertia lahue subsp. caerulea*											
Iridaceae		*Patersonia longifolia*	Purple Flag										
Iridaceae	*	*Romulea rosea*	Onion Grass			0.25	100						
Iridaceae	*	*Sisyrinchium rosulatum*	Sourweed										
Juncaceae	*	*Juncus acutiflorus*											
Juncaceae	*	*Juncus acutus*	Sharp Rush										
Juncaceae		*Juncus bufonius*	Toad Rush										
Juncaceae	*	*Juncus cognatus*				0.1	5						
Juncaceae		*Juncus homalocaulis*											
Juncaceae		*Juncus planifolius*											
Juncaceae		*Juncus sp.*											
Juncaceae		*Juncus usitatus*		4	400	0.2	20						
Juncaginaceae		*Triglochin procera*	Water Ribbons										
Lomandraceae		*Lomandra confertifolia*	Mat-rush										
Lomandraceae		*Lomandra filiformis*	Wattle Mat-rush										
Lomandraceae		*Lomandra*											
Lomandraceae		*Lomandra*	Wattle Mat-rush	1	100			0.5	100	5	500	5	100
Lomandraceae		*Lomandra glauca*	Pale Mat-rush										
Lomandraceae		*Lomandra longifolia*	Spiny-headed Mat-rush									0.25	1
Lomandraceae		*Lomandra multiflora*	Many-flowered Mat-rush					0.1	2	0.2	5	0.25	5
Lomandraceae		*Lomandra obliqua*											
Orchidaceae		*Acianthus fornicatus*	Pixie Caps										
Orchidaceae		*Chiloglottis reflexa*											
Orchidaceae		*Corybas pruinosus*	Toothed Helmet Orchid										
Orchidaceae		*Microtis parviflora*	Slender Onion Orchid										
Orchidaceae		*Microtis unifolia*											
Phormiaceae		*Dianella caerulea var. caerulea*	Blue Flax-lily										
Phormiaceae		*Dianella caerulea var. producta*								0.25	4	0.25	3
Phormiaceae		*Dianella longifolia*											
Phormiaceae		*Dianella longifolia var. longifolia*	Blueberry Lily										
Phormiaceae		*Dianella revoluta*	Blueberry Lily										
Typhaceae		*Typha orientalis*	Broadleaf Cumbungi										
Xanthorrhoeaceae		*Xanthorrhoea latifolia subsp.*											
Xanthorrhoeaceae		*Xanthorrhoea macronema*											

Key:

Family	*	Scientific Name	Common Name	78		79		80		81		82	
				C	A	C	A	C	A	C	A	C	A

1 is <5% - Rare (usually just 1 plant in the plot)
2 is <5% - uncommon (a couple of plants in the plot)
3 is <5% - Common
4 is <5% - Very Common (lots of plants but below 5% coverage)
5 is 5-25% coverage
6 is 26-50% coverage
7 is 51-75% coverage
8 is 76-100% coverage

Appendix B

Floristic Data

Appendix B Floristic Data (BBAM)

PlotName	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	Easting	Northing	Zone
Q1	15	0	0	0	0	0	25.3	0	1	0	383353.0002	383353.0002	56
Q2	6	7.5	0	10	0	0	32.6	2	1	5	383001.9994	383001.9994	56
Q3	12	24	17	0	0	14	23.3	0	1	36	383232.0007	383232.0007	56
Q4	11	18	5	60	0	26	0	1	1	57	382936.9974	382936.9974	56
Q5	6	0	0	0	0	0	22.6	0	1	1	382895.0013	382895.0013	56
Q6	42	32	2	64	10	42	2.3	1	0.95	76	383246.0022	383246.0022	56
Q7	42	45	0	60	0	20	1.3	3	0.95	43	383920.001	383920.001	56
Q8	31	53	0	78	2	44	2	0	0.5	16	385329.0014	385329.0014	56
Q9	36	49	8	62	4	4	0	3	0.95	23.5	385816.9987	385816.9987	56
Q10	11	8	2	24	0	2	30	1	1	4	383094.996	383094.996	56
Q11	8	3.5	0	56	2	38	12.6	2	1	7	382803.0024	382803.0024	56
Q12	11	1	13.5	24	0	6	26	4	0.5	20	383035.997	383035.997	56
Q13	44	55	23	82	34	70	22.3	1	0.95	21	384048.999	384048.999	56
Q14	41	47	15	80	24	46	15.6	1	0.95	0	384118.9979	384118.9979	56
Q15	26	70	2	60	0	8	1.3	4	0.95	8	384944.0029	384944.0029	56
Q16	38	80	74	82	16	54	4	0	0.73	0	385156.0036	385156.0036	56
Q17	35	83	52	36	10	72	0.6	1	0.73	61	385168.0013	385168.0013	56
Q18	29	67	75.5	46	44	74	0	3	0.73	77	385167.0035	385167.0035	56
Q19	42	51	3	56	4	20	9.3	1	0.95	25	385347.0021	385347.0021	56
Q20	45	56	11	68	10	42	9.3	2	0.95	12	385469.9971	385469.9971	56
Q21	39	25	0	28	6	12	0	1	0.93	29	386362.9973	386362.9973	56
Q22	43	45	11	72	4	30	0	0	0.93	23	386713.9981	386713.9981	56
Q23	41	45.5	19	60	32	78	14.3	0	0.73	34	386065.0007	386065.0007	56
Q24	43	42	2	88	12	22	0	0	0.73	10	386049.0038	386049.0038	56
Q25	37	51	20	66	20	50	9.3	1	0.73	4	386142.0004	386142.0004	56
Q26	38	42	0	66	4	20	0	1	0.93	14	386789.0023	386789.0023	56
Q27	43	48	4	76	28	70	3.3	0	0.95	90	386554.004	386554.004	56
Q28	39	27	0	94	2	12	0	0	0.67	79	386526.0011	386526.0011	56
Q29	38	12.5	0	96	2	12	0.6	0	0.95	56	386485.0028	386485.0028	56
Q30	40	36	0	94	8	12	0.6	0	0.95	49	386332.0011	386332.0011	56
Q31	41	34	1	84	12	28	0.6	0	0.95	19	386837.0014	386837.0014	56
Q32	19	0	0	32	0	8	32	0	0	0	386474.0028	386474.0028	56
Q33	18	0	0	26	0	4	33.33	0	1	0	385812.0017	385812.0017	56
Q34	59	42.5	2	68	8	30	5.33	1	0.93	7.7	386331.0034	386331.0034	56
Q35	39	7	27	74	0	26	22.67	1	1	0	385932.0035	385932.0035	56
Q36	50	16.5	6	52	16	18	0	0	0.95	27.5	386203.0032	386203.0032	56
Q37	45	30	20.2	26	8	46	0.67	2	0.73	44.5	386145.9996	386145.9996	56
Q38	69	23	3	62	8	36	0.67	2	0.95	20	385604.998	385604.998	56
Q39	11	1	13.5	24	0	6	26	4	1	20	383228.9992	383228.9992	56
Q40	47	10	6	66	8	28	5.33	0	0.75	63	383068.6505	383068.6505	56
Q41	56	9.5	0.5	70	10	16	2.67	0	0.6	6	383188.0009	383188.0009	56
Q42	9	0	0	8	0	6	33.33	0	1	0	384648.9996	384648.9996	56
Q43	54	10.5	6.5	68	14	16	0	0	0.67	52.5	386361.9995	386361.9995	56
Q44	49	8.5	16	56	4	6	0	0	0.67	39	386541.9981	386541.9981	56
Q45	13	0	0	0	0	80	6.67	0	0.5	0	385344.0006	385344.0006	56
Q46	57	9.5	62.5	10	26	48	0	0	0.73	40	385307.0015	385307.0015	56
Q47	9	0	0	12	0	16	33.33	0	0	0	386265.0037	386265.0037	56
Q48	12	0	0	8	4	12	33.33	0	0	0	386439.997	386439.997	56
Q49	36	0	0	88	0	18	20.67	0	1	0	386408.0031	386408.0031	56
Q50	32	0	0	100	4	30	18.67	0	1	0	386474.0028	386474.0028	56
Q51	13	0	0	8	0	16	33.33	0	0	0	386669.0006	386669.0006	56
Q52	43	8.5	19	70	0	44	8.67	2	1	3.4	385685.997	385685.997	56
Q53	31	19.5	5	68	4	26	24.67	1	1	7	385762.9967	385762.9967	56
Q54	71	62	1.5	16	2	34	0	0	0.73	25.5	386304.996	386304.996	56
Q55	46	63	7	14	0	28	0	0	0.73	36	386243.0037	386243.0037	56
Q56	22	8	0	22	0	2	28.67	0	0.83	0	386270.0006	386270.0006	56
Q57	16	0	0	14	0	6	30	0	0.83	0	386196.0024	386196.0024	56
Q58	16	0	0	0	0	8	33.33	0	0.83	0	386132.9959	386132.9959	56
Q59	30	17	0	18	0	10	28	0	1	0	385556.999	385556.999	56
Q60	18	4.5	0	30	0	6	29.33	0	1	0	385517.9961	385517.9961	56
Q61	51	35.5	2	54	0	42	10	1	0.95	14	383667.002	383667.002	56
Q62	53	59	7	24	28	74	2.67	3	0.95	48.5	386691.9982	386691.9982	56
Q63	41	48.5	1	48	10	62	22.67	1	0.6	31	383422.0015	383422.0015	56
Q64	44	28.5	6.5	58	4	26	0	0	0.95	25	387156.9979	387156.9979	56
Q65	66	38.5	6.5	62	22	40	0.67	0	0.95	82.5	386461.9969	386461.9969	56
Q66	43	28	26	82	14	38	0	1	0.93	7.5	386964.0039	386964.0039	56
Q67	44	43.5	20	82	2	32	0.67	0	0.95	4	387475.9966	387475.9966	56
Q68	42	42.5	14.5	60	6	22	0	0	0.95	18	387167.0001	387167.0001	56
Q69	53	36	1	60	0	62	16	2	0.6	55	383052.9999	383052.9999	56
Q70	10	0	0	0	0	26	33.33	0	0	0	383317.9966	383317.9966	56
Q71	55	42.5	7.5	88	2	56	2.67	1	0.95	51	383286.0028	383286.0028	56
Q72	42	26.5	10	50	2	28	19.33	2	0.95	23	383448.9984	383448.9984	56
Q73	50	35	2.5	70	0	76	8.67	0	0.95	73	383668.9975	383668.9975	56
Q74	68	16.5	2.5	70	8	94	16	1	0.95	92	383891.9981	383891.9981	56
Q75	51	25.5	19	16	34	78	1.33	0	0.95	43	384362.003	384362.003	56
Q76	12	0	0	56	0	0	33.33	0	1	0	385970.0003	385970.0003	56
Q77	32	18	3.5	0	0	42	24	0	0.95	21	383988.4614	383988.4614	56
Q78	46	5.7	9	0	0	22	50	0	0.95	14	383977.7641	383977.7641	56
Q79	14	0	0	42	0	2	84	0	1	0	386033.5497	386033.5497	56
Q80	27	8.5	0	0	26	10	30	0	0.95	52	384316.948	384316.948	56
Q81	39	22	3	16	16	28	30	0	0.95	74	384726.9626	384726.9626	56
Q82	46	19	2.5	24	42	4	0	0	0.95	60	384985.5178	384985.5178	56

Appendix C

Fauna Species List

Appendix C Fauna Species List

Family	Common Name	Scientific Name	TSC Act	EPBC Act	Exotic Species	Method
Aves						
Acanthizidae	Striated Thornbill	*Acanthiza lineata*				S/H
Acanthizidae	Brown Thornbill	*Acanthiza pusilla*				S/H
Acanthizidae	White-throated Gerygone	*Gerygone olivacea*				S
Accipitridae	Wedge-tailed Eagle	*Aquila audax*				S
Accipitridae	White-bellied Sea-Eagle	*Haliaeetus leucogaster*	V	Ma, Mi		S
Accipitridae	Whistling Kite	*Haliastur sphenurus*				FO
Aegothelidae	Australian Owlet-nightjar	*Aegotheles cristatus*				S
Alcedinidae	Laughing Kookaburra	*Dacelo novaeguineae*				S
Anatidae	Pacific Black Duck	*Anas superciliosa*				S
Ardeidae	Cattle Egret	*Ardea ibis*				FO
Artamidae	White-breasted Woodswallow	*Artamus leucorynchus*				S/H
Artamidae	Pied Butcherbird	*Cracticus nigrogularis*				S
Artamidae	Australian Magpie	*Cracticus tibicen*				S/H
Artamidae	Grey Butcherbird	*Cracticus torquatus*				S/H
Cacatuidae	Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*				FO
Campephagidae	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*				S/H
Charadriidae	Black-fronted Dotterel	*Elseyornis melanops*				S
Charadriidae	Masked Lapwing	*Vanellus miles*				S/H
Climacteridae	White-throated Treecreeper	*Cormobates leucophaea*				S/H
Columbidae	Wonga pigeon	*Leucosarcia picata*				IR
Corcoracidae	White-winged Chough	*Corcorax melanorhamphos*				S/H
Corvidae	Australian Raven	*Corvus coronoides*				FO, IR
Dicaeidae	Mistletoebird	*Dicaeum hirundinaceum*				S, H, FO
Estrildidae	Red-browed Finch	*Neochmia temporalis*				S/H
Hirundinidae	Welcome Swallow	*Hirundo neoxena*				S/H
Maluridae	Superb Fairy-wren	*Malurus cyaneus*				S/H
Meliphagidae	Eastern Spinebill	*Acanthorhynchus tenuirostris*				S
Meliphagidae	Yellow-faced Honeyeater	*Lichenostomus chrysops*				S/H
Meliphagidae	Noisy Miner	*Manorina melanocephala*				S/H
Meliphagidae	Lewin's Honeyeater	*Meliphaga lewinii*				S/H
Monarchidae	Magpie-lark	*Grallina cyanoleuca*				IR
Oriolidae	Olive-backed Oriole	*Oriolus sagittatus*				H
Pachycephalidae	Golden Whistler	*Pachycephala pectoralis*				S
Pardalotidae	Spotted Pardalote	*Pardalotus punctatus*				H
Petroicidae	Eastern Yellow Robin	*Eopsaltria australis*				S
Podargidae	Tawny Frogmouth	*Podargus strigoides*				S
Pomatostomidae	Grey-crowned Babbler	*Pomatostomus temporalis temporalis*	V			S/H
Psittacidae	Musk Lorikeet	*Glossopsitta concinna*				FO
Psittacidae	Crimson Rosella	*Platycercus elegans*				S/H
Psittacidae	Eastern Rosella	*Platycercus eximius*				H
Psittacidae	Rainbow Lorikeet	*Trichoglossus haematodus*				FO
Psophodidae	Eastern Whipbird	*Psophodes olivaceus*				H
Rhipiduridae	Grey Fantail	*Rhipidura albiscapa*				S/H
Rhipiduridae	Willie Wagtail	*Rhipidura leucophrys*				H
Strigidae	Powerful Owl	*Ninox strenua*	V			S
Threskiornithidae	Australian White Ibis	*Threskiornis molucca*				IR
Amphibia						
Hylidae	Broad-palmed Frog	*Litoria latopalmata*				S
Hylidae	Eastern Sedge-frog	*Litoria fallax*				S/H
Hylidae	Peron's Tree Frog	*Litoria peronii*				S/H
Hylidae	Striped Rocket Frog	*Litoria nasuta*				S
Myobatrachidae	Common Froglet	*Crinia signifera*				S
Myobatrachidae	Striped Marsh Frog	*Limnodynastes peronii*				S
Mammalia						
Bovidae	Domestic Cow	*Bos taurus*			*	S
Bovidae	Feral Goat	*Capra aegagrus hircus*			*	S
Canidae	European Red Fox	*Vulpes vulpes*			*	S, IR
Cervidae	Fallow Deer	*Dama dama*			*	IR
Dasyuridae	Brown Antechinus	*Antechinus stuartii*				IR
Dasyuridae	Brush-tailed Phascogale	*Phascogale tapoatafa*	V			IR
Equidae	Horse	*Equus ferus caballus*			*	S
Leporidae	European Hare	*Lepus europaeus*			*	S, IR
Leporidae	Feral Rabbit	*Oryctolagus cuniculus*			*	S
Macropodidae	Eastern Grey Kangaroo	*Macropus giganteus*				S, IR
Macropodidae	Red-necked wallaby	*Macropus rufogriseus*				S
Macropodidae	Swamp Wallaby	*Wallabia bicolor*				IR
Molossidae	White-striped Freetail Bat	*Austronomus australis*				BT
Molossidae	East-coast Freetail-bat	*Mormopterus norfolkensis*				BT
Molossidae	Southern Freetail-bat	*Mormopterus planiceps*				BT
Molossidae	Eastern Freetail-bat	*Mormopterus ridei*				BT
Petauridae	Sugar Glider	*Petaurus breviceps*				S
Phalangeridae	Common Brushtail Possum	*Trichosurus vulpecula*				IR, S
Phascolarctidae	Koala	*Phascolarctos cinereus*	V	V		S
Pseudocheiridae	Common Ringtail Possum	*Pseudocheirus peregrinus*				IR
Pteropodidae	Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V		S
Rhinolophidae	Eastern Horseshoe Bat	*Rhinolophus megaphyllus*				BT
Tachyglossidae	Short-beaked Echinda	*Tachyglossus aculeatus*				IR
Vespertilionidae	Gould's Wattled Bat	*Chalinolobus gouldii*				BT
Vespertilionidae	Chocolate Wattled Bat	*Chalinolobus morio*				BT*
Vespertilionidae	Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V			BT*
Vespertilionidae	Little Bentwing-bat	*Miniopterus australis*	V			BT
Vespertilionidae	Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	V			BT
Vespertilionidae	Southern Myotis	*Myotis macropus*	V			BT*
Vespertilionidae	Nyctophilis sp.	*Nyctophilus sp.*				BT
Vespertilionidae	Greater Broad-nosed Bat	*Scoteanax rueppellii*	V			BT*
Vespertilionidae	Eastern Broad-nosed Bat	*Scotorepens orion*				BT
Vespertilionidae	Eastern Forest Bat	*Vespadelus pumilus*				BT
Vespertilionidae	Eastern Cave Bat	*Vespadelus troughtoni*	V			BT*
Vespertilionidae	Little Forest Bat	*Vespadelus vulturnus*				BT*
Reptilia						
Chelidae	Eastern Long-necked Turtle	*Chelodina longicollis*				S, IR
Elapidae	Red-bellied Black Snake	*Pseudechis porphyriacus*				IR
Varanidae	Goanna	*Varanus varius*				IR

V = Vulnerable
Ma = Marine
Mi = Migratory
IR = IR Camera
S = Seen
H = Heard
FO = Fly-over
BT = Bat Detector
* = potentially occurring microbat species

Appendix G

BioLink (2019a,b,c)

Kings Hill Koala Habitat Assessment

Report to Kings Hill Developments

November 2018

(Updated October, 2019)

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Summary

The management of koalas across the Port Stephens Local Government Area is notionally guided by an approved Comprehensive Koala Plan of Management. With a view to updating this over-arching document, several studies relating to koala distribution, abundance and habitat were conducted in 2016-17 to update ecological knowledge. Amongst the output from these studies was revised koala habitat mapping, tentative identification of several contemporary local koala source populations or 'hubs', and the creation of a monitoring overlay for the Local Government Area. One such potential hub was identified in the general area of Kings Hill, vegetation communities in the locality also mapped as koala habitat given the presence of the preferred koala food tree (PKFT) species forest red gum (*Eucalyptus tereticornis*), grey gum (*E. punctata* and associated species), grey box (*E. moluccana*) and tallowwood (*E. microcorys*); isolated specimens of another PKFT – swamp mahogany (*E. robusta*) also occur around the periphery of a lowland wetland in the west of the site.

This project investigated aspects of koala distribution and abundance in those parts of the Kings Hill koala population hub owned by Kings Hill Developments to assist future management and planning. Koala activity was assessed using Spot Assessment Technique (SAT) methodology at 23 primary field sites at 500 m intervals, the resulting occupancy model further refined by infill activity / tree-use data from a further 21 field sites to effectively create a more refined, 350 m offset sampling grid overlay, with each associated 12.25 ha grid-cell coded in terms low, medium and high use as defined by SAT methodology, the latter two categories identifying areas occupied by resident koala populations. A koala density / population estimate was derived by undertaking a direct count of koalas within fixed-radius and east-west transect searches at each primary field site.

Collectively, evidence of koalas was recorded in 23 of the 44 sampled sites, wherein koala activity ranged from 3.33% – 90.00%. Thirteen of the 23 active field sites qualified as 'Medium' or 'High Use' koala activity and thus indicated habitat use by resident koala populations across approximately 30% of the area surveyed. Transect searches yielded a koala density estimate of approximately 0.05 koalas ha^{-1} across the area covered by the field survey program, which in turn informed a population estimate for the 539ha area of equivalent habitat covered by the field survey program of approximately 27 koalas.

Short to medium-term koala management within the Kings Hill Urban Release Area will ideally need to adopt a precautionary and staged approach to demonstrate that impacts are effectively minimised at all stages of the development process. The relatively large home range sizes required by individual koalas in naturally occurring, low density populations present a number of logistical and ecological challenges, not the least of which are accommodating landscape-scale occupancy and connectivity considerations, retention of a widely dispersed food resource, minimising threatening processes such as vehicle-strike and domestic dog encounters, while also planning to minimise impacts arising from stochastic events such as fire. Guidelines to assist longer-term, demonstrably

sustainable koala management outcomes on lands owned by Kings Hill Developments include the following:

- maintaining no less than a 30% occupancy status[1] of habitat being utilised by koalas throughout the development process, while at the same time ensuring that adequate linkages and habitat areas are maintained to assist ongoing processes of recruitment and dispersal;
- a concept of no net reduction in the area of koala habitat as a consequence of development within that area of the Kings Hill Urban Release Area owned by Kings Hill Developments; amongst other things this will require a site-focussed offset strategy to compensate for the loss of areas of preferred koala habitat to development;
- maintain or improve the overall carrying capacity of retained habitat / linkage areas by way of enrichment planting with preferred koala food trees, and
- In the absence of a koala friendly development landscape, the segregation / encapsulation of development precincts from koala habitat areas and linkages by way of the effective use of proven infrastructure such as exclusion fencing, koala-grids and underpasses.

In order to better understand the impacts on koalas within those areas that are zoned for residential development, a stadia-metric survey of PKFTs ≥ 300 mm DBH is also advocated, while a koala habitat restoration program focussed on the wetland area in the west of the site is considered to offer the greatest potential for offsetting site-based impacts.

[1] In order to meet the specified level of no less than 30%, the guideline envisages that at least 13 of the 44 sites referred to in the report will always need to have significant activity levels recorded (*i.e*. 10% activity or greater) at any one point in time.

1. Introduction

The management of koalas across the Port Stephens Local Government Area (PS LGA) is notionally guided by the Port Stephens Comprehensive Koala Plan of Management (PS-CKPoM) (Port Stephens Council 2002). Notwithstanding the statutory aspects and utility of this overarching document, new approaches and techniques have been developed over the period since the PS-CKPoM was adopted. These approaches and techniques can assist with the identification and classification of koala habitat, and help to better inform landscape-scale koala habitat and population assessments, and associated planning considerations.

As part of further informing the PS-CKPoM, a series of studies enabling a better understanding of changes in koala distribution, abundance and habitat use across the PS LGA over time were initiated by Port Stephens Council (PSC) in 2016. Amongst the output from these studies (Biolink 2016a, 2017, 2018) were a revised list of preferred koala food tree (PKFT) species, updated koala habitat mapping, the tentative identification of several contemporary local source populations or 'hubs', and the creation of a LGA-wide monitoring overlay comprising sampling points at 1 km intervals.

Following recommendations in the initial Biolink (2016a) report, a koala occupancy assessment based on the recommended monitoring overlay was conducted in 2017. Among other things, koala habitat mapping criteria was reviewed and updated across the PS LGA, based on differences in the type and relative abundance of an expanded list of PKFTs. PKFTs are a statically discrete suite of Eucalypts that occur in two ecological forms: 'primary' PKFTs are those species that express levels of utilisation by koalas that are independent of density and/or size class (Phillips *et al.* 2000 refers). Conversely, 'secondary' PKFTs are those that express levels of utilisation by koalas that are density and/or size-class dependent (Phillips and Callaghan 2000 refers). Primary PKFTs typically occur on high-nutrient substrates, while Secondary PKFTs typically occur on low-nutrient substrates. The Kings Hill site is – for the most part - located on low-nutrient substrates, and because of this, koala habitat is mostly comprised of species that function as Secondary PKFTs including forest red gum (*E. tereticornis*), grey gum[2] (*E. punctata*), grey box (*E. moluccana*) and tallowwood (*E. microcorys*). A localised area of potential Primary / Secondary (Class A) koala habitat characterised by the presence of swamp mahogany (*E. robusta*) occurs peripheral to the wetland area in the west of the site. Further details of the overall revision / mapping process are detailed in Biolink (2016a, 2017).

Based on the preceding considerations, the following habitat classifications apply to the process of identifying areas of Preferred Koala Habitat (PKH) across the Kings Hill Urban Release Area (KHURA):

- **Primary Koala habitat** - forest and/or woodland communities, groups or types occurring on soils of medium to high nutrient value whereupon the tallest stratum is dominated or co-dominated by Primary PKFTs.

[2] Includes closely related species *E. propinqua, E. canaliculata, E. biturbinata*.

- **Secondary (Class A) Koala Habitat** - forest and/or woodland communities, groups or types occurring on soils of medium to high nutrient value whereupon Primary PKFTs are sub-dominant or only occasional components of the tallest stratum species.
- **Secondary (Class B) Koala Habitat –** forest and/or woodland communities, groups or types occurring on soils of low to medium nutrient value whereupon Primary PKFTs are absent, the tallest stratum instead dominated or co-dominated by Secondary PKFTs >300 mm diameter at breast height (DBH).
- **Secondary (Class C) / Marginal Koala Habitat** – forest and/or woodland communities, groups or types occurring on soils of low to medium nutrient value whereupon Primary PKFTs are absent and Secondary PKFTs >300 mm DBH are sub-dominant or only occasional components of the tallest stratum species.

The Kings Hill koala population 'hub' was tentatively identified on the basis of habitat considerations and the presence of a road-kill cluster at the intersection of Italia Road and the Pacific Highway to the north of the KHURA, in addition to the results of recent ecological assessments relating to the Eagleton Quarry to the south which reported sightings of koalas and the presence significant koala activity[3] (Kleinfelder 2016). The presence of a hub was again alluded to by the results of an Optimized Generational Persistence Assessment (Biolink 2018). Bounded by the Balickera Canal and Italia Road in the north, the full extent of this hub extends to the former Irrawang Spillway in the south and thereafter all forested lands in the area bounded by the Williams River in the west and the Pacific Highway in the east. The Kings Hill koala population hub has a consolidated[4] habitat area of at least 1,300 ha which includes approximately 280 ha of vegetation cover associated with an embedded rural-residential subdivision. Presuming this latter area to be a local population 'sink' on the basis of the high probability of domestic dog encounters, at least 1000 ha remains, an area only marginally above the 900 ha identified by Biolink (2018) as necessary to sustain the minimum effective 'hub' population size of 50 individuals.

1.1. Project objectives

The greater proportion of the southern parts of the Kings Hill koala hub are owned by Kings Hill Developments (KHD), with much of this area zoned as **General Residential** (R2) as part of the KHURA. The intent of this project was to conduct field assessments to achieve the following objectives:

a) Investigate the status of the Kings Hill koala hub identified in Biolink (2016a, 2017),
b) Determine the extent of PKH utilisation / occupancy by koalas in the Kings Hill area with a primary emphasis on land owned by KHD, and

[3] As defined by SAT methodology and when correctly interpreted in terms of east coast (low) activity level thresholds

[4] A core area of relatively intact habitat with minimal fragmentation.

c) Provide guidelines for future management and planning on KHD-owned land.

2. Methodology

2.1. Study area

The study area was confined to land owned by KHD, which makes up a large portion of the southern half of the Kings Hill koala hub identified in the earlier work by Biolink (2017) (**Figure 1**).

2.2. Field survey

Aerial imagery of the study area was overlain with a 500 m x 500 m point-based grid, each point becoming a primary sampling point where it occurred within an area of eucalyptus woodland / forest (**Figure 1**). This grid in turn was locked onto the 1 km LGA-wide sampling grid overlay originally created for PSC and so enabled the sampling of a further five of PSC's permanent koala monitoring points (B_001, B_002, B_004, B_005 and B_009).

Infill sites centrally located between each set of four 500 m primary sites were added in order to further refine the direction and extent of koala activity resulting from the primary field site assessments. This approach results in a higher resolution, offset 350 m[5] grid (12.25 ha equivalent habitat area) for sampling / modelling purposes.

Universal Transverse Mercator (UTM) coordinates were determined for each corresponding point and uploaded into hand-held GPS to enable location in the field.

[5] Precise distance = 353.55 m

Figure 1. Location of the study area and KHD owned land (shown in white). Refer to **Appendix A** for specific site survey data. White squares represent permanent Port Stephens Council koala monitoring points.

Once located, koala activity[6] at each field site was measured using the SAT protocols of Phillips & Callaghan (2011). In order to enable a koala density / population estimate to be derived, a direct count of koalas was also conducted within a 25 m (0.196 ha) fixed-radius search focused around the center tree at each sampled primary site, as well as within a larger 250 m x 40 m (1 ha) east-west transect.

Given the widespread occurrence of PKFTs such as grey gum and grey box which are otherwise indicative of low-nutrient / low koala carrying capacity landscapes, koala activity across the Kings Hill site was interpreted in terms of the East Coast (low) population density level of utilisation as defined by Phillips & Callaghan (2011). **Table 1** details the koala activity threshold parameters that are applicable, both Medium (normal) and High use sites indicative of Core Koala Habitat as defined for the purposes of *State Environmental Planning Policy No. 44* (SEPP 44).

Table 1 Categorisations of koala activity based on use of mean activity level ± 99% confidence intervals. Activity levels in the Medium (normal) and High use range for East Coast (low) activity categories indicates occupancy by resident koala populations (Source: modified from Table 2 in Phillips and Callaghan 2011).

Activity category	Low use	Medium (normal) use	High use
East Coast (low)	< 9.97%	≥ 9.97% but ≤ 12.59%	> 12.59%

2.3. Data analysis

Central tendency measures were initially utilised to describe variation in koala activity levels across the study area, with proportional breakdowns of activity expressed on a cell by cell basis in terms of **Table 1**.

[6] Koala activity (%) is determined based on the number of trees with koala pellets and the number of trees sampled at the site (maximum 30 trees). For example, three (3) positive trees out of 30 sampled trees would yield a 10% activity level.

3. Results

Twenty-three primary sites were initially assessed between 19th – 26th February 2018 to effectively sample an equivalent habitat area of 575 ha (23 x 25 ha). Twenty-one infill sites were assessed over the period 3rd – 15th September 2019. Collectively, these 44 sites function to inform a revised equivalent habitat area of 539 ha.

3.1. Koala habitat

A total of 1264 trees were inspected, comprising at least eleven species from the Genus *Eucalyptus*. Spotted gum *Corymbia maculata* and white mahogany's *E. acmenoides / E. umbra* were the most commonly sampled tree species. **Table 2** details the tree species sampled during the field survey.

3.2. Koala habitat utilisation

Collectively, evidence of koalas was recorded at 23 of the 44 sampled field sites, an outcome which translates to an overall habitat utilisation estimate for koalas across the area covered by our field survey of 52.27% ± 8.00% (SE) of the available habitat. Koala activity at the 23 positive sites ranged from 3.33% – 90.00% (Mean activity level [active sites only]: 14.24% ± 3.79% (SE)) (**Appendix 1**).

Koala activity was recorded at four of the five LGA-wide monitoring sites (B_001, B_002, B_004 and B_005).

Table 2 List of tree species recorded during the field survey. Trees sampled = the total number recorded for each species; No. sites = the number of sites each species was recorded at.

Species	Common name	Trees sampled	No. sites
E. acmenoides / E. umbra	White mahogany	263	26
E. tereticornis	Forest red gum	124	22
E. siderophloia / E. crebra / E. fibrosa	Ironbark	150	34
E. moluccana	Grey box	82	10
E. punctata / E. propinqua / E. canaliculata	Grey gum	77	22
E. globoidea and allied species	Stringy barks	40	7
E. microcorys	Tallowwood	6	2
Corymbia maculata	Spotted gum	401	40
Angophora costata	Smooth-barked apple	17	3
Allocasuarina spp.	na	26	4
Melaleuca spp / M. stypheloides / M. nodosa	na / prickly-leaved tea tree / paperbark)	64	10
Corymbia intermedia / C. gummifera	Pink / red bloodwood	10	3
Callistemon salignus	Willow bottlebrush	1	1
Rainforest spp.	na	3	3

3.3. Koala activity and meta-population

Activity data from 13 of the 44 sampled field sites qualified as 'Medium' or 'High' use when considered in terms of the significant activity thresholds detailed in **Table 1.** This result in turn indicates that approximately 30% of the sampled habitat within the study area was supporting resident koala populations (*i.e*. core koala habitat) over the period of the assessment. The resulting distribution of koala activity when considered in terms of the original 500 m x 500 m grid cells that were sampled, as well as that resulting from the more refined 350 m x 350 m grid cells is illustrated in **Figure 2**, with a breakdown of results on a site by site basis detailed in **Appendix 1**. Three areas supporting resident koala aggregations/population cells (*i.e*. medium and/or high use cells) are identified in **Figure 2,** the native vegetation occurring therein is thus Core Koala Habitat as defined by SEPP No 44.

During the initial survey, no koalas were recorded within the 4.51 ha sampled by the 23 x 25 m (0.196 ha) fixed-radius searches. One koala was recorded within the 21-ha sampled by the transect searches to yield a coarse koala density estimate of 0.048 ± 0.04 (SE) koalas ha^{-1} within the area covered by the field survey. This in turn yields an unrefined population estimate for the area of approximately 27 koalas.

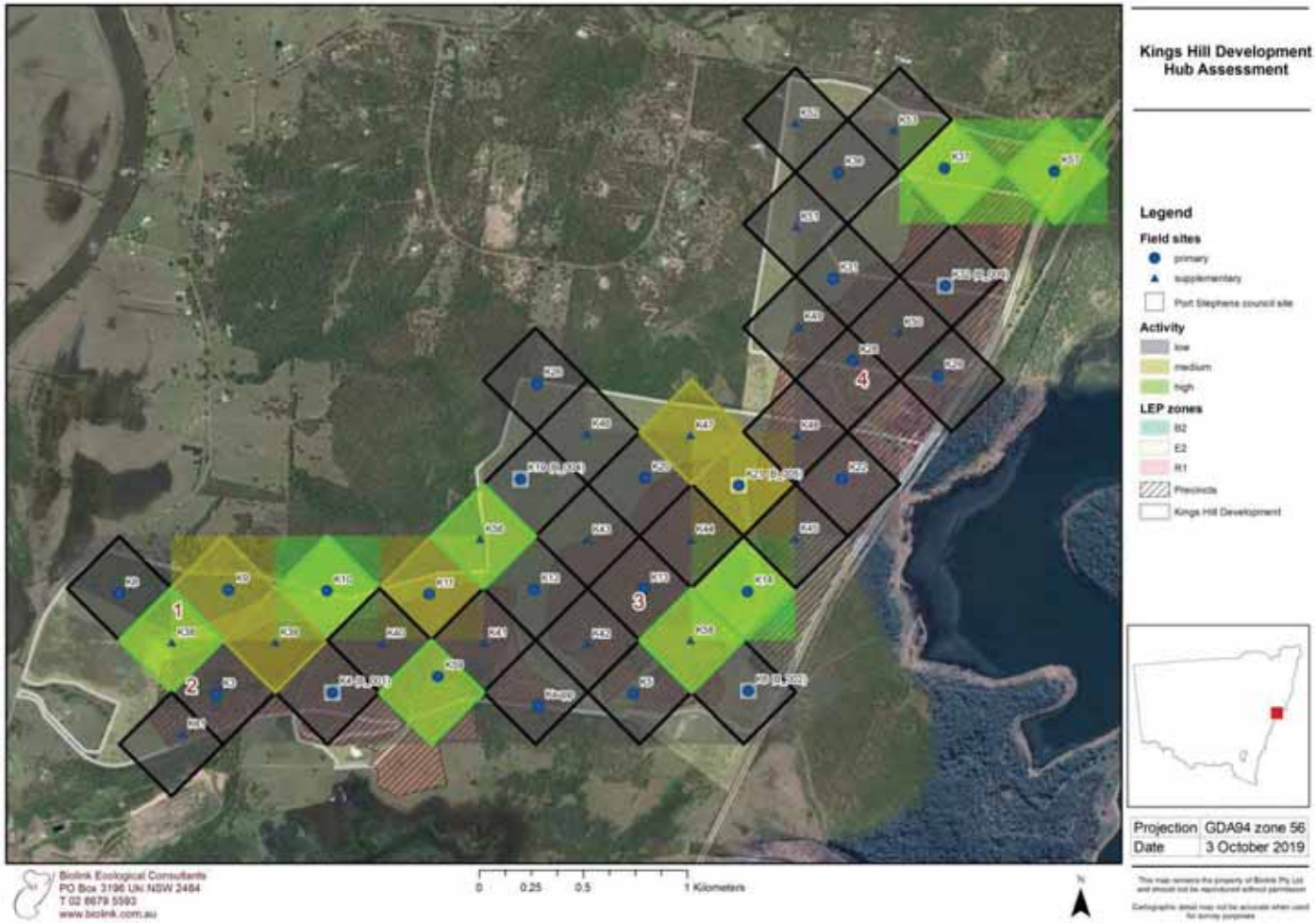

Figure 2 Field survey grids at both 500 m and 350 m (offset) scales of resolution, coded in terms of low, medium and high use by koalas in accord with activity thresholds prescribed by Phillips and Callaghan (2011). Vegetation occurring in cells coded as medium and/or high use are those being utilised by resident koala populations.

4. Discussion

The study area covered by the field survey program detailed in this report occupies approximately 50% of currently available koala habitat that otherwise comprises the Kings Hill koala population hub. Results imply the presence of at least three resident aggregations making use of lands owned by KHD. That no new areas of koala activity were identified by the sampling of infill sites confirms matters of site fidelity by resident population cells as well as the temporal persistence and capacity of faecal pellet evidence to consistently identify such areas by repeat sampling. Activity by one of these aggregations is loosely focused on an **Environmental Conservation** (E2) zoned area in the south-eastern extent of the site alongside the Pacific Highway. The second confirmed aggregation, or part thereof, is present in the north-eastern corner of the property near the intersection of Six Mile Road and the Pacific Highway and occurs on lands zoned E2 and R1. The proximity of significant koala activity along the southern edge of Six Mile Road implies continuity of this aggregation to the north into associated habitat areas extending northwards to Italia Road.

Our data further implies that a large spread of significant activity also occurs immediately adjacent to the north-western boundary of the KHD property (lands owned by Hunter Land). The southern extent of this aggregation on KHD lands thus appears to be peripheral and primarily contained within the existing E2 zone. While the presence of significant koala activity in the north (towards Italia Road) was expected based on earlier assessments by Kleinfelder (2016), the locations of significant koala activity to the west of lands owned by KHD represents new knowledge of relevance to longer-term hub management.

The density estimate obtained by this project (0.05 koalas ha^{-1}), while coarse, is generally consistent with those obtained from similar habitat types in other areas. Wilmot *et al*. (2019) reported a spotlighting-informed density estimate of 0.08 koalas ha^{-1} from Secondary B/C koala habitat in Wollondilly/Picton, while transformed radio-tracking data from koalas in the Campbelltown area to the north returned a similar density estimate of 0.06 koalas ha^{-1} for koalas in Secondary B/C koala habitat (Biolink 2016b).

The broader Kings Hill hub is likely to exceed the minimum population size of 50 koalas and available habitat of > 900 ha that satisfactorily meets the requirements to constitute an active hub / local source population for long-term management purposes (see concept below from Biolink 2018). Low density populations are arguably more vulnerable because of the larger home range sizes being utilised by individual animals require animals to spend more time on ground traveling between food trees, making them more susceptible to vehicle-strike, domestic dog attack and misadventure. For these reasons they require more stringent management measures than those applied to other populations.

"Presence of area of high-quality[7] Preferred Koala Habitat (PKH) sufficient in size so as to be capable of independently sustaining one or more breeding aggregations / resident populations, the minimum size of which was determined as 50 individuals. In habitat areas comprised of Plant Community Types identified as Primary and Secondary A PKH types this implies a minimum area of interconnected habitat of approx. 200 ha[8]. In areas of Secondary B/C habitat this implies minimum area of interconnected habitat patches wherein connected area of approx. 900 ha[9]."

5. Management Guidelines

Based on current LEP zoning of the study area, three main land-uses are permissible within the KHURA as follows: (1) **E2 - Environmental Conservation**; (2) **R1 - General Residential**; and (3) **B2 - Local Centre**. **Figure 3** details the LEP zoning overlayed with the resulting activity contours, within which we have identified the four associated development precincts presently zoned **R1** (pink outline). It is apparent from **Figure 3** that realisation of a development outcome within Precincts 1 – 4 will collectively result in the loss of a relatively large area (~ 155 - 185 ha) of native vegetation, some of which, based on the results of this study, is currently being utilised by resident koalas. A brief summary of the outcomes of this study in terms of the planning / land use zoning context follows:

- The southwestern extent of the study area comprises areas zoned R1 (Precincts 1 & 2 in **Figure 2**), the extent of which extends onto land not being the property of KHD. While this latter area was not assessed this project, activity levels along the KHD boundary that separates the two properties indicate that a substantive area of significant koala activity is likely to be present in this area. This should be confirmed as part of the wider King's Hill hub assessment in order to guide any future planning and management in this area. In addition, two significant cells are present across the western extent of the study area, and in which are all connected via a series of low-use (transient) and medium-use sites.
- The riparian corridor that bisects Precincts 3 and 4 is currently zoned E2. Field assessments indicate that a resident koala aggregation persists in this area, which also serves an important connectivity function, including access by koalas to the south where the former Irrawang Spillway offers some potential[10] for facilitating east-west connectivity for koalas and other wildlife beneath the Pacific Highway. Regardless of the occupancy status, this north-south corridor could be designed specifically for the movement of koalas and other wildlife.
- Part of Precinct 4 currently supports significant koala activity that is likely to be the southern extent of a resident aggregation that spreads north towards the Quarry. As with Precinct 1, areas

[7] Presence of Primary PKFTS > 100 mm dbh and/or Secondary PKFTs > 300 mm DBH.
[8] Calculation based on 50% habitat occupancy rate and an unbiased koala density estimate of 0.5 koalas ha^{-1}
[9] Calculation based on 50% habitat occupancy rate and unbiased /female home-range corrected koala density estimate of 0.05 koalas ha^{-1}
[10] Subject to modifications enabling access and utility by koalas.

inside the 10% activity contour that occurs on KHD lands should be protected from negative impact until further information becomes available regarding the capacity of the broader hub to absorb negative impacts that may arise from development.

Careful planning will be required across the lands owned by KHD and others if development is to occur without having a significant impact on the long-term population viability of the Kings Hill koala hub. To this end the following guidelines are proposed as a means of stimulating further discussions, while also laying the groundwork for a demonstrably sustainable planning outcome:

1. Notwithstanding stochastic or otherwise unforeseen impacts, development should strive to maintain a koala occupancy level of no less than 30% of the available habitat throughout the development process, while at the same time ensuring that adequate linkages and habitat areas are maintained to assist ongoing processes of recruitment and dispersal;
2. Ideally, that area inside the 10% activity contours that occurs on KHD lands should be protected from negative impact to the maximum extent possible or until such time as further information becomes available regarding the capacity of the broader hub to absorb negative impacts that may arise from development.
3. Development should adopt the objective of no long-term, net reduction in the extent of koala habitat that occurs within that part of the KHURA owned by KHD; this will require a focussed offset strategy to compensate for the loss of areas of PKH from the site, as well as ensuring that connectivity is maintained with other adjoining habitat areas;
4. Interim koala management measures should aim to maintain or improve the overall carrying capacity of retained habitat / linkage areas by way of enrichment planting with PKFTs, and
5. In the absence of a koala friendly development landscape, there should be a segregation of development precincts from koala habitat areas and linkages by way of effective use of wildlife management infrastructure such as exclusion fencing, koala-grids and underpasses.

A planning response that embodies a commitment to preceding guidelines and details the precise measures by which they will be achieved should ideally follow. To this end a stadia-metric survey of PKFTs ≥ 300 mm DBH is also advocated In order to better understand the impacts on koalas within those areas that are zoned for residential development, while a koala habitat restoration program focussed on the wetland area in the west of the site is considered to offer the greatest potential for offsetting site-based impacts.

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Appendix 1 – Field site data

Site No	Easting	Northing	Faecal pellet	PKFT present	Activity level (%)
Primary sites					
K3	383591	6378581	✓	*E. punctata or E. propinqua / E. tereticornis*	3.33
K4 (B_001)	384151	6378589	✓	*E. punctata or E. propinqua / E. tereticornis*	3.33
K5	385596	6378585	✓	*E. tereticornis / E. moluccana*	3.33
K6 (B_002)	386151	6378598	✓	*E. punctata or E. propinqua / E. tereticornis / E. moluccana*	6.67
K8	383123	6379065	×	*E. tereticornis*	0.00
K9	383653	6379084	✓	*E. punctata or E. propinqua / E. tereticornis*	10.00
K10	384125	6379078	✓	*E. tereticornis*	13.33
K11	384617	6379063	✓	*E. tereticornis*	10.00
K12	385121	6379084	✓	*E. punctata or E. propinqua*	6.67
K13	385647	6379088	✓	*E. punctata or E. propinqua*	6.67
K14	386147	6379075	✓	*E. punctata or E. propinqua / E. microcorys*	30.00
K19 (B_004)	385056	6379615	✓	*E. tereticornis*	3.33
K20	385654	6379621	×	*E. punctata or E. propinqua / E. tereticornis*	0.00
K21 (B_005)	386105	6379585	✓	*E. punctata or E. propinqua*	10.00
K22	386600	6379617	×	*E. punctata or E. propinqua / E. moluccana*	0.00
K26	385135	6380074	×	*E. punctata or E. propinqua*	0.00
K28	386652	6380184	×	*E. punctata or E. propinqua*	0.00
K29	387061	6380111	×	*E. punctata or E. propinqua / E. moluccana*	0.00
K31	386557	6380579	×	*E. punctata or E. propinqua*	0.00
K32 (B_009)	387097	6380544	×	*E. punctata or E. propinqua*	0.00
K36	386582	6381088	×	*E. tereticornis*	0.00
K37	387093	6381108	✓	*E. tereticornis*	33.33
Ksupp	385141	6378526	×	*E. moluccana*	0.00
Infill sites					
K38	383380	6378831	✓	*E. tereticornis (E. punctata ~50 m)*	20.00
K39	383877	6378831	✓	*No PKFTs (E. tereticornis / E. punctata or E. propinqua ~50 m)*	10.00
K40	384388	6378827	✓	*E. propinqua*	3.33

K41	384878	6378830	×	*E. tereticornis (E. punctata ~50 m)*	0.00
K42	385376	6378825	✓	*E. moluccana / E. punctate (E. tereticornis ~50 m)*	3.33
K43	385377	6379326	×	*E. punctata*	0.00
K44	385874	6379327	×	*E. propinqua*	0.00
K45	386374	6379331	×	*E. punctata / E. propinqua / E. moluccana*	0.00
K46	385376	6379834	×	*E. tereticornis*	0.00
K47	385872	6379827	✓	*E. moluccana*	10.00
K48	386378	6379826	×	*No PKFTs (E. punctata or E. propinqua ~100 m)*	0.00
K49	386395	6380349	×	*E. punctata or E. propinqua*	0.00
K50	386875	6380324	✓	*No PKFTs (E. punctata or E. propinqua ~50 m)*	6.67
K51	386379	6380829	×	*No PKFTs (E tereticornis ~50 m)*	0.00
K52	386376	6381327	×	*E. tereticornis*	0.00
K53	386850	6381292	×	*E. punctata / E tereticornis*	0.00
K56	384862	6379328	✓	*E. punctata (E. microcorys ~100 m)*	20.83
K57	387621	6381094	✓	*E. tereticornis / E.moluccana*	13.33
K58	385873	6378841	✓	*E. tereticornis / E.moluccana*	16.67
K59	384658	6378667	✓	*E. tereticornis*	90.00
K61	383432	6378392	×	*E. tereticornis*	0.00

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16th December 2019

Dear Mark

RE: Kings Hill Developments (KHD): Offsetting Advice.

This document has been prepared in response to a request for offsetting advice based on the potential impact on koalas within the designated development footprint across KHD-owned lands (herein referred to as the 'KHD lands'). Please note that this advice replaces that provided earlier (27th November, 2019) which was based on a now superseded development footprint. We appreciate being provided with the detail afforded us by the amended development footprint[1], consideration of which has resulted in several changes to our original offsetting advice.

On-site offsetting metrics

Based on field assessments conducted by Biolink across 2018-19 (Biolink 2019), it was estimated that resident koalas occupy approximately 30% (13 of 44 sites) of the area surveyed across KHD lands. At the request of KHD, each survey site was subsequently centered within an offset 350 m x 350 m grid-cell series (12.49 ha)[2] which was then assigned a measure of activity based on field survey results[3] (i.e. low, medium or high as defined by Phillips and Callaghan (2011). Grid-cells assigned medium or high activity scores reflect areas occupied by resident koalas. Further spatial interrogation of these data identified 39 grid-cells with a corresponding field survey site that was either within or intersected with what is now the amended development impact footprint across KHD lands. Of the total amount of vegetation within the amended development impact footprint (~220 ha), the intersected 39 grid-cells collectively capture 205.21 ha (**Table 1**).

The Port Stephens Council vegetation mapping layer utilised for this project was developed as a compilation of the Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS) vegetation mapping projects (NPWS 2000, Eco Logical Australia 2003) progressively

[1] JW Planning (provided December 2019)
[2] 350 m x 350 grid cell survey design used by Biolink (2019) to conduct field assessments using the Spot Assessment Technique (SAT) (Phillips and Callaghan 2011).
[3] Faecal pellet searches following the SAT protocols.

modified by other studies such as Bell and Driscoll (2006), Bell (2009) and Biolink (2017) amongst others.

Of the 205.21 ha of vegetation that is located within the identified development footprint and survey grid-cells, 53.29 ha from 13 grid-cells is coded for significant koala activity (**Table 1**), thus indicating occupancy (*i.e*. the presence of Core Koala Habitat) by resident koalas of 25.97% of available habitat.

Table 1. Field data from 39 grid-cells that intersect with the development footprint across KHD lands. The total mapped vegetation in hectares for each grid-cell shown, with the total and proportion within the development footprint. Koala activity resulting from field surveys (Biolink 2019) is shown to illustrate areas of significant habitat use by resident koalas (medium-high activity shaded light brown).

Site / Grid Cell	Total vegetation (ha)	Vegetation (ha) within development precinct	Proportion (%) total vegetation within development precinct	Koala activity
K3	11.30	10.21	90.36	Low
K4	11.77	9.24	78.51	Low
K5	6.80	4.83	71.02	Low
K6	6.24	1.44	23.08	Low
K8	10.99	7.86	71.50	Low
K9	12.34	7.46	60.42	Medium
K10	12.50	0.01	0.10	High
K11	12.50	5.38	43.04	Medium
K12	12.50	3.44	27.50	Low
K13	12.32	12.32	100.00	Low
K14	11.49	6.82	59.37	High
K20	12.50	2.41	19.27	Low
K21	12.50	4.18	33.40	High
K22	2.25	2.24	99.23	Low
K28	8.56	3.35	39.13	Low
K29	7.61	2.86	37.63	Low
K31	12.50	3.69	29.54	Low
K32	12.31	4.01	32.58	Low
K37	12.50	5.39	43.16	High
K38	9.93	5.71	57.56	High
K39	12.37	8.60	69.51	Medium
K40	12.50	10.15	81.21	Low
K41	12.18	9.85	80.85	Low
K42	11.90	9.35	78.59	Low

K43	12.50	5.85	46.80	Low
K44	12.50	12.50	100.00	Low
K45	8.14	4.64	57.05	Low
K46	12.50	0.11	0.88	Low
K47	11.69	0.71	6.09	High
K48	9.52	7.35	77.16	Low
K49	11.61	4.09	35.23	Low
K50	12.50	11.69	93.56	Low
K53	11.43	0.37	3.23	Low
K56	12.50	0.26	2.10	High
K57	9.10	4.73	52.00	High
K58	7.63	6.76	88.57	High
K59	5.91	4.75	80.36	High
K61	11.56	3.55	30.73	Low
Ksupp	8.62	1.83	21.21	Low
Totals	**418.08**	**205.21**	**49.08**	

Refinement of offsetting metrics

Preferred Koala Food Tree species (PKFTs) present across the development footprint include species[4] that are otherwise classed as 'secondary' PKFTs, and which express levels of utilisation by koalas that are density and/or size-class dependent (Phillips and Callaghan 2000). Further research indicates that there is an approximately 50% probability (100% utilisation) of koala faecal pellets occurring within 100 cm of the base of any PKFT > 300 mm DBH (Phillips and Wallis 2016). This knowledge places emphasis on the presence of PKFTs of this size as primary determinants of potential / preferred koala habitat.

A stadia metric survey was undertaken across the development footprint to map the number and extent of PKFTs >300 mm DBH[5], and thus enabling the potential impacts to be quantified in terms of estimating habitat loss and to further refine on-site offsetting metrics.

To estimate the extent of mapped vegetation not considered to be potential / preferred koala habitat by virtue of containing no PKFTS > 300 mm DBH, a series of polygons were created by Mark Aitkens (RPS Group) within the development footprint. These polygons were then refined using the following criteria:

[4] *Eucalyptus tereticornis* (forest red gum), *E. moluccana* (grey box), *E. microcorys* (tallowwood) and *E. punctata* (incl. associated species collectively referred to as 'grey gums').
[5] Stadia metric survey conducted by Mark Aitkens (RPS Group)

- The area comprising each polygon aligned with vegetation that was mapped using initial offsetting metric calculations, and
- A 10 m buffer applied around each of the mapped 4,617 PKFTs to reflect an estimated (upper-level) canopy drip line[6].

Summarising the preceding information, an estimated area of ~ 68 ha mapped vegetation was considered to not be potential / preferred koala habitat. As a result, a total of ~ 152 ha[7] of koala habitat is envisioned to be lost to the development footprint. Using the density estimate of 0.048 ± 0.04 (SE) koalas ha^{-1} calculated for KHD lands by Biolink (2019), it can be estimated that ~ eight koalas (nee 7.3) will be impacted to varying degrees as a result of clearing activities within the identified development precincts. Most of these animals will be located at higher density within grid-cells coded as areas of medium – high use (see **Table 1** and refer Biolink 2019 for grid-cell locations).

Offsetting calculations

To argue no long-term, net reduction in the extent of koala carrying capacity and occupancy across KHD lands, we would recommend that on-site offsetting should ideally plan to compensate for the displacement of a minimum of eight koalas. Applying the same rationale as that used to calculate the minimum habitat equivalents required to support and identify koala source populations or 'hubs', offsetting requirements can be calculated using 'Minimum Numbers Habitat Equivalents (MNHE)' as detailed in (Phillips *et al*. 2017).

The carrying capacity of koala habitat varies across the landscape, this reflecting habitat quality which can be measured in terms of the abundance of PKFTs. Primary PKFTs display preferential use by koalas that is significantly higher than other congeners, and with utilisation that is independent of size class (Phillips *et al*. 2000). Conversely, while secondary PKFT also display a level of use that is significantly higher than other congeners, its utilisation model is typically size-class dependent (Phillips and Callaghan 2000). Habitat areas that occur on soils of medium to high nutrient value (e.g. sandy, alluvial) typically support primary PKFTs (with resultant koala habitat categories of Primary and Secondary (Class A) habitat types that can support an average density of 0.3 koalas ha^{-1} (Phillips *et al*. 2017). On the KHD lands, the potential for these habitat types to occur or be created is restricted to a small wetland area in the southwest of the site. This area provides an opportunity for establishing high-carrying capacity koala habitat using the following primary PKFTs for offset planting:

- *E. robusta* (swamp mahogany) and/or
- *E. tereticornis* (forest red gum), and/or
- *E. microcorys* (tallowwood).

[6] Canopy drip lines were not recorded; however, based on field observations a 10 m buffer was considered sufficient to account for most (if not all) PKFTs on site (Biolink *pers. obs.*).
[7] 220 ha mapped vegetation minus 68 ha void of PKFTs > 300 mm DBH

Conversely, habitat areas that occur on soils with low-medium nutrient value (e.g. sandstone, rocky, uplifted meta-sediments) comprise secondary PKFTs. These areas have a lower carrying capacity and support an average density of 0.05 koalas ha^{-1}, giving rise to koala habitat categories of Secondary Class B and/or Secondary Class C habitat types that occur over the greater proportion of the KHD lands. KHD lands is – for the most part - located on low-nutrient substrates, and because of this, the following secondary PKFTs would be suitable for offset planting:

- *E punctata* (grey gum[8]),
- *E. moluccana (grey box) and/or,*
- *E. microcorys* (tallowwood)[9].

Given the preceding metrics and by way of hypothetical example, in order to compensate for the displacement of a minimum of eight koalas, offsetting requirements on KHD lands might include:

- Recreation of 10 ha of a Primary or Secondary Class A habitat based on a density of 0.3 koalas ha^{-1} (MNHE = three koalas), and
- 100 ha of Secondary Class B or C habitat based on a density of 0.05 koalas ha^{-1} (MNEH = five koalas), or
- Any combination of the above sufficient to satisfy the minimum displacement value of eight koalas.

Notionally, and in terms of occupancy, the offsetting requirement should be demonstrably satisfied[10] prior to the commencement of development activity and specifically the removal of koala habitat.

Offset timeframes[11]

Immediate planting of ~10 ha of Primary or Secondary Class A habitat prior to Phase 1 of the site works (1-3 years) will provide the most effective compensation for the proposed initial loss (75.88 ha). Site works should be prioritised so that areas identified as being occupied by resident koalas are cleared during the final phases to facilitate the transition of occupancy.

Immediate / early planting of the remaining offset requirements (Secondary Class B or C habitat) are also recommended, and would best compensate the final two Phases of the site works when achieved this way. This will provide >3 years establishment prior to the second Phase of site works (48.71 ha); and >8 years of establishment prior to the final, and largest Phase of site works (87.55 ha).

[8] Includes closely related species *E. propinqua and E. canaliculata*.
[9] *E. microcorys* can function as a primary or secondary PKFT.
[10] Ratio of occupied to unoccupied habitat of approximately 1:3.
[11] Refer details in Species Impact Statement (prepared by RPS Group) regarding site works phasing and timeframes

Minimising offsetting

There are opportunities that can be pursued which would reduce the number of displaced koalas, and subsequently the extent of required offsetting. These include:

1. Refinement of development precinct boundaries

Using the stadia-metric survey of PKFTs > 300 mm DBH, boundaries of the development precincts could be further refined in order to retain higher quality and/or denser areas of PKFTs.

2. Koala-friendly development precincts

The designation of one or more of the development precincts as koala-friendly could be achieved by integrating retention of PKFTs and associated koala management needs into urban design outcomes. Ideally, such areas would be positioned in areas that are adjacent to, or between zoned Environmental Precincts to maximise connectivity. A designated koala friendly development precinct would work to minimise the potential for anthropogenic mortality by way of a priori maximising PKFT tree retention (stadia metric survey infers) and placing a prohibition on the keeping and carriage of domestic dogs, supported by effective use of wildlife management infrastructure such as traffic calming devices (e.g. chicanes, speed bumps).

Please don't hesitate to contact the undersigned if you require any further information.

Yours Sincerely

Dr. Grant Brearley
Senior Ecologist

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29th November 2019

Dear Mark

RE: Kings Hill Developments (KHD): Infrastructure Advice.

This advice has been prepared in response to a request for infrastructure detail enforcing the principles of enclaving in so much as this relates to each of the identified development precincts that occur across lands owned by KHD. The intent of enclaving in areas of koala habitat is to effectively segregate / partition areas of development such that they are no longer accessible to koalas, thus reducing any associated threats such as domestic dog attack, vehicle-strike and/or misadventure. Given the current vegetated landscape that occurs within envisioned development precincts on KHD lands, there is also a need to accommodated egress from such areas of koalas that may have part or all of their respective home range areas within the development precincts. This advice thus focuses on 3 key infrastructure requirements that we consider necessary to assist longer-term koala management objectives for KHD lands as follows:

1. Koala bridges

Koala bridges are timber structures that enable koalas to traverse barriers such as fences that function form an obstacle to linear passage. On the Kings Hill site, one-way and two-way koala bridges will be required, the former to enable passive (one-way) egress from vegetated areas that are located within identified development precincts (once fenced), the second to enable two-way movement by koalas both into and out of areas such being managed for environmental purposes. The design of both instances is the same (Appendix 1), the one-way effect created by use of a galvanised metal sleeve 600 – 900 mm wide (upper edge located 1 m off the ground) on the lower end of the bridge on that side of the fence where a reverse crossing is not to be enabled.

On the Kings Hill site, koala bridges should be located at ~ 250 m intervals along fenced areas intended to that separate development precincts from areas to be managed for environmental purposes.

2. Fencing

Fencing is required to create a barrier between the wildlife habitat within the lands to be retained and managed for conservation purposes and that of the adjoining development precincts. The intent of fencing should be to contain koala movement within the designated environmental lands while at the same time restricting access to the corridor by people and domestic animals. This barrier effect can be achieved by way of a standard floppy-top design typically deployed on road upgrades. However, a recent review of the efficacy of fencing (in terms of impeding koala movement) that we completed for NSW Roads & Maritime Services (Phillips and Fitzgerald 2014), provided strong *defacto* support for acceptance of a broader range of fence types being recognised as capable of influencing/impeding koala movement. This knowledge has allowed us to promote less expensive designs that are capable of achieving the same end result. By example, the fencing standard we have recommended for purposes of the Ocean Drive Road Corridor Koala Management Framework (Biolink 2014) comprises 1500 - 1800 mm x 50 mm x 50 mm galvanised mesh supported above ground by 60mm galvanised pipe uprights at 3m intervals.

3. Koala grids

Koala-grids will be required at all access points into areas that are dedicated to environmental management, including gated areas. The intent of the koala-grid is to enforce the exclusion concept of fencing at locations where vehicular crossings occur or where access is otherwise required for management purposes. Originally designed for purposes of the Skyline Road upgrade undertaken by Lismore City Council in 2004, koala-grids proved 100% effective in restricting access by koalas over the course of a 5-year monitoring program (Biolink 2009). Koala-grids are constructed using 60mm tubular steel pipe at 200 mm centres as a means of restricting access by koalas to an exclusion area (Figure 1).

Figure 1. Koala-grid / fence –end configurations. The grid on the far right reflects recent design modifications initiated by NSW RMS as part of retro-fitting modifications on the Gulgan Road interchanges that afford access to the Pacific Highway between Ewingsdale and Chinderah on the NSW north coast.

Please don't hesitate to contact the undersigned if you require any further information.

Yours Sincerely

Dr. Stephen Phillips
M/Director / Principal Research Scientist

Attachment – Appendix 1 Koala Bridge specifications

References

Biolink (2014). Ocean Drive Road Corridor: Koala Management Framework. Final Report to Port Macquarie Hastings Council.

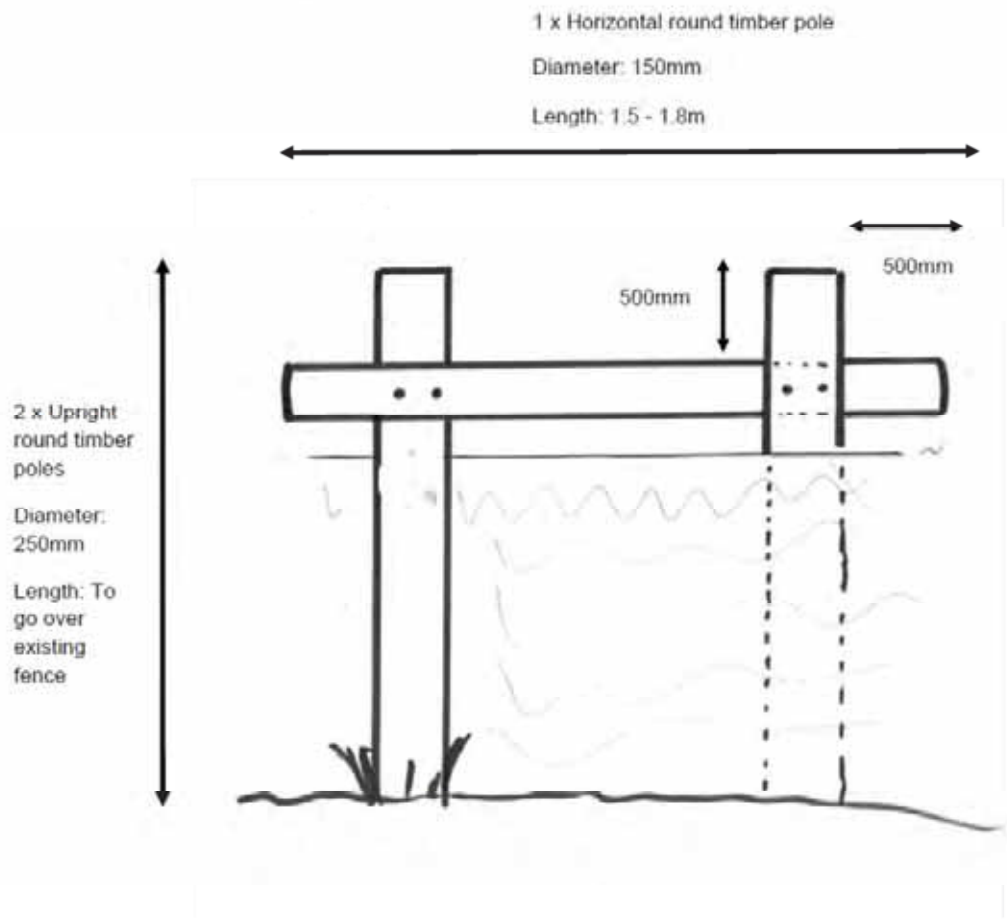
Phillips, S., and Fitzgerald, M. (2014). Review of koala road-kill data and issues relating to underpass use by koalas: Pacific Highway upgrades from Clothier's Creek to Ewingsdale, NSW. Final Report to NSW Roads & Maritime Services. Biolink Ecological Consultants.

Biolink. (2009). Koala Monitoring Report No 6 – Skyline Road Upgrade, Lismore NSW. Report to Lismore City Council.

APPENDIX 1
Typical Koala Bridge

Not to scale

a) Koala bridge design concept



b) View of koala bridge design from above

Appendix H

OWAD (2019a,b)

RAYMOND TERRACE KOALA SURVEY REPORT

Prepared by

OWAD Environment

for

PM №1 Pty Ltd c/o RPS Group

DOCUMENT CONTROL SHEET

Project Number: 181119

Client: PM №1 Pty Ltd c/o RPS Group

Report Title: Raymond Terrace Koala survey report

Report Author: Olivia Woosnam

Report Reviewers: Alex Dudkowski, Mark Aitkens

Project Summary: This report presents the results of a Koala survey, including the non-invasive sampling of Koala genetic material, conducted with two professional field detection dogs on a property located in Raymond Terrace, Port Stephens Council Local Government Area, New South Wales.

Document preparation and distribution history

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Version 1	24/01/2019		Olivia Woosnam	24/01/2019

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Signed on behalf of OWAD Environment

Olivia Woosnam
Director
Date: 24/01/2019

RAYMOND TERRACE KOALA SURVEY REPORT

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APPENDICES

Appendix 1 Field notes

1.0 EXECTUTIVE SUMMARY

OWAD Environment was contracted by PM №1 Pty Ltd c/o RPS Group to conduct a Koala and Quoll survey including non-invasive Koala genetic sampling on a property located in Raymond Terrace, Port Stephens Council Local Government Area, New South Wales, with the assistance of two professional field detection dogs certified for the detection of Koala and Quoll scats.

The field assessment was conducted over five consecutive days between 18 and 23 November 2018.

The detection dogs searched a total of 43km in accordance with an unbiased sampling grid designed by RPS Group.

This survey found evidence of Koala presence at 47 locations, in 28 of the 62 sampling cells (or 45%) assessed. No evidence of Quoll presence was detected during the survey.

Each sampling cell was attributed a relative Koala activity score to provide an indication of Koala distribution across the site.

A total of 12 samples of Koala genetic material (10 scat samples and two pap samples) were collected from 10 cells and submitted to a specialist laboratory for Koala DNA profiling, gender identification and pathogen detection *C. pecorum* and KoRV-A. All 12 samples (100%) successfully passed laboratory Quality Control and proceeded to analytical testing. A summary of analytical and genetics test results is provided below:

- 12 of the 12 samples (100%) collected and submitted to the laboratory provided a reliable DNA profile
- DNA profile matching revealed that the 12 genetic profiles obtained originate from 10 distinct individuals, being four females and six males
- Four of the unique individuals identified (40%) tested positive for *C. pecorum*
- All 10 individuals (100%) tested positive for KoRV-A
- The genetic relatedness test identified that two pairs of close relatives were sampled during this program. Further genotypic investigation identified both pairs as likely parent-offspring pairs
- Despite the limitations relating to the small sample size, one measure of genetic diversity could be performed to provide an indication of genetic diversity: allelic richness was found to be comparable to that of three distinct populations from South East Queensland

The evidence of pap observed at six locations on the subject site, and the results from the parent-offspring test performed on the unique DNA profiles obtained, provide empirical evidence of breeding on the subject site.

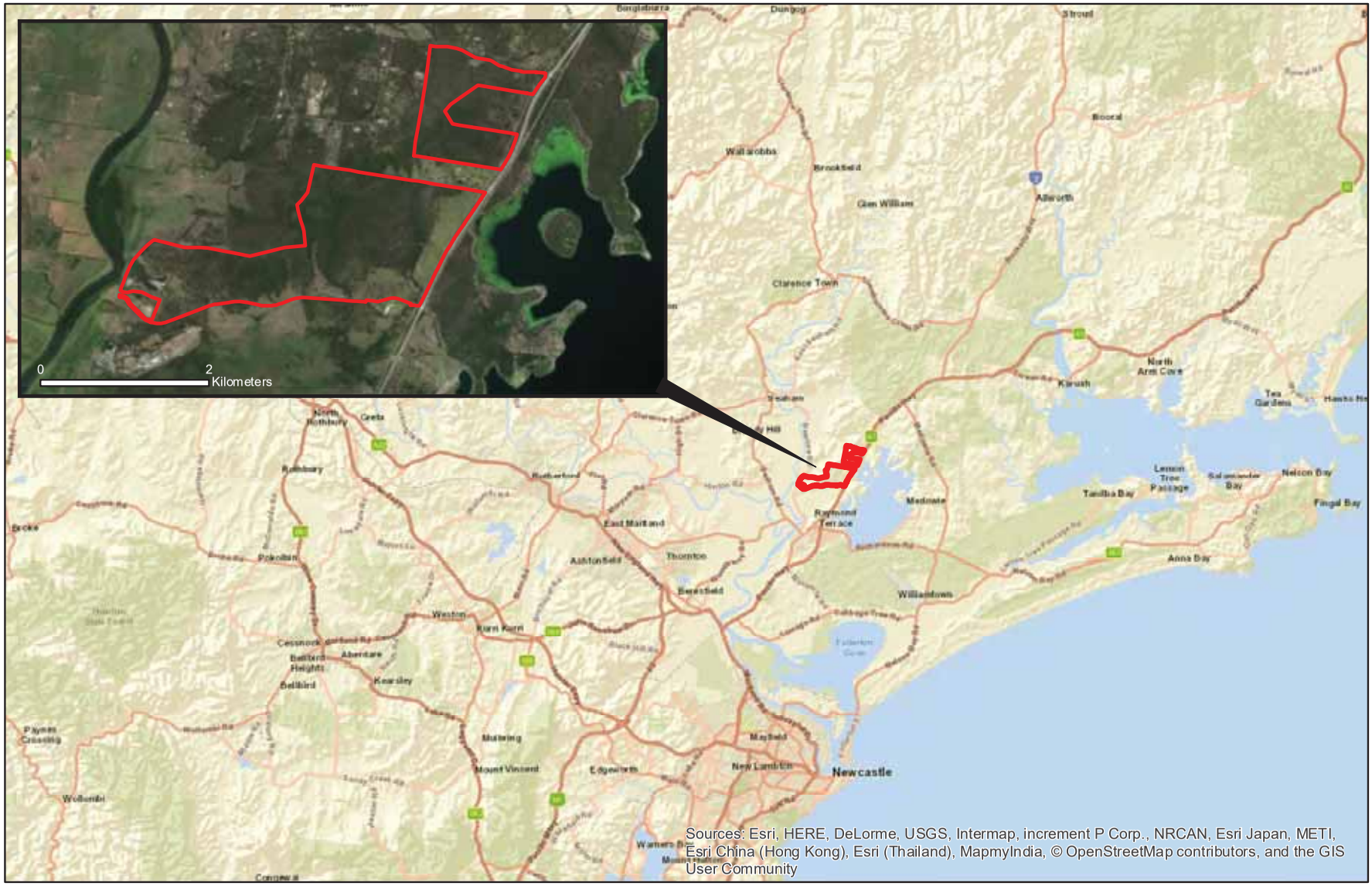
2.0 INTRODUCTION

OWAD Environment was contracted by PM №1 Pty Ltd c/o RPS Group to conduct a Koala survey on a property located in Raymond Terrace, Port Stephens Council Local Government Area, New South Wales. This survey was conducted with the assistance of two professional field detection dogs certified for the detection of Koala and Quoll scats, and included the collection and analysis of Koala genetic material collected.

The subject site is approximately 515ha in size and is located approximately 20km north of Newcastle (see **Figure 2.1**). It is situated between the Pacific Highway to the east and Williams River to the west.

The primary purpose of this study was to evaluate Koala distribution on the subject site, with the assistance of two purpose-bred professional field detection dogs that detect and locate Koala scats. Even though this study was designed specifically for Koala assessment purposes, both detection dogs used in this study also detect and locate Quoll scats including indiscriminately *Dasyurus maculatus, D. hallucatus* and *D. viverrinus* scats.

This report presents the findings of this study.



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Project No.: 181119
Created by: OW
On: 30/11/2018

LEGEND

Subject site

FIGURE 2.1
SUBJECT SITE LOCATION

Raymond Terrace Koala survey report

3.0 FIELD SURVEY METHODOLOGY

3.1 SAMPLING DESIGN

A systematic unbiased sampling design was applied and deemed appropriate for this site to allow rapid assessment across the site whilst enabling relatively homogenous geographic coverage of the site. The site was divided by RPS Group into sixty-four (64) sampling cells each of 6.25ha, being 250m x 250m or equivalent surface area (see **Figure 2.1**). These were classed into three different categories, corresponding to their priority for field assessment.

3.2 FIELD SURVEY

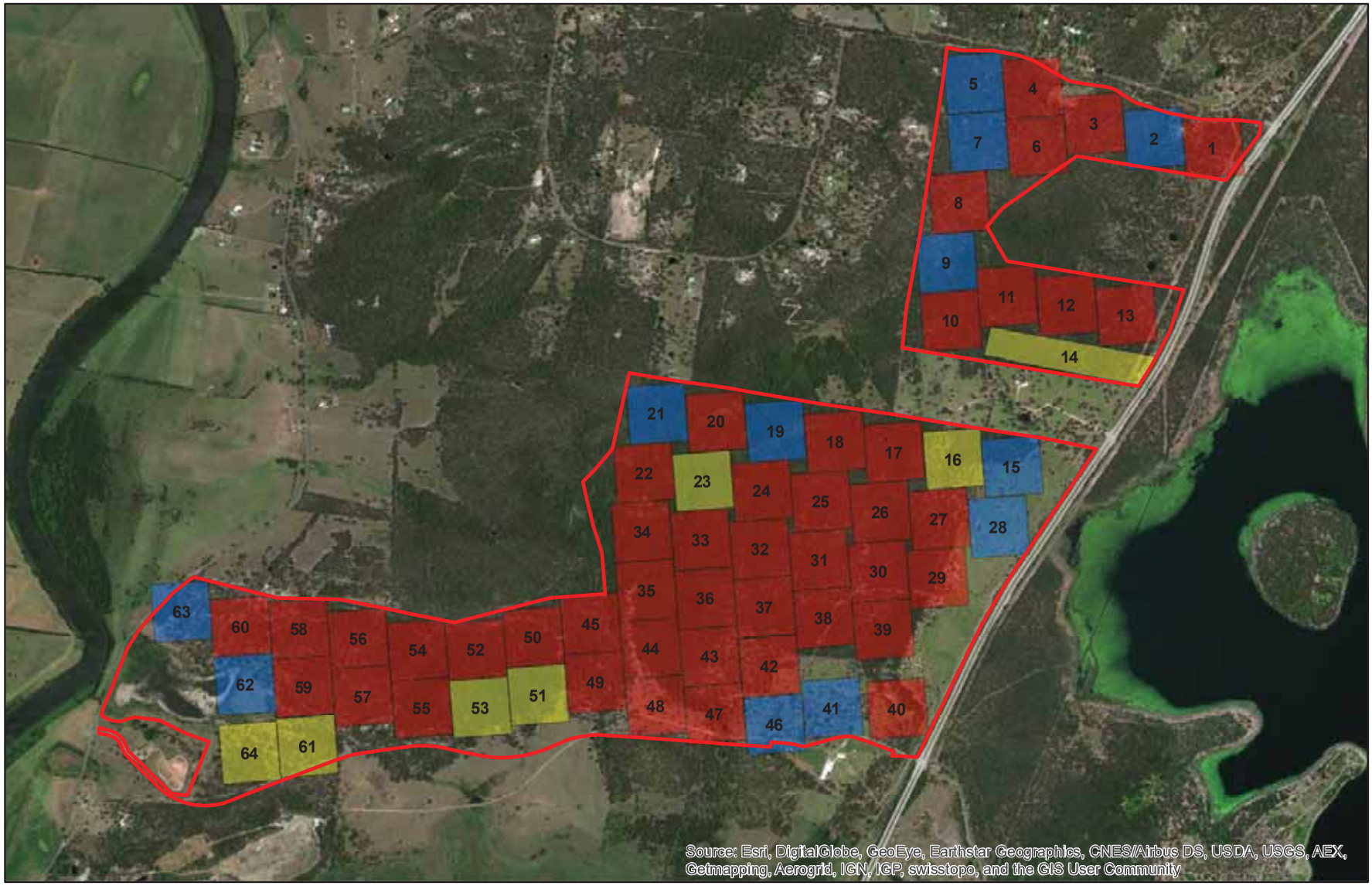
The field survey was conducted by Olivia Woosnam (senior koala ecologist, Certified Environmental Practitioner, professional detection dog handler), Alex Dudkowski (field ecologist, Certified Environmental Practitioner, professional detection dog handler) and two professional detection dogs ('Taz' and 'Missy'); both certified for Koala and Quoll scat detection.

Left: 'Taz' in work gear - jacket and tracking collar paired handheld GPS unit
Right: 'Missy' indicating on a Koala scat

The field survey was conducted under OWAD Environment's Scientific Licence number SL101634, and Animal Care and Ethics Committee Approval and Animal Research Authority number TRIM18/567 for Koala and Quoll scat surveys using detection dogs.

3.2.1 Detection dog search protocol

One search was performed within each sampling cell. Each search was time-based, allowing five minutes of 'active search time' by the detection dog in each cell. A chronometer was started when the dog was prompted to search; was stopped if/when the dog indicated, allowing for the survey team to assess the scats and enter field data; and the chronometer was resumed when the handler prompted the dog to continue searching, until the five minute time limit was reached.



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Project No.: 181119
Created by: OW
On: 16/11/2018
Updated on: 07/12/2018

LEGEND

Subject site

Sampling cells:

Priority 1 (# = cell number)

Priority 2 (# = cell number)

Priority 3 (# = cell number)

FIGURE 3.1
SAMPLING CELLS

Raymond Terrace Koala survey report

OWAD ENVIRONMENT

One detection dog was handled at a time. The dog was led on leash to the areas to assess. The dog was then taken off the leash and when prompted by the handler, scanned the ground layer for target scats, as well as above the ground for scats that may be above ground level (e.g. scats fallen on rocks, logs, or stuck in branches or in bark along tree trunks). The dog worked independently and searched non-discriminatorily, scanning the air for any scent particles of its target odours. It was not directed to any specific feature, tree or tree species; the handler only gave the dog the initial general direction of the search. During searches, the dog was redirected, recalled or stopped at a distance using an Acme dog whistle, as required to keep the dog within the target cell or for safety reasons (e.g. prevent the dog from running into barbed wire fencing). The handler kept the dog within immediate sight at all times.

When the detection dogs find a target scat, they lie down nose on scat and hold the indication until the handler tells them they can stop indicating. If the scat is visually obstructed by leaf litter and/or ground vegetation which is a frequent occurrence with Koala scats, they use their paws and/or nose to expose a least one Koala scat. In instances where the leaf litter is particularly thick, they may also retrieve a Koala scat with a 'soft mouth' and deposit it in the handler's hands. See examples below of Taz actively helping the handlers recover Koala scats.

Above: Taz actively helping her handlers recover Koala scats from the forest floor

In order to minimise the risk of data loss in case of GPS unit malfunction, the study team recorded the coordinates of all target scats found with two handheld GPS units (model Garmin Alpha 320 and Garmin GPSMap 78). The detection dogs' search tracks were recorded with a Garmin T5 dog tracking collar which was paired with the Alpha 320 unit and took one waypoint every 2.5 seconds. Similarly, in order to minimise the risk of dog tracking data loss in case of equipment malfunction, OWAD Environment carried two dog tracking collars and two handheld GPS units paired with both tracking collars. While working, the detection dogs wore a red 'detection dog' jacket with reflective stripes at all times.

Click on this link to watch a video of OWAD Environment performing a detection dog search during a recent survey: https://www.youtube.com/watch?v=yJ9JHdITFKQ&t=2s.

3.2.2 Opportunistic searches

When the detection dogs were not actively searching (e.g. when walking or driving between sampling cells), the study team continued to pay attention to the leaf litter and/or tree canopies in case target scats, live Koalas or any signs of potential Quoll presence were spotted.

3.2.3 Quality Assurance

Field quality assurance procedures

In all studies undertaken by OWAD Environment, field quality assurance (QA) procedures are undertaken to ensure that the data collected in the field is representative of the true site conditions and is therefore valid for interpretation. QA procedures include the use of experienced koala ecology expert staff, professionally trained detection dogs and handlers, the use of appropriate scat based survey methodologies and the implementation of daily field quality control (QC) searches.

Field QC searches were conducted each day throughout this survey. Either the detection dog found naturally deposited Koala scats within the first few minutes of working each day, in which case there was no need for the field assistant to deposit scats for quality control. Or, if no naturally deposited scats were found within the first few minutes, then the field assistant randomly deposited scats, ensuring the handler did not know when or where scats may have been placed. When the field assistant deposited scats for QC purposes, the field assistant started a separate chronometer (without the handler knowing) and recorded the time it took the dog/handler team to find the scats.

A QC search enables the assessment of the dog/handler team's ability to find the target scent in the specific conditions of the survey, within a maximum time of 5 minutes. This enables to ensure that there are no exceptional circumstances that may be disabling the dog/handler team's ability to find the target (e.g. a scent that may be obscuring the scent of the target odour for the dog, or handler fatigue which may affect handler's ability to effectively handle the dog). Crucially, the handler is never informed in advance where scats are deposited for QC purposes. Not disclosing this information is crucial to ensure there is no bias in how the handler handles the dog. It is only after the dog/handler team has found scats deposited for QC purposes that the field assistant discloses that these were not naturally deposited scats hence should not be recorded as an actual result in the study.

The detection accuracy of our dogs is closely monitored throughout the year. The results of all field QC searches are recorded, and are available for each project upon request by the client.

Field quality control search interpretation

Should the dog/handler team find a deposited QC scat within 5 minutes, the field QC search is marked as successful, the time is recorded for record-keeping purposes and work continues. Should the dog/handler team find a naturally deposited within 5 minutes after a QC scat has been deposited for QC purposes, the field QC search is marked as successful, the time is recorded for statistics purposes, the coordinates of the naturally deposited scats are recorded as a result in the study and work continues.

Should the dog/handler team fail to find the deposited QC scat / or a naturally deposited scat within 5 minutes[1], the field QC search would be marked as unsuccessful. In the event that a QC search were to fail, the search team would stop work immediately to try and identify the reason for failure. Upon identification of the potential cause, a second QC search would be immediately conducted to confirm the reason for initial failure. Should the second QC search also fail, the study team would reassess the site conditions / environmental conditions / the detection dog / search protocol / handling protocols etc. If the potential cause for failure cannot

[1] This instance has never occurred to date.

be quickly identified and remediated, the study team would liaise with the client. No further survey work would be conducted until the reason(s) for failure are identified and remediated.

3.3 KOALA SCAT COLLECTION AND SUBMISSION

3.3.1 Selection of scats for collection

Koalas typically produce 100 to 150 scats in each 24 hour period (Ellis *et al* 1998). Depending on factors such as local weather events, ecosystems, microbacterial activity, insect predation, geography and moisture, Koala scats in Eastern Australia can maintain some structural integrity for up to 12 months or more (Witt and Pahl 1995, Rhodes *et al* 2011).

In this study, all scats the field survey team found that had some structural integrity were recorded. However, only scats that were potentially viable for laboratory analysis were collected and submitted for laboratory analysis. Scats potentially viable for analysis met the following criteria:

- Deposited up to approximately 4 weeks prior to field assessment
- Not significantly damaged by rain/moisture/dew
- Not damaged by fire
- Not damaged by mould or fungi
- Not extensively predated on by insects
- Not covered in dust/dirt/debris
- Not significantly damaged by any other factor not listed above

Each time fresh scats or pap (see **Section 5.4** for further detail on pap) were found, a careful visual inspection was performed by the field survey team to assess whether the scats/pap may fit the above criteria and were in sufficient condition to be viable for analysis. Only scats/pap that were considered to have some potential of containing sufficient genetic material were collected and submitted to the laboratory.

Identifying fresh scats

Fresh scats are typically dark brown to black on the outside, have a shiny surface, bright green or yellow inside, and solid to the touch (or soft if extremely fresh e.g. deposited within a few hours). Occasionally, fresh scats can be unusually yellow or red on the surface.

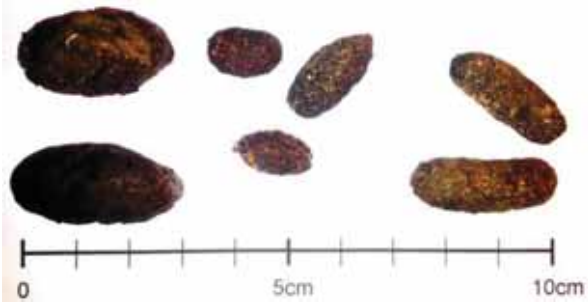
Old scats typically have a duller surface, have less color contrast between the outside and the inside, and crumble under minimal compression. See **Plate 1** as an example of 2-week old scats and 9-month old scats produced by the same individual, with scats aged in the natural environment.

Plate 1: Fresh Koala scats (left) and old Koala scats (right) from the same individual

Identifying scats from potentially distinct individuals

Typically, one individual produces scats that are relatively consistent in both shape and size. There can be significant variations in the shape and/or size of scats produced by different individuals: they can be oblong or round in shape, and can range in size from approximately 10mm to 40mm. **Plate 2** is a typical example of the variations in Koala scat size and shape produced by distinct individuals. These variations were used by the study team in the field to infer whether a particular individual may have previously been sampled from a nearby location, or whether at one location there may be fresh scats from distinct individuals. Indeed in instances where at one location there were fresh scats potentially originating from more than one individual, these variations in scat size/shape assisted the study team in estimating how many putative distinct individuals these may originate from, in order to sample each putative individual in distinct scat collection kits.

Plate 2: Variations in Koala scat size and shape originating from distinct individuals



3.3.2 Scat collection and handling protocol

When potentially viable Koala scats were found, their condition was assessed in the field. If deemed potentially viable for analysis, a sample was collected. The scats were collected following the methods described by Wedrowicz *et al* (2013): they were collected from the environment using toothpicks, ensuring no direct contact with humans or the detection dogs, and minimal friction on the forest floor so as not to 'rub off' the genetic material. The toothpicks were then securely inserted into a piece of foam, and the foam placed and secured into a purpose-built collection kit (see **Plate 3**). Where possible, multiple scats were collected and placed in each kit. The reason for collecting more than one scat per presumed individual at each location, where possible, was to provide several chances of isolating DNA of sufficient quality and quantity to enable genetic profiling (see **Section 3.2.2** for further detail on DNA quality and DNA concentration testing).

On each collection kit, a pre-affixed label was completed which included the following information:

- A unique sample code
- Site identification and date collected
- Name of entity collecting the sample (OWAD Environment)
- Coordinates (UTM zone 56 format)

Each kit was then placed in a paper bag. Where the study team found fresh scats at one location potentially originating from multiple koala individuals, these were placed into distinct collection kits.

Plate 3: Koala scat collection kit

While the survey team is in the field, the work vehicle can reach high temperatures and this can damage genetic material. Kits were therefore placed in a double insulated cool container with ice packs and desiccant sachets to control both the temperature and humidity. This storage method also successfully contains the scent and prevents dissipation of the detection dogs' target scent in the vehicle.

At the end of each fieldwork day, the collected kits were removed from the field container, transferred into a cardboard box with desiccant sachets and stored at ambient temperature in a cool room away from direct sunlight.

3.3.3 Sample submission protocol

At completion of the field survey, the samples were carefully packed in a cardboard parcel with desiccant sachets, and posted to the laboratory via overnight postage. A hard copy of the sample tracking sheet was placed in the parcel, which contained the following information:

- List of sample codes contained in the parcel
- Coordinates of sampling location of each sample
- Date sample collected from the field
- Date posted
- Laboratory services required

An electronic copy of the sample tracking sheet was also emailed to the laboratory.

4.0 SCAT ANALYSIS METHODOLOGY

4.1 LABORATORY TEAM

The laboratory team was led by:

- Dr Fiona Hogan (Molecular Ecologist, WildDNA Director, lead project coordinator)
- Dr Faye Wedrowicz (Molecular Ecologist, WildDNA Laboratory Manager)

Drs Fiona Hogan and Faye Wedrowicz have extensive experience in the isolation and analysis of DNA from non-invasive biological sources such as feathers and scats (Hogan *et al* 2008; Wedrowicz *et al* 2013). Drs Hogan and Wedrowicz developed and published the genetic methods used for this study (i.e. DNA profiling from a single Koala scat; Wedrowicz *et al* 2013), detecting *Chlamydia pecorum* and Koala retrovirus KoRV-A in Koala scats (Wedrowicz *et al* 2016), validating the use of DNA sourced from Koala scats for population genetic studies (Wedrowicz *et al* 2017, Wedrowicz *et al* 2018), and designing molecular markers to infer gender of Koalas using DNA isolated from Koala scats (Wedrowicz *et al* 2018).

4.2 SCAT ANALYSIS PROTOCOL

4.2.1 Surface wash

Scats received by WildDNA were processed upon arrival. Epithelial cells on the outer surface of the scat were removed using the washing technique described in Wedrowicz *et al* (2013).

4.2.2 DNA isolation and Quality Control

Genomic DNA was isolated from epithelial cells (surface washes) as per the methods described in Wedrowicz *et al* (2013) using the QIAamp DNA Stool Mini Kit. Each DNA sample was tested to determine the total quantity of DNA isolated (i.e. concentration, containing both koala and non-koala DNA) and the quality of the target DNA isolated (i.e. amplification of a Koala specific locus using the polymerase chain reaction). This process is referred herein as 'Quality Control' or 'QC'. Samples were scored as 'pass', 'low quality pass' or 'fail' after QC. Only the DNA isolate of the highest DNA concentration and of a 'pass' or 'low quality pass' standard from each kit is used for downstream genetic analysis. The scat washing process, DNA isolation and QC were conducted by WildDNA.

4.2.3 Genetic analysis

All genetic testing for this study were conducted by the Australian Genome Research Facility (AGRF) under the instruction of WildDNA. AGRF is accredited by the National Association of Testing Authorities (NATA) Australia in the field of Biological Testing and operates in compliance with the international standard ISO/IEC 17025:2005.

Genetic testing involved three types of analyses:

- **Gender**
  Gender was determined by targeting the X and Y chromosomes using molecular markers specially designed for sexing koalas from south east Queensland (Wedrowicz *et al* 2018).
- **DNA profiling**
  Samples were genotyped for 12 koala-specific microsatellite markers which provided a unique DNA profile. A reliable DNA profile, derived from replicate analysis, allowed

distinct individuals to be identified with a high degree of confidence (the probability that two individuals would share the same DNA profile by chance is less than 1 in 1,000,000,000). Further details of the DNA profiling process are described in Wedrowicz *et al* (2013) and Wedrowicz *et al* (2018).

- **Pathogen detection**
  Samples were tested for infection of *C. pecorum* and KoRV-A using target-specific molecular markers as described in Wedrowicz *et al* (2016).

4.3 ANALYSIS OF GENETIC DATA

Genotypic data derived by AGRF were used to generate data unique to an individual scat (hence Koala); this included gender, a unique DNA profile (DNA profile matching) and the presence of pathogenic infections for each unique individual identified. Individual data were also used to assess pairwise relatedness between distinct individuals sampled in this study.

5.0 FIELD SURVEY RESULTS

5.1 FIELD SURVEY EFFORT

The field survey was conducted over five consecutive days between 18 and 23 November 2018.

The field survey team assessed 62 of the 64 sampling cells shown in **Figure 2-1**. All Priority 1 and Priority 2 cells were successfully assessed. Two cells of Priority 3 (cell numbers 21 and 63) were not assessed due to access limitations.

The detection dogs actively searched a total of approximately 43 kilometres while actively searching for their target scents. The kilometres searched by the detection dogs within each cell are shown in **Table 1** below. The detection dogs' search tracks are shown on **Figure 4.1**.

Table 1: Search effort per cell

Cell №	Metres searched
1	770
2	740
3	640
4	550
5	650
6	630
7	740
8	500
9	480
10	560
11	720
12	550
13	760
14	650
15	640
16	750
17	610
18	550
19	570
20	400
22	500
23	500
24	520
25	520
26	720
27	850
28	1,710
29	660
30	610
31	670
32	590

Cell №	Metres searched
33	600
34	380
35	480
36	480
37	670
38	630
39	580
40	680
41	1,880
42	760
43	570
44	620
45	680
46	1,910
47	830
48	730
49	490
50	480
51	520
52	560
53	570
54	700
55	570
56	500
57	660
58	690
59	810
60	840
61	880
62	1,020
64	860
TOTAL	**42,940**

5.2 FIELD QUALITY CONTROL

All Quality Control searches performed during this survey were successful. Note, on 22 November the survey conditions were unusual (i.e. dust storm); on that day multiple QC searches were performed throughout the day as the conditions deteriorated, to ensure these atypical conditions did not impair the dogs' detection abilities.

5.3 EVIDENCE FOUND

5.3.1 Quoll

No Quoll scats were found during this field assessment. See **Section 6.1** for limitations of interpretation of this result.

5.3.2 Koala

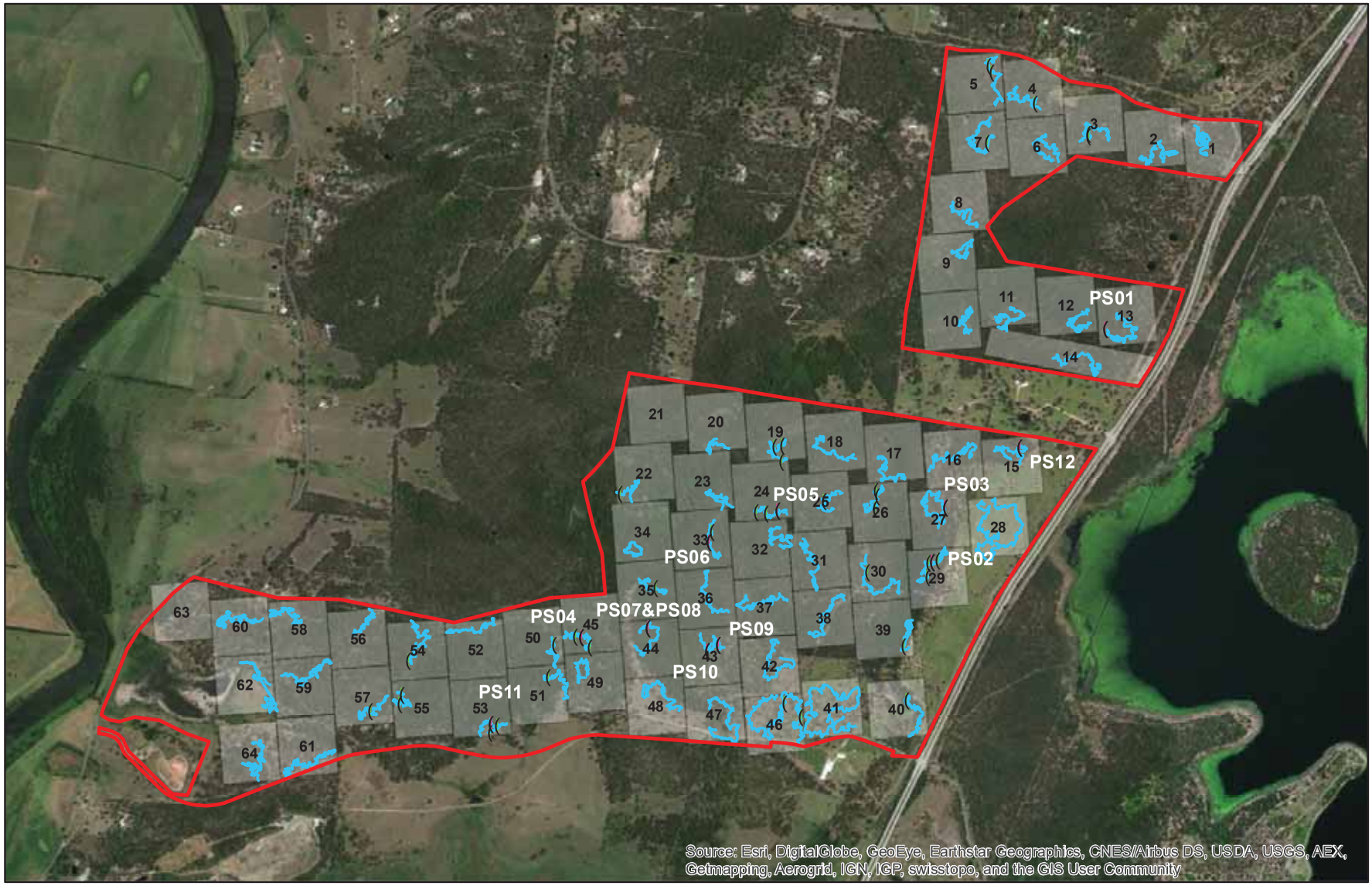
Koala scats or pap (see **Section 5.4** for further detail on pap) were found at a total of 47 locations in 28 of the 62 cells (or 45%) assessed.

A total of 12 samples deemed potentially viable for analysis were collected from 10 of the cells and submitted to the laboratory. Locations of scats/pap found, including samples collected for laboratory analysis, are shown on **Figure 4.1**. Field observations including coordinates are provided in **Appendix 1**.

Tree species under which Koala scats/pap were found were recorded (see **Appendix 1**). Spotted Gum *Corymbia maculata* was the tree species with the most records in this study, recorded in 38% of instances where Koala scats/pap were found[2].

Note, during the field assessment the survey team with the agreement of RPS Group derived from the prescribed search protocol for three cells. Cell numbers 28, 41 and 46 only contained few scattered trees, therefore limiting the search to 5 minutes in these cells would have resulted in the dog/handler team spending a significant amount of time running between trees rather than searching. Therefore the survey team instead proceeded to a full coverage in these three cells.

[2] Note, the tree under which a Koala deposits scats is only a valid indicator that this individual has visited that tree; it is not necessarily a valid indicator of the diet of that individual.



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On: 28/11/2018

LEGEND

- Subject site
- # Sampling cell (# = cell number)
- Detection dog search tracks (total 43km)
- (Koala scats/or pap found
- (Koala scats/or pap found, sample collected for analysis (and sample code)

FIGURE 5.1
FIELD SURVEY RESULTS

Raymond Terrace Koala survey report

OWAD ENVIRONMENT

5.4 RELATIVE KOALA ACTIVITY LEVELS

An indication of relative Koala activity levels detected within the site may be inferred from the field results.

A score was derived for each cell based on:

- The number of locations where Koala scats were found within the cell;
- Whether there was an abundance of scats found (indicative of Koalas utilising an area for extensive periods);
- Whether scats of varying age classes were found (indicative of repeat visitation); and/or
- Whether evidence of breeding was found as indicated by the presence of pap. Pap is a substance produced by a mother with joey, that contains gut bacteria the joey needs to process leaves. It is produced in the mother's caecum and delivers it from the cloaca. Joeys feed on pap from approximately 4 months of age and until approximately 10 months of age.

Digestive system of the Koala

Table 2 below shows the activity scores obtained and the corresponding number of cells. The details for each cell are shown in **Table 3**, and displayed on **Figure 4.2** using the same color code.

Table 2: Activity scores obtained

Activity score	Number of cells
Nil	34
1	12
2	6
3	4
4	4
6	2

Table 3: Relative Koala activity scores

Cell №	Number of finds	Abundance of scats at one location? +1 per location	Different age classes at one location? +1 per location	Evidence of breeding within the cell? +1 per cell	Score
1	0				Nil
2	0				Nil
3	2	+1	+1		4
4	1				1
5	2	+1			3
6	0				Nil
7	1				1
8	0				Nil
9	0				Nil
10	0				Nil
11	0				Nil
12	0				Nil
13	1			+1	2
14	0				Nil
15	1				1
16	0				Nil
17	0				Nil
18	0				Nil
19	3			+1	4
20	0				Nil
22	1				1
23	0				Nil
24	3			+1	4
25	1				1
26	3				3
27	1	+1	+1		3
28	0				Nil
29	4	+1	+1		6
30	1				1
31	0				Nil
32	0				Nil
33	2				2
34	0				Nil
35	1				2
36	0				Nil
37	0				Nil
38	0				Nil
39	1				1
40	1				1
41	0				Nil
42	0				Nil
43	2				2
44	1	+1	+1	+1	4
45	3				3
46	2				2
47	0				Nil
48	0				Nil

Cell №	Number of finds	Abundance of scats at one location? +1 per location	Different age classes at one location? +1 per location	Evidence of breeding within the cell? +1 per cell	Score
49	0				Nil
50	1				1
51	1				1
52	0				Nil
53	3	+1	+1	+1	6
54	1				1
55	2				2
56	0				Nil
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58	0				Nil
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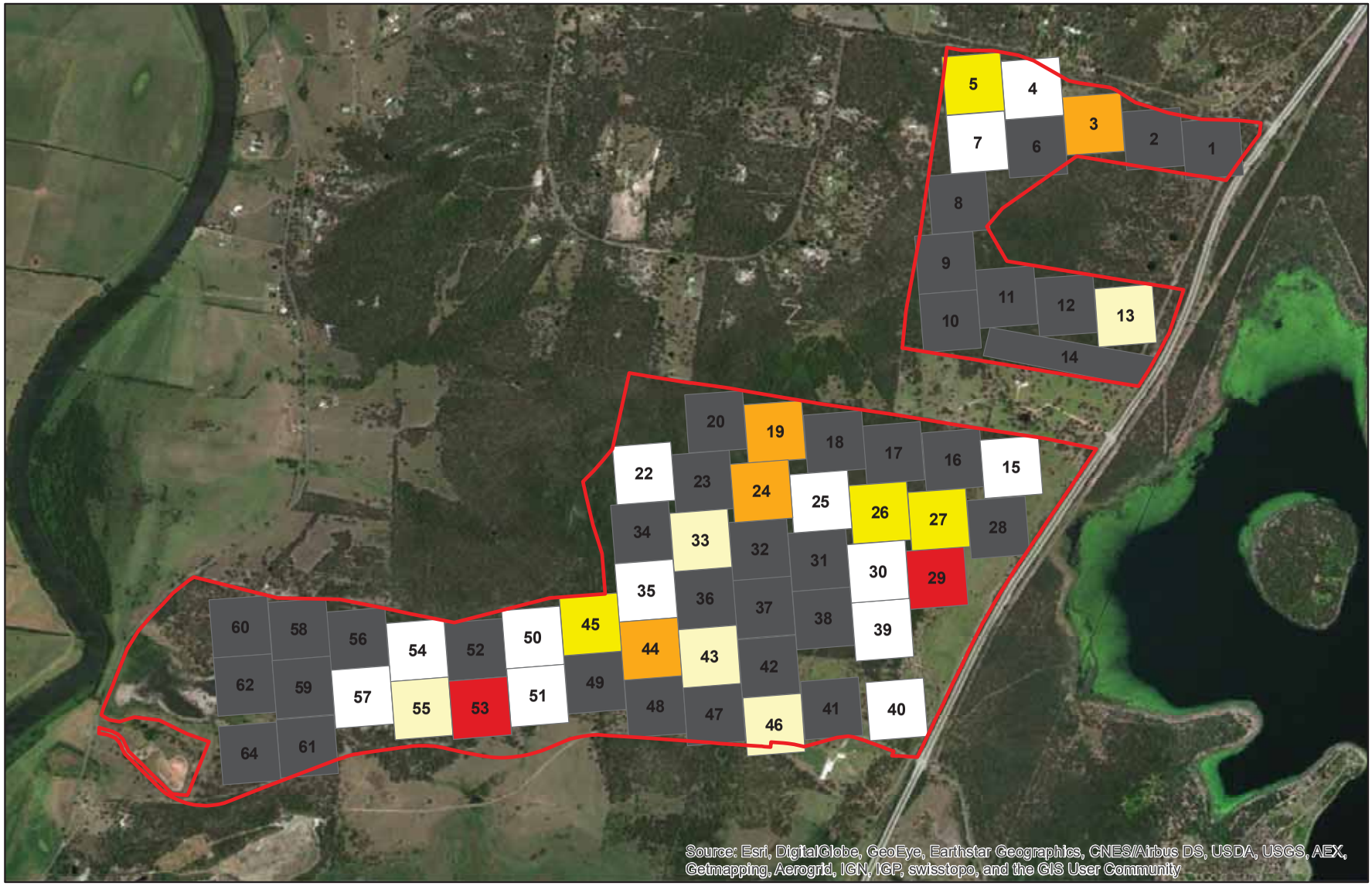
60	0				Nil
61	0				Nil
62	0				Nil
64	0				Nil



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Project No.: 181119
Created by: OW
On: 28/11/2018

LEGEND

Subject site

Relative Koala activity scores (with cell numbers displayed)

Nil
1
2
3
4
6

FIGURE 5.2
RELATIVE KOALA ACTIVITY LEVELS DETECTED

Raymond Terrace Koala survey report

6.0 LABORATORY RESULTS

6.1 QUALITY CONTROL RESULTS

All 12 samples (100%) collected from the site and submitted to WildDNA passed laboratory QC and proceeded to testing for DNA profiling, gender identification, and *C. pecorum* and KoRV-A detection. These included 10 scat samples and two pap samples.

6.2 LABORATORY ANALYSIS RESULTS

12 of the 12 samples tested (100%) provided a reliable DNA profile.

Genotype profile matching revealed that the 12 DNA profiles obtained originate from 10 distinct individuals, being four females and six males.

C. pecorum was detected in the scats or pap of four individuals[3] (or 40%) while KoRV-A was detected in all 10 individuals (100%).

These results are summarised in **Table 4** below.

Table 4: Summary of laboratory analysis results

Sampling location(s) of unique individuals indentified	Gender	*C. pecorum* detected?	KoRV-A detected?
PS01	Male	Yes	Yes
PS02	Female	Yes	Yes
PS03 / PS12	Male	No	Yes
PS04 / PS09	Male	No	Yes
PS05	Female	No	Yes
PS06	Female	Yes	Yes
PS07	Female	No	Yes
PS08	Male	No	Yes
PS10	Male	Yes	Yes
PS11	Male	No	Yes
TOTAL	**4 females 6 males**	**4/10 (40%)**	**10/10 (100%)**

[3] See **Section 7.2.3** for limitations regarding *C. pecorum* detection results.

6.3 PAIRWISE RELATEDNESS

Pairwise relatedness testing (see **Table 5**) revealed that two pairs of individuals had statistically significant relatedness values:

- The male sampled at PS04/PS09, and the male sampled at PS08
- The female sampled at PS07 and the male sampled at PS08

Further genotypic investigation of the above individuals identified both pairs as likely parent-offspring pairs.

Of note, samples PS07 and PS08 were collected from the same location by the field survey team. An abundance of scats was observed at that location, of same age class but of two distinct size/shape classes (see **Appendix 1**) hence the team collected two samples in two distinct collection kits. Given that at that location there was also pap observed, of a slightly older age class, it is possible that the two individuals identified are a mother (PS07) and her subadult offspring male (PS08).

Table 5: Statistically significant genetic relatedness found
Lower 95% confidence values are reported using the Dyadic Maximum Likelihood estimator

Sampling location(s) of unique individuals and their gender	PS04/ PS09 (male)	PS07 (female)
PS08 (male)	**0.50**	**0.40**

The other pairs of individuals may have some degree of relatedness, but none of the values were significantly greater than zero. Only the statistically relevant results are provided in **Table 5** above.

6.4 GENETIC DIVERSITY

With the limited sample size (n=10 individuals), a full assessment of genetic diversity is not possible here. However, allelic richness [4] is a useful indicator of genetic diversity and could be calculated and can shed some light onto the genetic diversity of the Koala population sampled in this study.

The allelic richness of the 10 individuals sampled here was compared to that of three distinct populations recently identified in South East Queensland (OWAD Environment 2018). Allelic richness for the Port Stephens Koala population (individuals sampled in this study) compared to those in South East Queensland were as follows:

Table 6: Allelic richness results

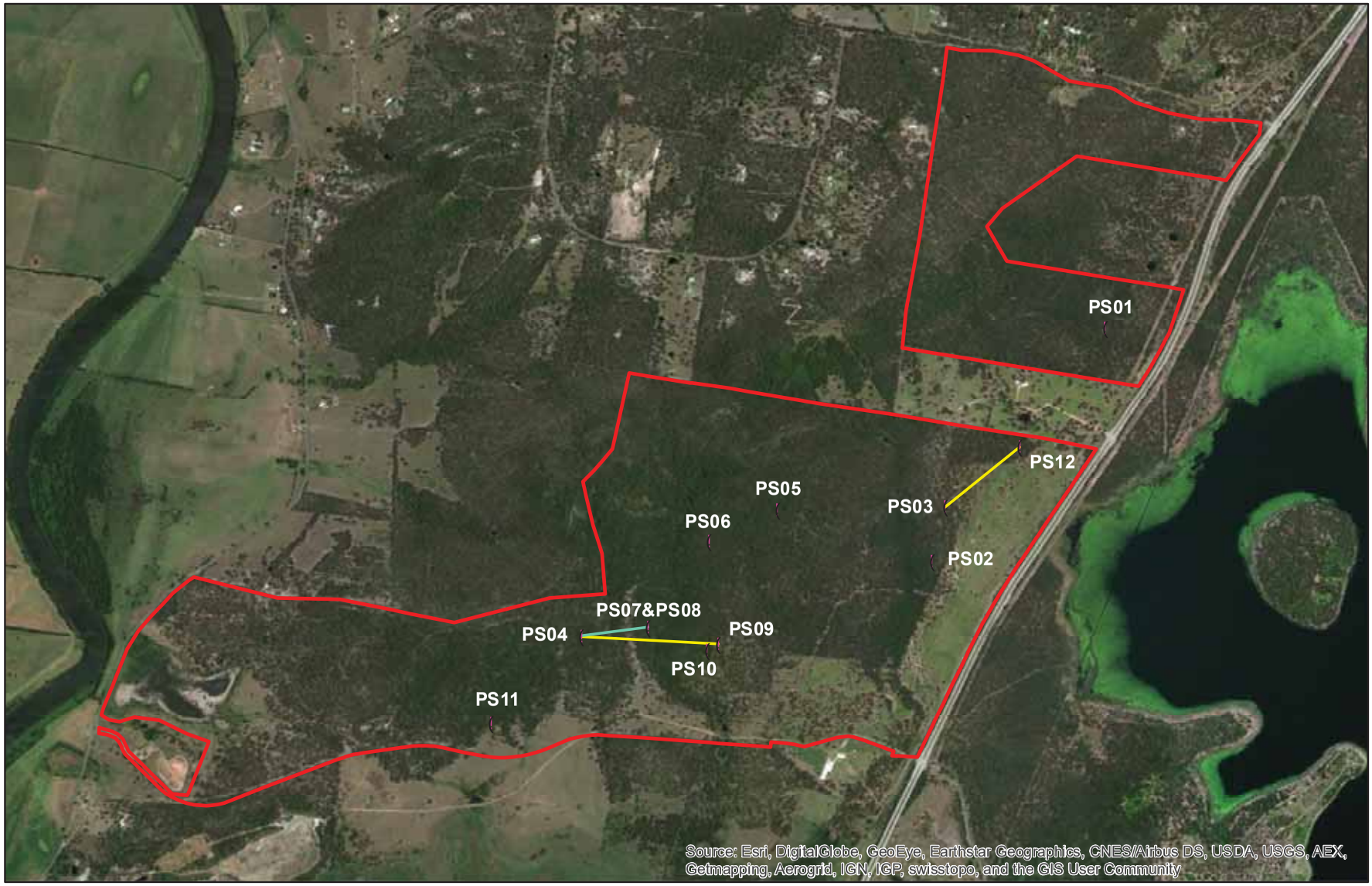
Population	Allelic richness	95% confidence interval for allelic richness
Port Stephens	5.2	(4.3 – 5.8)
SEQ1 (Brisbane Central)	4.9	(4.4 – 5.4)
SEQ2 (Brisbane North)	4.8	(4.2 – 5.3)
SEQ3 (Brisbane South-West)	6.4	(5.4 – 7.2)

[4] Allelic richness = mean number of alleles per locus, corrected for differences in sample size.
Allele = each of two or more alternative forms of a gene that arise by mutation and are found at the same place on a chromosome (locus).

The population sampled in this study had a level of diversity that was not significantly different to any of the three distinct populations identified to date in South East Queensland. Further sampling and analysis of further individuals that belong to the population occurring on the subject site would be useful in order to increase the sample size, which would enable further assessment of allelic richness.

6.5 POPULATION STRUCTURE

The small sample size and the lack of available genetic data from the greater landscape do not allow for any interpretation of population structure. Due to lack of data, it is at this stage not possible to determine whether the population sampled as part of this study is isolated from surrounding areas or not. Determining such would require a minimum of genetic sampling and analysis from the greater landscape.



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Created by: OW
On: 23/01/2019

LEGEND

- Subject site
- (Sampling locations of Koala genetic material (and sample code)
- Same unique individual sampled at >1 location
- Close relatives: PS04/PS09 - PS08, and PS07 - PS08

* PS07 and PS08 (sampled from the same location) are distinct individuals and were identified as close relatives *

FIGURE 6.1
GENOTYPE MATCHING AND RELATEDNESS RESULTS

Raymond Terrace Koala survey report

7.0 DISCUSSION

In this study Koala activity was detected at 28 of the 62 cells assessed, or 45%. This is similar to various other studies performed in recent years by OWAD Environment in Eastern Australia in potential or known Koala habitat, using similar methods and search protocols as this study (i.e. timed searches with professional detection dogs). The Koala activities detected by OWAD Environment in other regions are provided below for comparison:

- New South Wales North Coast, four State Forests: 19/39 sites or 49% (OWAD Environment 2015a)
- South East Queensland, Ipswich City Council area: 94/217 sites or 43% (OWAD Environment 2015b and 2016a)
- South East Queensland, Logan City Council area: 27/58 sites or 47% (OWAD Environment 2015c)
- South East Queensland, Lockyer Valley area: 12/39 sites or 31% (OWAD Environment 2016b)

The closest site assessed by OWAD Environment using similar methods and protocols was Maria River State Forest which is located approximately 200km northeast of the subject site, where Koala scats were detected in 5 of 10 sites assessed (50%).

The Koala activity levels detected on the subject site are comparable with all of the above studies.

Of note, during the field assessment pap was observed in six instances in five different cells. Pap found ranged in age from approximately three weeks old, to two to three months old. This provides evidence of recent successful breeding on the subject site. Further evidence of breeding was obtained by the genetic tests which detected two pairs of likely parent-offspring individuals. There is therefore strong evidence of breeding on the subject site.

The allelic richness value included in this report provides an indication of the genetic diversity for the Koala population that was sampled in this study. Allelic richness was found to be comparable to that found in three distinct populations identified in South East Queensland (OWAD Environment 2018b).

Further sampling in the greater landscape surrounding the subject site would be required to gain an understanding of population structure. In the absence of available data from this region of NSW, it is not possible to determine whether the individuals that occur on site are e.g. isolated and genetically distinct, and may be experiencing genetic erosion due to isolation; or whether they are part of a larger population that is genetically fit, with strong gene flow and good migration rates in/out of neighbouring populations in the greater landscape. Future studies in the greater landscape may shed light onto the population structure of Port Stephens Koalas, which would in turn provide a better understanding of the Koala population that currently occurs on the subject site.

The 40% incidence of *C. pecorum* found in this study is comparable with that found in South East Queensland using the same *C. pecorum* laboratory detection methods. Indeed when combining four recent studies in South East Queensland (OWAD Environment 2017a, 2017b, 2018a and 2018b), a 40% *C. pecorum* prevalence was also found from the 184 individuals tested to date in South East Queensland using the same methods.

KoRV-A was detected in 100% of the individuals tested in this study. This result is in line with current data available. KoRV-A is known to be ubiquitous in most Queensland and New South

Wales free-ranging Koala populations (Meers *et al* 2014, Chappell *et al* 2016), with all populations tested in these States to date showing a prevalence of 100% regardless of detection methods used. To date, 100% of the 191 South East Queensland individuals tested for KoRV-A using the same methods as this study have also tested positive (OWAD Environment 2017a, 2017b, 2018a and 2018b).

8.0 STUDY LIMITATIONS

8.1 TARGET SCAT DETECTABILITY

The use of purpose-bred, purpose-trained professional detection dogs greatly minimises the risk of not detecting a target when it is in fact are present. The professional detection dogs and their handlers used in this study were extensively trained by a professional scent detection dog expert. The dogs are continuously trained and developed by their handlers throughout the year, and the handlers and the dogs maintain their professional certification. Before deploying each new detection dog in the field, OWAD Environment thoroughly tests each dog. A dog is not deployed for project work until it consistently performs to 100% target detection rate and 100% scent discrimination (i.e. never indicates on non-targets) in field trials performed over several consecutive days.

8.1.1 Trained scent threshold

Even though the professional detection dogs used in this study can *perceive* the scent of their target scats long after these have decomposed, they are purposely trained to *not indicate* on 'trace odour' − that is, a scent threshold that corresponds to scats that are so old that they have lost all structural integrity and are already decomposed.

8.1.2 Inferring absence

While for the purpose of this study recovering a single Quoll scat would have been an absolute finding, failure to detect Quoll scats in an area is not necessarily conclusive. That is, absence of evidence is not evidence of absence. While the risk of 'false negative' was minimised via the use of professional detection dogs and the sampling design which resulted in good coverage of the subject site, the lack of Quoll scat detection in this study may suggest either of the following:

- Quolls are not present in the area (i.e. true absence);
- Quolls are currently present on the subject site, however scats were not detected because:
  - no scats were deposited in or near the areas sampled; or
  - there were scats in the vicinity of areas sampled, however wind conditions were blowing the scent of Quoll scat away from the detection dog hence the scent was not perceivable by the canine; or
  - Quoll scats were deposited in the relatively recent past at the areas sampled, but were too decomposed for the dogs to indicate/below their trained threshold for indication (whether residue odour still perceivable by the dog, or odour so old that even residue odour has disappeared)[5].

Finally, it must be noted that as with any scat-based survey, the absence of scats at time survey does not negate the possibility of Quolls visiting the site and depositing scats in the future.

[5] In 2015/2016 OWAD Environment conducted a trial to assess how long Quoll scats could persist in various natural environments. It was found that depending on the ecosystem and on scat content (i.e. amount of hair and/or bone fragments in the scat), these decomposed within 2 months or lasted up to 7 months. Similarly to the ongoing reinforcement on Koala scat detection in controlled plots, the detection dogs are only rewarded for indication on Quoll scats that still have some structural integrity.

8.2 SCAT ANALYSIS LIMITATIONS

8.2.1 Scat condition

The key limitation of current methods for extracting genetic material from Koala scats is that the scats need to be relatively fresh (up to approximately 4 weeks old), be in good physical condition (be intact/undamaged) and not have been exposed to rain. Wet or damp conditions and other environmental factors (e.g. mechanical abrasion, insect predation, variable site conditions) may affect the quality and quantity of the target DNA (i.e. Koala, KoRV-A and *C. pecorum*) available for isolation.

8.2.2 Personnel collecting scats

There are a number of prerequisites in order for the personnel collecting scats to provide the laboratory with reasonably viable Koala genetic material for analysis purposes:

- Ability to identify and differentiate Koala scats from other animal scats −
  OWAD Environment personnel is highly experienced in identifying Koala scats and differentiating them from similar looking scats from other animals (e.g. Possum). 100% of the >400 scat samples collected and submitted to date by the OWAD study team for analysis have been confirmed by the laboratory as originating from Koala. Additionally, OWAD's professional detection canines have receive extensive discrimination training and never indicate (0%) on any similar looking scats that don't originate from Koala[6].
- Ability of personnel to estimate the age and condition of Koala scats −
  Assessing whether a sample may be in sufficient/appropriate condition or not for analysis is paramount. OWAD Environment is highly experienced in estimating the age and condition of Koala scats for genotypic analysis purposes, and prior to conducting this study had extensive prior experience conducting multiple Koala genetic sampling programs.
- Appropriate timing for scat collection −
  Even though the field survey was not conducted during the most favorable season for non-invasive genetic sampling, the site and weather conditions at time of survey were appropriate. The forest floor was dry with no recent significant rainfall event, fungal activity was limited and ambient humidity was low. These seasonally atypical favorable conditions are likely to have contributed to the success in obtaining reliable DNA profiles from 100% of the samples collected.
- Appropriate collection, storage and postage of scats −
  OWAD Environment personnel followed the scat collection and storage procedures detailed in **Section 2.3**. Scat collection, storage and packing of the kits for postage was done with great care to minimise damage to genetic material from the time of collection in the field to reception by the WildDNA laboratory. In this study there was no loss of genetic material during postage and handling.
- Ability to distinguish scats from putative distinct individuals −
  At each location where fresh scats are found, field personnel must be sufficiently experienced to assess whether these may potentially originate from distinct individuals, as scats from distinct individuals should be placed in distinct collection kits. OWAD Environment is very experienced in making these educated presumptions. Such a case did occur in one instance in this study: PS07 and PS08 were collected from the same location and these two samples were found to indeed originate from two distinct individuals (one female and one male).

[6] Both detection dogs used in this study also have Quoll scat as a target scent, however OWAD personnel can easily distinguish a Quoll scat from a Koala scat.

8.2.3 Chlamydia pecorum detection

A positive *C. pecorum* result from scat or pap analysis indicates that the individual carries the bacterium, however this does not necessarily mean that the individual displays clinical symptoms of the disease. Further research is required to determine whether a there is a threshold of bacterium count found in scat or pap analysis that would equate to clinical symptoms.

A negative *C. pecorum* result from scat or pap analysis does not necessarily mean that the individual is not infected. Indeed an individual could carry the bacterium but the infection hasn't spread to the gastrointestinal tract hence is not detectable in scat. Further research is required to determine whether the bacterium is necessarily detectable in scat or pap if an individual is known to display clinical symptoms.

8.3 LIMITATIONS OF DATA INTERPRETATION

The interpretations provided in this report are only valid indications for the subject site and the individual Koalas sampled and tested as part of this study.

The number of individual Koalas detected in this study does not represent a population census for the subject site. Indeed the survey performed in this study was not a full search of the subject site, but sampling only. Moreover, obtaining reliable census would require several rounds of genetic sampling as a form of 'mark recapture' sampling program.

With regard to the lack of evidence of Quoll presence in this study, like any other scat-based survey where sampling is required, the lack of Quoll evidence at time of survey does not preclude the possibility that (1) Quolls may be present in the future at the areas samples, and/or (2) Quolls are present on the site but outside of the areas sampled as part of this study, and/or (3) Quolls have visited the areas sampled in the past but have not recently deposited scats in the areas that were sampled.

9.0 CONCLUSION

OWAD Environment was contracted by PM №1 Pty Ltd c/o RPS Group to survey the subject site with the assistance of two professional field detection dogs certified for the detection of Koala and Quoll scats, and collect potentially viable Koala scat samples for genetic testing purposes.

RPS Group defined 64 sampling cells across the site. 62 of the 64 sampling cells were successfully assessed.

The detection dogs searched a total of 43km over 5 days in accordance with an unbiased sampling grid designed by RPS Group. This survey found evidence of Koala presence at 47 locations, in 28 of the 62 cells (or 45%) assessed. No evidence of Quoll presence was detected during this assessment.

Each sampling cell was attributed a relative Koala activity score to provide an indication of Koala distribution across the site.

A total of 12 Koala genetic samples were collected from 10 cells and submitted to a specialist laboratory for Koala DNA profiling, gender identification and pathogen detection *C. pecorum* and KoRV-A. All 12 samples (100%) successfully passed laboratory Quality Control and proceeded to analytical testing. A summary of analytical and genetics test results is provided below:

- 12 of the 12 samples tested (100%) provided a reliable DNA profile
- Genotype profile matching revealed that these 12 DNA profiles originate from 10 distinct individuals, being four females and six males
- Four of the 10 unique individuals identified (40%) tested positive for *C. pecorum*,
- All 10 individuals (100%) tested positive for KoRV-A
- Two pairs of closely related individuals were identified, and both were identified as likely parent-offspring pairs
- Allelic richness, a measure of genetic diversity, was found to be comparable with three populations from South East Queensland

The evidence of pap observed at six locations on the subject site, and the results from the genotypic analysis identifying two likely parent-offspring pairs, provide strong evidence of breeding on the subject site.

This report may be used by RPS Group to complement any other information obtained for the subject site for ecological assessment purposes.

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APPENDIX 1
FIELD NOTES

Waypoint №	Cell №	Found at (mn's in that search)	Tree species	Observations	Sample code (where applicable)	Coordinates (UTM zone 56	
						Easting	Northing
01	40	4mn55s	Grey Gum	One very old scat >6 months old.		386167	6378715
02	3	1mn50s	Stringybark spp.	Abundance of scats of varying age classes from circa 2 months to >6 months old, and two distinct shape/size classes.		386960	6381171
03		1mn55s	Stringybark spp.	A few scats circa 2 months old.		386959	6381181
04	13	00mn00s (dog indicated on leash before search started)	Stringybark spp.	Pap circa 3-4 weeks old = **evidence of breeding**.	PS01	387031	6380331
05	4	1mn10s	E. tereticornis	A few scats circa 3 months old.		386725	6381314
06	29	1mn57s	C. maculata	A few scats circa 2 months old.		386304	6379324
07		2mn23s	C. maculata	Abundance of scats of at least 3 age classes (circa 2 weeks, circa 6 weeks and >6 months old), and two distinct shape/size classes.	PS02	386277	6379316
08		2mn49s	Stringybark spp.	A few scats circa 1 month old.		386262	6379313
09		4mn34s	C. maculata	One scat circa 3 months old.		386258	6379251
10	27	4mn22s	E. umbra	Abundance of scats of two distinct age classes, circa 3 weeks and circa 3 months old, and two distinct shape/size classes.	PS03	386334	6379554
11	25	1mn59s	C. maculata	A few very old scats >6 months old.		385807	6379582
12	30	1mn12s	Grey Gum	A few scats circa 3 months old.		385996	6379273
13	54	4mn47s	C. maculata	A few scats circa 2 months old.		383997	6378887
14	55	2mn52s	Stringybark spp.	A few scats circa 3 months old.		383957	6378700
15		4mn50s	C. maculata	A few scats circa 3 months old.		383968	6378738
16	57	3mn36s	C. maculata	A few scats circa 2-3 months old.		383830	6378668
17	51	4mn44s	Overlapping C. maculata and stringybark spp.	A few scats circa 6 months old.		384604	6378815
18	50	0mn50s	Grey Gum	A few scats circa 3 months old.		384631	6378956
19	45	2mn04s	E. tereticornis	A few scats circa 3 months old.		384724	6378992
20		3mn00s	Stringybark spp.	A few scats circa 2-3 weeks old.	PS04	384751	6378990
21		4mn48s	Grey Gum	Two old scats >6 months old.		384787	6378944
22	39	0mn24s	Grey Gum	A few scats circa 3 months old.		386155	6378950
23	26	2mn02s	Stringybark spp.	A few scats circa 3 months old.		386034	6379627
24		2mn43s	Overlapping stringybark spp. and Grey Gum	A few scats circa 2 months old.		386037	6379604
25		4mn07s	Overlapping C. maculata and stringybark spp.	A few very small scats distinctly different to those observed at previous two locations in this cell, circa 2 months old.		386029	6379550

Waypoint №	Cell №	Found at (mn's in that search)	Tree species	Observations	Sample code (where applicable)	Coordinates (UTM zone 56	
						Easting	Northing
26	24	1mn26s	Stringybark spp.	A few scats circa 3-4 weeks old.	PS05	385603	6379539
27		2mn53s	Stringybark spp.	A few scats circa 2 months old.		385555	6379528
28		4mn57s	C. maculata	Pap circa 2-3 months old = **evidence of breeding**.		385511	6379535
29	19	0mn34s	Overlapping Grey Gum and E. tereticornis	Pap circa 2 months old = **evidence of breeding**.		385622	6379754
30		3mn31s	E. tereticornis	Pap circa 2 months old = **evidence of breeding**.		385591	6379819
31		4mn50s	Stringybark spp.	Particularly small scats circa 4-6 weeks old (the joey associated with the pap observed at previous two locations in this cell?).		385623	6379823
32	22	0mn27s	E. tereticornis	Two scats circa 3 months old.		384918	6379614
33	33	1mn16s	C. maculata	A few scats circa 4-6 weeks old.		385316	6379447
34		3mn38s	C. maculata	A few scats circa one month old. Appear consistent with the scats observed at previous location in this cell, only these scats in slightly better physical condition.	PS06	385305	6379404
35	35	2mn49s	Grey Gum	A few scats circa 3-4 months old		385074	6379204
36	44	4mn45s	C. maculata	Abundance of scats of two shape/size classes circa 3 weeks old, possibly originating from two distinct individuals. Also presence of pap circa 2-3 months old = **evidence of breeding**.	PS07 PS08	385040	6379029
37	43	3mn20s	Grey Gum	Two scats circa one month old.	PS09	385347	6378957
38		4mn49s	Stringybark spp.	A few scats circa 3 weeks old.	PS10	385297	6378928
39	53	3mn52s	Overlapping C. maculata and Grey Gum	Abundance of pap ranging in age from circa 3 weeks to circa 2 months old. **Evidence of breeding**.	PS11	384356	6378613
40		4mn35s	Overlapping C. maculata and stringybark spp.	A few old scats >6 months old.		384383	6378604
41		4mn50s	C. maculata	A few scats circa 3-4 months old.		384351	6378573
42	15	2mn57s	C. gummifera	A few scats circa 3-4 weeks old.	PS12	386660	6379815
43	46	3mn17s	C. maculata	One scat circa 2-3 months old.		385707	6378641
44		10mn20s	C. maculata	A few scats circa 3 months old.		385634	6378701
45	5	1mn58s	C. maculata	Abundance of scats circa 2-3 months old.		386523	6381476
46		2mn20s	Ironbark spp.	A few scats circa 4-5 months old.		386536	6381448
47	7	4mn15s	C. maculata	A few scats circa 4 months old.		386519	6381141

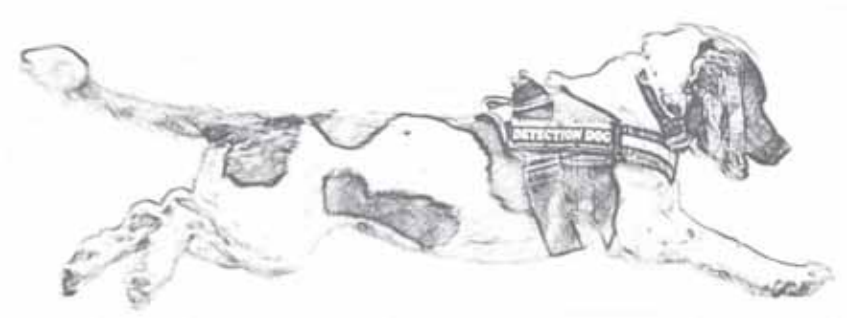
PORT STEPHENS LGA KOALA GENETIC SAMPLING REPORT

Prepared by

OWAD Environment

for

PM №1 Pty Ltd c/o RPS Group



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Report Title: Port Stephens LGA Koala genetic sampling report

Report Author: Olivia Woosnam

Report Reviewers: Alex Dudkowski, Mark Aitkens

Project Summary: This report presents the results of a Koala sampling program conducted in targeted areas of Port Stephens Local Government Area (New South Wales) in order to provide further understanding of the Koala in the region.

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Signed on behalf of OWAD Environment

Olivia Woosnam
Director
Date: 12/12/2019

PORT STEPHENS LGA
KOALA GENETIC SAMPLING REPORT

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APPENDICES

Appendix 1 Field notes (July 2019 fieldwork)

1.0 EXECTUTIVE SUMMARY

Following an initial study on the site known as Kings Hill in November 2018, OWAD Environment was contracted by PM №1 Pty Ltd c/o RPS Group to conduct further investigations of Koala *Phascolarctos cinereus* on further lands within Port Stephens Council Local Government Area (LGA). The genetic profiles of ten distinct individuals had been obtained in November 2018 from the Kings Hill site, however the information these could reveal was limited due to the absence of a basic understanding of population structure and genetic diversity within Port Stephens LGA.

A second sampling program was therefore undertaken in the broader landscape within Port Stephens LGA to provide greater insight into the relative significance of the individuals sampled within the Kings Hill site and, if possible, obtain a preliminary understanding of contemporary Koala population structure in the area.

The July 2019 sampling program was conducted with the assistance of purpose-bred professional field detection dogs on a selection of seven subject lands including Mambo Wetlands, Wanda Wetlands, Stoney Ridge Reserve, Karuah BioBank, Grahamstown Dam West (north), Grahamstown Dam West (centre) and Boomerang Park. Koala scat samples containing genetic material were obtained from these lands in order to further investigate Koala genetic indicators, so as to assess the relevance of the Kings Hill site for the Koala in the region. Supplementary genetic material was obtained from individuals in care with Port Stephens Koalas; some of these individuals were rescued (or last rescued) by carers outside of the July 2019 subject lands (e.g. Clarence Town and Anna Bay).

The July 2019 fieldwork found evidence of Koala presence on all subject lands except Boomerang Park. The detection dogs searched 52.8km and 34 Koala genetic samples were collected for analysis. Reliable Koala DNA profiles (and associated information) were obtained for 23 unique individuals.

A total of 33 unique individuals have now been sampled and successfully profiled from Port Stephens LGA from the 2018 and 2019 surveys, being 17 females and 16 males. 30% of individuals (10/33) tested positive for *Chlamydia pecorum*, while 100% (33/33) tested positive for Koala retrovirus KoRV-A.

Population structure analysis within Port Stephens LGA was successful and revealed very strong structuring in the region. At this stage, at least two distinct population clusters are identified with the individuals sampled from the Tomaree Peninsula (cluster PS1) being distinctly differentiated from the individuals sampled from all other areas (currently identified as cluster PS2). Some indicators suggest there may be further structuring within PS2, with the Koalas east of the Pacific Highway (currently pairing with PS2) showing less genetic diversity than the Koalas sampled on the Kings Hill site west of the highway.

Of all areas investigated to date within Port Stephens LGA where reliable genetic profiles were obtained, the highest level of genetic diversity was found on the Kings Hill site. Further, there is evidence that cluster PS2 (the population occurring at Kings Hill) is connected to other populations in the greater landscape including a known population in the Port Macquarie region 200km north.

All indicators (field results and genetic results) observed for population cluster PS1 suggest a population that is isolated and at immediate risk of being lost. A greater degree of genetic differentiation was found between the PS1 and PS2 clusters, than between PS2 and Port Macquarie 200km north. This suggests that there is greater mixing between Koalas north and south in the greater landscape (to/from Port Stephens LGA), than east to west within Port

Stephens LGA; and/or that PS2 has retained more historical diversity than PS1 has. In other terms, PS1 may be experiencing genetic drift.

Overall, the findings of this study suggest that:

- Population cluster PS2 (which includes the Kings Hill site) is currently connected to other populations in the greater landscape, including a known population 200km north. The genetic diversity of PS2 is high, however greater diversity was found west of the highway (Kings Hill site) than east of the highway within this cluster which may suggest a loss of gene flow within this cluster. Management should aim to maintain and restore gene flow where possible so as to avoid further possible genetic differentiation within Port Stephens LGA;
- Population cluster PS1 (Tomaree Peninsula) is isolated and has lower genetic diversity than PS2. In the absence of intensive and targeted management measures, this population may be at risk of being lost; and
- Koalas on the Kings Hill site showed the least concerning indicators of all lands assessed whether in terms of genetic indicators or in terms of Koala activity levels detected. Management should aim to minimise and mitigate impacts to Koalas on this land.

Further details on genetic assessment methods and results referred to in this report are currently being prepared for publication in a peer-reviewed journal.

2.0 INTRODUCTION

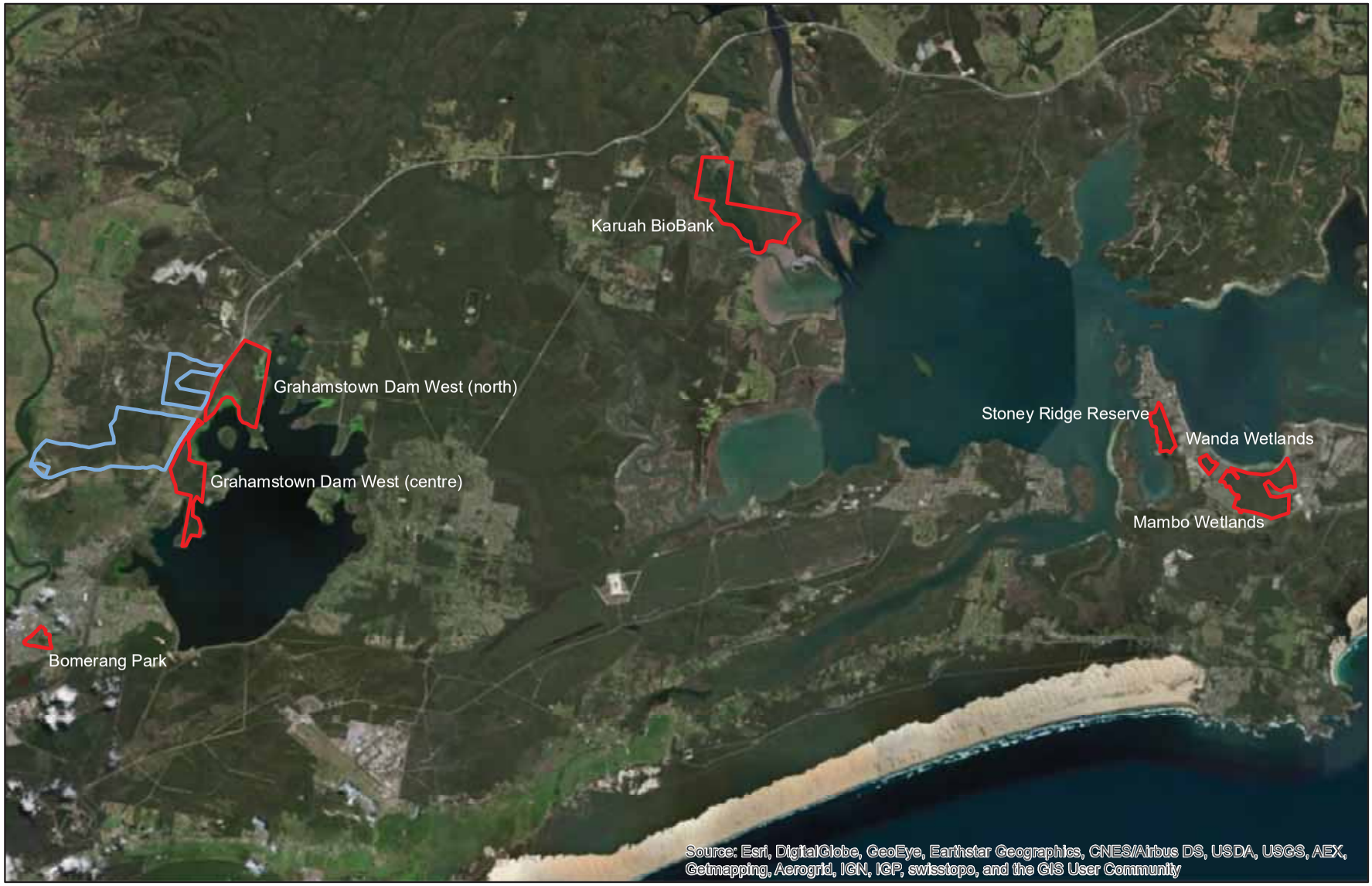
Following an initial site investigation of Koala *Phascolarctos cinereus* conducted in November 2018 on the site known as Kings Hill, OWAD Environment (OWAD) was contracted by PM №1 Pty Ltd c/o RPS Group to conduct further work in the greater landscape in order to provide more information about Koalas distribution and obtain further genetic samples in the region.

The July 2019 sampling program was conducted across a selection of seven lands owned by Port Stephens Council and Hunter Water Corporation, and located in Port Stephens Council Local Government Area (thereafter referred to as Port Stephens LGA). These lands amount to a total surface area of 847ha. The fieldwork was performed by Certified Environmental Practitioners with the assistance of two purpose-bred professional field detection dogs. The lands sampled in July 2019 are depicted on **Figure 2.1** and included the lands known as:

- Mambo Wetlands (170ha)
- Wanda Wetlands (12ha)
- Stoney Ridge Reserve (44ha)
- Karuah BioBank (262ha)
- Grahamstown Dam West (north) (212ha)
- Grahamstown Dam West (centre) (122ha)
- Boomerang Park (25ha)

The primary purpose of this study was to collect further Koala genetic samples non-invasively obtained from the greater landscape surrounding the Kings Hill site, in order to further investigate Koala distribution and provide further insight into genetic diversity, population structure and health status in the landscape.

This report presents the field results of the July 2019 assessment, the results of all genetic analysis work performed to date, and further discussion based on all work performed to date in Port Stephens LGA.



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LEGEND

Subject lands (July 2019)

Kings Hill site

FIGURE 2.1
JULY 2019 SUBJECT LANDS

Port Stephens LGA Koala genetic sampling

OWAD ENVIRONMENT

3.0 FIELD SURVEY METHODS

3.1 FIELD SURVEY TEAM

The field survey was conducted by Olivia Woosnam (Principal Koala Ecologist, Certified Environmental Practitioner, professional detection dog handler), Alex Dudkowski (Senior Koala Ecologist, Certified Environmental Practitioner, professional detection dog handler) and two professional detection dogs ('Taz' and 'Missy'). The dogs were purpose-bred from long lines of successful field detection dogs, and were raised and trained by a CCPDT[1] certified dog trainer specialising in the conditioning and training of detection dogs and handlers. Olivia and Alex received formal training by the trainer, and are re-assessed for each new dog and each new target scent added to any of their dogs.

Left: 'Taz' in work gear - jacket and tracking collar paired handheld GPS unit
Right: 'Missy' indicating on a Koala scat

The field survey was conducted under OWAD's Scientific Licence number SL101634, and OWAD's Animal Care and Ethics Committee Approval and Animal Research Authority number TRIM18/567.

3.2 FIELD SURVEY DESIGN

Prior to field survey, a certain amount of time was allocated for each of the subject lands. One full day was allocated for each of the Karuah BioBank site, Grahamstown Dam West (north) and Grahamstown Dam West (centre), and two days allocated to sample the remaining four lands.

In order to enable maximum genetic sampling within the five days allocated for fieldwork, convenience sampling was selected as the most appropriate design. Convenience sampling is a form of non-probability sampling where areas are selected because of their accessibility to the researchers. For this survey, it entailed (where possible/where existing) making use of existing

[1] Certification Council for Professional Dog Trainers, see www.ccpdt.org.

4WD tracks, walking trails, wildlife tracks etc. to access as many areas as possible within each subject land.

3.3 FIELD SURVEY PROCEDURES

3.3.1 Search protocol

One detection dog was handled at a time. The dog was led on leash to an area to assess. The dog was then taken off the leash and when prompted by the handler, scanned the ground layer for potential Koala scats, as well as above the ground for scats that may be above ground level (e.g. scats fallen on rocks, logs, bushes, stuck in branches or in bark along tree trunks). The dog worked independently and searched non-discriminatorily, scanning the air for any scent particles of its target odours. It was not directed to any specific feature, tree or tree species; the handler only gave the dog the general direction of the search. During searches, the dog was redirected, recalled or stopped at a distance using an Acme dog whistle, as required to keep the dog within the subject land or for safety reasons (e.g. prevent the dog from running into barbed wire fencing). The handler kept the dog within immediate sight at all times.

When the detection dogs find a target scat, they lie down nose on scat and hold the indication until the handler gives them a 'bridging cue'. If the scat is visually obstructed by leaf litter and/or ground vegetation, which is a very frequent occurrence with Koala scats, they use their paws and/or nose to expose a least one scat. In instances where the leaf litter is particularly thick, they may also retrieve a Koala scat with a 'soft mouth' and deposit it in the handler's hands. See examples below of Taz actively helping the handlers recover Koala scats.

Above: Taz actively helping her handlers recover Koala scats from the forest floor

In order to minimise the risk of data loss in case of GPS unit malfunction, the study team records the coordinates of all target scats found with two handheld GPS units (model Garmin Alpha 320 and Garmin GPSMap 78). The detection dogs' search tracks are recorded with a Garmin T5 dog tracking collar which is paired with the Alpha 320 unit and takes one waypoint every 2.5 seconds. Similarly, in order to minimise the risk of dog tracking data loss in case of equipment malfunction, OWAD carries two dog tracking collars and two handheld GPS units paired with both tracking collars. While working, the detection dogs wear a red 'detection dog' jacket with reflective stripes at all times.

3.3.2 Opportunistic searches

When the detection dogs are not actively searching (e.g. when driving, opening access gates etc.), the study team pays attention to the leaf litter and/or tree canopies in case scats or live Koalas are spotted.

3.3.3 Field Quality Assurance

Field Quality Assurance procedures

In all studies undertaken by OWAD, field Quality Assurance (QA) procedures are undertaken to ensure that the data collected in the field is representative of the true site conditions and is therefore valid for interpretation. QA procedures include the use of experienced Koala ecology expert staff, professionally trained detection dogs and handlers, the use of appropriate study designs and protocols, and the implementation of daily field quality control (QC) searches.

Field QC searches are performed at least once each day on all projects. Either the detection dog finds naturally deposited target scats within the first few minutes of working each day, in which case there is no need for the field assistant to deposit scats for QC purposes. Or, if no naturally deposited scats are found within the first few minutes of searching, then a third party (if available, an accompanying staff external to OWAD; or if not available, the field assistant) randomly deposits target scats, ensuring the handler does not know when or where scats may have been placed. When scats are deposited for QC purposes, the field assistant starts a separate chronometer (without the handler knowing) when the dog/handler team is within approximately 100 metres from the QC scats, and records the time it takes the dog/handler team to find target scats (whether the QC scats or naturally deposited target scats, whichever are found first).

A QC search enables the assessment of the dog/handler team's ability to find target scats in the specific conditions of a particular site, within a maximum time of 5 minutes. This enables to ensure that there are no exceptional circumstances that may be disabling the dog/handler team's ability to find the target (e.g. a scent that may be obscuring the scent of the target odours for the dog; handler fatigue which may affect the handler's ability to effectively handle the dog, etc.). Crucially, the handler is never informed in advance where or when scats are deposited for QC purposes. Not disclosing this information is crucial to ensure there is no bias in how the handler handles the dog. It is only after the dog/handler team has found target scats during a QC search that the field assistant discloses that this was a QC search. The field assistant performs at least one QC search each day, however they may perform more than one each day.

Field Quality Control search interpretation

- Should the dog/handler team find a deposited QC scat within 5 minutes, the field QC search is marked as successful, the time is recorded for record-keeping purposes and work continues. The coordinates of the QC scat may be recorded for QA purposes, but is not recorded as an actual result in the survey.

- Should the dog/handler team find naturally deposited target scats within 5 minutes after a QC search has started, the field QC search is marked as successful, the time is recorded for statistics purposes and work continues. The coordinates of the naturally deposited scats found are recorded as a result in the study.

- Should the dog/handler team fail to find target scats within 5 minutes after a QC search has started (whether the deposited QC scat or naturally deposited target scats), the field

assistant would stop the handler and disclose that a QC search has failed[2]. In the event that a QC search were to fail, the survey team would stop work immediately to try and identify the reason for failure. Upon identification of the potential cause, a second QC search would be immediately conducted to confirm the reason for initial failure. Should the second QC search also fail, the study team would reassess the site conditions / the environmental conditions / the detection dog / the handler/ the search protocol etc. If the cause for failure cannot be quickly identified and remediated, the study team would liaise with the client. No further survey work would be conducted until the reason(s) for failure are identified and remediated.

3.4 KOALA GENETIC MATERIAL SAMPLING PROCEDURES

3.4.1 Selection of samples

Koalas typically produce 100 to 150 scats in each 24 hour period (Ellis *et al* 1998). Depending on factors such as local weather events, ecosystems, microbacterial activity, insect predation, geography and moisture, Koala scats in Eastern Australia can maintain some structural integrity for up to 12 months or more (Witt and Pahl 1995, Rhodes *et al* 2011).

In this study, all scats found that had some structural integrity were recorded. However, only scats that were potentially viable for laboratory analysis were collected and submitted for laboratory analysis. Scats potentially viable for analysis met the following criteria:

- Deposited up to approximately 8 weeks prior to field assessment
- Not significantly damaged by rain/moisture/dew
- Not damaged by fire
- Not damaged by mold or fungi
- Not extensively predated on by insects
- Not covered in dust/dirt/debris/sand
- Not significantly damaged by any other factor not listed above

Each time fresh scats were found, a careful visual inspection was performed by the field survey team to assess whether the scats may fit the above criteria and were in sufficient condition to be viable for analysis. Only scats that were considered to have some potential of containing sufficient genetic material were collected and submitted to the laboratory.

Identifying fresh scats

Fresh scats are typically dark brown to black on the outside, have a shiny surface, bright green or yellow inside, and solid to the touch (or soft if extremely fresh e.g. deposited within a few hours). Occasionally fresh scats can be bright yellow, purple/blue, or red on the surface. Old scats typically have a duller surface, have less color contrast between the outside and the inside, and tend to crumble under minimal compression. See **Plate 1** as an example of 2-week old scats and 9-month old scats produced by a known unique individual, with scats aged in the natural environment.

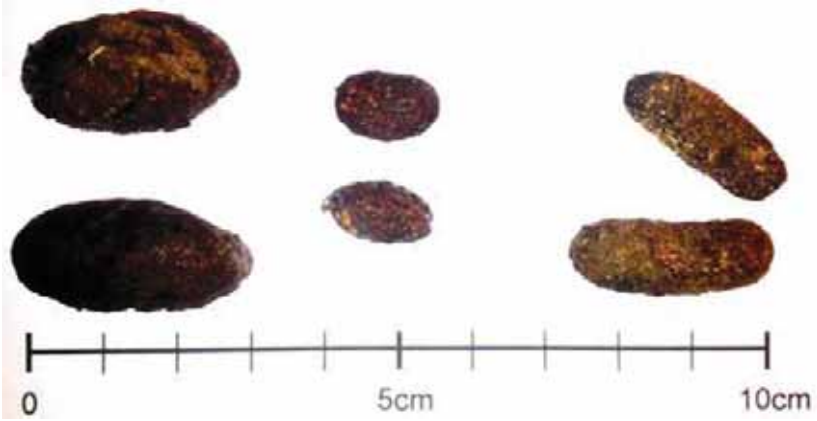
[2] This instance has never occurred to date.

Plate 1: Fresh (left) vs. old (right) Koala scats originating from the same individual (scale 1:1)

Identifying scats from potentially distinct individuals

Typically, one individual produces scats that are relatively consistent in both shape and size. There can be significant variations in the shape and/or size class of scats produced by different individuals: they can be oblong or round in shape, and can range in size from approximately <10mm to >40mm. **Plate 2** is a typical example of the variations in Koala scat size/shape class originating from three known distinct individuals. These variations were used by the survey team in the field to infer whether a particular individual may have previously been sampled from a nearby location, or whether at one location there may be fresh scats from distinct individuals. Indeed in instances where at one location there were fresh scats potentially originating from more than one individual not previously sampled nearby, these variations in scat size/shape were useful in estimating how many putative distinct individuals these may originate from in order to sample each putative individual in distinct collection kits.

Plate 2: Variations in Koala scat size and shape originating from 3 distinct individuals (scale 1:1)



3.4.2 Sample collection and handling protocol

When potentially viable Koala scats were found, their condition was assessed in the field. If deemed potentially viable for analysis, a sample was collected. The scats were collected following the methods described by Wedrowicz *et al* (2013): they were retrieved from the environment using toothpicks, ensuring no direct contact with humans or the detection dogs, and minimal friction on the forest floor so as not to mechanically damage the genetic material. The toothpicks were carefully inserted into the scats, ensuring the toothpick is driven far enough into each scat to secure it but not too far so as to cause the scat to split. The toothpicks were then inserted into a piece of foam, and the foam placed and secured into a purpose-built Koala scat collection kit (see **Plate 3**). Where possible, multiple scats were collected and placed in each kit. The reason for collecting more than one scat per presumed individual at each location, where

possible, was to provide several chances of isolating the best possible quantity and quality of DNA from each sample (see **Section 4.2.2** for further detail).

On each collection kit, a pre-affixed label was completed with the following information:

- Unique sample code
- Project location
- Date collected
- Name of entity collecting the sample (OWAD Environment)
- Sampling coordinates, in UTM zone 56 format

Plate 3: Koala scat collection kit

Each kit was then placed in a light paper bag with small holes (5mm diameter) pre-punctured to prevent moisture buildup.

While the survey team was in the field, the kits (in their paper bags) were placed in a double insulated cool container with desiccant sachets to control the temperature and prevent humidity buildup within the container. This storage method also successfully contains the scent and prevents dissipation of the detection dogs' target scent through the vehicle.

At the end of each fieldwork day, the collected kits were removed from the field container, transferred into a cardboard box with desiccant sachets and stored at ambient temperature in a cool dark room.

3.4.3 Sample submission protocol

At completion of the field survey, the samples were carefully packed in a cardboard parcel with desiccant sachets, and posted to the laboratory via overnight postage. A hard copy of the sample tracking sheet was placed in the parcel, which contained the following information:

- List of sample codes contained in the parcel
- Coordinates of sampling location of each sample
- Date sample collected from the field
- Date posted
- Laboratory services required

An electronic copy of the sample tracking sheet was also emailed to the laboratory.

4.0 SCAT ANALYSIS METHODOLOGY

4.1 LABORATORY TEAM

The laboratory team was led by:

- Dr Faye Wedrowicz (Molecular Ecologist, WildDNA Laboratory Manager)
- Dr Fiona Hogan (Molecular Ecologist, WildDNA Director, lead project coordinator)

Drs Hogan and Wedrowicz have extensive experience in the isolation and analysis of DNA from non-invasive biological sources such as feathers and scats (Hogan *et al* 2008; Wedrowicz *et al* 2013). They developed and published the genetic methods used for this study i.e. DNA profiling from a single Koala scat (Wedrowicz *et al* 2013), detecting *Chlamydia pecorum* and Koala retrovirus KoRV-A in Koala scats (Wedrowicz *et al* 2016), validating the use of DNA sourced from Koala scats for population genetic studies (Wedrowicz *et al* 2017, Wedrowicz *et al* 2018), and designing molecular markers to infer gender of Koalas using DNA isolated from Koala scats (Wedrowicz *et al* 2018).

4.2 SCAT ANALYSIS PROTOCOL

4.2.1 Surface wash

Scats received by WildDNA were processed upon arrival. Epithelial cells on the outer surface of all scats submitted were removed using the washing technique described in Wedrowicz *et al* (2013).

4.2.2 DNA isolation and laboratory Quality Control

Genomic DNA was isolated from epithelial cells (surface washes) as per the methods described in Wedrowicz *et al* (2013) using the QIAamp DNA Stool Mini Kit. The surface was obtained from each scat was tested to determine the total quantity of DNA isolated (i.e. concentration, containing both koala and non-koala DNA) and the quality of the target DNA isolated (i.e. amplification of a Koala specific locus using the polymerase chain reaction). This process is referred herein as laboratory Quality Control or 'laboratory QC'. Samples were scored as 'pass', 'low quality pass' or 'fail' after laboratory QC. Only the DNA isolate of the highest DNA concentration and of a 'pass' or 'low quality pass' standard from each kit was used for downstream genetic analysis. The scat washing process, DNA isolation and laboratory QC were conducted by WildDNA.

4.2.3 Genetic analysis

All genetic testing for this study was conducted by the Australian Genome Research Facility (AGRF) under the instruction of WildDNA. AGRF is accredited by the National Association of Testing Authorities (NATA) Australia in the field of Biological Testing and operates in compliance with the international standard ISO/IEC 17025:2005.

Genetic testing for this study involved three types of analyses:

- **Gender** − Gender was determined by targeting the X and Y chromosomes using molecular markers specially designed for sexing koalas from south east Queensland (Wedrowicz *et al* 2018).
- **DNA profiling** − Samples were genotyped for 12 Koala-specific microsatellite markers which provided a unique DNA profile. A reliable DNA profile, derived from replicate

analysis, allowed distinct individuals to be identified with a high degree of confidence (the probability that two individuals would share the same DNA profile by chance is less than 1 in 1,000,000,000). Further details of the DNA profiling process are described in Wedrowicz *et al* (2013) and Wedrowicz *et al* (2018).

- **Pathogen detection** − Samples were tested for presence/absence of *C. pecorum* and KoRV-A using target-specific molecular markers as described in Wedrowicz *et al* (2016).

4.3 ANALYSIS OF GENETIC DATA

Genotypic data derived by AGRF were used by WildDNA to generate data unique to an individual scat (hence to a unique Koala). This included identifying the number of unique individuals sampled (if one individual was sampled more than once, identifying their associated sampling locations), and the gender and pathogenic infection results for each unique individual identified.

Individual data obtained from both the November 2018 and the July 2019 sampling programs were then used to perform a number of genetic analyses to assess genetic diversity and investigate population structure.

5.0 JULY 2019 − FIELD SURVEY RESULTS

The field survey was conducted over five consecutive days between 15 and 19 July 2019. Weather conditions during the field survey were fair, however there had been a significant rain event three weeks prior and a minor rain event two weeks prior.

5.1 FIELD SURVEY EFFORT

A total of 52.8km was searched by the detection dogs while actively searching for Koala scats. The detections dog search tracks are displayed on **Figures 5.3** to **5.8**.

5.2 FIELD QUALITY CONTROL

All field QC searches performed during this survey were successful. On all field QC searches in this study, the dog/handler team found naturally deposited Koalas scats within 5 minutes of starting a QC search.

The results of this study are therefore guaranteed to be a true representation of Koala scat presence/absence in all areas investigated during this survey, at the time these were surveyed (within the parameters of study limitations, see **Section 9** for further detail).

5.3 EVIDENCE FOUND

5.3.1 Koala scat locations

Koala scats were found at a total of 172 locations, on all lands except Boomerang Park (see **Figure 5.1**). Note, 'location' here does not necessarily mean under a single tree. It can be under one individual tree if no overlapping canopy, or under several trees with overlapping canopies, or under no tree canopy (i.e. Koala defecated while moving on the ground), or under a dead tree. The detection dogs have no bias whatsoever as to where Koala scats may or may not be located; they simply take their handler to wherever scats are. See **Appendix 1** for field observations recorded for every location where Koala scats were found during the July 2019 field assessment. Click on the video below to view some footage taken during this field assessment.

5.3.2 Koala genetic material collected

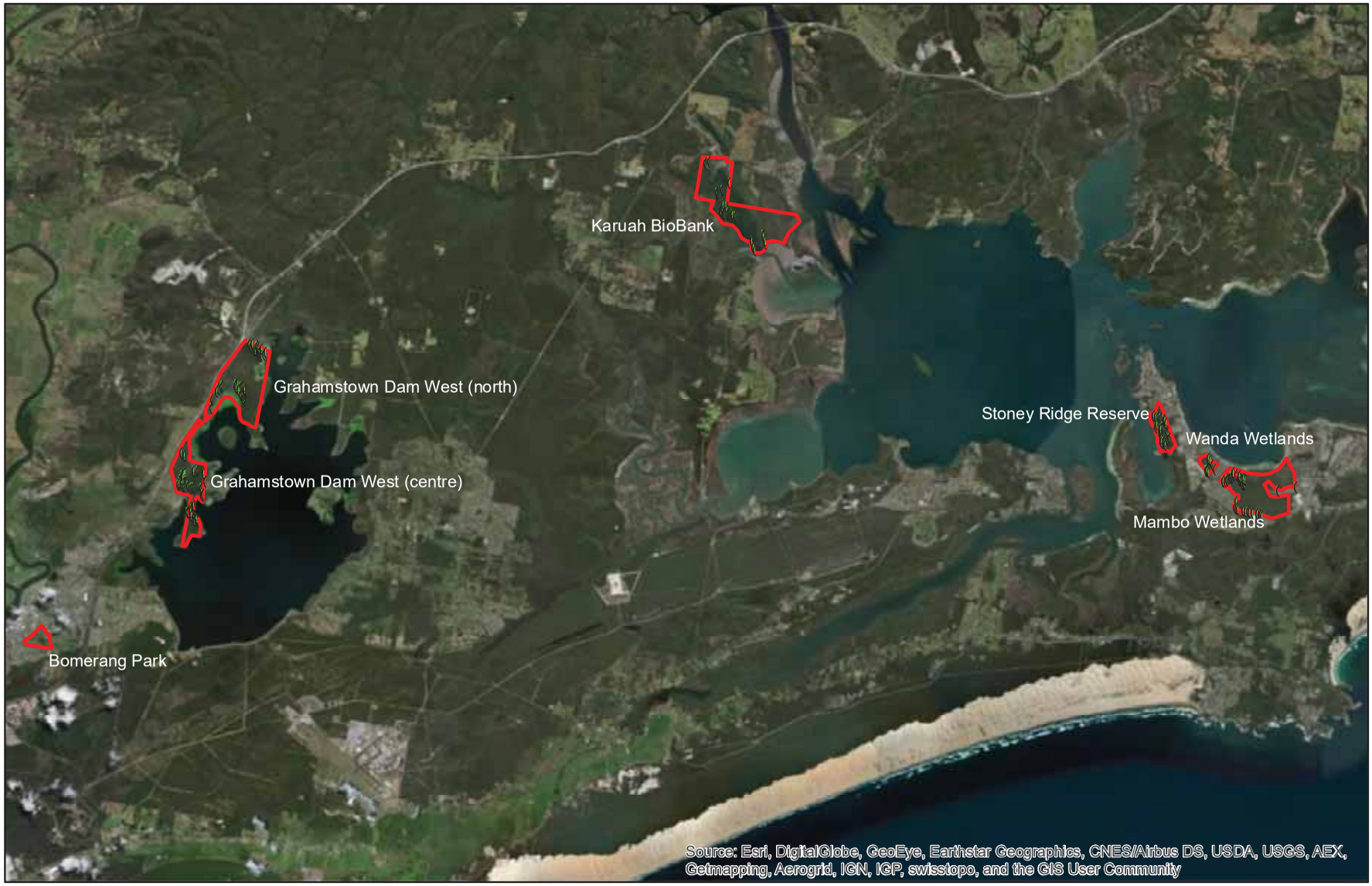
A total of 34 genetic samples were collected during the July 2019 survey period.

These included 28 samples collected from six of the subject lands assessed, and an additional six samples that were obtained from six captive individuals in the care of Port Stephens Koalas[3].

Scat samples from the captive individuals were collected on 18 July 2019. One OWAD staff entered the holding pens accompanied at all times by a Port Stephens Koalas representative. Prior to entering the facility, the OWAD staff about to enter the pens thoroughly disinfected and washed their hands, and secured plastic bags over their fieldwork shoes up the ankle. No contact was made with any Koala and nothing was touched other than the floor, which was only contacted with the shoes securely wrapped in bags and occasionally with the disinfected hands (e.g. to remove a branch debris to access a scat). When bending down to collect scats, the staff paid particular attention to not put a knee on the ground. This served both to minimise the potential risk of introducing pathogens from the wild into the facility, as well as to not transfer the scent of Koala/Koala scat onto the staff's clothing and hence into the work vehicle (target scent containment for the detection dogs). Great care was applied to collect scats as quickly as possible and to remain as silent as possible during the process, so as to minimise disturbance to the captive individuals. In order to minimise time and noise inside the holding pen, the staff who entered the pen only plucked scats with toothpicks, then gave them to the second OWAD staff who remained outside the pens. The second staff inserted them into the foams, placed them in the collection kits, completed the labels and wrapped the samples in paper bags. These were then placed inside the sample containment box as per usual. Upon leaving the facility, in order to not introduce the dog's target scent inside the vehicle both staff thoroughly washed and disinfected their hands, and the staff who had entered the pens disposed of the plastic bags used over their shoes.

The locations of the 28 scat samples collected in the field, and the locations where the six captive Koalas sampled where picked up by carers (or last picked up, for individuals that have been into care more than once) are displayed on **Figure 5.2**. More detailed maps of field results and areas searched are provided in **Figures 5.3** to **5.8**.

[3] Port Stephens Koalas is an organisation that was established in 2016. It is the new embodiment of the Hunter Koala Preservation Society (HKPS) formed in June 1987. Their current Koala care facility is under refurbishment to create a Koala Hospital at the new Port Stephens Koala Sanctuary currently under construction at One Mile beach. More details at https://portstephenskoalas.com.au.



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Project No.: 190714
Created by: OW
On: 07/08/2019

LEGEND

Subject lands (July 2019)

Koala scats found

FIGURE 5.1
OVERVIEW OF JULY 2019 FIELD SURVEY FINDINGS
Port Stephens LGA Koala genetic sampling

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Project No.: 190714
Created by: OW
On: 07/08/2019

LEGEND

- Subject lands (July 2019)
- Sampling location of Koala genetic material collected in the field
- Pick up location of captive individuals sampled

FIGURE 5.2
OVERVIEW OF KOALA GENETIC MATERIAL COLLECTED (July 2019)
Port Stephens LGA Koala genetic sampling

0 0.5 1 2 Kilometers

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Project No.: 190714
Created by: OW
On: 03/08/2019

LEGEND

- Subject lands
- Detection dog search tracks (10.7km)
- # Koala scats found and collected # = unique sample code
- # Location where captive individual sampled was picked up (or last picked up) # = unique sample code
- # Koala scats found (not collected) # = waypoint number

FIGURE 5.3
INSET 1 - FIELD RESULTS July 2019

Port Stephens LGA Koala genetic sampling

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Project No.: 190714
Created by: OW
On: 03/08/2019

LEGEND

- Subject lands
- Detection dog search tracks (6km)
- # Koala scats found and collected # = unique sample code
- # Koala scats found (not collected) # = waypoint number

FIGURE 5.4
INSET 2 - FIELD RESULTS July 2019

Port Stephens LGA Koala genetic sampling

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Project No.: 190714
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On: 03/08/2019

LEGEND

- Subject lands
- Detection dog search tracks (9.2km)
- # Koala scats found and collected # = unique sample code
- # Koala scats found (not collected) # = waypoint number

FIGURE 5.5
INSET 3 - FIELD RESULTS July 2019

Port Stephens LGA Koala genetic sampling

0 0.5 1 2 Kilometers

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Project No.: 190714
Created by: OW
On: 03/08/2019

LEGEND

Subject lands

Detection dog search tracks (13km)

Koala scats found and collected # = unique sample code

Koala scats found (not collected) # = waypoint number

FIGURE 5.6
INSET 4 - FIELD RESULTS July 2019

Port Stephens LGA Koala genetic sampling

OWAD ENVIRONMENT

0 0.5 1 2 Kilometers

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Project No.: 190714
Created by: OW
On: 03/08/2019

LEGEND

- Subject lands
- Detection dog search tracks (11.9km)
- # Koala scats found and collected # = unique sample code
- # Koala scats found (not collected) # = waypoint number

FIGURE 5.7
INSET 5 - FIELD RESULTS July 2019

Port Stephens LGA Koala genetic sampling

OWAD ENVIRONMENT

0 0.25 0.5 Kilometers

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Project No.: 190714
Created by: OW
On: 03/08/2019

LEGEND

Subject lands

Detection dog search tracks (2km)

FIGURE 5.8
INSET 6 - FIELD RESULTS July 2019

Port Stephens LGA Koala genetic sampling

6.0 GENETIC ANALYSIS RESULTS

6.1 SAMPLING PERIODS

A total of 46 samples were collected from Port Stephens LGA over two sampling periods:

- November 2018: 12 samples collected from the Kings Hill site
- July 2019: 28 samples collected from the subject lands assessed, and six samples obtained from six captive individuals in the care of Port Stephens Koalas

6.2 LABORATORY QUALITY CONTROL

41 of the 46 samples (89%) collected by OWAD and submitted to WildDNA passed laboratory QC and proceeded to testing for Koala DNA profiling, gender identification, and *C. pecorum* and KoRV-A detection.

6.3 DNA PROFILES OBTAINED

6.3.1 Reliable DNA profiles obtained

37 of the 41 samples (90%) tested provided a reliable Koala DNA profile.

6.3.2 Unique DNA profiles identified

Genotype matching revealed that the 37 DNA profiles obtained originate from 33 distinct individuals, being 17 females and 16 males.

These results are summarised in **Table 1** (next page). The sampling locations of all reliable DNA profiles obtained are shown on **Figures 6.1** to **6.4**.

Overall 33 distinct individuals were identified from 41 scat samples tested, or an overall success of 80.5% for this study in identifying unique Koalas. This is a very high success rate when identifying unique animals from DNA extracted from scat.

Scat sampling and analysis is performed for many species across the globe in an attempt to identify unique individuals. Success rates vary greatly, but rarely exceed 60%. For instance Cristescu *et al* (2018) identified 193 Koala individuals from 383 scat samples tested (50.4% success); Ferreira *et al* (2018) identified 65 Cabrera Vole individuals from 323 scat samples tested (20.1% success); Hedmark *et al* (2004) identified 16 Wolverine individuals from 32 scat samples tested (50% success); Kohn *et al* (1999) identified 30 Coyote individuals from 238 scat samples tested (12.6% success).

The 80.5% success obtained in this study is very high, but is on par with previous studies conducted by OWAD in collaboration with WildDNA (e.g. OWAD Environment (2017a, 2018b) 141 unique Koalas identified from 201 scat samples tested, or 70.1% success). This high success can be attributed to two key elements: (1) the expertise of OWAD staff in selecting potentially viable samples, and their experience in making educated assumptions to distinguish scats from putative distinct individuals, and (2) the development and implementation of a strict laboratory Quality Control process, which minimises the proportion of potentially unviable samples that are tested.

6.4 PATHOGEN DETECTION

C. pecorum was detected in the scats of 10/33 individuals (or 30%).

KoRV-A was detected in all 33 individuals (100%).

See **Section 7.4** for further discussion on these results.

6.5 PAIRWISE RELATEDNESS

Pairwise relatedness testing revealed that 10 pairs of individuals sampled were likely first or second degree relatives:

- Likely first degree relatives (i.e. parent-offspring pairs or full siblings):

  PS04 - PS08
  PS07 - PS08
  PS15 - PS17
  PS17 - PS19
  PS29 - PS32

- Likely second degree relatives (e.g. half siblings):

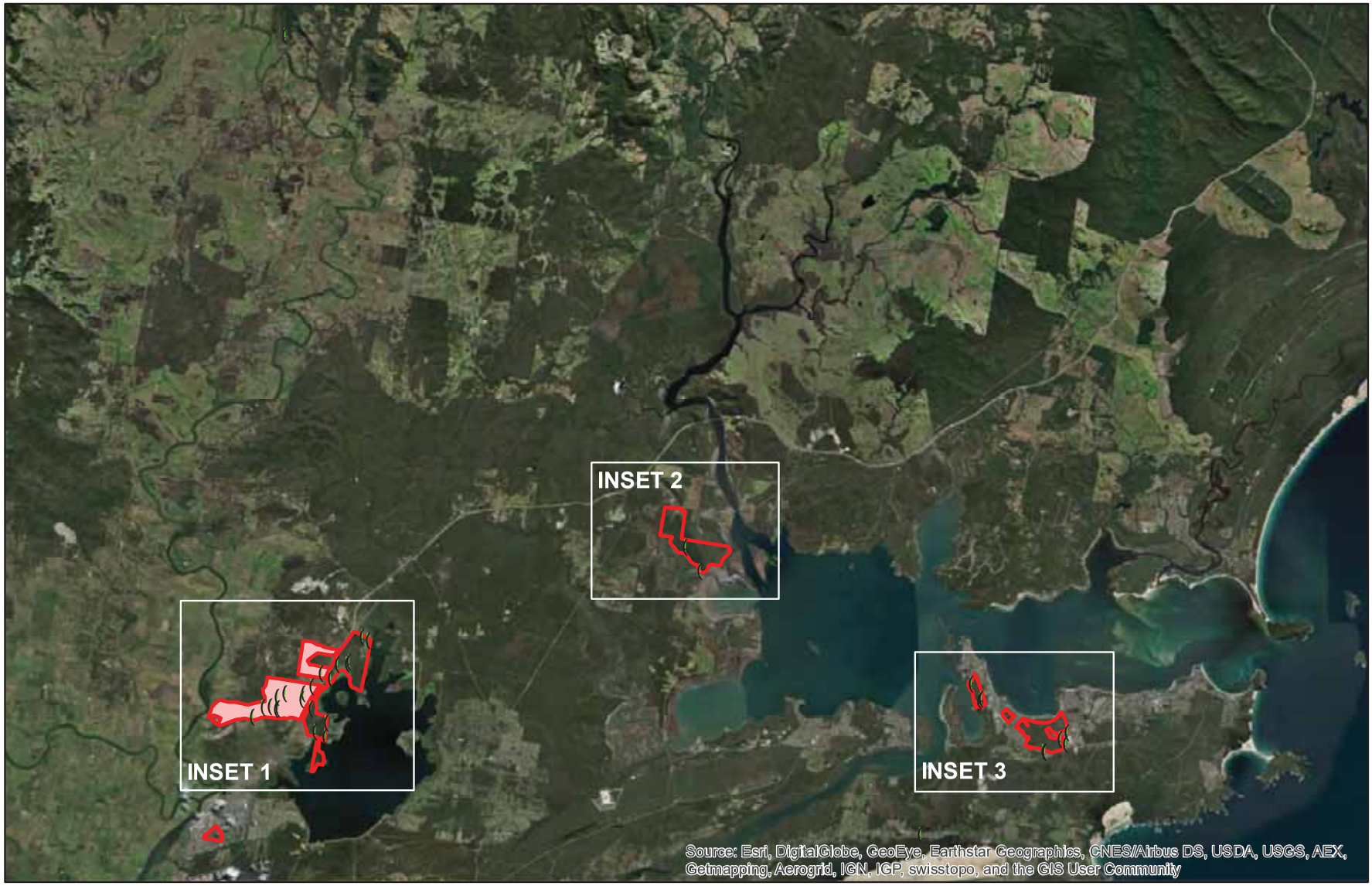
  PS16 - PS17
  PS17 - PS33
  PS21 - PS35
  PS28 - PS31
  PS42 - PS43

These pairs of first or second degree relatives are identified on **Figures 6.2** to **6.4**.

Further discussion regarding additional pairwise relatedness results is provided in **Section 7.3**.

Table 1: Summary of laboratory analysis results

Sampling location/s of unique individuals identified	Sampling period	Sampling location	Gender	*C. pecorum* detected?	KoRV-A detected?
PS01	Nov 2018	Kings Hill	Male	Yes	Yes
PS02	Nov 2018	Kings Hill	Female	Yes	Yes
PS03 / PS12	Nov 2018	Kings Hill	Male	No	Yes
PS04 / PS09	Nov 2018	Kings Hill	Male	No	Yes
PS05	Nov 2018	Kings Hill	Female	No	Yes
PS06	Nov 2018	Kings Hill	Female	No	Yes
PS07	Nov 2018	Kings Hill	Female	Yes	Yes
PS08	Nov 2018	Kings Hill	Male	Yes	Yes
PS10	Nov 2018	Kings Hill	Male	No	Yes
PS11	Nov 2018	Kings Hill	Male	Yes	Yes
PS13/PS14/PS15	July 2019	Mambo Wetlands	Female	No	Yes
PS16	July 2019	Stoney Ridge Reserve	Male	No	Yes
PS17	July 2019	Stoney Ridge Reserve	Female	No	Yes
PS19	July 2019	Stoney Ridge Reserve	Female	No	Yes
PS20	July 2019	Mambo Wetlands	Female	Yes	Yes
PS21	July 2019	Mambo Wetlands	Male	No	Yes
PS24	July 2019	Karuah BioBank	Male	No	Yes
PS25	July 2019	Karuah BioBank	Male	No	Yes
PS26	July 2019	Karuah BioBank	Male	Yes	Yes
PS27	July 2019	Grahamstown Dam West (north)	Male	Yes	Yes
PS28	July 2019	Grahamstown Dam West (north)	Female	Yes	Yes
PS29	July 2019	Grahamstown Dam West (north)	Female	No	Yes
PS30	July 2019	Grahamstown Dam West (north)	Male	No	Yes
PS31	July 2019	Grahamstown Dam West (north)	Female	Yes	Yes
PS32	July 2019	Grahamstown Dam West (north)	Male	No	Yes
PS33	July 2019	Mambo Wetlands	Female	No	Yes
PS35	July 2019	Mambo Wetlands	Female	No	Yes
PS36	July 2019	Anna Bay/Bobs Farm	Male	No	Yes
PS37	July 2019	Glen William	Male	No	Yes
PS42	July 2019	Grahamstown Dam West (centre)	Female	No	Yes
PS43	July 2019	Grahamstown Dam West (centre)	Female	No	Yes
PS44	July 2019	Grahamstown Dam West (centre)	Female	No	Yes
PS46	July 2019	Grahamstown Dam West (centre)	Female	No	Yes
TOTAL 33 INDIVIDUALS			**17 females 16 males**	**10/33 (30%)**	**33/33 (100%)**



0 15 30 Kilometers

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Project No.: 190714
Created by: OW
On: 02/10/2019

LEGEND

- Subject lands
- Kings Hill site
- (Sampling locations of reliable Koala DNA profiles obtained

FIGURE 6.1
OVERVIEW OF GENETIC RESULTS

Port Stephens LGA Koala genetic sampling

0 2.75 5.5 Kilometers

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Project No.: 190714
Created by: OW
On: 02/10/2019

LEGEND

- Subject lands
- Kings Hill site
- Sampling locations of reliable Koala DNA profiles obtained (# = sampling location code)
- Close relatives
- Same individual sampled at >1 location

FIGURE 6.2
INSET 1 - GENETIC RESULTS

Port Stephens LGA Koala genetic sampling

0 1 2 Kilometers

N

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Project No.: 190714
Created by: OW
On: 02/10/2019

LEGEND

Subject lands

Sampling locations of reliable Koala DNA profiles obtained
(# = sampling location code)

FIGURE 6.3
INSET 2 - GENETIC RESULTS

Port Stephens LGA Koala genetic sampling

OWAD ENVIRONMENT

0 1.5 3 Kilometers

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Project No.: 190714
Created by: OW
On: 02/10/2019

LEGEND

- Subject lands
- Sampling locations of reliable Koala DNA profiles obtained (# = sampling location code)
- Close relatives
- Same individual sampled at >1 location

FIGURE 6.4
INSET 3 - GENETIC RESULTS

Port Stephens LGA Koala genetic sampling

6.6 POPULATION STRUCTURE

Population structure was investigated by analysing the genetic profiles of individuals sampled in Port Stephens to date, as well as the genetic profiles already obtained from other regions in New South Wales, Queensland and Victoria. Further details on population structure methods and results will be included in a scientific article currently being prepared for publication in a peer-reviewed journal. The sections below provide a summary of the key findings.

6.6.1 Broad structure

Population structure analysis[4] identified that the individuals sampled to date belong to at least two distinct population clusters, referred to as population clusters PS1 and PS2. Even though the sample size of unique DNA profiles obtained in the region is currently limited, the results obtained here reveal a strong correlation between geographic location and population structure, with a very strong differentiation between the individuals originating from the Tomaree Peninsula (cluster PS1) and all other Koalas from other areas sampled to date (cluster PS2). **Table 2** and **Figure 6.5** provide visual representations of the population structure found.

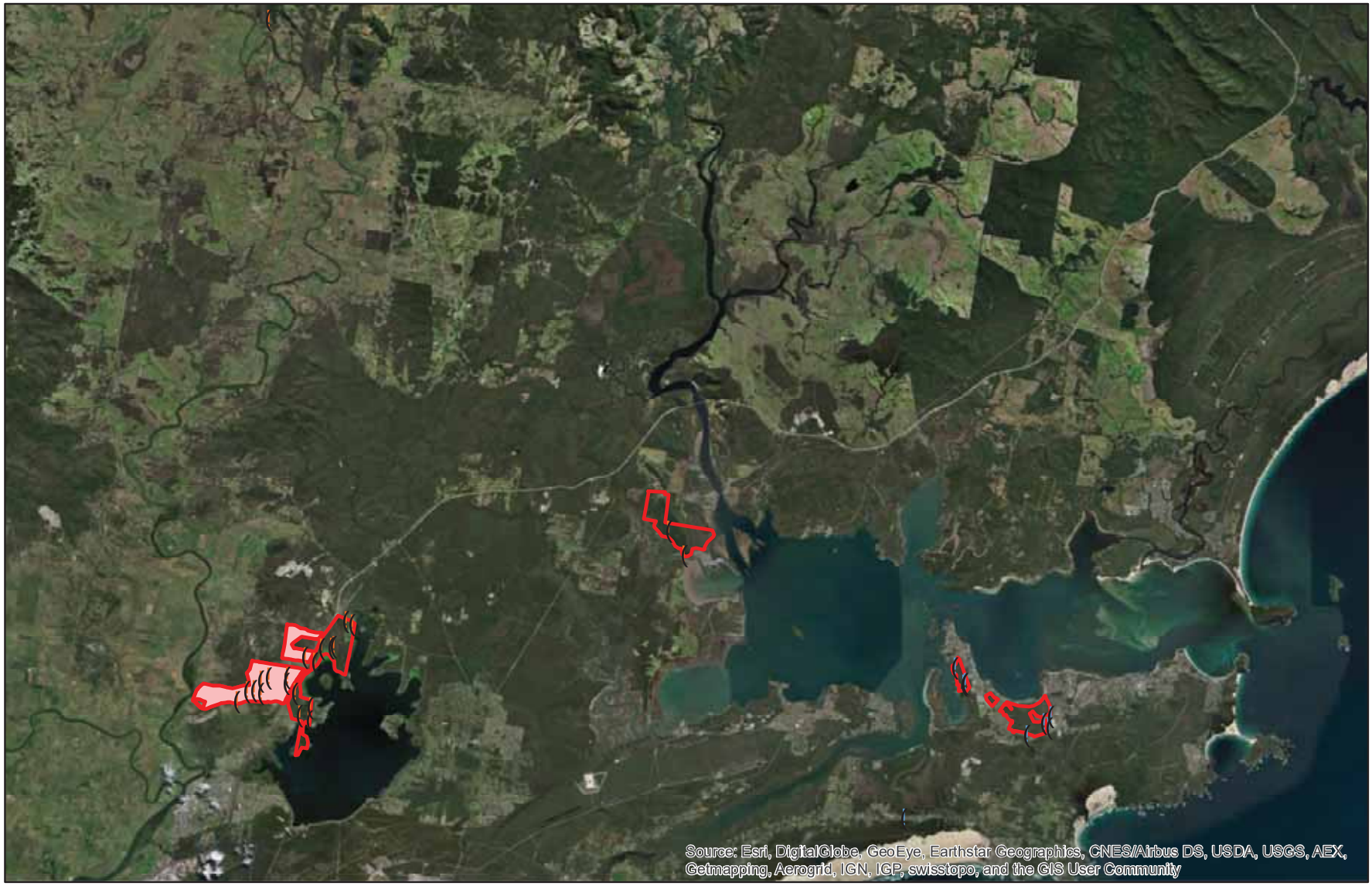
Table 2: Koala population structure

Population cluster	Sampling location	Sample code*
PS1	Stoney Ridge Reserve	PS16, PS17, PS19
	Mambo Wetlands	PS13, PS20, PS21, PS33, PS35
	Anna Bay/Bobs Farm	PS36
PS2	Kings Hill	PS01, PS02, PS03, PS04, PS05, PS06, PS007, PS08, PS10, PS11
	Karuah BioBank	PS24, PS25, PS26
	Grahamstown Dam West (north)	PS27, PS28, PS29, PS30, PS31, PS32
	Glen William	PS37
	Grahamstown Dam West (centre)	PS42, PS43, PS44, PS46

* For individuals sampled at >1 location, only the first sampling location is listed

There was little evidence of mixing between Koalas from PS2 with Koalas from PS1. Three individuals had admixed genotypes: two were from PS2 and had approximately 60% of their genotype shared with a known population in Port Macquarie 200km north, approximately 30% shared with PS2, and less than 10% shared PS1. The third admixed individual was from PS1, with approximately 50:50 of its ancestry shared between PS1 and the Port Macquarie population. The genotypes of these individuals suggests that mixing of genes between PS1 and PS2 is very limited. Moreover, a higher degree of genetic differentiation was observed between the PS1 and PS2 clusters, than between PS2 and Port Macquarie 200km north. This suggests that there is greater mixing between Koalas north and south in the greater landscape, than east to west within Port Stephens LGA; or that PS2 has retained more historical diversity than PS1 has. This observation is further supported by the number of private alleles in the PS2 cluster (n=7), compared to the PS1 cluster (n=1).

[4] Further details on population structure methods and results will be included in a scientific article currently in preparation.



0 5 10 20 Kilometers

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Project No.: 190714
Created by: OW
On: 07/11/2019

LEGEND

Subject lands

Kings Hill site

Distinct Koala population clusters identified:

Sampling locations of individuals belonging to population cluster PS1

Sampling locations of individuals belonging to population cluster PS2

FIGURE 6.5
KOALA POPULATION STRUCTURE

Port Stephens LGA Koala genetic sampling

6.6.2 Fine-scale differentiation

Further investigations of all individuals profiled to date provided preliminary evidence that there is further fine scale spatial structure within population cluster PS2.

Within PS2, greater genetic diversity was observed at Kings Hill compared to any other area sampled to date, including Grahamstown Dam West lands and Karuah Biobank.

Even though Principal Component Analysis (PCA) indicated that Koalas in Kings Hill are significantly more connected to Koalas at Grahamstown Dam West/Karuah BioBank than they are to Koalas on the Tomaree Peninsula, it also provided indication of a potential division between the Kings Hill site and Grahamstown Dam West/Karuah BioBank. This may be driven by the Pacific Highway which intersects these areas within cluster PS2.

6.7 GENETIC DIVERSITY

Genetic diversity was investigated by analysing the genetic profiles obtained to date within Port Stephens LGA, as well as the genetic profiles already obtained from a number of other regions in New South Wales, Queensland and Victoria. Further details on genetic diversity analysis methods and results will be included in a scientific article currently being prepared for publication in a peer-reviewed journal. The sections below provide a summary of the key findings.

6.7.1 Port Stephens LGA compared to South East Queensland

When comparing key indicators of genetic diversity between all Port Stephens LGA individuals profiled to date with those of three distinct populations identified in South East Queensland, a high level of genetic diversity was found in Port Stephens LGA. South East Queensland is a region known to have high levels of genetic diversity, yet allelic richness[5] in Port Stephens LGA was found to be higher than two of the three populations currently identified in South East Queensland (see **Table 3**).

Table 3: Allelic richness for Port Stephens LGA vs three known base populations

	Port Stephens	**SEQ 1 (Central)**	**SEQ2 (North)**	**SEQ3 (South/West)**
Number of individuals samples	33	77	15	33
Total alleles detected (at all 12 loci)	92	88	70	115
Mean number of alleles per locus	7.7	7.3	5.8	9.6
Allelic richness	**6.25**	**5.30**	**5.21**	**7.38**
95% confidence interval for allelic richness	(5.58-6.83)	(4.75-5.83)	(4-67-5.67)	(6.42-8.17)

[5] Allelic richness = mean number of alleles per locus, corrected for differences in sample size between groups.

6.7.2 Within Port Stephens LGA

When assessing allelic richness by grouping the individuals sampled to date within Port Stephens LGA according to the population structure identified in **Section 6.6** (cluster PS1 or cluster PS2), a significant difference in allelic richness was found between PS1 and PS2 (see **Table 4**). Indeed the allelic richness estimate for PS1 is 1.65 lower than that of PS2, moreover even the upper bound confidence interval of PS1 is 0.5 lower than the lower bound confidence interval of PS2. This indicates that population PS1, occurring on the Tomaree Peninsula, appears to have significantly less genetically diversity than population PS2.

Table 4: Allelic richness within Port Stephens LGA

	Allelic richness (95% confidence for allelic richness)
Cluster PS1	**3.39** (2.92 – 3.75)
Cluster PS2	**5.04** (4.25 – 5.75)

When considering all key genetic indicators investigated (mean number of alleles sampled, allelic richness and observed heterozygosity) according to sampling locations of all profiles obtained to date within Port Stephens LGA, the following was found:

- Koalas on the Kings Hill site have the greatest genetic diversity; and
- Koalas on the Tomaree Peninsula have the lowest genetic diversity.

7.0 DISCUSSION

In this section, we present and discuss further results based on all OWAD/WildDNA work performed to date in Port Stephens LGA.

7.1 DISTRIBUTION AND CURRENT KOALA HABITAT MAPPING

Koala activity was detected in all areas assessed to date except Boomerang Park. In August 2019 OWAD consulted the Port Stephens Koala Habitat Planning Map, and found no apparent correlation between this map's Koala habitat layers and the findings of this study on some of the lands assessed to date. Significant portions of the Kings Hill site, of Grahamstown Dam West and of the Karuah BioBank site appear to be currently mapped as 'marginal' yet a substantial amount of Koala activity was detected and genetic diversity was high in all of these lands. Moreover, nutritional analysis work performed on the Kings Hill site (Ford and Youngentob 2019) demonstrated good forage values for the Koala on the Kings Hill site. Accordingly, the current Koala habitat mapping layers are not reflective of the actual situation on these lands, and are an under-representation of actual distribution and habitat values for the Koala on these lands. These areas are important and should not be considered or managed as being only of marginal significance, as managing them as such could result in inadequate management decisions (planning/land use decisions, lack of conservation measures) which could lead to further genetic differentiation and further isolation of populations in Port Stephens LGA, which would reduce their chances of survival across the region.

The Koalas at Kings Hill occupy habitat that is of higher importance than that indicated by the Port Stephens Koala Habitat Planning Map.

7.2 INDICATIVE KOALA ACTIVITY LEVELS

7.2.1 Port Stephens LGA compared to other regions

In terms of qualifying the levels of Koala activity detected to date in Port Stephens LGA compared to other regions, an evaluation can be provided as a guide by comparing OWAD's findings to date with a selection of other recent studies (<5 years) performed by OWAD in other regions where Koala presence was also detected.

Even though various studies have used a variety of sampling designs, on all studies the amount of ground searched by the detection dogs is recorded (kilometres travelled by the dogs while actively searching, recorded by their GPS tracking collar). The number of Koala scat locations found per kilometer searched provides an indicative measure of how much search effort needs to be applied to detect evidence of Koala presence in any given region, and hence can be used to provide a sense of the general Koala activity level in that region. The greater the indicative value obtained, the higher the activity level. Conversely, the smaller the value obtained the lower the activity level.

The indicative value obtained for the work performed to date in Port Stephens LGA is 2.288 (219 scat locations/95.7km searched). **Table 5** (next page) puts this value into perspective with the values of 16 other studies performed in other regions. When compared to these other studies, the level of Koala activity detected to date in Port Stephens LGA is relatively high.

A relatively high activity level may be cause for concern as to date in all studies performed by OWAD where scats were analysed, higher activity levels were accompanied by concerning genetic indicators.

Table 5: Indicative Koala activity values: Port Stephens LGA compared to other regions

State	Location	Value*
QLD	Aratula (Scenic Rim LGA)	3.118
NSW	Carwong State Forest	3.000
QLD	Purga (Ipswich LGA)	2.851
QLD	Killarney (Southern Downs LGA)	2.542
QLD	Amberley (Ipswich LGA)	2.471
NSW	Port Stephens (LGA-wide av. value to date)	2.288
NSW	Royal Camp State Forest	2.250
NSW	Maria River State Forest	1.900
QLD	Helidon (Lockyer Valley LGA)	1.043
QLD	Brisbane (LGA-wide av. value)	1.013
NSW	Far North Coast (Tyalgum)	1.000
NSW	Blue Mountains	0.769
QLD	Toowoomba	0.667
NSW	Clouds Creek State Forest	0.385
QLD	Aroona (Ipswich LGA)	0.279
NSW	Blayney	0.077
NSW	Pilliga	0.055

HIGH — Relative Koala activity level — LOW

* Indicative value

Please note: the table above is provided as a guide only and is only a valid indicator for the areas searched by OWAD within each of the areas referred to above, at the time these were assessed. Activity levels are to be read and understood in conjunction with genetic results.

The relatively high level of Koala activity detected in Port Stephens LGA is of potential concern.

7.2.2 Within Port Stephens LGA

A similar evaluation can be performed within the different areas of Port Stephens LGA assessed to date, in order to provide an indication of the relative Koala activity levels detected in each of those areas. The results are provided in **Table 6** below, with areas arranged from highest to lowest activity levels.

Table 6: Indicative Koala activity values detected within Port Stephens LGA

Area name	Number of Koala scat locations detected	Kilometres searched	Value*
Wanda Wetlands & Mambo Wetlands	45	10.7	4.205
Grahamstown Dam West (centre)	43	11.9	3.613
Stoney Ridge Reserve	21	6	3.500
Grahamstown Dam West (north)	39	13	3.000
Karuah BioBank	24	9.2	2.609
Kings Hill	47	42.9	1.096
Boomerang Park	0	2	0
TOTAL	219	95.7	2.288

* Indicative value

Please note: the table above is provided as a guide only and is only a valid indicator for the areas searched by OWAD as part of this study, at the time these were assessed. Activity levels are to be read and understood in conjunction with genetic results.

The very high activity levels detected in Wanda Wetlands and Mambo Wetlands, combined with the lower level of genetic diversity and the high degree of relatedness found in these areas, are of immediate concern as these are indicators typically observed in isolated populations that occur over restricted areas and are at high risk of being lost.

The activity level detected on the Kings Hill site was lower than that detected on all other PSC LGA lands assessed to date where Koala presence was found. It must be understood here that a high level of Koala activity is typically not a positive sign, and is often correlated with concerning genetic indicators (e.g. low genetic diversity and/or little to no evidence of migration or gene flow, suggestive of isolation which results in Koalas occurring at higher densities). The medium Koala activity level detected on the Kings Hill site is a positive indicator that tends to suggest that individuals in that area are not being pressured to occur at abnormally high densities. The genetic indicators for the ten individuals sampled from the Kings Hill site tend to support the same, with the Kings Hill individuals sampled and tested showing the highest level of genetic diversity of all PSC LGA groups of individuals tested to date.

The medium level of Koala activity detected on the Kings Hill site is a positive indicator.

7.3 GENETIC INDICATORS

Population structure analysis of Koalas sampled in Port Stephens LGA showed strong differentiation between the areas sampled to date. Strong genetic differentiation was observed between two currently inferred population clusters within Port Stephens LGA, currently identified as cluster PS1 (Tomaree Peninsula) and cluster PS2 (Kings Hill, Karuah BioBank and Grahamstown Dam West). These two clusters, although occurring within the same local region, exhibit significant genetic differentiation indicating the presence of at least two distinct Koala populations within Port Stephens LGA. As a matter for comparison, the genetic differentiation found between PS1 and PS2 was greater than the differentiation between cluster PS2 and a population in Port Macquarie.

The PS2 cluster also had a higher number of private alleles than the PS1 cluster, which is an indication of distinctiveness. The low number of private alleles in PS1 could be the result of genetic drift occurring in the PS1 cluster. Genetic drift usually occurs in smaller populations, were alleles can become extinct by chance.

Relatedness was higher than expected in population PS1, but not in cluster PS2. Indeed the number of pairwise relationships with r[6]>0.125 was very high for individuals in cluster PS1 (92.9%). This value is much higher than that found in cluster PS2 (23.6% at Kings Hill, 41.8% at Karuah BioBank/Grahamstown Dam West). This suggests that Koalas sampled within cluster PS1 are much more related than would be expected, and have less genetic diversity than Koalas within cluster PS2.

Investigations into the genetic diversity and differentiation of individuals sampled at three locations (Kings Hill, Tomaree Peninsula and Karuah BioBank/Grahamstown Dam West) provided preliminary evidence that there could be further fine-scale spatial Koala population structure in Port Stephens LGA. Evidence suggests a potential division between Kings Hill and Karuah

[6] r = relatedness value. As a guide, r>0.5 indicates first degree relatives (i.e. parent-offspring or full siblings), 0.25<r<0.5 indicates second degree relatives (e.g. half siblings, grandparent-grandchild), and 0.125<r<0.25 indicates third degree relatives (e.g. great grandparent-great grandchild).

BioBank/Grahamstown Dam West; this may be driven by the Pacific Highway which intersects the two areas. Further sampling would be required to investigate fine-scale population structure.

Greater genetic diversity was observed in Kings Hill compared to Karuah BioBank/Grahamstown Dam West or the Tomaree Peninsula. Koalas on the Tomaree Peninsula (cluster PS1) exhibited the lowest genetic diversity across all parameters tested.

Kings Hill Koalas have the highest genetic diversity found to date in Port Stephens LGA.

Kings Hill Koalas are genetically more similar to Port Macquarie Koalas than they are to Koalas on the Tomaree Peninsula.

7.4 PATHOGEN PREVALENCE

7.4.1 Chlamydia pecorum

The 30% incidence of *C. pecorum* found in Port Stephens LGA to date (10/33) is slightly lower than that found to date in South East Queensland (39%) using the same *C. pecorum* detection methods (OWAD Environment 2017a, 2017b, 2018a and 2018b).

Understanding *C. pecorum* prevalence in any given region, and its distribution within that region, is important so that the spread of the pathogen is not unintentionally facilitated. This is of particular relevance in terms of management decisions as well as in terms of wildlife caring activities, so as to not introduce *C. pecorum* into areas where the pathogen was previously absent.

In this study, *C. pecorum* was detected in 11% of individuals in the PS1 cluster (1/9) and in 37.5% of PS2 individuals (9/24). 50% prevalence was detected at the Kings Hill site (5/10 individuals), and 30% on the Grahamstown Dam West lands (3/10 individuals). Please note that these figures are indicative only, restricted sample sizes may mean these results may not be representative of actual *C. pecorum* prevalence.

50% of individuals sampled from Kings Hill tested positive for *Chlamydia pecorum*.

***C. pecorum* was detected on lands sampled immediately either side of the Pacific Highway.**

7.4.2 Koala retrovirus (KoRV-A)

KoRV-A was detected in 100% of the individuals tested to date in Port Stephens LGA. This result is in line with current data available. KoRV-A is known to be ubiquitous in most Queensland and New South Wales free-ranging Koala populations (Meers *et al* 2014, Chappell *et al* 2016), with all populations tested in these States to date showing a prevalence of 100% regardless of detection methods used.

100% of the individuals sampled to date by OWAD (from both Queensland and New South Wales) and tested for KoRV-A using the same methods as this study have tested positive for KoRV-A.

100% of individuals tested to date in Port Stephens LGA tested positive for KoRV-A.

7.5 A DISCUSSION ABOUT KOALA DETECTION TOOLS

It must be noted here that in this study, evidence of Koala presence was detected in some areas where previous detection methods used had either failed to detect any presence, or found only very limited evidence. This is not surprising, and is a very common occurrence in many studies performed by OWAD in both Queensland and New South Wales. The success of this study, like all studies performed by OWAD, is due to a combination of factors including:

- The use of purpose-bred, professional trained detection dogs of an appropriate breed, trained by a highly experienced CCPDT[7] trainer.
- The handlers of the dogs, who:
  - Are highly experienced Koala survey experts.
  - Are professional field detection dog handlers, formally trained by the CCPDT trainer who also provides ongoing coaching and mentoring.
  - Ensure their dogs are generalised on Koala scat and pap, and are not unintentionally specialised (e.g. some could unintentionally specialise their dogs in e.g. Koalas from a particular region only, or dogs may not recognise pap as a target, or may not recognise that the pellets from an individual affected by a particular pathogen as a target, etc.) – OWAD maintains a vast 'scent bank' and for ongoing training purposely uses scats from a wide variety of regions (across the Koala's distribution) both from wild and captive individuals, including scats from captive individuals known to have a variety of medical conditions/diseases.
  - Thoroughly test each new detection dog before it is deployed on studies; a dog is not deployed on project work until it consistently performs to 100% target detection and 100% discrimination[8] rate across the variety of Koala scats presented.
  - Maintain their detection dogs all year round and continuously monitor their performance.
  - Have developed strict Quality Assurance/Quality Control procedures that are implemented on every project to ensure the results are correct and reliable.
  - Are Certified Environmental Practitioners (Environmental Institute of Australia and New Zealand), and are therefore committed to practice in accordance with the EIANZ Code of Ethics and Professional Conduct which is central to sound environmental practice.

OWAD very regularly finds evidence of Koala presence in areas where extensive survey work had previously been conducted using other detection tools that had found little or to no evidence. These occurrences are simply too numerous to provide an exhaustive list. Two examples are provided below for illustration purposes:

- Undullah, Queensland (OWAD Environment 2015c). OWAD was requested to perform a rapid one-day assessment of a 285ha property. Over the 2.5 years immediately preceding, extensive survey work had been conducted by both Energex environmental officers and external ecology consultants using transect searches, call play-back, spotlighting and scat searches performed by humans – none of which had detected any sign of Koala presence. OWAD spent one day on the property and performed a rapid assessment at 16 sampling sites (search at each site stopped after 5mn or when finding Koala scats, whichever came first). It took less than 12 minutes of search time on this property for OWAD to find the first evidence

[7] Canine Detection Certification Council, the only recognised international certification body for professional dog trainers.

[8] This means the dogs never indicate on an object that is not a target object.

of Koala presence. Evidence of Koala presence was found at 31% of sites sampled, including locating a live individual. OWAD was asked to revisit the property in 2018 for one day to collect genetic material. Several scat samples were collected, which all provided reliable DNA profiles each originating from distinct individuals (OWAD Environment 2018a).

- Pilliga, New South Wales (OWAD Environment 2016c). OWAD was requested to conduct a one-day survey in Pilliga East State Forest, New South Wales, which is 135,000ha in size. There had been only two records of Koala presence found in that forest since 2003, despite numerous consultants performing extensive amounts of Koala survey work in recent years using a range of tools and techniques as this area was the subject of significant gas projects. OWAD found Koala scats within one day. The scats found were relatively fresh and OWAD suspected they originated from a mother with joey. The coordinates of these scats were provided to a local ecologist in case the suspected pair may still be present in the vicinity/or revisit the area. A few days later, the local ecologist spotted a female with joey approximately 200m from the scats found by OWAD.

These instances above are merely two examples provided here for illustration purposes; similar experiences are very frequent occurrences throughout OWAD's work in numerous project areas in both Queensland and New South Wales.

OWAD frequently finds evidence of Koala presence in areas where other detection tools and methods failed to detect any evidence of presence.

7.5.1 Difficulties of spotting Koala scats

One of the major reasons why Koala scat surveys conducted by humans alone are notoriously unsuccessful at detecting signs of Koala presence, lies in the fact that these surveys rely solely on human vision as the detection tool. Yet human vision as a detection tool is extremely limited.

Even when a Koala scat is in plain sight, it can very easily go undetected by the human eye. See the photograph on the right as an example: it was taken exactly 1m away from a Koala scat sitting in plain sight. If you cannot quickly distinguish the scat on this photograph, do not worry this is perfectly normal. (Its location will be revealed on the next page.)

At any one time, the human brain receives an extraordinary amount of visual information at once, and is not designed to individually analyse every single object perceived at any one time. In order to make sense of and process the vast amount of incoming data perceived at any one time, the human brain 'groups' data together into things that look alike (e.g. shape, colour, texture, still or moving). In the photograph below, the chances are that the reader's brain automatically formed two key groups: the grass strands, and the leaf litter. Once the brain has automatically formed groups about a set of visual data, it is then very difficult to perceive this set of data any differently.

The photographs below now reveal the location of the Koala scat that was hiding in plain sight. The photograph on the right was taken exactly 10cm away from the scat. The chances are that some readers will now return to the previous page to try to locate the scat again – and the chances are some readers may still find it difficult to locate it. It must be noted here that in this example, the leaf litter is relatively simple with almost no ground cover vegetation, and the scat is in plain sight/not obstructed. When humans alone conduct Koala scat searches, this is typically as easy as it gets.

The example above illustrates just how difficult it can be for human eyes to detect Koala scats, and how extremely easily it can be to miss them even when they are in plain sight. Even though humans can train their brains to improve their Koala scat spotting skills, there still remains an extremely high risk of failing to spot scats when they were in fact present.

Koala scats are very difficult to spot for the human eye.

Different detection tools are associated with different degrees of confidence in detection.

The second major limitation that is inherent to relying solely on human vision as a detection tool, is that humans must be in extremely close proximity of a Koala scat in order to have a chance of spotting it. Even if the scat is unobstructed and in plain sight, the human typically has to be within 1-2 metres in order for the human brain to distinguish it from all the other elements in the field of vision. Unfortunately many Koala scats are not in plain sight, so humans typically have to physically scratch through leaf litter and/or disturb any low-lying vegetation that might be obstructing the scats. To add to the issue, many other animals produce scats that look similar to Koala scat, so the human also typically has to bend down, physically pick up the scat and assess its nature (Koala or non- Koala). The pictures below show known Koala scats and known non-Koala scats, illustrating how similar looking these can look.

Koala scats

Brushtail Possum scats

Ringtail Possum scats

All this is not only physically straining, but is also extremely slow and laborious and hence extremely costly. A team of two humans can typically only search at best approximately 300 trees each day, which is extremely limited when one considers that the dry forests of Eastern Australia very often occur at >2,500 stems per hectare, and can be as dense as 10,000 stems per hectare or more. To make up for the very small number of trees that can be searched each day, one can increase the number of days applied at any given site. But this must remain a realistic request that the entity funding the work can/is willing to afford both in terms of monetary cost and in terms of time/delay. As a result, for any site that is very small in size, it may be realistic and achievable to request and obtain sufficient time and sufficient funding to search a statistically relevant proportion of trees represented on the site. However for sites larger than a few hectares at best, it is typically not realistic nor achievable to request and obtain sufficient funding and time to search a statistically relevant proportion of the trees represented on the site. As a result, many Koala scat surveys relying on human vision that are performed across Eastern Australia only sample a statistically irrelevant proportion of trees.

Relying on human vision for detection results presents a twofold risk of false negative:
− High risk of false negative in the areas searched
− High risk of false negative due to sampling/weak statistical power

The use of appropriately and professionally bred/trained/handled/managed detection dogs, used within adequately designed surveys, with adequate quality control procedures in place, and with proven Koala scat identification skills (validated via scat analysis), greatly minimises both risks of false negatives.

7.5.2 Koala scat identification

Another potential limitation of relying on humans as the sole detection tool in Koala scat surveys, is the potential risk of scat misidentification. As shown on the pictures on the previous page, some non-Koala scats can look extremely similar to Koala scats. The risk of misidentification is too often overlooked, and often not even spoken of in the Koala expert industry. However this is a very real risk even for highly experienced experts, and misidentification could potentially be occurring at higher rates than anyone may suspect. Unless a Koala expert puts their Koala scat identification skills to the test empirically (i.e. scat analysis), then there is no empirical evidence to confirm their identification skills.

In 2016, a highly renowned Koala expert with decades of experience collected some Koala scat samples on behalf of OWAD and submitted them to WildDNA for analysis. Unexpectedly, almost 10% of their samples turned out to be Possum scats. This threw into question their scat identification skills in both mistaking non-Koala scats for Koala scats as directly observed here, but also potentially vice versa (i.e. actual Koala scats put down to non-Koala scats). This has major implications as a degree of uncertainty now overshadows all Koala studies performed by this particular expert throughout their career.

OWAD automatically test their Koala scat identification skills on an ongoing basis by regularly sending scat samples for genetic analysis as part of projects throughout the year. However OWAD have the advantage that their dogs do the identification for them. OWAD concedes that despite the human team members being highly experienced themselves in Koala scat identification, it is not uncommon for their detection dogs to indicate on unusual scats or pap that the humans could have potentially misidentified if it wasn't for their dogs indicating on these. On several occasions when OWAD first began to send scats to WildDNA, upon receiving some samples the laboratory questioned the origin of the samples submitted and asked whether to still analyse these. OWAD replied to absolutely analyse these; that their detection dogs should never be wrong, and that if any sample OWAD ever submitted were ever found to be originating from anything other than Koala, then they needed to know in order to remediate the issue immediately. OWAD has to date submitted >2,000 scats to WildDNA and not one has ever originated from any species other than Koala.

The Koala scat identification skills of scats found in the natural environment by any expert (be it human or canine) can only be scientifically measured and empirically proven via scat analysis.

7.5.3 Koala scat detection rates and false negatives

In 2015, OWAD performed formal field trials to estimate the Koala scat detection rates of experienced ecologists, by using one of their detection dog/handler teams searching for Koala scats in the same areas as a basis for comparison. These were time-limited searches, with both parties (human team and dog/handler team) searching for a total of 5mn at each plot. These plots were placed at a variety of different bushlands in Logan and Ipswich City Council LGAs, in areas known to have high or very high Koala densities (so that the human team had a fair chance of finding evidence). Each site was classed in one of three categories 'easy' 'medium' or 'hard' according to their visual complexity, which took into account forest structure, forest density, amount and nature of leaf/branch litter, as well as density of shrub layer and of groundcover vegetation. This trial was performed primarily to estimate the detection rates and identify the potential false-negative rates associated with Koala scat searches that rely solely on humans/human vision. Some of the key findings of these trials are provided below:

- In the 'easy' plots (e.g. recently mown parkland with no leaf litter, no understory and no groundcover vegetation other than mown grass), the **human false-negative rate was 50%** compared to the findings of the dog/handler team.
- In the 'medium' plots (e.g. open forest with limited leaf litter, little to no regrowth, little to no shrubs and little to no groundcover vegetation), the **human false-negative rate was 92%** compared to the findings of the dog/handler team.
- In the 'hard' plots (e.g. closed forest with some regrowth, medium to thick leaf litter, some shrubs and/or dense groundcover vegetation), the **human false-negative rate was 100%** compared to the findings of the dog/handler team.

Overall in these trials, the human false-negative rate was 79% compared to the findings of the dog/handler team. That is, the human team failed to find Koala scats in 79% of plots where the dog/handler team found scats.

During these trials, as in all fieldwork performed by OWAD, Quality Control testing was also performed. In 30% of the plots, a third party deposited Koala scats without either of the search parties knowing when of where QC scats may have been deposited. The constant 'menace' of potential guaranteed Koala scats in a plot ensured constant pressure on both search parties so as to push both search parties to always apply maximum care. When placing QC scats, the third party also always ensured that the human team had a fair chance of finding these scats by placing them in plain sight and very close to the starting point (within 20 metres). At each plot, regardless of whether QC scats had been placed or not, the third party also always gave both teams the general direction of the search at that plot. This ensured that when QC scats had been placed, both teams covered the area where QC scats had been placed.

The dog/handler team found Koala scats (whether the QC scats placed or naturally deposited scats) in 100% of the plots where QC scats had been deposited, or a **100% success in QC testing for the dog/handler team**. However the human team failed to find Koala scats in 100% of such plots – the human team did not find neither the QC scats placed nor naturally deposited scats. As a result this was a staggering **0% success in QC testing for the human team**. In other terms, the human team had a 100% false-negative rate in QC testing.

Overall in these trials, the dog/handler team found Koala scats at 66% of plots, versus only 14% for the human team.

The dog/handler team found Koala presence in 372% more plots than the human team.

The results of these trials are of extreme concern as it clearly demonstrated and quantified the potentially **extreme risk of false-negative when relying solely on humans/human vision for Koala scat surveys**. Moreover this trial was purposely performed in areas known to be occupied by Koalas at known high to very high Koala densities, so as to maximise the chances for the human team to find Koala scats. Yet even in areas known beforehand to be well frequented by Koalas, and the additional constant menace of potential QC scats − humans therefore always expected to find scats – even in those highly favourable conditions, the success rate was still extremely poor.

When Koala scat surveys that rely solely on humans/human vision find very limited evidence of Koala presence, the species is in fact likely to be well represented.

The use of appropriately and professionally bred/trained/handled/managed detection dogs, used within adequately designed surveys, with adequate quality control procedures in place, and with proven Koala scat identification skills (validated via scat analysis), greatly improves Koala detection.

7.5.4 Emerging detection tools

Drones fitted with heat-sensing cameras are currently being tested as a potential tool to obtaining presence/absence data, possibly even census data. However this technology is currently still at experimental trial phase, and comes with major inherent limitations.

Drones, like any direct observation method, require that the target animal be present within the study site when the assessment is being performed.

- If a drone can assess the entirety of a given study site in one day, this suggests that the site is relatively small in size (< approximately 25ha, which is the average daily coverage reported in one of the latest studies by Corcoran *et al* 2019). If this site of small size is connected to the landscape, the likelihood is that Koalas that frequent the site only have portions of their territories that overlap with the site. In order to be captured by the drone, individuals would have to happen to be physically present within the portion of their home range that is on the site, on the day the drone is flown. The chances of underestimating the numbers or of obtaining a false-negative result, although not reported to date, are therefore likely to be high.
- If a drone cannot assess the entirety of a given study site in one day, this would suggest a larger study site (>approximately 25ha) which creates other limitations. Koalas can move significant distances in 24 hours and drone technology cannot identify or distinguish distinct/unique individuals. As a result, this could result in overestimates, underestimates, or even false-negatives. Corcoran *et al* (2019) conducted a Koala detection exercise on a severely isolated 125ha site in South East Queensland, known to contain 48 Koalas all of which fitted with tracking collars. These 48 individuals are believed to be all the individuals on that site, and possibilities of individuals leaving or entering the site are considered very low (<10%). It took the drone 5 days to scan the entirety of the site, and the drone counted 132 Koalas – or almost threefold the actual number. The fact that this study was conducted on a small and severely isolated site where individuals are physically trapped, where Koalas occur at high densities, explains the relatively high detection rate achieved of 85% but also the severe overestimate of numbers of individuals. Even in those conditions however, it is interesting to note that the drone still failed to capture 15% of the individuals known to be present on the site. In sites that are connected to the greater landscape where Koalas may occur at lower densities, however, the situation may be entirely different and it is conceivable that drone technology may either underestimate the numbers, or even provide a false-negative result (i.e. not detect any Koala when Koalas in fact present in the area). The latter is most likely the reason why the recent drone exercise that was performed on Grahamstown Dam West (north) failed to detect any Koala presence (Chad Beranek pers. comm.). The drone exercise scanned 75ha in Grahamstown Dam West (north) over the course of 5 days, and the drone did not detect any Koalas. However in this study, OWAD performed a rapid assessment of this land over the course of one day (including searching parts of the area scanned by the drone), a significant amount of Koala activity was detected throughout, and the DNA profiles of six distinct individuals were obtained on this land including some sampled within the area scanned by the drone.

At this stage, drones are not a proven tool to reliably determine Kola presence/absence nor to obtain census data.

8.0 STUDY LIMITATIONS

8.1 KOALA SCAT DETECTABILITY

The use of purpose-bred, purpose-trained professional field detection dogs greatly minimises the risk of not detecting Koala scats when they are in fact present. The professional detection dogs and their handlers used in this study were extensively trained by a professional field detection dog and handler training expert. The dogs are continuously trained and developed by their handlers throughout the year, and the handlers and the dogs maintain their professional certification. Each time OWAD acquires a new dog, OWAD thoroughly tests the dog before it is deployed on its first project. A dog is not deployed for project work until it consistently performs to 100% target detection rate and 100% discrimination (i.e. never indicates on non-targets). These field trials are performed over several consecutive full days to replicate the demanding conditions of project work, and test the dog's physical endurance and mental focus to ensure it is able to work long hours over consecutive days while maintaining its 100% target detection and 100% discrimination rate.

8.1.1 Trained scent threshold and Koala scat indication

Even though the professional detection dogs used in this study can *perceive* the scent of Koala scats long after these have decomposed, they are purposely trained to *ignore* 'trace odour' − that is, a scent threshold that corresponds to Koala scats that are so old that they have lost all structural integrity and are entirely decomposed.

Additionally, OWAD's detection dogs are specifically trained to indicate not on a target *scent*, but on a target *object*. They use their sense of smell to analyse scent particles traveling through the air to guide them to areas where they perceive the scent of Koala scat, but they only *indicate* on the object (not on the scent) i.e. only if/when a least one actual scat is still present. If they can detect a target scent that is above their trained scent threshold, they will proceed to investigating this location in search for the target object. If the scats at that location have already decomposed (e.g. in wet ecosystems) and hence no longer physically present, they independently identify that the target *object* is no longer present and they move away of their own volition. When they do find a target object, they actively assist their handlers recover scats by using their paws, nose and/or mouth to expose or retrieve at least one Koala scat from the forest floor. This ensures that OWAD's findings are contemporary so as to inform on current and recent Koala activity only, not historical presence.

8.1.2 Inferring absence

While for the purpose of this study recovering a single Koala scat is an absolute finding, failure to detect Koala scats in an area is not necessarily conclusive. That is, absence of evidence is not evidence of absence. In this study, this would apply to Boomerang Park where no sign of current or recent Koala presence was detected. The lack of Koala scat detection in Boomerang Park may suggest either of the following:

- Koalas are not present in Boomerang Park, and haven't been present for >12 months (i.e. true absence);
- Koalas are currently present/or visiting Boomerang Park, however scats were not detected (i.e. false negative) because:
  - No scats were deposited in or near the areas sampled in this park; or
  - There were scats in the vicinity of areas sampled, however wind conditions were blowing the scent of Koala scat away from the detection dog hence the scent was not perceivable by the canine; or

- Koala scats were deposited in the relatively recent past at the areas sampled (<12 months), but were already decomposed hence the dogs correctly did not indicate.

Finally, it must be noted that as with any scat-based survey, the absence of scats at time survey does not negate the possibility of Koalas visiting Boomerang Park and depositing scats in the future.

8.2 SCAT ANALYSIS LIMITATIONS

8.2.1 Scat condition

The key limitation of current methods for extracting genetic material from Koala scats is that the scats need to be relatively fresh (up to approximately 8 weeks old), be in good physical condition (be intact/undamaged) and not have been exposed to rain. Wet or damp conditions and other environmental factors (e.g. mechanical abrasion, insect predation, variable site conditions) can affect the quality and quantity of the target DNA (i.e. Koala, KoRV-A and *C. pecorum*) available for isolation.

In this study, the November 2018 round of sampling provided ideal conditions with very dry weather for weeks preceding fieldwork, a very dry forest floor, low fungal activity on the forest floor, and low predation observed on the Koala scats sampled. Some of the scats collected and submitted to WildDNA during the November 2018 sampling event are estimated to have been approximately 8 weeks old or older. These ideal conditions likely explain the excellent laboratory Quality Control results (100%) and that 100% of samples collected during that round provided a reliable DNA profile.

The July 2019 round of sampling however provided less than ideal conditions for non-invasive genetic sampling as there had been several rain events during the few weeks preceding fieldwork. As a result, at time of survey the forest floor was still largely wet or damp, with standing water in some of the lower-lying areas, and there was significant amount of fungal activity observed in many areas. In July 2019, the survey team therefore had to target fresher scats (<6 weeks old, but as fresh as possible) and perform a very careful visual inspection of scats as a significant proportion of scats (even if relatively fresh ones) were visibly affected by fungal activity, predation (insects, bacteria) and/or weather. These less than ideal conditions likely explain why four samples collected in the field in July 2019 failed to pass laboratory QC, and why three of the samples collected in the field that proceeded to testing failed to provide a reliable DNA profile.

Regarding the captive individuals sampled in July 2019, one (PS38) failed laboratory QC. This particular individual had been flagged by the carers as having very serious ongoing digestive issues and was under several strong medications for such. When sampling this individual, OWAD noted that this individual was not producing 'well formed' scats: they lacked the typical hard surface or coating Koala scats normally have, coating which where WildDNA obtains genetic material from. It is assumed that this individual's very soft stools resulted in that individual's scats failing laboratory QC, and/or perhaps it could also be due to the medication this individual was taking. A second captive individual's scats (PS34) had only just passed laboratory QC, and unfortunately failed to provide a reliable DNA profile. It is unknown why this sample failed to provide a reliable profile, perhaps the effect of medication this individual may have been taking.

8.2.2 Personnel collecting scats

There are a number of prerequisites in order for personnel collecting scats to provide the laboratory with reasonable chance of obtaining viable genetic material for analysis purposes:

- *Ability to identify and differentiate Koala scats from other animal scats*
  OWAD personnel is highly experienced in identifying Koala scats and differentiating them from similar looking scats originating from other animals (e.g. Possum). Additionally, OWAD's professional detection canines never indicate (0%) on any similar looking scats that don't originate from Koala[9]. To date, 100% of the >2,000 scats collected by OWAD and submitted for analysis have been confirmed by the laboratory as originating from Koala.
- *Ability of personnel to estimate the age and condition of Koala scats*
  Assessing whether a sample may be in sufficient/appropriate condition or not for analysis is paramount. OWAD is highly experienced in estimating the age and condition of Koala scats for genotypic analysis purposes, and prior to conducting this study had extensive prior experience conducting multiple Koala genetic sampling programs.
- *Appropriate timing for scat collection*
  Even though the July 2019 fieldwork was conducted during the most favorable season for non-invasive genetic sampling, weather conditions prior to and at time of survey provided less than ideal conditions for genetic sampling. As a result, a substantial amount of scats that were fresh enough were damaged and not collected; OWAD had to pay additional care in the selection of genetic material that was collected. Conversely, the November 2018 fieldwork was not performed during the most favorable season however unusual dry weather in the region prior and at the time of the 2018 fieldwork did provide ideal conditions for non-invasive genetic sampling.
- *Appropriate collection, storage and postage of scats*
  OWAD personnel followed the scat collection and storage procedures detailed in **Section 2.3**. Scat collection, storage and packing of the kits for postage was done with great care to minimise damage to genetic material from the time of collection in the field to reception by the WildDNA laboratory. In this study, there was no loss of any genetic material during postage and handling.
- *Ability to distinguish scats from putative distinct individuals*
  At each location or nearby locations where potentially viable scats are found, field personnel must be sufficiently experienced to assess whether these may potentially originate from the same/or distinct individuals, as this guides whether to sample scats and in how many distinct sampling kits to place these. OWAD is very experienced making these educated presumptions. In this study, there were ten instances where OWAD estimated that scats observed at one location/or at very close locations may originate from distinct individuals (PS02-03, PS04-07/08, PS07/08, PS09-10, PS13-14/15, PS16-17, PS20/21, PS24/25, PS27-28 and PS30-31). In nine of these ten instances, the laboratory results showed that these educated presumptions were correct.

8.2.3 Chlamydia pecorum detection

A positive *C. pecorum* result indicates that the individual carries the bacterium, however this does not necessarily mean that the individual displays clinical symptoms of the disease. Further research is required to determine whether there is a threshold of bacterium count found in scat that would equate to clinical symptoms.

[9] OWAD's detection dogs also have the scats of three species of Quoll as targets, however Quoll scat and Koala scat are very easily distinguished.

A negative *C. pecorum* result does not necessarily mean that the individual is not infected. Indeed an individual could carry the bacterium but the infection hasn't spread to the gastrointestinal tract hence is not detectable in scat. Further research is required to determine whether the bacterium is necessarily detectable in scat if an individual is known to display clinical symptoms.

8.3 LIMITATIONS OF DATA INTERPRETATION

The interpretations provided in this report are only valid indications for the lands assessed in Port Stephens LGA to date, at the time these were assessed, and for the individual Koalas sampled and successfully profiled to date in Port Stephens LGA.

The number of individual Koalas detected in lands assessed to date does not in any way represent a population census of the lands assessed. The work performed in this study was not designed to obtain a census, but to gain an understanding of Koala presence/absence and to sample genetic material.

9.0 CONCLUSIONS

OWAD Environment was contracted by PM №1 Pty Ltd c/o RPS Group to investigate a number of areas in the Port Stephens LGA with the assistance of two purpose-bred professional field detection dogs, to quickly locate and collect Koala genetic material for subsequent genetic analysis. Areas investigated included the Kings Hill site sampled in November 2018, and seven lands sampled in July 2019 being Mambo Wetlands, Wanda Wetlands, Stoney Ridge Reserve, Karuah BioBank, Grahamstown Dam West (north), Grahamstown Dam West (centre) and Boomerang Park.

Koala activity was detected in all lands assessed except for Boomerang Park where no evidence of Koala presence was detected.

The unique DNA profiles of 33 distinct individuals was obtained, including 17 females and 16 males. These included three DNA profiles obtained from individuals in care. 30% of these individuals (10/33) tested positive for *Chlamydia pecorum*, and 100% (33/33) tested positive for Koala retrovirus KoRV-A.

A high level of genetic diversity was found in Port Stephens LGA. However, it is evident that the Koala population in Port Stephens LGA is not a single homologous population but rather consists of at least two genetically distinct population clusters that are clearly separated. The reason for this separation is currently unknown and was not investigated as part of the work performed to date.

Of all areas investigated to date in Port Stephens LGA where reliable genetic profiles were obtained, the highest level of genetic diversity was observed on the Kings Hill site. Further, there is evidence that the population Kings Hill's Koalas belong to is connected to other populations in the greater landscape, including a known population in Port Macquarie 200km north. The geographic extent of the population which Kings Hill's Koalas belong to is currently unknown. However, Kings Hill's Koalas are genetically closer to Port Macquarie Koalas than to Koalas on the Tomaree Peninsula.

Even though Koalas immediately west of the Pacific Highway (Kings Hill) and immediately east of the highway (Grahamstown Dam West) currently identify as the same population, there could be further structuring within that population. This study found greater genetic diversity west of the highway, which may indicate that the Pacific Highway may be affecting gene flow and may have started to erode the genetic fitness of individuals east of the highway. As a precaution, management should aim to maintain and where possible restore gene flow so as to avoid further possible genetic differentiation and isolation of Koalas in Port Stephens LGA.

Koalas residing on the Tomaree Peninsula have reduced genetic diversity, potentially a result of genetic drift. Genetic drift can commonly occur in small isolated populations where allelic diversity is lost. All indicators for this population (high activity levels detected, lower genetic diversity, and genetically highly distinct from other Koalas sampled from other areas in the LGA) suggest a population that could be at immediate risk of being lost.

It is important to maintain genetic diversity to ensure populations are able to adapt to environmental change and not suffer the effect of deleterious genes and inbreeding depression. Genetic diversity is best conserved in a single large population with a vast geographic range, and is at greater risk of being lost if managed as small, fragmented and isolated sub-groups. Increasing genetic diversity can be achieved by encouraging gene flow through the landscape. In the first instance this should be done by protecting and restoring habitats, and then by

maintaining existing/or creating new habitat corridors and installing fauna crossing structures to cross inhospitable barriers such as major roads.

Further details on genetic methods and results referred to in this report are currently being prepared for publication in a peer-reviewed journal.

This report may be used by RPS Group to further inform environmental reporting for the Kings Hill site.

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APPENDIX 1 FIELD NOTES (JULY 2019 FIELDWORK)

Waypoint №	Date	Coordinates		Sample code (if applicable)	Comments/observations
		Easting	Northing		
1	15-Jul-19	414318.294	6378169.17		Scats > 3 months old. Particularly large scats. Note, found under tree <10cm DBH. Found in 0mn42s of starting searching that day.
2	15-Jul-19	414327.497	6378188.54		Same huge scats, also > 3 months old. Note, found under Melaleuca.
3	15-Jul-19	414389.976	6378191.63		Small scats > 3 months old.
4	15-Jul-19	414426.031	6378205.25		Scats > 3 months old. Found under a tree with a tag, tag number 1409.
5	15-Jul-19	414513.48	6378279.39		Scats > 3 months old.
6	15-Jul-19	414544.151	6378287.09		Scats > 3 months old.
7	15-Jul-19	414554.955	6378305.7		Huge scats > 3 months old. Scats consistent with those found at waypoints 1 and 2. Easily recognisable as scats are very distinctly larger than normal. Note, found under tree <10cm DBH.
8	15-Jul-19	414599.813	6378341.89		Same huge scats < 2 months old but damaged, not viable for analysis hence not collected.
9	15-Jul-19	414735.995	6378252.37		Scats < 2 months old but damaged, not viable for analysis hence not collected.
10	15-Jul-19	414759.367	6378215.21		Scats > 3 months old.
11	15-Jul-19	414788.855	6378207.92		Very old scats > 6 months old.
12	15-Jul-19	414821.747	6378153.32		Scats > 3 months old.
13	15-Jul-19	414843.846	6378100.63		Scats > 3 months old.
14	15-Jul-19	414837.576	6378099.58		Scats < 2 months old but damaged, not viable for analysis hence not collected.
15	15-Jul-19	414871.708	6378097.1		Scats > 3 months old.
16	15-Jul-19	414892.201	6378122.44		Abundance of scats > 3 months old under a clump of trees. Clearly at least two distinct scat size/shape classes.
17	15-Jul-19	414905.391	6378223.45		Scats > 3 months old.
18	15-Jul-19	414863.447	6378251.8		Scats > 3 months old.
19	15-Jul-19	414763.165	6378318.57		Scats > 3 months old.
20	15-Jul-19	414669.6	6378356.13		Scats > 3 months old, the same particularly large scats previously observed at several locations.
21	15-Jul-19	414600.263	6378409.42		Scats > 3 months old.
22	15-Jul-19	414677.917	6377639.21		Very old scats > 6 months old. Note, found under Melaleuca.
23	15-Jul-19	414639.065	6377471.57		Scats > 3 months old. Note, found under Melaleuca.
24	15-Jul-19	414677.365	6377452.61		Scats > 3 months old. Note, found under Melaleuca.
25	15-Jul-19	414717.203	6377440.09		Abundance of scats > 3 months old. Note, found under a clump of trees comprising only Melaleuca.
26	15-Jul-19	414860.874	6377404.52		Scats > 3 months old. Note, found under a dead and burnt tree.
27	15-Jul-19	414924.032	6377382.44		Scats > 3 months old.
28	15-Jul-19	414979.014	6377373.93		Scats > 3 months old.

Waypoint №	Date	Coordinates		Sample code (if applicable)	Comments/observations
		Easting	Northing		
29	15-Jul-19	415033.876	6377368.64		Very old scats > 6 months old.
30	15-Jul-19	415121.719	6377341.56		Abundance of scats circa 2 months old but damaged, not viable for analysis. Note, found under Melaleuca.
31	15-Jul-19	415237.162	6377319.37		Scats circa 2 months old but damaged, not viable for analysis.
32	15-Jul-19	415300.775	6377287.65		Scats > 3 months old, the same particularly large scats previously observed at several locations.
33	15-Jul-19	415324.885	6377273.34	PS13	A few scats > 3 months old + a few fresher scats < 4 weeks old. Not in ideal condition, but sample collected in case these are the 'best on offer'.
34	15-Jul-19	415361.943	6377257.02	PS14 PS15	Abundance of scats of a variety of age classes (> 6 months old to a few weeks old) and of a variety of shape/size classes. Two samples collected potentially originating from two distinct individuals? Could possibly include scats from the same individual sampled at location PS13, but since PS13 scats were not in ideal condition decision made to collect here too to increase chances of obtaining viable genetic material.
35	16-Jul-19	414085.921	6378501.55		Scats > 3 months old. Found in 14mn33s of starting searching that day.
36	16-Jul-19	413943.052	6378409.95		Scats > 3 months old, particularly large. Look similar in shape/size to the particularly large ones observed at multiple locations the previous day.
37	16-Jul-19	413895.592	6378457.99		Fresh scats <1 month old but damaged by moisture. Not collected.
38	16-Jul-19	413867.777	6378455.86		Scats > 3 months old.
39	16-Jul-19	413874.72	6378476.54		Scats < 1 month old but damaged by moisture. Not collected.
40	16-Jul-19	413887.562	6378486.97		Scats > 3 months old.
41	16-Jul-19	414030.166	6378609.27		Scats > 3 months old.
42	16-Jul-19	413977.708	6378736.54		Abundance of scats > 3 months old.
43	16-Jul-19	413946.189	6378783.27		Scats > 3 months old.
44	16-Jul-19	412840.658	6379269.78	PS16	Scats > 3 months old of one size/shape class + some very small scats circa 6 weeks old. Sample of the latter collected.
45	16-Jul-19	412886.087	6379326.16	PS17	Scats circa 6 weeks old which appear to be a different size/shape class (larger) than PS16. Sample collected.
46	16-Jul-19	412848.372	6379469.41		Same scats as PS17. (Not re-collected.)
47	16-Jul-19	412823.768	6379507	PS18	Fresh scats < 1 month old. Sample collected.
48	16-Jul-19	412664.116	6379458.37		Abundance of scats > 3 months old. Note, found under a clump of trees comprising only Melaleuca.
49	16-Jul-19	412684.252	6379310.75		Same scats as PS18, but in slightly less good condition as those collected at PS18. (Not re-collected.)

Waypoint №	Date	Coordinates		Sample code (if applicable)	Comments/observations
		Easting	Northing		
50	16-Jul-19	412690.936	6379222.01		Very old scats > 6 months old.
51	16-Jul-19	412738.096	6379219.98		Very old scats > 6 months old.
52	16-Jul-19	412785.662	6379150.22		Scats > 3 months old.
53	16-Jul-19	412488.848	6379916.49	PS19	Scats consistent in shape/size but from a variety of age classes, from >3 months old to circa 4 weeks old. Sample of the fresher ones collected.
54	16-Jul-19	412540.217	6379883.79		Abundance of scats consistent in shape/size with the ones observed at previous location.
55	16-Jul-19	412585.753	6379896.17		Scats consistent in shape/size with the ones observed at previous location.
56	16-Jul-19	412652.979	6379840.21		Scats > 3 months old.
57	16-Jul-19	412738.774	6379804.16		Scats > 3 months old.
58	16-Jul-19	412769.892	6379782.81		Very old scats > 6 months old.
59	16-Jul-19	412809.281	6379726.62		Scats > 3 months old.
60	16-Jul-19	412711.47	6379636.95		Scats > 3 months old.
61	16-Jul-19	412694.695	6379594.12		Very old scats > 6 months old.
62	16-Jul-19	412662.76	6379580.53		Scats > 3 months old.
63	16-Jul-19	412533.842	6379628.51		Scats > 3 months old.
64	16-Jul-19	412571.685	6379694.93		Scats > 3 months old.
65	16-Jul-19	416246.665	6378023.76	PS20 PS21	Abundance of scats of a variety of age classes (> 6 months old to < 2 weeks old). Potentially different shape/size classes. Two samples collected potentially originating from two distinct individuals.
66	16-Jul-19	415776.139	6377937.4		Abundance of old scats of a variety of shape/size and age classes (but all > 3 months old) across the forest floor in this area. Appears to include the same huge scats as previously observed at many previous locations.
67	17-Jul-19	401198.776	6386113.55	PS22	Abundance of fresh scats < 1 month old. Sample collected. Found in 1mn40s of starting searching that day.
68	17-Jul-19	401122.685	6385455.32	PS23	Fresh scats < 1 month old. Sample collected.
69	17-Jul-19	401141.544	6385435.55		Scats > 3 months old.
70	17-Jul-19	401126.301	6385383.95		Scats > 3 months old.
71	17-Jul-19	401143.998	6385282.9		Fresh scats that appear to be the same as PS23. (Not re-collected.)
72	17-Jul-19	401039.274	6385289.18		Very old scats > 6 months old.
73	17-Jul-19	400977.683	6385324.49		Very large scats > 3 months old. Appear consistent in size/shape as the huge scats previously observed at many locations.
74	17-Jul-19	400969.718	6385380.4		Scats circa 6 weeks but too damaged for analysis.
75	17-Jul-19	401006.794	6385424.34		Scats circa 6 weeks but too damaged for analysis.
76	17-Jul-19	401013.635	6385472.08		Scats > 3 months old.

Waypoint №	Date	Coordinates		Sample code (if applicable)	Comments/observations
		Easting	Northing		
77	17-Jul-19	401028.71	6385540.53		Scats > 3 months old.
78	17-Jul-19	401349.59	6385214.53		Very old scats > 6 months old.
79	17-Jul-19	401279.961	6385275.6	PS24 PS25	Abundance of scats of a variety of age classes (> 6 months old to < 1 week old) and of a variety of shape/size classes. Two samples collected potentially originating from two distinct individuals.
80	17-Jul-19	401791.114	6384568.41		Scats circa 2 months old but too damaged for analysis.
81	17-Jul-19	401838.032	6384394.25		Scats > 3 months old.
82	17-Jul-19	401872.995	6384329.18	PS26	A few scats circa 4 weeks old. Sample collected.
83	17-Jul-19	402169.199	6384493.86		Scats > 3 months old.
84	17-Jul-19	402136.55	6384581.24		Scats circa 2 months old but too damaged for analysis. Note, scats not under any tree canopy.
85	17-Jul-19	402101.87	6384693.88		Scats > 3 months old.
86	17-Jul-19	402096.208	6384716.55		Abundance of scats circa 3 months old.
87	17-Jul-19	401010.121	6385919.75		Scats > 3 months old.
88	17-Jul-19	400863.078	6385852.1		Very old scats > 6 months old.
89	17-Jul-19	400545.159	6386629.14		Scats > 3 months old.
90	17-Jul-19	400655.743	6386666.83		A few scats > 3 months old.
91	18-Jul-19	388428.767	6381815.03		Scats circa 2 months old but too damaged for analysis. Found in 1mn22s of starting searching that day.
92	18-Jul-19	388465.509	6381740.71		Abundance of scats of two distinct shape/size and age classes: one shape/size class circa 3 months old and the other shape/size class > 6 months old.
93	18-Jul-19	388560.918	6381660.07		Very old scats > 6 months old.
94	18-Jul-19	388594.407	6381658.33		Scats > 3 months old.
95	18-Jul-19	388658.817	6381641.54		Scats circa 2-3 months old.
96	18-Jul-19	388689.15	6381603.51		Scats > 3 months old.
97	18-Jul-19	388687.146	6381573.11		Scats > 3 months old.
98	18-Jul-19	388703.33	6381526.06		Scats circa 2 months old but too damaged for analysis.
99	18-Jul-19	388703.21	6381511.64		Scats circa 2 months old but too damaged for analysis.
100	18-Jul-19	388734.881	6381504.79		Scats > 3 months old.
101	18-Jul-19	388765.382	6381527.19		Scats > 3 months old.
102	18-Jul-19	388816.939	6381552.94		Abundance of scats of a variety of age classes ranging from > 3 months old to circa 6 weeks old, but the latter too damaged for analysis (not collected).
103	18-Jul-19	388863.787	6381605.8	PS27	Same observations as previous location: scats of a variety of age classes ranging from > 3 months old to circa 6 weeks old. A few of the latter may be in sufficient condition, sample collected.

Waypoint №	Date	Coordinates		Sample code (if applicable)	Comments/observations
		Easting	Northing		
104	18-Jul-19	388767.664	6381691.87		Scats circa 3 months old.
105	18-Jul-19	388665.382	6381741.73		A few old scats circa 4-5 months old.
106	18-Jul-19	388632.639	6381768.86		Scats circa 3 months old. Particularly small scats not previously observed.
107	18-Jul-19	388629.062	6381745.1	PS28	Abundance of scats of a variety of age classes and of a variety of shape/size classes. Including the same small scats observed at previous location, circa 6 weeks old. Sample of these collected.
108	18-Jul-19	388517.633	6381832.99		A few scats circa 6 weeks old but too damaged for analysis.
109	18-Jul-19	387410.187	6380120.18	PS29	Abundance of scats across the forest floor in this location. Scats of a variety of age classes and of a variety of shape/size classes. Sample of the fresher scats collected.
110	18-Jul-19	388275.066	6380375.43		Scats circa 2-3 months old.
111	18-Jul-19	388312.14	6380404.67		Large scats circa 6 weeks old but too damaged for analysis.
112	18-Jul-19	388317.354	6380466.27		Abundance of large scats circa 6 weeks old (consistent with those observed at previous location) but too damaged for analysis.
113	18-Jul-19	388322.447	6380555.25		Very old scats > 6 months old, of a distinct shape/size class than those observed at previous two locations.
114	18-Jul-19	388321.277	6380600.92		Scats > 3 months old.
115	18-Jul-19	388303.453	6380618.8		Scats > 3 months old.
116	18-Jul-19	388237.611	6380705.09		Very small scats circa 6 weeks old but too damaged for analysis.
117	18-Jul-19	388196.943	6380678.58		A few old scats > 6 months old.
118	18-Jul-19	388131.355	6380767.21	PS30	Abundance of scats of a variety of age classes and of a variety of shape/size classes. Sample the fresher scats collected.
119	18-Jul-19	388078.225	6380765.06		Scats > 3 months old.
120	18-Jul-19	388050.567	6380707.09	PS31	A few scats circa 6 weeks old. Sample collected.
121	18-Jul-19	388087.962	6380657.95		Scats > 3 months old.
122	18-Jul-19	388153.309	6380599.03		Scats > 3 months old.
123	18-Jul-19	388197.387	6380514.15		Scats > 3 months old.
124	18-Jul-19	388199.59	6380468.27		Scats circa 2 months old but too damaged for analysis.
125	18-Jul-19	387698.121	6380712.21		Very old scats > 6 months old.
126	18-Jul-19	387676.651	6380679.26	PS32	Abundance of scats circa 4 weeks old + a few older scats circa 3 months old. Sample of the fresher scats collected.
127	18-Jul-19	387602.298	6380638.94		Same observations as previous location. (Same not re-collected as the fresh scats are likely to originate from the same individual.)
128	18-Jul-19	387568.185	6380563.49		Abundance of particularly small scats circa 3 months old.
129	18-Jul-19	387431.061	6380346.28		A few scats circa 2 months old but too damaged for analysis.
PS33	18-Jul-19	416174.677	6377571.25	PS33	Joannie. Blind female Koala in care. Coordinates indicate where this individual was picked up from the wild.

Waypoint №	Date	Coordinates		Sample code (if applicable)	Comments/observations
		Easting	Northing		
PS34	18-Jul-19	416063.416	6378772.35	PS34	Maree. Blind female Koala in care. Under medication. Coordinates indicate where this individual was picked up from the wild.
PS35	18-Jul-19	415987.091	6377747.27	PS35	Eila. Female Koala in care. Coordinates indicate where this individual was picked up from the wild.
PS36	18-Jul-19	410497.872	6374016.16	PS36	Tai. Male Koala in care. Coordinates indicate where this individual was picked up from the wild.
PS37	18-Jul-19	385612.559	6405287.17	PS37	Clarence. Male Koala in care. Coordinates indicate where this individual was picked up from the wild.
PS38	18-Jul-19	412234.684	6381367.53	PS38	Tolley. Old male Koala in care. Has been in and out of care numerous times. Currently under strong medication as he has severe digestive issues. Coordinates indicate where this individual was *last* picked up from the wild.
130	19-Jul-19	386871.967	6377500.63		Scats circa 6 weeks old but too damaged for analysis. Found in 6mn40s from starting searching that day.
131	19-Jul-19	386869.091	6377473.43	PS39	A few scats circa 1 month + a few scats < 6 hours old of same shape/size class. Sample of the latter collected.
132	19-Jul-19	386882.096	6377442.42		Scats circa 6 weeks old but too damaged for analysis.
133	19-Jul-19	386868.187	6377380.06		Scats circa 3 months old.
134	19-Jul-19	386791.79	6377357.12		Scats > 3 months old.
135	19-Jul-19	386786.508	6377351.96		Abundance of scats circa 2-3 months old.
136	19-Jul-19	386891.644	6377270.66		Scats > 3 months old.
137	19-Jul-19	386938.514	6377244.81		Scats > 3 months old.
138	19-Jul-19	386969.228	6377222.21		Old scats > 6 months old.
139	19-Jul-19	386983.369	6377132.55		Scats circa 6 weeks old but too damaged for analysis.
140	19-Jul-19	387048.455	6377119.88		Very old scats > 9 months old.
141	19-Jul-19	387035.855	6377181.27	PS40	Abundance of old scats + abundance of fresh scats < 6 weeks old. Sample collected.
142	19-Jul-19	386999.428	6377203.59		Scats circa 6 weeks old but too damaged for analysis.
143	19-Jul-19	386960.078	6377433.22	PS41	A few scats of two age classes, < 4 weeks old and circa 6 weeks old. The < 4 weeks old scats were too damaged for analysis (visible fungi on their surface), however two of the slightly older scats were found above the ground/not in contact with leaf litter (stuck in bark along tree trunk) and were collected.
144	19-Jul-19	386953.082	6377454.98		Scats > 3 months old.
145	19-Jul-19	386962.615	6377498.44		Scats circa 2-3 months old.
146	19-Jul-19	386952.826	6377535.15		Scats circa 6 weeks old but too damaged for analysis.
147	19-Jul-19	387182.102	6377803.09		Scats circa 2 months old but too damaged for analysis.

Waypoint №	Date	Coordinates		Sample code (if applicable)	Comments/observations
		Easting	Northing		
148	19-Jul-19	387191.781	6377833.8	PS42	Abundance of fresh scats < 12 hours old. On the 4WD track, not under any tree canopy. Sample collected.
149	19-Jul-19	387258.733	6378168.87		Scats of two distinct age classes, circa 3 months old and > 6 months old.
150	19-Jul-19	387223.976	6378382.25	PS43	Abundance of scats of two distinct age classes, circa 3 months old and circa 4 weeks old. Sample of the latter collected.
151	19-Jul-19	387055.621	6378450.52		Very old scats > 6 months old.
152	19-Jul-19	386948.051	6378456.5		Abundance of scats of various shape/size classes and of various age classes ranging from circa 2 months old to > 6 months old.
153	19-Jul-19	386728.429	6378409.43		Scats circa 3-4 months old.
154	19-Jul-19	386713.391	6378388.52		Scats circa 3-4 months old.
155	19-Jul-19	386684.274	6378369.34		Scats circa 3-4 months old.
156	19-Jul-19	386643.617	6378334.83		Old scats > 6 months old.
157	19-Jul-19	386659.514	6378280.46		Scats circa 3-4 months old.
158	19-Jul-19	386620.84	6378244.76		Scats > 3 months old. Note, found under tree <15cm DBH.
159	19-Jul-19	386587.97	6378225.98		Old scats > 6 months old + a few scats < 2 months old but too damaged for analysis.
160	19-Jul-19	386571.751	6378169.02		Scats circa 3 weeks old but too damaged for analysis.
161	19-Jul-19	386583.188	6378144.1		Scats circa 3 weeks old but too damaged for analysis.
162	19-Jul-19	386567.837	6378126.07		Abundance of old scats > 6 months old.
163	19-Jul-19	386534.228	6378089.98		Abundance of scats circa 3 weeks old but too damaged for analysis.
164	19-Jul-19	386647.109	6378037.16		Scats circa 6 weeks old but too damaged for analysis.
165	19-Jul-19	386703.877	6378039.47		Scats circa 2 months old (but too damaged for analysis) + a few scats > 3 months old.
166	19-Jul-19	386795.889	6378049.61	PS44	Abundance of scats circa 3 months old + abundance of fresh scats circa 3 weeks old. Sample of the latter collected.
167	19-Jul-19	386856.218	6377986.21		A few scats circa 3 weeks old, not collected as they appear similar to the ones already collected from previous location.
168	19-Jul-19	386911.226	6378019.66		Abundance of scats circa 3-4 months old.
169	19-Jul-19	386942.359	6378018.02		Scats circa 3-4 months old.
170	19-Jul-19	387149.197	6377993.54	PS45	A few very large scats circa 1 month old. Not consistent in shape/size with any scats previously observed in this area. Most scats appeared to be affected by fungi however one scat was found above the forest floor (not in direct contact with leaf litter) and was collected for analysis.
171	19-Jul-19	386717.481	6378859.81		Abundance of scats of two distinct age classes, circa 3 months old and > 6 months old.
172	19-Jul-19	386621.685	6378934.11	PS46	A few scats < 1 week old. Sample collected.

Appendix I

Marsh and Youngentob (2019)

Report on nutritional analysis of eucalypt leaves collected from Kings Hill

Prepared by Karen Ford and Kara Youngentob

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Introduction

The nutritional quality of eucalypt leaves for koalas (*Phascolarctos cinereus*) is determined by a combination of nutrients and plant secondary metabolites (PSMs). Protein is one of the most important nutritional aspects of forage quality because it is considered a limiting nutrient for many herbivores (Mattson 1980). Protein is required in adequate amounts to support animal growth and reproduction, but it is present at relatively low concentrations in eucalypts (Wallis et al. 2010). However, even eucalypts that contain adequate protein may not always be good food for koalas. This is because PSMs can limit the ability of animals to access protein, either because some PSMs (e.g. tannins) bind to proteins and make them indigestible (Marsh et al. 2003, DeGabriel et al. 2008, Wallis et al. 2010), or because others (e.g. formylated phloroglucinol compounds and unsubstituted B-ring flavanones) have toxic properties that limit the amount of leaves that animals can eat (Marsh et al. 2007, Marsh et al. 2015, Marsh et al. 2019).

Koalas can sense differences in the nutrient and PSM properties of eucalypt leaves, probably through differences in taste and smell (Lawler et al. 1999), and they adjust their feeding accordingly (Moore et al. 2005, Marsh et al. 2007, Marsh et al. 2014). For example, koalas eat less foliage from trees with formylated phloroglucinol compound (FPC) concentrations that exceed 15-20 mg/g dry weight than they do from trees with lower FPC concentrations (Moore et al. 2005, Marsh et al. 2007, Marsh et al. 2014). Likewise, there is a noticeable drop in the amount of foliage that koalas eat when unsubstituted B-ring flavanone (UBF) concentrations increase from 3 to 6 mg/g dry weight (Marsh et al. In preparation). In contrast, high concentrations of digestible nitrogen (nitrogen is a proxy for protein) in food can improve the capacity of eucalypt folivores to tolerate PSMs, allowing them to ingest more PSMs than they otherwise would if their intake of digestible N was low (Au et al. 2013).

Eucalypt foliar nutritional quality can also influence koalas at the population level. Au (2018) surveyed eucalypt nutritional quality at 75 locations across Australia that each had long-term data on koala population densities. She found a strong correlation between koala densities and the FPC and digestible protein concentration of eucalypt foliage (Au 2018). It is likely that digestible protein concentrations place key limitations on koala population densities by regulating reproductive success, as has been shown for common brushtail possums (*Trichosurus vulpecula*) living in eucalypt forests (DeGabriel et al. 2009). In that study, female possums living in areas with lower digestible N had lower reproductive success and their young grew at a slower rate (DeGabriel et al. 2009). Captive koalas expending minimal energy require at least 271 mg digestible N per $kg^{0.75}$ per day for maintenance (Cork 1986). Cork (1986) estimated that koalas could meet these requirements when eating eucalypt foliage containing at least 1% digestible N, although the requirements of wild koalas may be slightly higher, particularly during lactation (Krockenberger 2003). In support of this, Au et al. (in prep) observed that koala population density is markedly lower in areas with average foliar digestible N of 0.9% or less dry weight, and koala densities increase with higher foliar values of digestible N.

The nutritional quality of foliage can differ between eucalypt species. For example, eucalypt species in the *Symphyomyrtus* subgenus produce FPCs, and often have higher digestible N concentrations than do species in the *Monocalyptus* subgenus, which produce UBFs instead of FPCs (Tucker et al. 2010, Wallis et al. 2010). However, nutritional quality can also vary between individual trees within species (Wallis et al. 2002, Moore et al. 2004). Thus, habitat quality is dependent not only on the eucalypt species composition in a given area, but also on the variation in nutritional quality between individual trees in the habitat. Variation in nutritional quality between trees of a particular species is often more striking between areas than within them. For example, the mean FPC concentration of *Eucalyptus viminalis* foliage at Cape Otway, Victoria, is 7.97 mg/g dry weight and digestible N is

1.41% dry weight, whereas in Cooma, NSW, *E. viminalis* FPCs average 17.76 mg/g dry weight and digestible N is 1.11%. This means that habitat assessments that rely only on data about the presence or abundance of preferred koala food tree species can easily over- or under-estimate the true value of habitat for koalas. The best management decisions are therefore made with a thorough understanding of the underlying nutritional quality of habitat, and how it varies across a site.

Objectives

The purpose of this study was to understand the nutritional quality of eucalypts at Kings Hill, Raymond Terrace, for koalas and to use the nutritional quality data to estimate the carrying capacity of the site. Specific objectives were to:

1) Determine the mean and range in nutritional quality of potential koala food tree species at Kings Hill.
2) Determine the mean nutritional quality of selected transects at Kings Hill, within and outside of the development zone, and the mean nutritional quality of the site as a whole.
3) Use the mean transect and site nutritional quality data to estimate the carrying capacity for koalas at Kings Hill.
4) Investigate whether koala scat observations within the Kings Hill site coincided with areas of higher nutritional quality.

Methods

In consultation with Associate Professor Robert Clark, from the Australian National University Statistical Consulting Unit, we designed a survey approach to cover as much area as possible to account for within and between tree species variability across the Kings Hill property at Raymond Terrace. This was done to look at the quality of forage across the site and compare the transects and site as a whole to existing data on forage quality across the range of the koala. We also stratified our sampling to include polygons with and without koala scat detected by dogs to investigate whether there was a relationship between forage quality and koala scat observations.

We established 9, 250m transects. Trees were sampled in clumps of 4, with each clump spaced approximately 80m apart, resulting in a total of 16 trees per transect. Studies have shown that the genetics of a tree strongly influences the chemical composition of its leaves, and that eucalypt trees of the same species are less likely to be related to each other if they are at least 60 m apart (Andrew et al. 2007). Thus, distance between sampled clumps was an important consideration for the sampling design of our study. We only sampled eucalypt tree species that were from a list of koala food trees developed for a separate foliage quality project (see accompanying files). At the beginning of each transect, the tree closest to the initial GPS point with a diameter at breast height (DBH) of at least 10 cm was chosen as the central tree in the first clump. That tree and its three nearest neighbours of any species that fit the same criteria were also sampled.

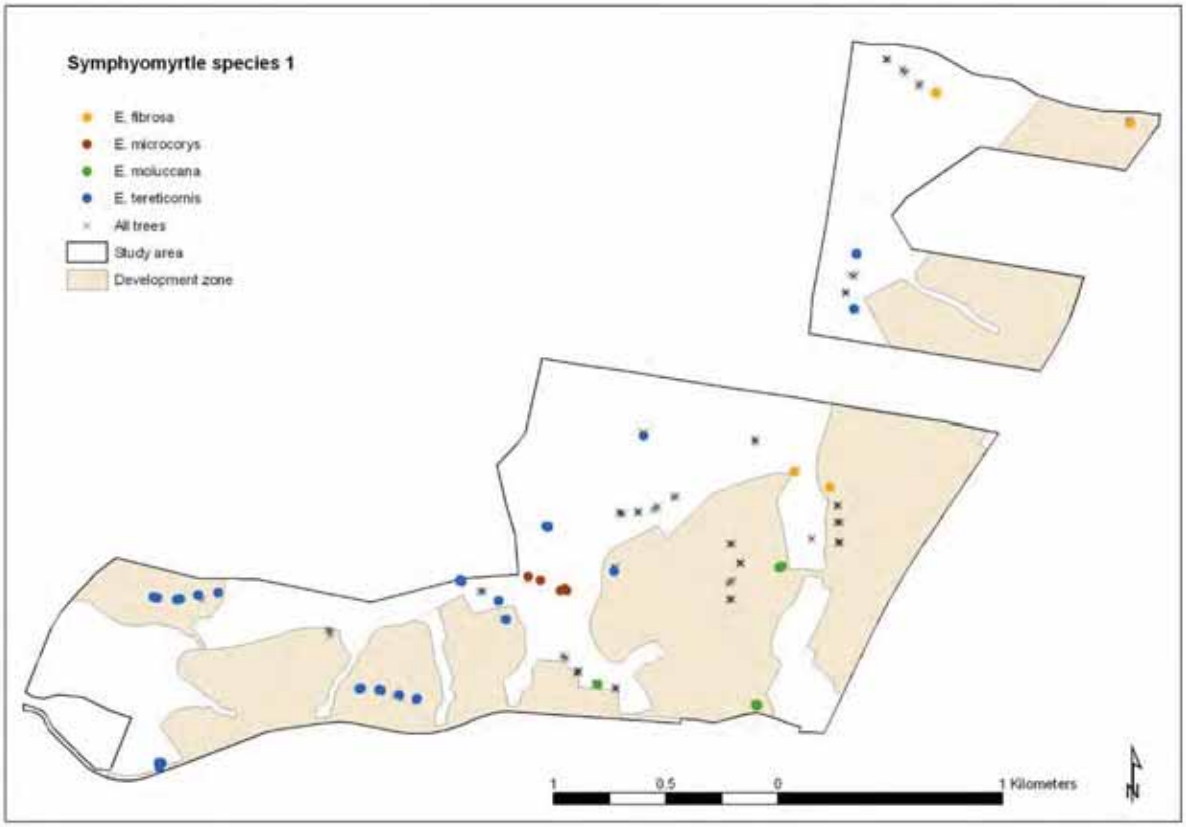
Each transect crossed two grid cells that either both had koala scat observations from detection dogs or both did not have any scat detected. There were five “koala scats observed” transects and four “no scats observed” transects. Furthermore, transects were stratified so that four were outside the development zone, three were within it, and two were on the edge and crossed the development zone boundary. To ensure that all koala food tree species at Kings Hill were sampled, and to maximize site-area coverage, we also spot sampled a further 11 clumps of 4 to 6 trees spaced

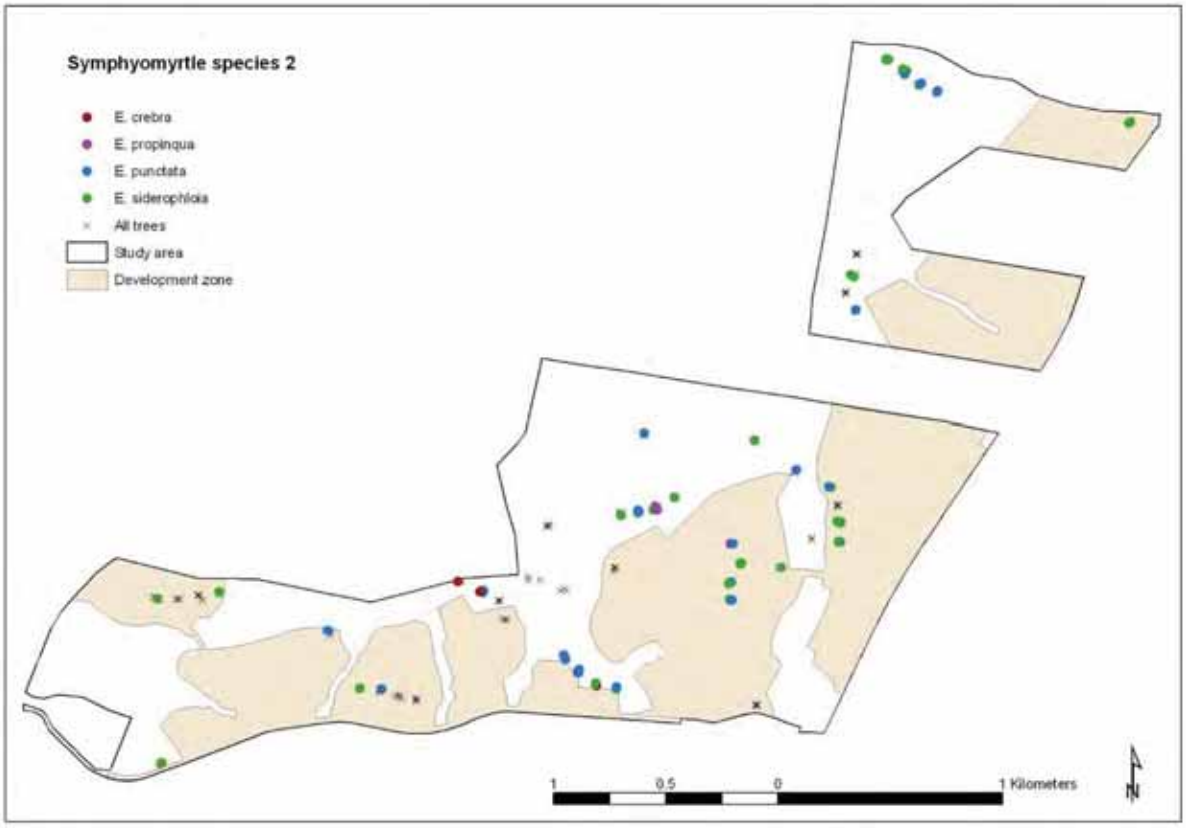
across the site. We sampled a total of 201 trees across 13 species (Table 1). Sampling locations for trees of each species are shown in the three panels in Figure 1.

Table 1. The number of eucalypt species across three subgenera sampled at Kings Hill.

Species	Subgenus	Samples collected
C. gummifera	*Corymbia**	1
C. maculata	*Corymbia**	6
E. acmenoides	*Monocalyptus*	37
E. globoidea	*Monocalyptus*	12
E. umbra	*Monocalyptus*	23
E. crebra	*Symphyomyrtus*	5
E. fibrosa	*Symphyomyrtus*	5
E. microcorys	*Symphyomyrtus*	6
E. moluccana	*Symphyomyrtus*	8
E. propinqua	*Symphyomyrtus*	4
E. punctata	*Symphyomyrtus*	27
E. siderophloia	*Symphyomyrtus*	33
E. tereticornis	*Symphyomyrtus*	34

**Corymbia* may be eaten by koalas at times, but are not considered preferred browse. We collected a few samples of *Corymbia* species from the area to investigate their nutritional quality. However, these were not included in the transect tallies (they were collected in addition to the four trees sampled per clump) and their values were excluded from the transect and site-based nutritional quality analyses.


Symphyomyrtle species 1
E. fibrosa
E. microcorys
E. moluccana
E. tereticornis
All trees
Study area
Development zone
1
0.5
0
1 Kilometers


Symphyomyrtle species 2
E. crebra
E. propinqua
E. punctata
E. siderophloia
All trees
Study area
Development zone
1
0.5
0
1 Kilometers

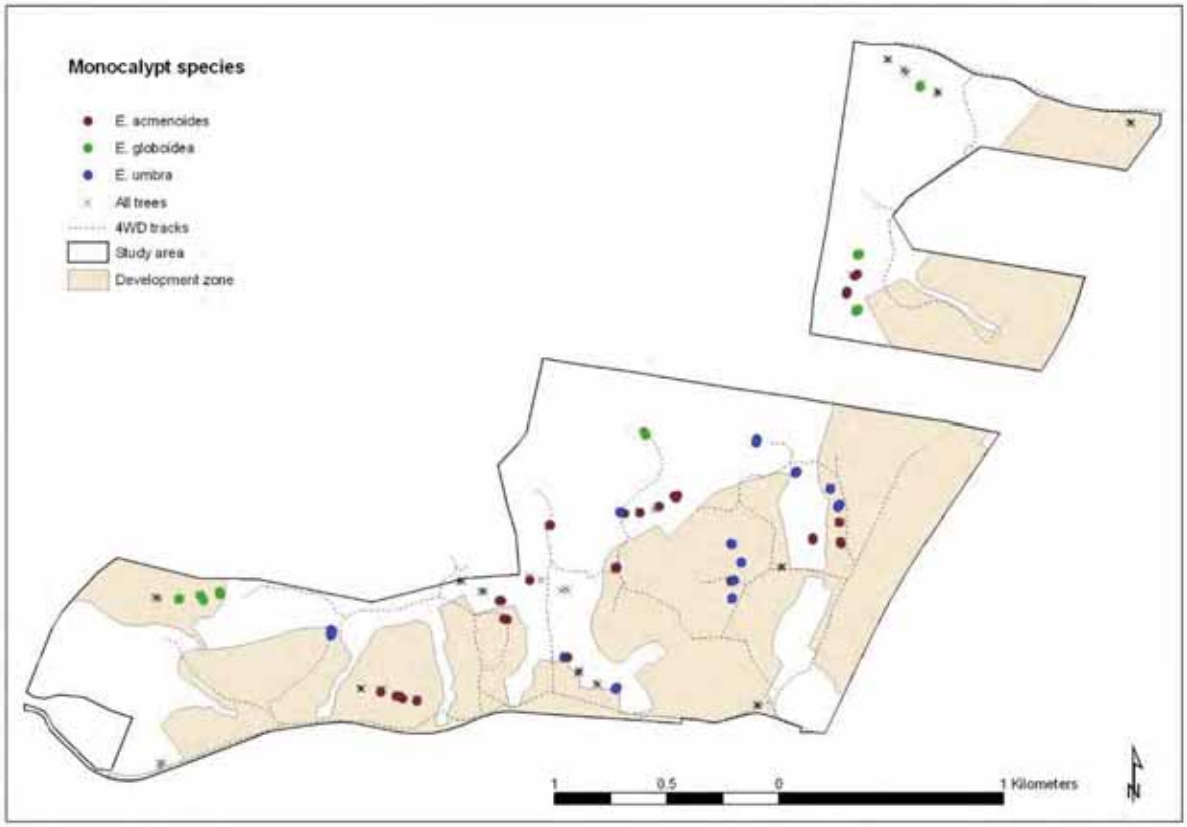


Figure 1. Maps of leaf sample collection locations at Kings Hill. All sampled trees are marked with black crosses on all three maps, with different species highlighted in colour on each map. The species have been split across three maps to increase the visibility of individual trees.

Tree leaves were sampled between the 4th and 10th of December 2018 by obtaining a branch from a sunlit portion of the canopy of each tree using an arborist throwline launcher or an extendable cutting pole. Once a branch was obtained from the tree, approximately 50g of mature, fully expanded foliage was collected and placed in dry ice (solid CO_2) to freeze. Once all samples were collected, they were transported to the Australian National University in a portable freezer at -20 °C for further analysis. The frozen leaf samples were freeze dried and then ground to pass through a 0.5m screen using a Tecator Cyclotec Mill (Foss, Hillerod, Denmark). A portion of the freeze-dried leaf powder was transported to the University of Western Sydney to collect NIR spectra for modelling unsubstituted B-ring flavanones (UBFs) and formylated phloroglucinol compounds (FPCs) using existing calibrations from samples previously analysed by Dr Jessie Au. We collected NIR spectra from each sample at 1 nm intervals from 400 nm to 2498 nm using a FOSS – NIRSystems 6500 scanning spectrophotometer with spinning cup attachment (Foss - NIRSystems, Silver Spring, Maryland, USA). Using FPC and UBF NIR models developed from the same species of eucalypt, we predicted FPC and UBF concentrations in the Kings Hill samples. The calibrations had a prediction accuracy with an r^2 of 0.952 for FPCs and 0.991 for UBFs.

Total nitrogen (N) was measured on 140 of the 201 Kings Hill samples using a Leco TruSpec carbon/nitrogen analyser (Leco Corporation, Saint Joseph, Missouri, USA). To determine the digestible N in each sample, we performed an *in vitro* digestion of the same 140 Kings Hill samples, following the protocol of DeGabriel et al. (2008). In summary, 0.8050 ± 0.0050 g of dry, ground sample was weighed into a preweighed ANKOM F57 filter bag (Ankom Technology, Macedon, New

York). These samples underwent three digestion phases: 1) a 24 h incubation in buffer (0.05M Tris–BASE buffer, pH 7.1), 2) a 24 h digestion in pepsin (2 $g.L^{-1}$), and 3) a 48 h fermentation stage (cellulase 6.25$g.L^{-1}$, pH 4.75) at 37°C. Digestible N is calculated by the proportional difference in N of a sample before and after digestion. The digestible N measure accounts for the protein-binding effect of tannins, a common group of plant secondary metabolites (PSMs), and provides an integrative measure of the amount of protein available for animal digestion. Digestible nitrogen, rather than total nitrogen, provides a better indication of foliage quality for those animals that are sensitive to the effects of protein-binding by tannins.

Total N and digestible N were predicted in the remaining 60 Kings Hill samples using an NIR calibration developed from the 140 analysed samples. Prediction accuracy for total N gave an r^2 of 0.985 and 0.962 for digestible N.

Results and Discussion

Total and digestible nitrogen

Eucalypt trees sampled at Kings Hill contained a range of total and digestible N concentrations (Figure 3). Digestible N concentrations were lower than total N in most species due to the binding of protein by tannins in the leaves. Thus, digestible N concentrations better reflect the portion of N that is actually available to the animal. Most *E. tereticornis, E. moluccana, E. propinqua* and *E. punctata* trees contained relatively high concentrations of digestible N (Figure 3b). Most *E. globodia* and *E. microcorys* also tended to have good (i.e. ≥ 1% DM) foliar concentrations of digestible N. *Eucalyptus acmenoides, E. umbra, E. crebra, E. fibrosa*, and *E. siderophloia* were poorer in digestible N (Figure 3b).

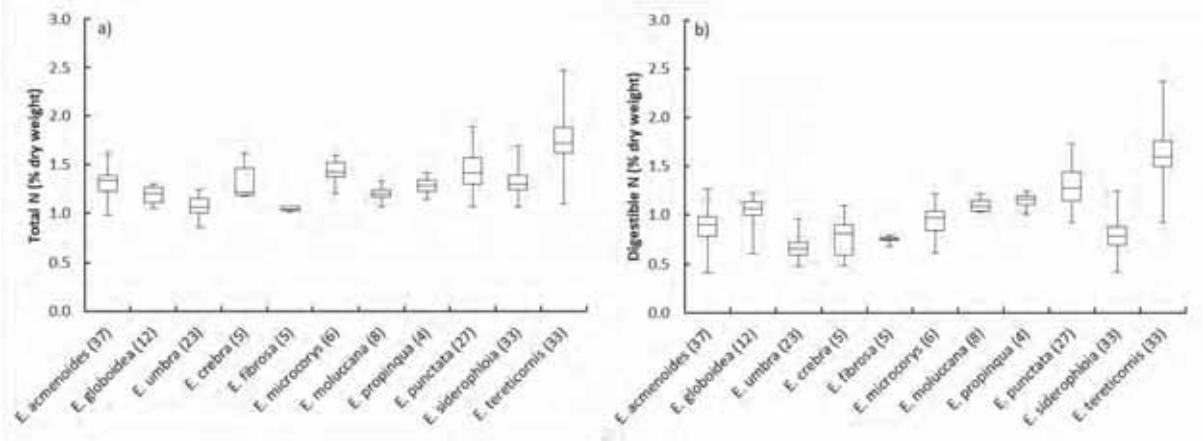


Figure 3. The range in a) total, and b) digestible nitrogen (N) concentrations for eucalypt species sampled at Kings Hill. Boxes show the first quartile, median and third quartile for each eucalypt species, and whiskers show the maximum and minimum concentrations. The number of samples collected is shown in brackets after the species name.

Different transects within the Kings Hill site also varied in total and digestible N concentrations (Figure 4). For example, more than 75% of the trees sampled in transect 8 had concentrations of available N higher than 1% dry weight, whereas more than 75% of the trees in transect 3 were below this concentration (Figure 4b). Much of this variation appeared to be driven by the species composition at each location. The variation between transects can also be seen in Figure 5, where transects with high proportions of trees containing good concentrations of digestible N (from a forage quality perspective) have predominantly yellow and green crosses, whereas transects with poorer quality trees have a high proportion of orange and red crosses. The data files accompanying this report contain shape files that allow the data to be visualised more clearly for each tree, since some of the trees in the sampled clumps overlap and obscure the colour for nearby trees at the scale of the figures below.

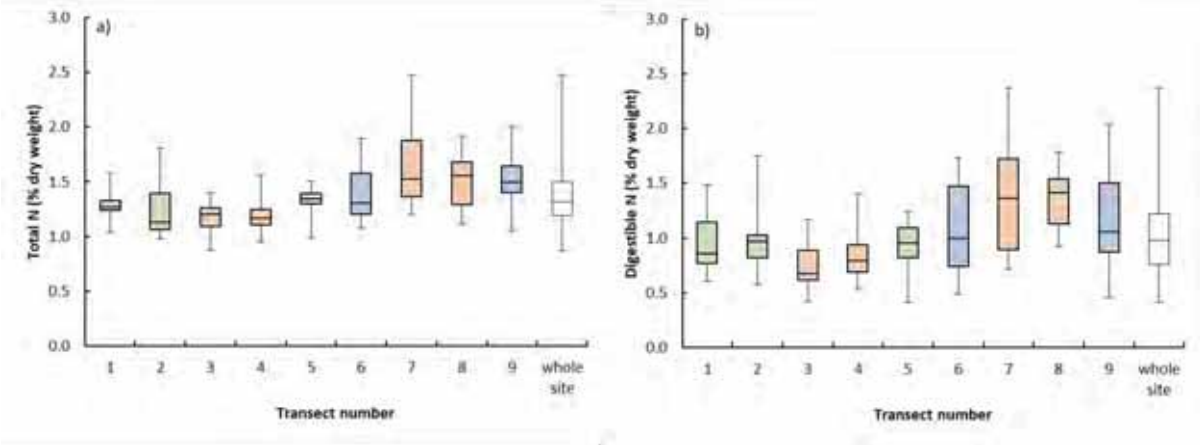


Figure 4. The range in a) total, and b) digestible nitrogen (N) concentrations for eucalypt trees at each transect sampled at Kings Hill (16 trees per transect). Boxes show the first quartile, median and third quartile for each transect, and whiskers show the maximum and minimum concentrations. Transects coloured green are outside the development zone, blue are on the edge and orange are within.

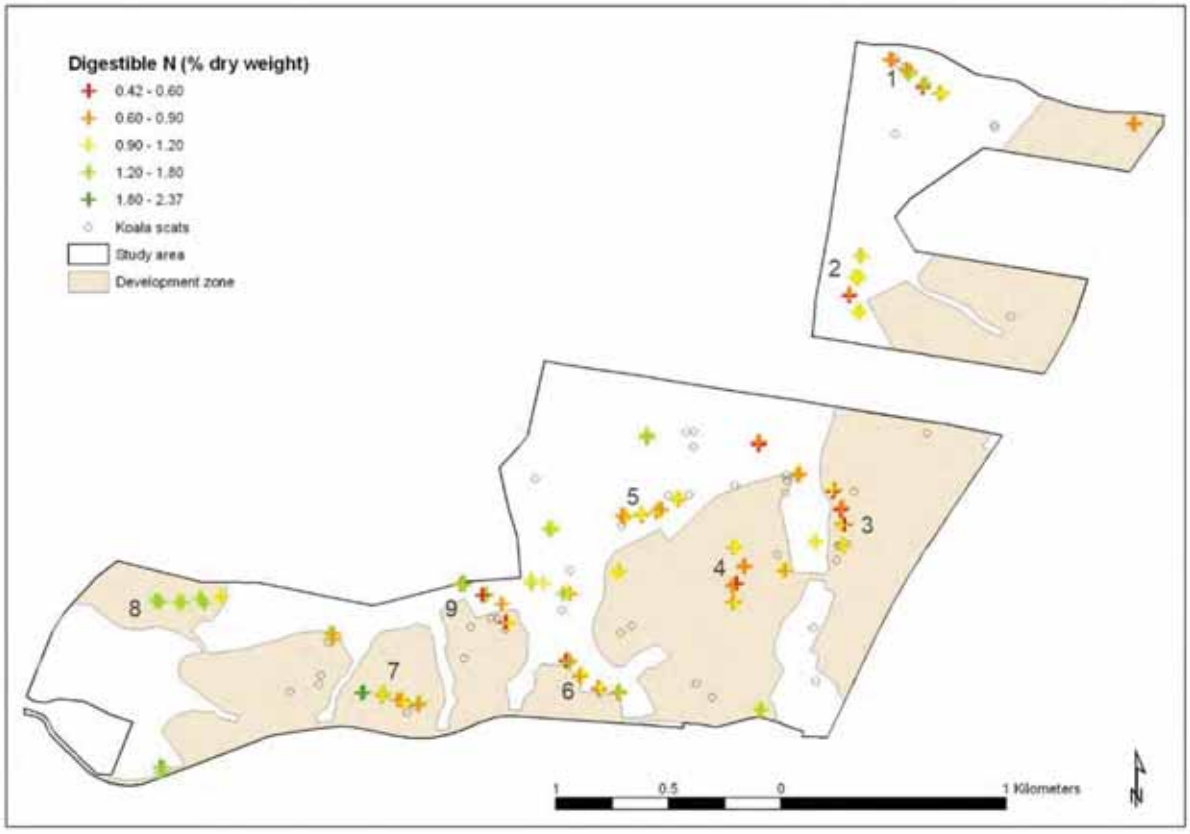


Figure 5. Tree sampling locations coloured by digestible N concentration. Trees with the highest concentrations (best quality for koalas) range from green to yellow, while the poorest quality trees are orange and red. Locations at which koala scats were found by detector dogs are shown with open circles. Transects are numbered to correspond with transect labels on Figure 4. Additional clumps of trees that were sampled outside the transect lines are included, but they are not numbered.

Herbivore deterrent PSMs: formylated phloroglucinol compounds and unsubstituted B-ring flavanones

Eucalypt species in the *Symphyomyrtus* subgenus can produce a class of plant secondary metabolites (PSMs) called formylated phloroglucinol compounds (FPCs). When FPCs are present at concentrations higher than 15-20 mg/g dry weight, koalas eat less from those trees, preferring individual trees with lower FPC concentrations. Species from the *Monocalyptus* subgenus do not produce FPCs, but can instead produce a different class of PSMs, unsubstituted B-ring flavanones (UBFs). These compounds also deter koalas from feeding, and at relatively low concentrations (e.g. 3-6 mg/g dry weight). The presence of UBFs, together with generally lower concentrations of digestible N, may explain why *Monocalyptus* species often make up a smaller proportion of the diets of koalas than do *Symphyomyrtus* species.

The foliar FPC concentration of *Symphyomyrtus* species at Kings Hill varied both within species and between species, as expected. Several species (e.g. *E. crebra, E. fibrosa, E. siderophloia* and *E. microcorys*) had relatively low FPC concentrations in all trees sampled (Figure 6a). However, koalas may not be able to meet their protein requirements if they were to eat only *E. crebra, E. siderophloia* and *E. fibrosa* due to the low digestible N concentrations in most trees of those species. *Eucalyptus*

microcorys had moderate foliar concentrations of digestible N, but the low FPCs observed at Kings Hill for that species increases its overall browse quality because koalas can access the digestible N without having to contend with high levels of FPCs. Although 25% of the *E. tereticornis* trees sampled at Kings Hill contained FPCs at concentrations higher than 15 mg/g dry weight (Figure 6a), the very high concentrations of digestible N in this species are likely to make it an excellent source of food for koalas, particularly given that koalas can select individual trees with lower FPC concentrations. For similar reasons, *E. punctata*, *E. propinqua* and *E. moluccana* are also likely to be important food species at Kings Hill.

More than half of the *E. acmenoides*, more than three quarters of the *E. umbra,* and all of the *E. globoidea* trees sampled at Kings Hill contained concentrations of UBFs that could be expected to reduce the amount of foliage that koalas can eat from those trees (Figure 6b). Together with the low digestible N concentrations in many *E. acmenoides and E. umbra* in particular, koalas at Kings Hill may eat some of these trees in small amounts, but they are not likely to be a major dietary component.

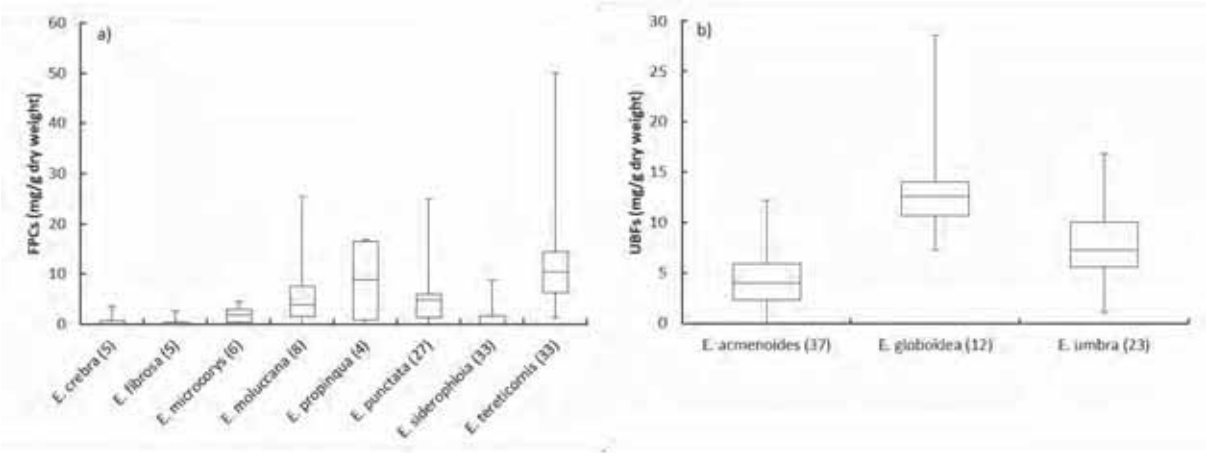


Figure 6. The range of a) concentrations of FPCs in *Symphyomyrtus* species, and b) concentrations of UBFs in *Monocalyptus* species sampled at Kings Hill. Boxes show the first quartile, median and third quartile for each species, and whiskers show the maximum and minimum concentrations. The number of samples collected is shown in brackets after the species name.

Transects at Kings Hill also differed in the range of concentrations of FPCs and UBFs observed (Figure 7). This variation was predominantly due to variation in the species present at each transect. All transects had at least some trees with minimal concentrations of both FPCs and UBFs (Figure 7). These trees are shown in green at their sampling locations in Figures 8 and 9. *Symphyomyrtus* trees shown in yellow in Figure 8 are also likely to be readily eaten by koalas.

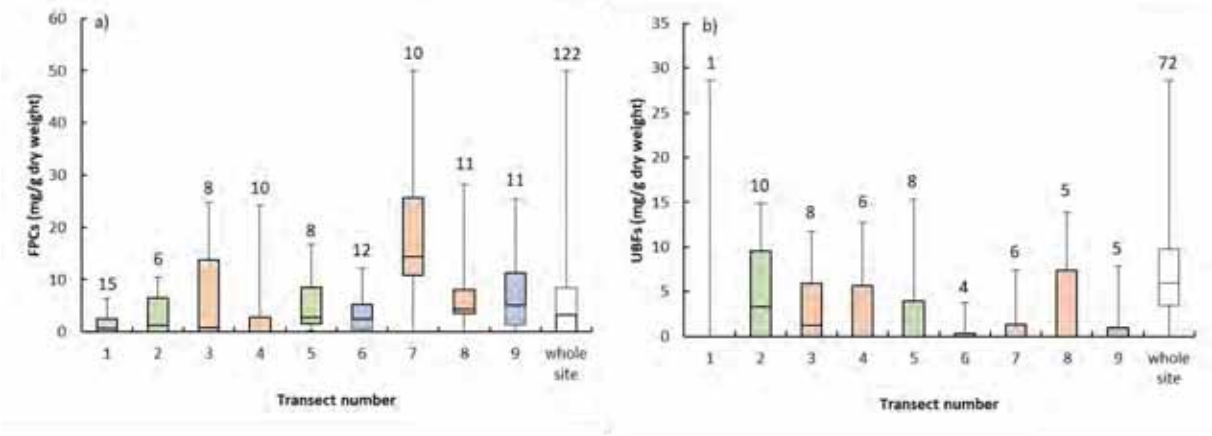


Figure 7. The range of a) concentrations of FPCs in *Symphyomyrtus* species, and b) concentrations of UBFs in *Monocalyptus* species for transects at Kings Hill. The number of trees in each boxplot depends on the number of trees of each subgenus sampled along that transect (out of a possible 16), and is shown above each box. Boxes show the first quartile, median and third quartile for each transect, and whiskers show the maximum and minimum concentrations. Transects coloured green are outside the development zone, blue are on the edge and orange are within.

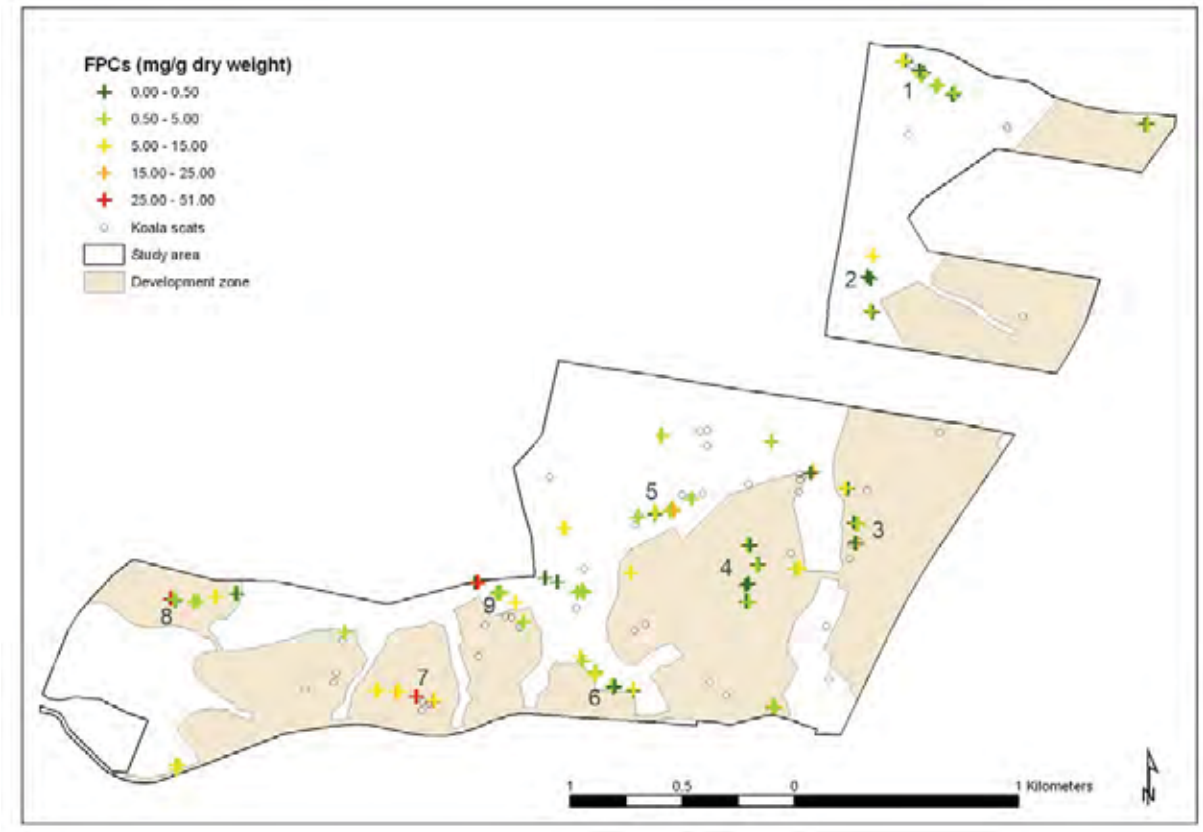


Figure 8. Tree sampling locations for *Symphyomyrtus* species coloured by FPC concentration. Trees with the lowest concentrations (best quality for koalas) are green and yellow, while the poorest quality trees are orange and red. Locations at which koala scats were found by detector dogs are shown with open circles. Transects are numbered to correspond with transect labels on Figure 7. Additional clumps of trees that were sampled outside the transect lines are included, but they are not numbered.

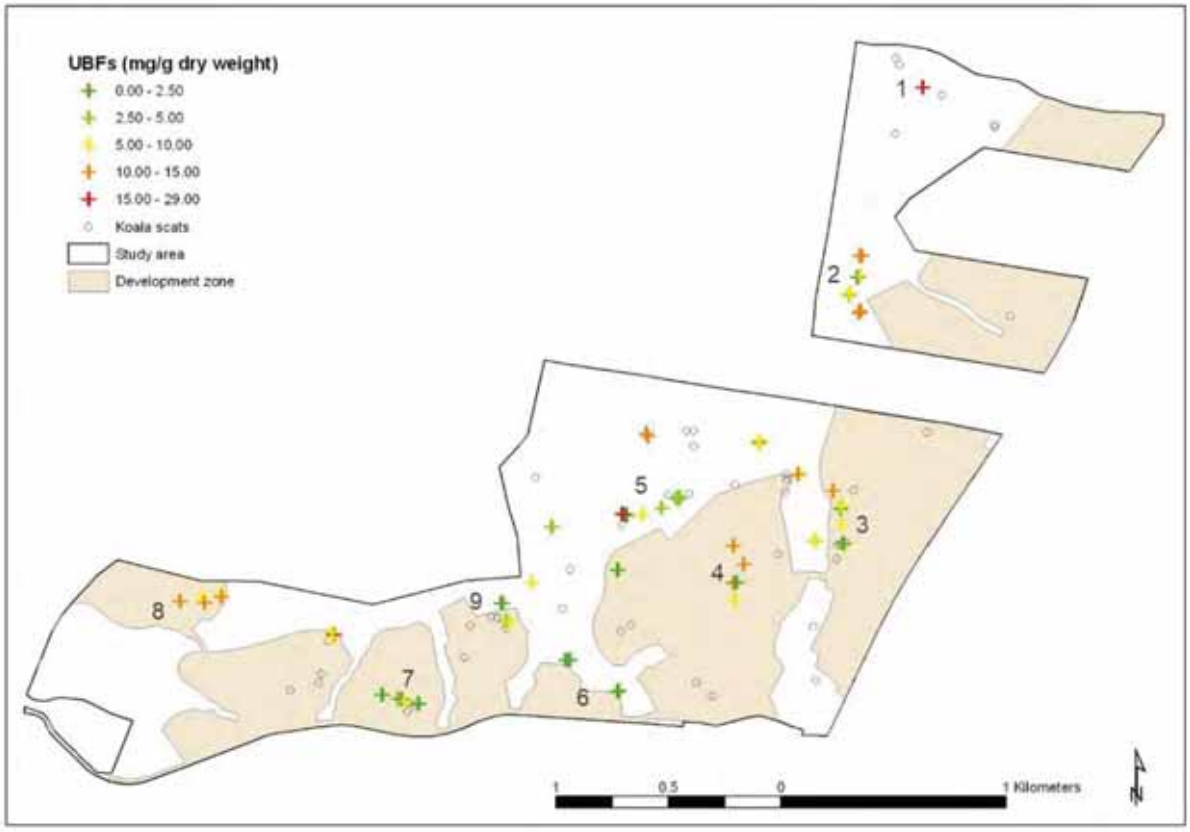


Figure 9. Tree sampling locations for *Monocalyptus* species coloured by UBF concentrations. Trees with the lowest concentrations (best quality for koalas) are green, intermediate values are yellow, and the poorest quality trees are orange and red. Locations at which koala scats were found by detector dogs are shown with open circles. Transects are numbered to correspond with transect labels on Figure 7. Additional clumps of trees that were sampled outside the transect lines are included, but they are not numbered.

Relationship between koala scat observations and foliage quality

Notably, koala scats located by detector dogs did not always correspond with the locations where trees with high digestible N, low FPC or low UBF concentrations were sampled. It is known that koala observations and scat are not always directly associated with the trees in which koalas prefer to browse. Besides browsing, koalas spend time in trees for shade and thermoregulation, and potentially to avoid predators or competition from conspecifics. A single koala could easily cross the distance of multiple sampling grids, and this was observed in the DNA results from koala scat collected at the site. Therefore, the fact that we did not see a strong relationship between koala scat observations and the quality of forage was interesting, but not entirely unexpected. A koala almost anywhere in the Kings Hill site would readily be able to move to areas with high forage quality.

We also noted, as we travelled across the site on foot, that the detection dogs appeared to have focussed on areas with minimal understory vegetation, and this may have created a detection bias in the koala scat data. The trees we sampled followed a predetermined transect line, irrespective of understory vegetation density, that incorporated two grid cells. As a result, our transect lines often crossed areas that were not searched by the detection dogs. Future investigations into potential relationships between koala scat detection and forage quality at a fine spatial resolution should

focus sampling effort in the exact locations that have been searched and avoid upscaling detection dog searched areas to larger “grid-level” values of koala occupancy.

Foliage quality and koala population densities

Previous work by our group found a strong relationship between foliage quality (particularly the concentrations of digestible N and FPCs) and the density of koalas in populations for which there is reliable, long-term density data (Figures 10, 11, and 12). The proportion of *Symphyomyrtus* to *Monocalyptus* species at sites was also related to koala density. Figure 11 shows that, if they were considered to be independent, different transects at the Kings Hill site could be predicted to support different densities of koalas; from around 0.4 to 1.5 koalas per hectare. It is unlikely, however, that transects at Kings Hill are independent, because koala home-ranges can be easily larger than the area represented by each 250 m transect. Furthermore, DNA profiling of koala scats collected at Kings Hill clearly showed that at least some individual koalas move greater distances than the spacing between the sampling transects. If the mean of all trees collected at Kings Hill is used to infer the quality of the site as a whole, Figure 11 suggests that, on average, the Kings Hill site could support koalas at a density of around 0.5 to 0.75 animals per hectare.

Limitations

It is important to note that the transect and site forage quality presented here is based on simple averages of the sampled trees. In some transects, such as transect 3, there were actually a few moderately high quality symphyomyrtle trees, but their value was masked by a dominance of lower quality trees across the whole of the transect. Both forage quality and quantity have a role in the assessment of habitat quality. However, we do not yet know if there is a better way to weight the contribution of individual high quality trees to the overall carrying capacity of a landscape. Our current models that link forage quality with koala densities are based on average values for a site (Figure 11). It is important to recognise that transects ranked as lower quality may contain a few higher quality trees that provide good forage for koalas in the immediate area and contribute to maintaining koala populations across the Kings Hill site. In addition, given the diversity of tree species at the Kings Hill site, transects through highly diverse areas may not have included representatives of every tree species. Additional species-based estimates of forage quality that cover more of the site could be developed using the existing tree species nutritional quality data, combined with field survey data to document the species of every individual tree in a given area.

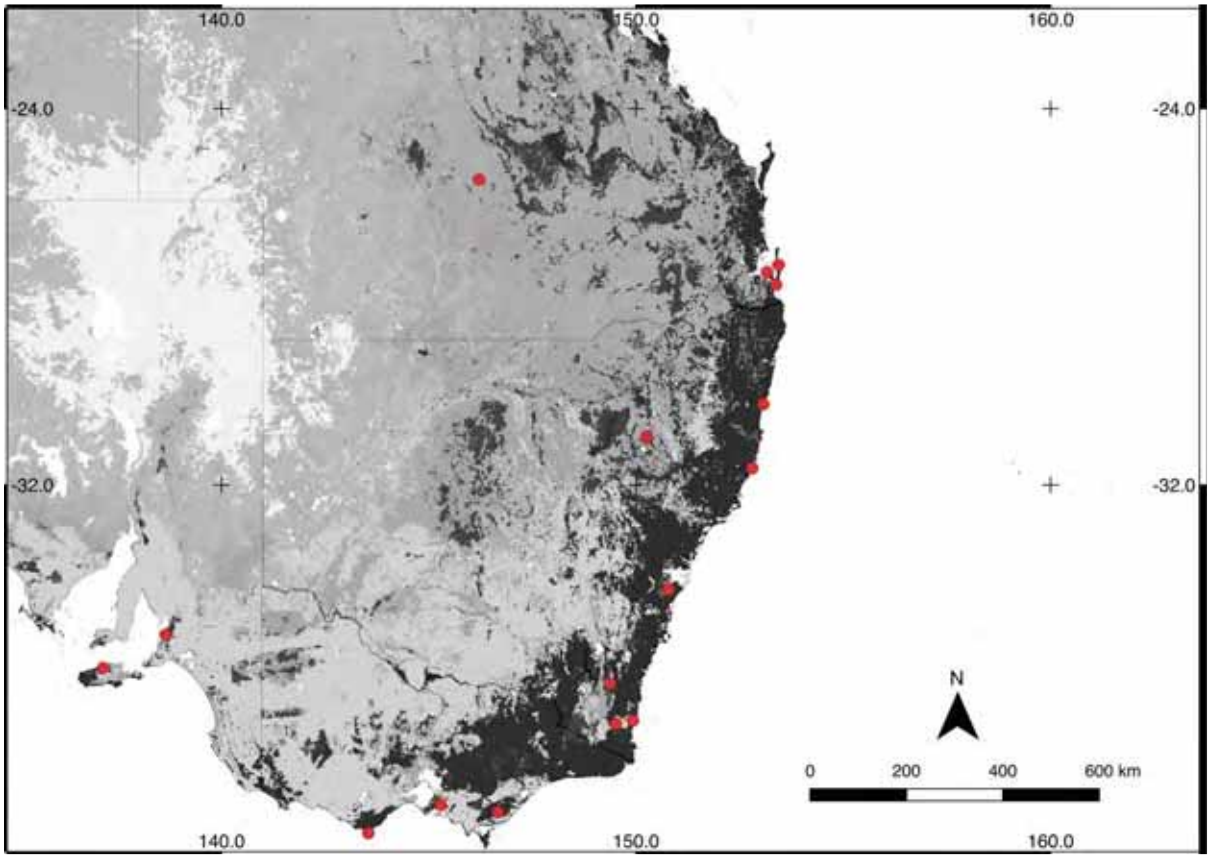


Figure 10. Map of sixteen surveyed regions (red circles) with koala density data across four Australian states; Queensland, New South Wales, Victoria and South Australia. Land cover (forest and woodland) is represented by the grey shading of the map. Transects sampled at these locations comprised the data presented in Figures 11 and 12.

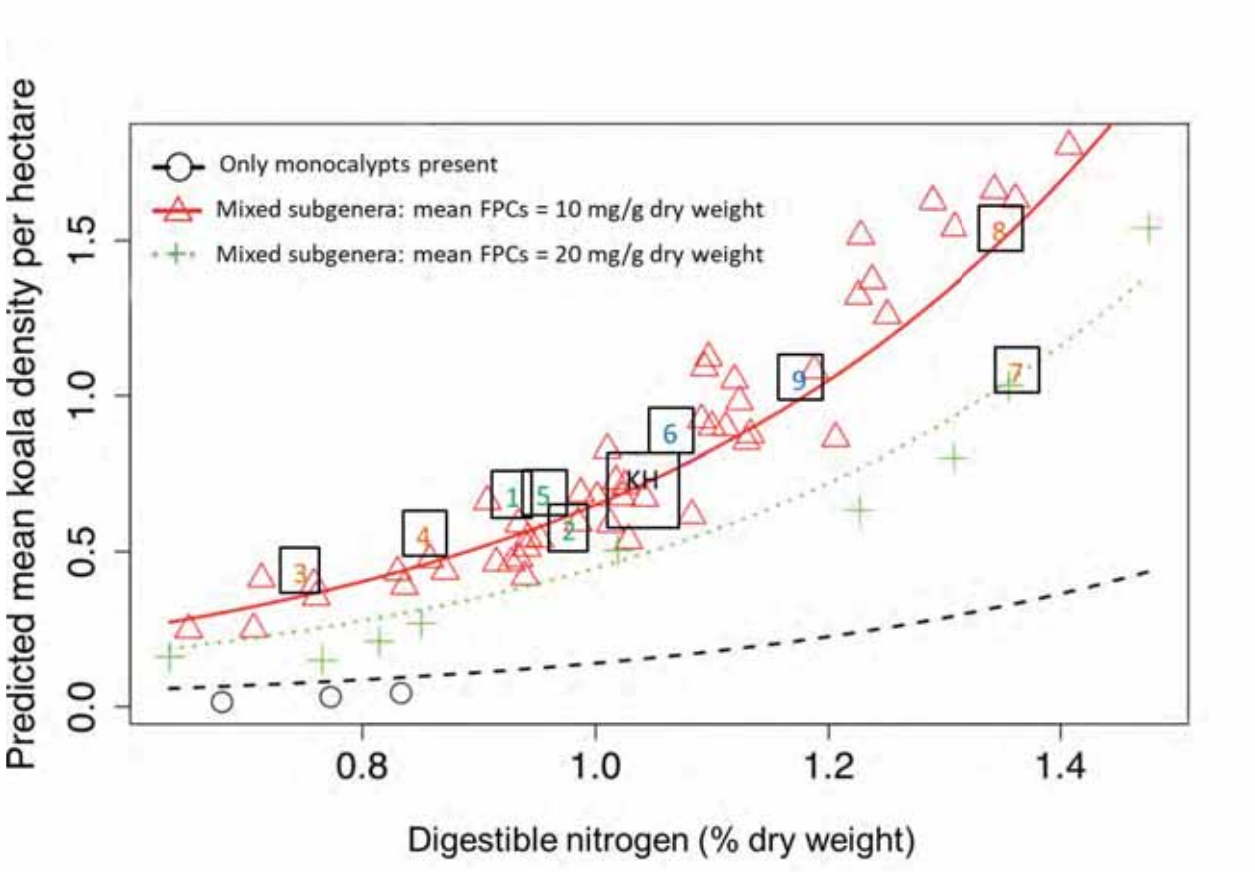


Figure 11. Model based on data from Jessie Au's PhD Thesis on the relationship between the mean density of koalas per hectare relative to the digestible N and FPC concentration of foliage at transects across Australia. Model = log(koala.ha^{-1} + 0.05) ~ digestibleN + FPCs + (proportion of Symphyomyrtus > 0) + (1|Region). Kings Hill transects have been superimposed on the figure using the mean digestible N and FPC concentration for each transect without consideration of "region" effects. Transect numbers in green are outside of the development zone, orange are within and blue are on the edge. The mean of the entire site is represented on the figure by "KH". This figure should be interpreted as the predicted density of sites with koala occurrence in relation to forage quality, rather than actual density. It may not fully account for other local factors that can influence population such as predation, disease, past land use, ongoing disturbance, etc.

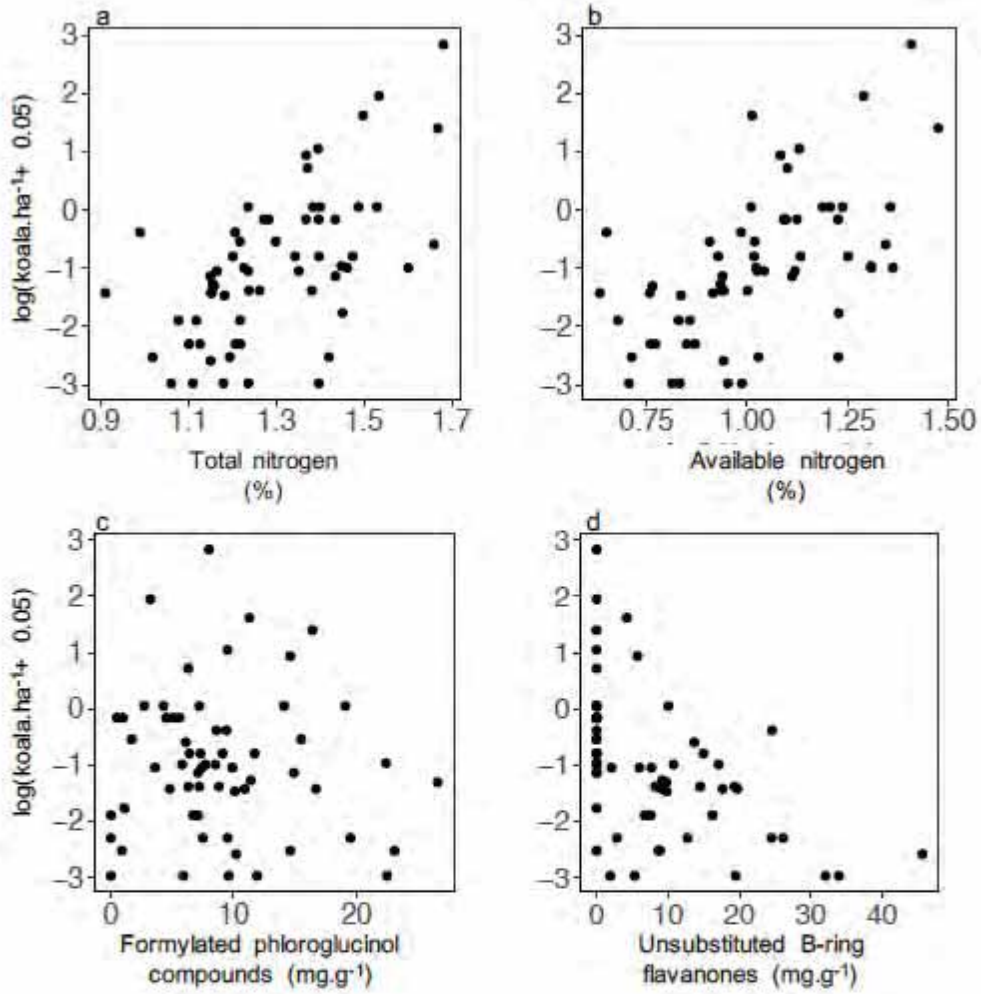


Figure 12. Scatterplot showing univariate relationship between log(koala.ha^{-1} + 0.05) and concentrations of (a) total nitrogen, (b) digestible nitrogen (available nitrogen), (c) formylated phloroglucinol compounds and (d) unsubstituted B-ring flavanones. Data from Jessie Au's PhD Thesis investigating relationships between forage quality and koala population density.

Recommendations

The existing data on the foliar chemistry of each eucalypt species sampled at the Kings Hill site could be extrapolated to provide estimates of forage quality for the entire study area. This would require collecting additional information about the abundance of each eucalypt species at a plot level (i.e. 30 nearest-neighbour trees with a DBH of at least 10 cm, identified to the species level), across multiple plots in each polygon. The existing nutritional data for the same species could then be resampled to provide a statistical estimate of forage quality at the plot level. Thus, by utilising data on eucalypt species composition across the study area, the data in the current report could be extended to understand the nutritional quality of additional locations or polygons within the Kings Hill site that were not directly sampled during the nutritional survey. A similar approach was used to estimate eucalypt forage quality for koalas across a much larger area on the South Coast of NSW, where plot-

level data on eucalypt species was collected to investigate the contribution of one species, *E. sieberi*, to the forage quality of plots with variable tree species composition (Au et al. in prep).

Accompanying files

1) Excel file containing raw nutritional data for each tree, as well as summaries for each eucalypt species and transect.
2) Shape files containing tree sampling locations, species and nutritional data for each tree.
3) List of eucalypt species known to be eaten by koalas.

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Appendix J

Biodiversity Conservation Monitoring (2018)

BIOCM

Biodiversity Conservation Monitoring Pty Ltd

johnpaulking@biocm.com.au

Jason Wasiak

Director – Principal Urban Planner

JW Planning Pty Ltd

05/12/2018

Attn: Methods for Winter Bird Survey KHD lands (forest and woodlands only) July August 2018, Kings Hill NSW.

Dear Jason,

Introduction

Recent research has shown that inventory-based studies such as transects recommended in several survey guidelines (e.g. LHCCREMS 2002) can generate data of less completeness than other bird survey methods, such as a "standardised search" approach (Watson 2003). In comparative studies of bird survey techniques fixed transects were shown to record only 38.9% species completeness, compared to the stopping rule-based area searches which peaked at 75% completeness (Watson 2004). In short, Watson (2004) believes that fixed area sampling efforts of only 20 minutes may only be suitable for the smallest of sites, or sites with limited complexity.

Methods

To target rare winter birds and record diversity and abundance of avian species across the site, four sample methods were used:

1. 3ha sample areas (stopping rule-based area searches);
2. 400m^2 fixed area 20-minute surveys;
3. Targeted searches of flowering trees; and
4. Active meanders between sample sites.

Due to the scale and complexity of this site a combination 3ha stopping rule-based area search areas (n=10) were surveyed using every day. At the same locations and in conjunction with the above, 400m^2 quadrats (n=10) were searched for 20 mins; were all birds species were recorded and counted. All surveyor movements made between sample points were undertaken on foot, providing active searches between fixed locations across the site and provided opportunities to locate flowering trees. Sample locations can be seen in Figure 1 attached.

Birds were surveyed across the study area for six days during the winter of 2018 (dates in Table 1). An additional 4 days of spot sampling were undertaken (also in winter) to target flowering trees. These areas of flowering trees surveyed were sampled on every sample day (10 days). All samples targeted periods of high

bird activity, predominantly between the hours of 6 am - 9 am and 3pm - 6pm and only during suitable weather. As a minimum the surveys included:

Table 1. Survey dates 2018

Dates of sampling	Sampling undertaken
28/07/2018	Targeted searches and survey of flowering trees.
29/07/2018	Targeted searches and survey of flowering trees.
30/07/2018	Targeted searches and survey of flowering trees. Area and time searches and meanders.
31/07/2018	Targeted searches and survey of flowering trees. Area and time searches and meanders.
1/08/2018	Targeted searches and survey of flowering trees. Area and time searches and meanders.
2/08/2018	Targeted searches and survey of flowering trees. Area and time searches and meanders.
3/08/2018	Targeted searches and survey of flowering trees. Area and time searches and meanders.
8/08/2018	Targeted searches and survey of flowering trees.
9/08/2018	Targeted searches and survey of flowering trees.
10/08/2018	Targeted searches and survey of flowering trees. Area and time searches and meanders.

Estimating the area of search

Generally, for smaller patches (<50 hectares) one moves freely throughout the patch in every sample period. In comparison, larger patches (>50 hectares) can be broken into sub-sets and these sampled as independent (i.e. not overlap samples). In total, ten 3 ha sample areas were established using a mobile GIS application. The surveyor moved around freely looking and listening within the area until the stopping rule is triggered. During this time all species were recorded by ear and unknown species were keyed out on site with the use of a digital recorder.

Stopping rule

A stopping rule in which “surveying was stopped after a minimum of two new (or fewer species) were encountered after the first search of the area” was applied.

Fixed survey duration quadrants

In total 10 fixed area quadrats (400m^2 each) were erected and surveyed on five occasions over a two-week period for a 20 minute survey period at each site (n=10). Surveys were conducted between 0700 and 1000 hours or between 1700 and 1900 hours, windy or rainy days were avoided. Assumptions that needed to be meet included, all birds exactly in the quadrat were detected, that birds did not move before detection, distances are measured accurately, and individual birds are detected independently.

Results

The attached data sheets show avian species abundance recorded during the 20 min fixed area surveys over six days. No rare migratory birds were recorded onsite during surveys. Whilst several threatened species

were recorded, all these species have previously been recorded onsite. Results of the targeting of winter flowering trees showed that generally *Eucalyptus crebra* was in patchy flowering throughout the period, but did have strong flowering on a handful of trees throughout the survey period (these trees were searched every day). Overall, whilst the Regent Honeyeater and the Swift Parrot were recorded in the Lower and Central Hunter region during the 2018 winter, they were not recorded onsite during these surveys.

If you have any questions, please contact me on the provided number 04908870199.

Regards,

John Paul King

A
B
C
D
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J

Legend

Scientific name	Common name	Status	Recorded history onsite (2003-2018) A	B	C	D
Ephippiorhynchus asiaticus	Black-necked Stork	E1,P				Annually
Haliaeetus leucogaster	White-bellied Sea-Eagle	V,P	Annually			Annually
Calyptorhynchus lathami	Glossy Black-Cockatoo	V,P,2		Occasionally		
Ninox strenua	Powerful Owl	V,P,3	Annually	Annually	Annually	Annually
Tyto novaehollandiae	Masked Owl	V,P,3			Occasionally	
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V,P	Since 2017			
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V,P	Occasionally		Annually*	Annually
Daphoenositta chrysoptera	Varied Sittella	V,P	Annually			
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V,P				Since 2018
Petroica boodang	Scarlet Robin	V,P	Since 2016		Since 2016*	

*Use the ecotone between A and C shown by red dashed boundary over Yellow fill

Datum: GDA 1994	Client: KHD	Drafted by John Paul King 24/09/2018 Version 1.1
Projection: GDA 1994 MGA Zone 56	Purpose: Ecology	
Location: Kings Hill, NSW	N	Biodiversity Conservation Monitoring Pty Ltd 35 Hannan St Maitland NSW, 2320 johnpaulking@biocm.com.au

Figure 1. Threatened birds recorded during winter surveys in 2018 and history of records oniste.

Appendix K

Dr Mark Clements (2020)

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Conservation genomics of an Australian orchid complex with implications for the taxonomic and conservation status of *Corybas dowlingii*

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Abstract

This study assessed genomic diversity in an Australian species complex in the helmet orchids to clarify taxonomic delimitation and conservation status of the threatened species *Corybas dowlingii,* a narrow endemic from southeast Australia. Taxonomic delimitation between the three closely related species *C. aconitiflorus*, *C. barbarae,* and *C. dowlingii* has been mainly based on floral traits which exhibit varying degrees of overlap, rendering species delimitation in the complex difficult. Genomic data for the species complex was generated using double-digest restriction-site associated DNA (ddRAD) sequencing. Maximum likelihood, NeighborNet, and Bayesian structure analyses showed genetic differentiation within the species complex and retrieved genomic signatures consistent with hybridisation and introgression between *C. aconitiflorus* and *C. barbarae,* and an intermediate genetic position of *C. dowlingii* indicating a hybrid origin of the species. The genetic structure analysis showed varying levels of genetic admixture for several *C. aconitiflorus*, *C. barbarae,* and *C. dowlingii* samples, thus further corroborating the presence of hybridisation and introgression within the species complex. The taxonomic status of *C. dowlingii* D.L.Jones was revised to *C.* × *dowlingii* D.L.Jones *stat. nov.* to reflect its hybrid origin. The conservation status of *C.* × *dowlingii* was assessed based on key ecological and ethical aspects, and recommendations made regarding its conservation status in Australian conservation legislation.

Keywords: Australasia, Species delimitation, ddRAD sequencing, Diurideae, Taxonomy, Orchidaceae

Introduction

Orchidaceae is the world's second largest flowering plant family, comprising over 27,800 species and 736 genera (Chase et al. 2015; (List 2018) that display extraordinary morphological and ecological diversity. Orchids inhabit a wide range of terrestrial and epiphytic habitats worldwide exhibiting their highest species diversity in the tropics (Cribb et al. 2003). However, many orchid species possess only narrow distributions, rendering them vulnerable to threats such as climate change, habitat destruction or over-exploitation (Cribb et al. 2003).

In the Australian flora, orchids rank within the ten largest angiosperm families, and exhibit a high level of endemicity with about 90 % of Australian native orchids found nowhere else (Govaerts et al. 2017). Orchids constitute over 15 % of Australia's threatened plant species and over one third of Australia's critically endangered plants (EPBC 1999). Over the last

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decade, new orchid species have been described at a rate of approximately 500 species per year worldwide (Chase et al. 2015). However, species delimitation in orchids is often challenging, which is reflected by the large number of taxonomic synonyms in orchids (Govaerts et al. 2017). In Australia, the number of orchid species recognised for the country has increased from around 900 species to more than 1,300 over the past two decades (Hopper 2009; Govaerts et al. 2017). This increase has been partly attributed to the discovery and description of new species and partly to the application of narrower species concepts elevating many infraspecific taxa to species level (Hopper 2009; Chase et al. 2015). The resulting uncertainties in the taxonomic status of many Australian orchid species greatly hamper effective conservation management and allocation of scarce resources.

The *Corybas aconitiflorus* complex (Acianthinae, Diurideae) is a group of small geophytic, colony-forming herbs with globose tubers. They possess a single heart-shaped leaf and a solitary flower with an enlarged hood-shaped dorsal sepal that imparts the impression of a helmet, hence the vernacular name 'helmet orchids' (Pridgeon et al. 2001). The flowers are mostly dull-coloured with shades of reddish or brownish purple, sometimes white to pinkish, and are pollinated by fungus gnats of the family Mycetophilidae Newman 1834 (Pridgeon et al. 2001). As in most orchids, the fruit is a dehiscent capsule with numerous dust-like seeds.

Previous molecular studies provided insights into phylogenetic relationships in *Corybas* (Clements et al. 2002, Lyon 2014) and identified an unresolved clade of four closely related species which constitute the *C. aconitiflorus* complex: three of the species are endemic to Australia (*C. aconitiflorus* Salisb., *C. barbarae* D.L.Jones, and *C. dowlingii* D.L.Jones) and one to Java (*C. imperiatorus* (J.J.Sm.) Schltr.) (Lyon 2014). Among the Australian species of the complex, *C. aconitiflorus* and *C. barbarae* are locally common and widespread, extending over 2,000 km along the Australian east coast, broadly in sympatry (AVH 2018). In contrast, *C. dowlingii* is narrowly endemic in New South Wales, extending ca. 100 km from Bulahdelah north of Newcastle to Freemans Waterhole south of Newcastle (Jones 2004; AVH 2018)), and occurs within the distribution range of both *C. aconitiflorus* and *C. barbarae* (AVH 2018). *Corybas dowlingii* is listed as vulnerable species at federal level (EPBC 1999) and as endangered under the New South Wales Threatened Species Conservation Act (1995) due to its highly restricted distribution and anthropogenic pressures on its habitat.

Previous molecular systematic studies in Diurideae based on the internal transcribed spacer (ITS) confirmed the taxonomic placement of *Corybas* within subtribe Acianthinae (Kores et al. 2001; Clements et al. 2002), and a combined phylogenetic analysis of ITS and 68 morphological characters in Acianthinae showed the *C. aconitiflorus* complex as unresolved polytomy

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together with *C. cerasinus,* an endemic species from northern Queensland (Australia) and New Zealand endemic *C. cheesemanii* (Clements et al. 2002). However, *C. dowlingii* was not described at the time of the study of (Clements et al. 2002). A molecular study in *Corybas* based on five plastid and three nuclear markers further resolved phylogenetic relationships in the genus and showed *C. aconitiflorus*, *C. barbarae*, *C. dowlingii*, and *C. imperatorius* as a clade, however relationships among these species remained unclear due to lack of statistical support (Lyon 2014). While sequence divergence among the three Australian species was shallow, *C. imperiosus* was situated on a long branch in the phylogenetic tree reconstruction (Lyon 2014). Morphologically, *C. dowlingii* is only weakly differentiated from *C. aconitiflorus* and *C. barbarae*. Its flowers are dark purplish red, and the labellum is of the same colour with some whitish areas and sparse bristles (Jones 2004, 2006). It is distinguished from the other two species mainly by differences in flower size and colouration, and a later, yet overlapping flowering time. *Corybas aconitiflorus* has greyish to reddish purple flowers that are smaller than in *C. dowlingii*, and has a whitish labellum with sparse tiny bristles (Jones 2004, 2006). *Corybas barbarae* has white to pinkish flowers of a similar size to *C. dowlingii* and possesses a white labellum covered in dense bristles (Jones 2004, 2006). Due to the low genetic divergence within the *C. aconitiflorus* complex observed in previous molecular studies (Clements et al. 2002; Lyon 2014), and the weak morphological differentiation between the three species with partly overlapping character states, further molecular studies with more informative molecular markers are required to assess species delimitation within the complex and to re-evaluate the conservation status of *C. dowlingii*.

Recent advances in high-throughput DNA sequencing and bioinformatics offer powerful genomic approaches to resolve complex inter- and intraspecific relationships at unprecedented resolution, facilitating the re-assessment of taxonomic concepts in species complexes and the conservation status of rare and threatened species (Ahrens et al. 2017; Bateman et al. 2018; Coates et al. 2018; Cozzolino et al. 2019; Taylor and Larson 2019).

Restriction-site-associated DNA sequencing (Baird et al. 2008) is a next generation sequencing method based on reduced representation library sequencing, which is a cost-effective method to obtain genome-scale data from non-model organisms (Davey et al. 2011; Lemmon and Lemmon 2013). For RADseq, genomic DNA is digested using one or two restriction enzymes (ddRAD). DNA fragments of a certain size range are selected as subset for library preparation and then subjected to high throughput sequencing (Miller et al. 2007; Baird et al. 2008; Peterson et al. 2012)(Miller et al. 2007; Lemmon and Lemmon 2013). RADseq has been successfully used to clarify inter- and intraspecific relationships and to assess taxonomic delimitation in

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species complexes, including in orchids (Brandrud et al., 2019a, b; Wagner et al. 2013; Jones et al. 2013; Eaton and Ree 2013; Escudero et al. 2014; Takahashi et al. 2014; Mort et al. 2015; Herrera and Shank 2016; Beheregaray et al. 2017; Bateman et al. 2018; Hipp et al. 2018). The aims of this study were to assess genetic diversity and structure within the *C. aconitiflorus* complex based on genomic data derived from double-digest restriction-site associated DNA sequencing (ddRADseq) in order to clarify species delimitation within the complex and to evaluate the taxonomic and conservation status of the narrow endemic *C. dowlingii*.

Materials and methods

Material studied

In total, 72 samples were included in the study, of which 70 samples from the *C. aconitiflorus* complex: *C. aconitiflorus* (24 samples, 9 localities), *C. barbarae* (32 samples, 5 localities), and *C. dowlingii* (14 samples, 2 localities). *Corybas pruinosus* (A.Cunn.) Rchb.f. (2 samples) was included as outgroup based on Clements et al. (2002). Sampling focussed on the south-eastern distribution of the *C. aconitiflorus* complex to which *C. dowlingii* is endemic and extended from the restricted distribution of *C. dowlingii* (between Port Macquarie and Newcastle, New South Wales) ca. 300 km northwards to the border between New South Wales and Queensland (Uralba), ca. 1,200 km southwards to Tasmania (Ulverstone), and ca. 600 km eastwards to Lord Howe Island. For each population, one herbarium voucher was taken per species sampled and lodged at CANB. Sampling locations are shown in Fig. 1 and further details on plant material studied are provided in Tab. 1.

DNA extraction, ddRAD library preparation, and sequencing

Total DNA was extracted from silica-dried leaf material using a modified CTAB protocol (Weising et al. 2005). DNA quality was assessed using a spectrophotometer (NanoDrop, Thermo Scientific) and gel electrophoresis on 2 % agarose gels, and DNA quantity was determined using a Qubit fluorometer (Thermo Fisher Scientific).

Double-digest restriction-site associated DNA (ddRAD) sequencing libraries were prepared following Peterson et al. (Peterson et al. 2012). During the initial establishment phase, double restriction enzyme digests of genomic DNA were carried out for three *Corybas* samples (*C. aconitiflorus* CNS_G04732, *C. barbarae* CNS_G04671, *C. dowlingii* CNS_G04727) testing eight different restriction enzyme combinations comprising a six base cutter (*PstI* or *EcoR1*) and a four base cutter (*MspI*, *HypCH4VI*, *MseI* or *NIaIII*). Digests were followed by ligation

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of barcoded adapters compatible with the restriction site overhang, bead purification, and amplification of the non-size selected sequencing library via PCR. Sequencing libraries were evaluated based on gel electrophoresis using TapeStation (Agilent Technologies, Santa Clara, CA, USA) to select the most suitable restriction enzyme combination that indicated the least amount of likely repetitive sequences. After this initial test, the enzyme combination *Pst*I and *Nla*III was selected for the three *Corybas* samples, including ligation of barcoded adapters, purification of the pooled digested-ligated fragments followed by size selection via Blue Pippin (Sage Science, Beverly, Massachusetts, USA) for two ranges, a narrow (280-342bp) and a wide (280-375bp) range. The two pooled libraries were amplified via PCR with indexed primers, and sequenced on the Illumina MiSeq platform for single-ended, 160 bp reads at the Australian Genome Research Facility (AGRF; Melbourne, Victoria, Australia). The sequencing data for the narrow and wide size selected libraries was analysed using the Stacks pipeline (Catchen et al. 2011, 2013) to assess the number of ddRAD loci per sample, the average coverage per sample, and the number of unique and shared ddRAD loci across the three samples. The narrow library yielded between 116,991 and 276,091 ddRAD loci per sample and an average coverage of 6.5-9.2 per sample and the wide library resulted in 85,229 to 203,174 ddRAD loci per sample and an average coverage of 6.4–9.4 per sample. The narrow size selection yielded a higher number of shared ddRAD loci across the three samples than the wider size selected sequencing library. Based on the evaluation of two pooled libraries, the narrow size selection was chosen for ddRAD sequencing for the complete sample set. Quality and reproducibility of libraries and DNA sequencing were assessed by running five samples in duplicate (6.9 % of all samples). Multiplexed libraries were sequenced on one lane of a NextSeq500 sequencing platform (Illumina Inc., San Diego, CA, USA) as single-ended, 150 bp reads at the Australian Genome Research Facility (AGRF; Melbourne, Victoria, Australia).

Bioinformatics and data filtering

Quality of the sequence reads was examined using FastQC v.0.11.5 (Andrews 2010). Raw sequences were demultiplexed, trimmed and further processed using the ipyrad pipeline v.0.6.15 (Eaton and Overcast 2016). In an initial filtering step, reads with more than five low quality bases (Phred quality score < 20) were excluded from the data set. The phred quality score offset was set to 33. The strict adapter trimming option was selected and a minimum read length of 35bp after trimming was chosen to retain a read in the dataset. After these quality-filtering steps, the reads were clustered within and across samples by similarity of 85% using

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the vclust function in VSEARCH (Edgar 2010). The alignment was carried out using MUSCLE (Edgar 2004) as implemented in ipyrad. Clusters with less than six reads were excluded in order to ensure accurate base calls. The resulting clusters represent putative RAD loci shared across samples. A maximum number of five uncalled bases ('Ns') and a maximum number of eight heterozygote sites ('Hs') was allowed in the consensus sequences. The maximum number of SNPs within a locus was set to ten and the maximum number of indels per locus to five. For the sample set including all accessions of the *C. aconitiflorus* complex as well as two accessions of *C. pruinosus* as outgroup ipyrad runs for two different datasets were performed, i.e. based on loci shared by 20 individuals (m20) and on loci shared by 70 individuals (m70). Additionally, the same settings were used for ipyrad runs excluding the outgroup (*C. pruinosus,* 2 samples). The datasets generated and analysed during the current study are available at CSIRO's Data Access Portal, [*DOI will be provided in published manuscript*].

Phylogenomic and genetic structure analysis

Phylogenetic relationships were inferred using maximum likelihood (ML) based on concatenated alignments applying the GTR+ Γ model of nucleotide substitution using RAxML v.8.2.4 (Stamatakis 2014) for both datasets (m20, m70) including the outgroup. Statistical support was assessed via a rapid bootstrapping with 100 pseudoreplicates (Stamatakis et al. 2008)(Stamatakis et al. 2008) under the same ML analysis settings.

NeighborNet analysis of the *C. aconitiflorus* complex was carried out in SplitsTree v.4.13 (Huson and Bryant 2006) using the unlinked SNP output of the m20dataset excluding the outgroup. The unlinked SNPs represent one randomly chosen SNP per locus and are therefore considered independend markers. Equal angle split transformation and uncorrelated P distance were selected for the NeighborNet analysis.

Genetic structure of the *C. aconitiflorus* complex was analysed using the Bayesian Markov Chain Monte Carlo (MCMC) clustering method implemented in the program Structure v.2.3.4 (Pritchard et al. 2000) based on both datasets (m20, m70) excluding the outgroup. For both datasets, the Structure output format of unlinked SNPs (.ustr) of the ipyrad pipeline was used as input file. Data analysis assumed correlated allele frequencies and admixture and prior population information was not included in the analysis (Hubisz et al. 2009). After preliminary runs with a smaller number of cycles and because of computational limitations, we conducted three independent runs for each value of K = 3–8 with 100,000 MCMC cycles

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following a burn-in of 10,000 MCMC cycles for the final analyses. The range of K-values was chosen based on the number of expected species (3) and number of eight observed clades in the RAxML analysis. The number of genetic groups best fitting the dataset was determined using the delta K method (Evanno et al. 2005) as implemented in Structure Harvester (Earl and vonHoldt 2012).

Results

An average of 2,98 (± 1,01) filtered Illumina reads per sample were used for the analyses. A total number of 362,412 pre-filtered loci passed the ipyrad pipeline. After subsequent filtering steps, the number of retained loci for the final datasets varied between 3,597 (m70) and 12,420 (m20) for the datasets including the outgroup, and between 4,293 (m70) and 14,915 (m20) loci for the datasets excluding the outgroup. The latter included 60,489 SNPs (see Table 2). The average read depth per locus was 20.87 (±4.01) reads. Further statistics of the ddRAD datasets are summarized in Tab. 2.

Maximum likelihood analysis

The ML tree reconstruction based on the m20 dataset including the outgroup retrieved the *C. aconitiflorus* complex as monophyletic group with maximum bootstrap support (BS 100) (Fig. 2). Genetic divergence between the *C. aconitiflorus* complex and *C. pruinosus* was considerably higher than within species as indicated by branch length (Fig. 2). Within the C. aconitiflorus complex, the ML reconstruction did not provide support for the monophyly of the three species *C. aconitiflorus*, *C. barbarae*, and *C. dowlingii* (Fig. 2).

A well-supported cluster (BS 96) comprising individuals from *C. barbarae* from North Coast (Broken Bago) was depicted as branching off first, followed by a second well supported cluster of *C. barbarae* (BS 100) from North Coast (Broken Bago). The next dichotomy showed one branch unifying individuals from *C. barbarae* from North Coast (Queens Lake and Uralba) and a highly supported branch (BS 97) harbouring individuals from *C. barbarae*, *C. dowlingii* and *C. aconitiflorus*. Within the latter branch, the first two diverging clusters were formed by individuals of *C. dowlingii* from North Coast (Broken Bago), both receiving high support (BS 92 and BS 94, respectively). The next diverging branch showed a dichotomy with one branch that harboured a moderately supported cluster (BS 85) unifying individuals of *C. aconitiflorus* from North Coast and South Coast, respectively (Uralba and Nowra) next to a highly supported cluster (BS 100) comprising individuals of *C. barbarae* and *C.*

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dowlingii. The latter cluster split into two highly supported clusters (BS 100), one with all individuals of *C. barbarae* from Lord Howe Island and the other with individuals of *C. dowlingii* from North Coast (Lake Cathie).

The second branch of the dichotomy was well supported (BS 90) and comprised the remaining samples of *C. aconitiflorus* from Central Coast and South Coast (Sydney and Nowra), all *C. aconitiflorus* samples from south Victoria (Colquhoun, Belgrave, Orbost, Shallow Inlet, Wilson Promontory) and Tasmania (Ulverstone) (Fig. 2). Within the latter, the *C. aconitiflorus* individuals from south Victoria and Tasmania formed a weakly supported subcluster (BS 60).

The ML analysis of the m70 dataset yielded congruent results for highly supported relationships and differed in topology for nodes that remained unsupported or received low statistical support in the analysis. Results of the ML analysis of the m70 dataset are presented in Online Resource 1.

NeighborNet analysis

The NeighborNet network based on 13,708 unlinked SNPs of the m20 dataset of the *C. aconitiflorus* complex showed one large group comprising *C. barbarae* from the Australian mainland, one large group comprising *C. aconitiflorus,* and in intermediate position within the NeighborNet *C. barbarae* from Lorde Howe Island and *C. dowlingii* (Fig. 3). However, genetic distances between the branches in the NeighborNet were overall low and exhibited patterns of reticulation. Subgroups within the network were largely consistent with well supported clusters found in the ML analysis.

Within the large group of *C. barbarae* from the Australian mainland, the NeighborNet diagram showed three branches that harboured individuals from Queens Lake (North Coast), two branches that comprised individuals from Broken Bago (North Coast) and one branch with *C. barbarae* from North Coast (Uralba). *Corybas barbarae* samples from Lord Howe Island formed a group that clustered together with *C. dowlingii* from Lake Cathie (North Coast), which corresponded to the relationships found in the ML analysis. Within the *C. aconitiflorus* group, samples from south Victoria and Tasmania formed a weakly differentiated subgroup, whereas *C. aconitiflorus* samples from NSW (Nowra, Sydney, Uralba) were found in more proximate position to *C. dowlingii* from Broken Bago, corresponding to relationships found in the ML analysis (Fig. 3). The NeigbourNet analysis based on the m70 dataset yielded highly congruent results to the analysis of the m20 dataset and are provided in Online Resource 2.

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Genetic structure analysis

In the following we report on the results of the Bayesian cluster analysis with Structure based on the m70 SNP dataset, which comprised 4,066 unlinked SNPs and a lower proportion of missing data than the m20 dataset as missing data can introduce biases to Structure analyses. For the m70 dataset, the best number of genetic groups (K) as determined by the modal Δ K distribution was K=7. The resulting bar plot (Fig. 4) showed several distinct genetic clusters and samples with varying degrees of genetic admixture. The genetic clusters retrieved by the Structure analysis did not correspond to current species concepts in the *C. aconitiflorus* complex.

The majority of *C. barbarae* samples from the mainland fell into three genetically distinct clusters that exhibited a low or no signal of genetic admixture. Two of these clusters unified samples from North Coast (Broken Bago), which also formed two well-supported clades in the ML analysis and two distinct branches in the NeighborNet analysis. The third *C. barbarae* cluster in the Structure analysis comprised a group of eleven samples from North Coast (Queens Lake), which were also found as highly supported cluster in the ML analysis and as a distinct branch in the NeighborNet analysis. The *C. barbarae* samples from Lord Howe Island and the *C. dowlingii* samples from Lake Cathie together formed another genetically distinct cluster. These samples were also found as highly supported clade in the ML analysis and in the NeighborNet analysis. For the remaining *C. barbarae* samples from North Coast (Queens Lake) and from North Coast (Uralba) the Structure analysis indicated high levels of genetic admixture (Fig. 4). High levels of genetic admixture were also found for *C. dowlingii* from Broken Bago (North Coast) and several samples of *C. aconitiflorus* from South Coast (Nowra). The remaining *C. aconitiflorus* samples from Central Coast and South Coast (Sydney and Nowra) displayed moderate levels of genetic admixture, whereas the *C. aconitiflorus* samples from south Victoria and Tasmania displayed low levels or no genetic admixture in the Structure bar plot (Fig. 4). The results from the Structure analysis based on the m20 dataset are provided in Online Resource 3.

Discussion

Accurate delimitation of species and infraspecific taxa is of critical importance to conservation biology as these are commonly used measures of biodiversity (Coates et al. 2018). However, taxon delimitation still heavily relies on the evaluation of morphological and ecological traits, which can be subject to convergent or parallel evolution and environmental

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plasticity. Further, taxonomic boundaries can be blurred through hybridisation and introgression, which are frequently observed phenomena among closely related orchid species (Dressler 1981; Cozzolino et al. 2006; Pinheiro et al. 2010; Nauheimer et al. 2018).

Recent advances in high throughput sequencing and statistical analyses now facilitate unprecedented fine-scale resolution of inter- and intraspecific relationships with detailed insights into genetic diversity and population structure. Hence, these approaches provide critical genomic data to evaluate taxonomic concepts in species complexes and to inform the development of effective conservation strategies for threatened species. Reduced representation library sequencing approaches, such as RADseq, ddRADseq and genotyping-by-sequencing (GBS), have proven to be powerful tools for disentangling complex relationships and delimiting taxonomic boundaries in orchids (Ahrens et al. 2017; Bateman et al. 2018; Brandrud et al. 2019a). Here, we present a study using more than 13,000 SNPs to unravel the complex relationships in the *C. aconitiflorus* complex containing three morphologically similar orchid species endemic to Australia.

Our genomic study provided insights into genetic diversity and structure of the *C. aconitiflorus* complex at fine-scale resolution. The results from the molecular analyses present a complex pattern that indicates occasional gene flow between *C. aconitiflorus* and *C. barbarae*. The apparent non-monophyly of the three species in the phylogenetic results is coherent with patterns expected in the presence of reticulation. The phylogenetic reconstruction showed genetically admixed samples of *C. aconitiflorus* and *C. barbarae* either towards the basal position of the main clade for each species comprising samples which exhibited no or low levels of admixture, or in intermediate position between the *C. aconitiflorus* and *C. barbarae* main clades. In the phylogenetic tree reconstruction, *Corybas dowlingii* clustered most closely to samples of *C. aconitiflorus* and *C. barbarae* for which genetic signatures of hybridisation were detected in the NeigborNet and Structure analysis. The NeighborNet and Structure analyses revealed conflicting phylogenetic signal and genetic admixture in several samples, providing evidence for occasional hybridisation and introgression between *C. aconitiflorus* and *C. barbarae*. In the NeighborNet analysis (Fig. 3), the majority of *C. aconitiflorus* and *C. barbarae* samples formed a cluster each, while all *C. dowlingii* samples were found in intermediate position, together with several *C. aconitiflorus* and *C. barbarae* samples. Further, the NeighborNet analyses indicated conflicting genetic signal for the latter *C. aconitiflorus*, *C. barbarae* and *C. dowlingii* samples, which is consistent with patterns expected in the presence of hybridisation and introgression. The Structure analysis revealed considerable genetic structure within the species complex with

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seven genetic groups, and detected genetic admixture in several *C. aconitiflorus*, *C. barbarae* and *C. dowlingii* samples (Fig. 4). Within *C. aconitiflorus*, the highest degrees of genetic admixture were found in areas where the distributional range overlaps with *C. barbarae*, whereas *C. aconitiflorus* populations from areas where *C. barbarae* was absent (i.e. in Ulverstone in Tasmania and five locations in Victoria) showed no or low levels of genetic admixture. Thus, the results of this study indicate occasional hybridisation and introgression between *C. barbarae* and *C. aconitiflorus,* and provide genetic evidence that *C. dowlingii* is of hybrid origin. However, the genetic results also showed that samples of *C. aconitiflorus* and *C. barbarae*, respectively, are genetically more similar than to the other species, with the exception of samples which exhibited genetic signatures of hybridisation. Notably, *C. aconitiflorus* and *C. barbarae* samples which did not show signatures of admixtures genetically distinct from the other species in all analyses. Furthermore, genetically pure samples from different populations of the same species consistently clustered more closely together than those from co-occurring populations of the other species. This indicates that the two species, *C. aconitflorus* and *C. barbarae* maintain genetic coherence despite occasional hybridisation in areas where they co-occur.

The detected signatures of hybridisation and introgression are also in line with the presence of intermediate morphological character states in this species complex, in particular in floral traits such as flower colour and size. The intermediate position of *C. dowlingii* in the NeighborNet graph as well as the clustering of *C. dowlingii* samples with *C. barbarae* samples in the Structure analysis and the signature of genetic admixture found in several *C. aconitiflorus, C. dowlingii* and *C. barbarae* samples in the Structure analysis, point to a hybrid origin of *C. dowlingii*. Notably, the study also uncovered signatures of hybridisation and introgression in individuals that did not exhibit the *C. dowlingii* morphotype and which were morphologically assigned to either *C. aconitiflorus* or *C. barbarae.* These results highlight existing challenges in interpreting morphological variation in the complex and thus in identifying hybrids and introgressed individuals based on morphological traits alone.

Based on the results of this genomic study, we propose to change the taxonomic status of *C. dowlingii* in accordance with Article 50 of the International Code of Nomenclature for algae, fungi, and plants (Turland et al. 2018) to reflect its hybrid origin, as follows:

Corybas × *dowlingii* D.L.Jones, The Orchadian 14(9): 419-420, f.1 (2004) (pro sp.).

Assessment of conservation status of *C.* × *dowlingii*

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Based on the molecular results of this study, which indicate that *C.* × *dowlingii* is of hybrid origin, the question arises whether and to what extent the taxon may merit conservation. A recent review of conservation legislation found that legal definitions of species are quite flexible and can accommodate a range of infra-specific taxa and divergent populations (Coates et al. 2018). While traditionally the protection of pure, genetically distinct species that do not interbreed successfully have been favoured in conservation science and policy (Agapow et al. 2004), it is increasingly recognised that biological diversity generated by hybridisation can also hold conservation value (Allendorf et al. 2001; Agapow et al. 2004). While the evolutionary importance of hybridisation in the diversification of plants has long been recognised, recent genomic studies highlighted the prevalence of hybridisation in the natural world (Taylor and Larson 2019). Further, the detection of ancient hybridisation in genomic studies, which indicate that hybridisation occurred in many taxa at some point in the past, has led to a greater appreciation of the evolutionary importance of hybridisation and introgression and improves our understanding of potential long-term consequences of hybridisation (Taylor and Larson 2019). Hybridisation can lead to greater fitness compared to parental species, i.e. heterosis (hybrid vigour), and is seen as important evolutionary processes that promotes adaptation and speciation. Hybrids can exhibit novel adaptive traits that allow for increased ecosystem resilience to environmental stressors and can allow for the successful colonisation of novel habitats (Stebbins 1959). However, hybrids can also have negative impacts on biodiversity, in particular in cases where hybrids pose risks to the survival of their parental species or to other native vegetation (Rhymer and Simberloff 1996). Based on a review of species hybrids and their conservation or management, Jackiw et al. (Jackiw et al. 2015) strongly advocate for a case by case approach in assessing the conservation value of hybrids.

In the following, we will apply the framework to guide the conservation of species hybrids based on ethical and ecological considerations developed by Jackiw et al. (Jackiw et al. 2015) to assess the conservation value of *C.* × *dowlingii*. A key ecological consideration is whether the hybrid is likely to pose a risk to the survival of the parental species, for example through decreasing the genetic variability in parental species or by causing extinction through genetic assimilation as long-term consequences of recurrent hybridisation and introgression (Rhymer and Simberloff 1996). This is of particular importance in cases where parental species are already threatened by other factors. *Corybas* × *dowlingii* has only a narrow distribution whereas both parental species are common and occur over a large distributional range with both sympatric and allopatric distributions. From this perspective, the hybrid species *C.* ×

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dowlingii as well as hybrids that occasionally form between the two parental species and which do not exhibit the *C. dowlingii* morphotype, are unlikely to negatively affect the long-term evolutionary persistence of the parental species.

Another consideration concerns species fitness as hybrid species exhibiting a higher fitness than the parental species may have detrimental effects either for the parental species or to other native species, as has been documented for example in invasive weeds (Stebbins 1959; Rhymer and Simberloff 1996). *Corybas* × *dowlingii* is only known from a few populations extending ca. 100 km from Bulahdelah to Freemans Waterhole in New South Wales, overlapping with the geographic distribution of the two parental species and occurring in the same habitat. Based on our ecological observations in the field, there is no indication of increased fitness of *C.* × *dowlingii* compared to its parental species. From this perspective, the hybrid species is also unlikely to negatively affect the survival of the parental species or other native vegetation.

An important consideration from an evolutionary perspective is that hybrids are often regarded as beneficial. They hold the potential to act as catalysts for speciation or more generally as pathway for evolution, for example in cases where hybrids exhibit novel properties such as in floral scent (Stökl et al. 2008; Vereecken et al. 2010), habitat requirements (Jacquemyn et al. 2012) or genome duplication and rearrangements (de Storme and Mason 2014). These novel traits might lead subsequently to the formation of a new species. Therefore, the maintenance of evolutionary processes becomes a key ethical consideration in the conservation of species hybrids (Jackiw et al. 2015). Given that *C.* × *dowlingii* is unlikely to pose a threat to the long-term survival of its parental species nor other native species, in the following we will examine possible beneficial aspects that may warrant the conservation of *C.* × *dowlingii,* such as the potential of the hybrid species to act as pathway for evolution.

In the New Caledonian hybrid species *Corybas* × *halleanus* E.Faria, a greater tolerance to lower humidity was observed for the hybrid species compared to its more moisture dependent parental species (Faria 2016). The hybrid species thus exhibits increased resilience to environmental stressors, which enables the hybrid to colonise novel habitat, thus rendering the conservation of this hybrid species beneficial. In contrast, *C.* × *dowlingii* is found in the same habitat as its parental species and growing sympatrically with *C. barbarae* (Jones 2004), thus not exhibiting novel habitat requirements.

In terms of pollination biology, observations on pollinators in the *C. aconitiflorus* complex are still scarce. While the pollination strategy of the genus has been regarded as food or brood

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deceptive based on observations from other *Corybas* species (Pridgeon et al. 2001), recent observations in *C. aconitiflorus* indicate that the species is food-rewarding (Kuiter and Findlater-Smith 2017). Fungus gnats of the genus *Phthinia* Winnertz 1863 (Mycetophilidae) were observed to visit the flowers to forage on the column mound which has been reported to exude nectar and females where found leaving the flowers with pollinia attached to their thorax (Kuiter and Findlater-Smith 2017). The repeated and directed visiting behaviour of the fungus gnats was regarded as indication that the fungus gnats are attracted through floral scent. Further, the plant-pollinator relationship was found to be specific in the *Corybas* populations in Victoria, where only one *Phthinia* species was observed to visit the flowers (Kuiter and Findlater-Smith 2017). However, the detection of genetically admixed individuals in our molecular study implies that the plant-pollinator relationship between *C. aconitiflorus* and *C. barbarae* is less specific and allows for occasional cross-pollination.

Orchid hybrids hold the potential to develop novel floral traits, which can result in reproductive isolation between the hybrid and parental species. This is of particular importance in orchids as the plant-pollinator interaction is often highly specific (Nilsson 1992). For example, the hybrid between two European *Ophrys* species was found to exhibit a novel floral scent which resulted in a pollinator shift (Vereecken et al. 2010). In the sun orchids (*Thelymitra*), hybrids are often found which have shifted their pollination system from outcrossing to obligatorily selfing (Jeanes 2004, 2009, 2013), which likewise presents an immediate reproductive isolation mechanism. Hence, pollination studies in *C.* × *dowlingii* are desirable to assess if the hybrid exhibits novel floral traits leading to reproductive isolation from its parental species. Likewise, changes in ploidy levels in association with hybridisation (allopolyploidisation) can also lead to immediate reproductive isolation between the hybrid and its parental species. Allopolyploid hybrid species tend to derive from parents that are evolutionarily more divergent than parents of homoploid hybrid species (Chapman and Burke 2007; Paun et al. 2009). In *Corybas*, cytogenetic studies found evidence for polyploidisation in the genus, e.g. in *C. cheesmanii* (Hook.f.) Kuntze with 2=54+2, pointing to a triploid or hexaploid origin (Dawson et al. 2007), however no chromosome counts are available for the *C.* × *dowlingii* nor its parental species. To assess possible reproductive isolation of *C.* × *dowlingii* from its parental species based on genome duplication or re-arrangements, cytogenetic studies in the *C. aconitiflorus* complex are required. However, given that hybridsation between closely related species is more likely to give rise to homoploid hybrids (Chapman and Burke 2007; Paun et al. 2009), we consider the establishment of reproductive

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isolation of *C.* × *dowlingii* from its parental species through genome duplication or re-arrangements as unlikely.

Our overall assessment of key ecological and societal considerations indicated a low conservation concern for *C.* × *dowlingii* and highlighted areas for further studies to assess the degree of reproductive isolation of *C.* × *dowlingii* from its parental species to increase our understanding of the potential evolutionary fate of this species. In an environment of limited financial resources, it is of key importance to consider whether it is ethical to direct conservation funds and effort to hybrid species. In the case of *C.* × *dowlingii*, our overall assessment under the current available evidence points toward a low priority for conservation of the hybrid species, in particular considering that the two parental species are common and tend to hybridise occasionally. Hence, the maintenance of evolutionary processes that may result in the emergence of novel traits driving further diversification appears warranted in this species complex without particular conservation emphasis on the hybrid species *C.* × *dowlingii*. Based on the results of this study, we regard the conservation status of *C.* × *dowlingii* of 'least concern' and recommend changing its current conservation status in the threatened species legislations of New South Wales and Australia accordingly.

Conclusions

This conservation genomic study clarified taxonomic delimitation in the *C. aconitiflorus* complex and provided molecular evidence for occasional hybridisation and introgression between *C. aconitiflorus* and *C. barbarae*. *Corybas dowlingii* was found to be of hybrid origin and its taxonomic status was changed to *C.* × *dowlingii* to reflect this. Based on our assessment of the conservation status of *C.* × *dowlingii* considering key ecological and ethical aspects, we conclude that the conservation status of *C.* × *dowlingii* is of least concern and recommend this to be reflected in the Australian legislation at state and federal level.

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Figure and Table captions

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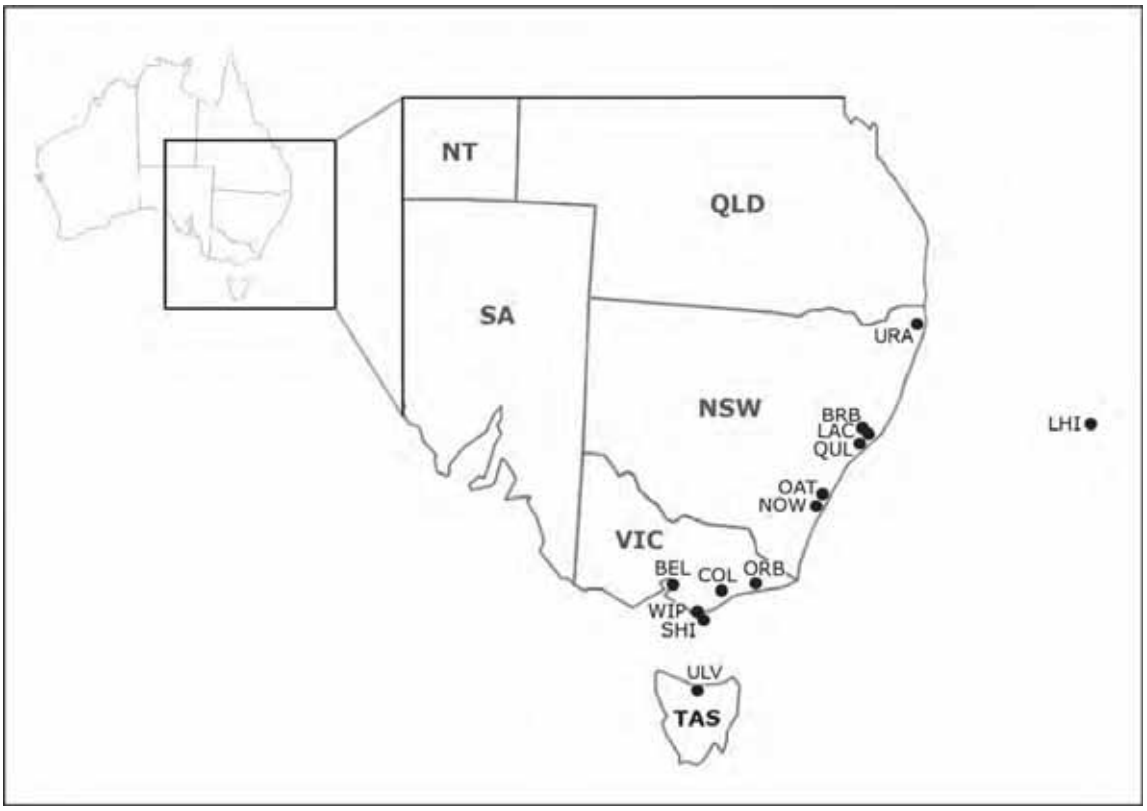

Fig. 1 Sampling locations for study of genomic diversity of the *C. aconitiflorus* complex in southeastern Australia. Australian state abbreviations in bold. BEL: Belgrave South; BRB: Broken Bago; COL: Colquhoun; LAC: Lake Cathie; LHI: Lord Howe Island; NOW: Nowra; OAT: Oatly Park; ORB: Orbost; QUL: Queens Lake; SHI: Shallow Inlet; URA: Uralba Nature Reserve; ULV: Ulverstone; WIP: Wilson Promontory

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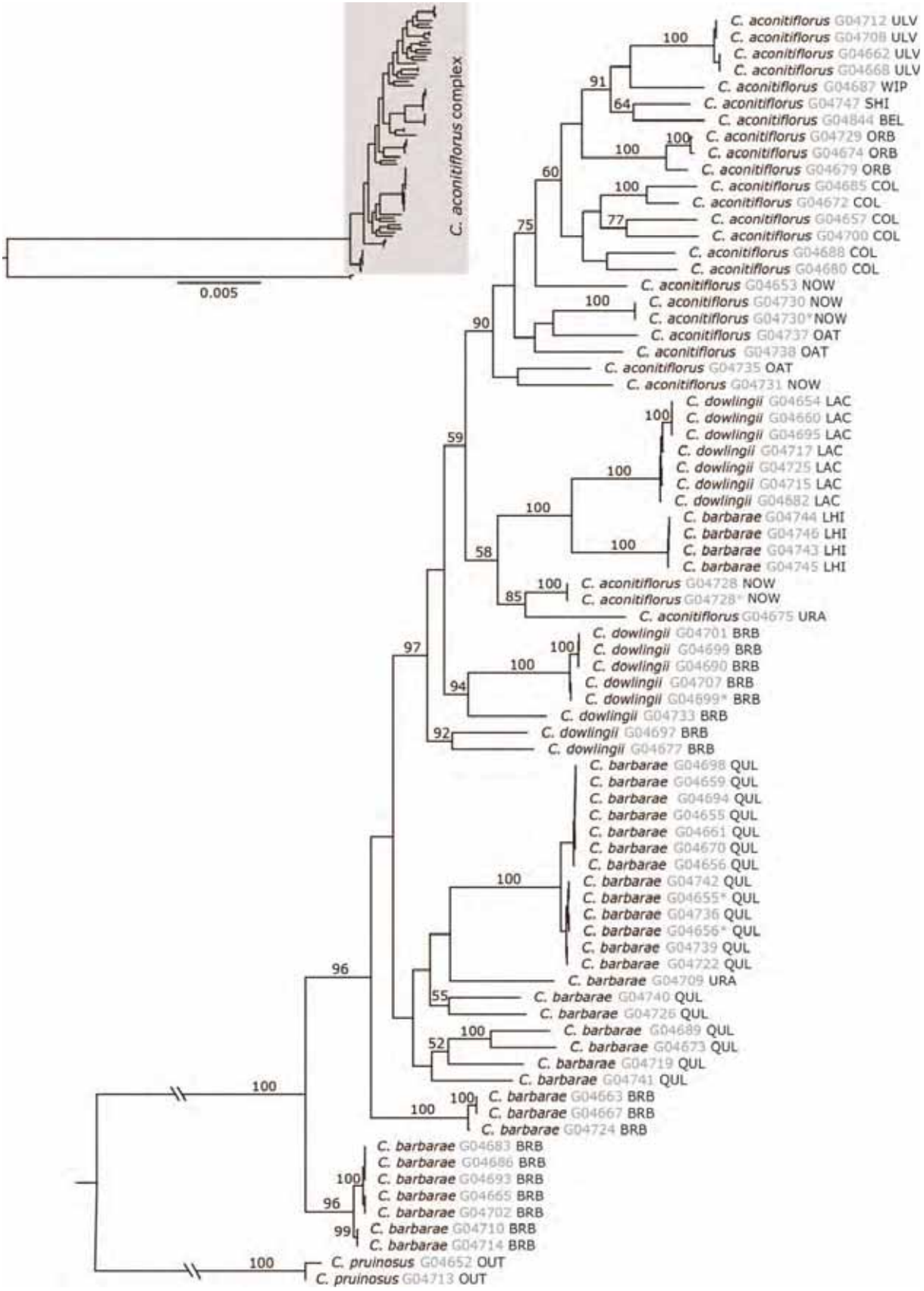

Fig. 2 Maximum likelihood phylogeny of the *Corybas aconitiflorus* complex based on 12,420 ddRAD loci (m20 dataset including outgroup). BEL: Belgrave South; BRB: Broken Bago;

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COL: Colquhoun; LAC: Lake Cathie; LHI: Lord Howe Island; NOW: Nowra; OAT: Oatly Park; ORB: Orbost; QUL: Queens Lake; SHI: Shallow Inlet; URA: Uralba Nature Reserve; ULV: Ulverstone; WIP: Wilson Promontory. Bootstrap support values above 50 are given above branches. Duplicate samples are marked with an asterisk

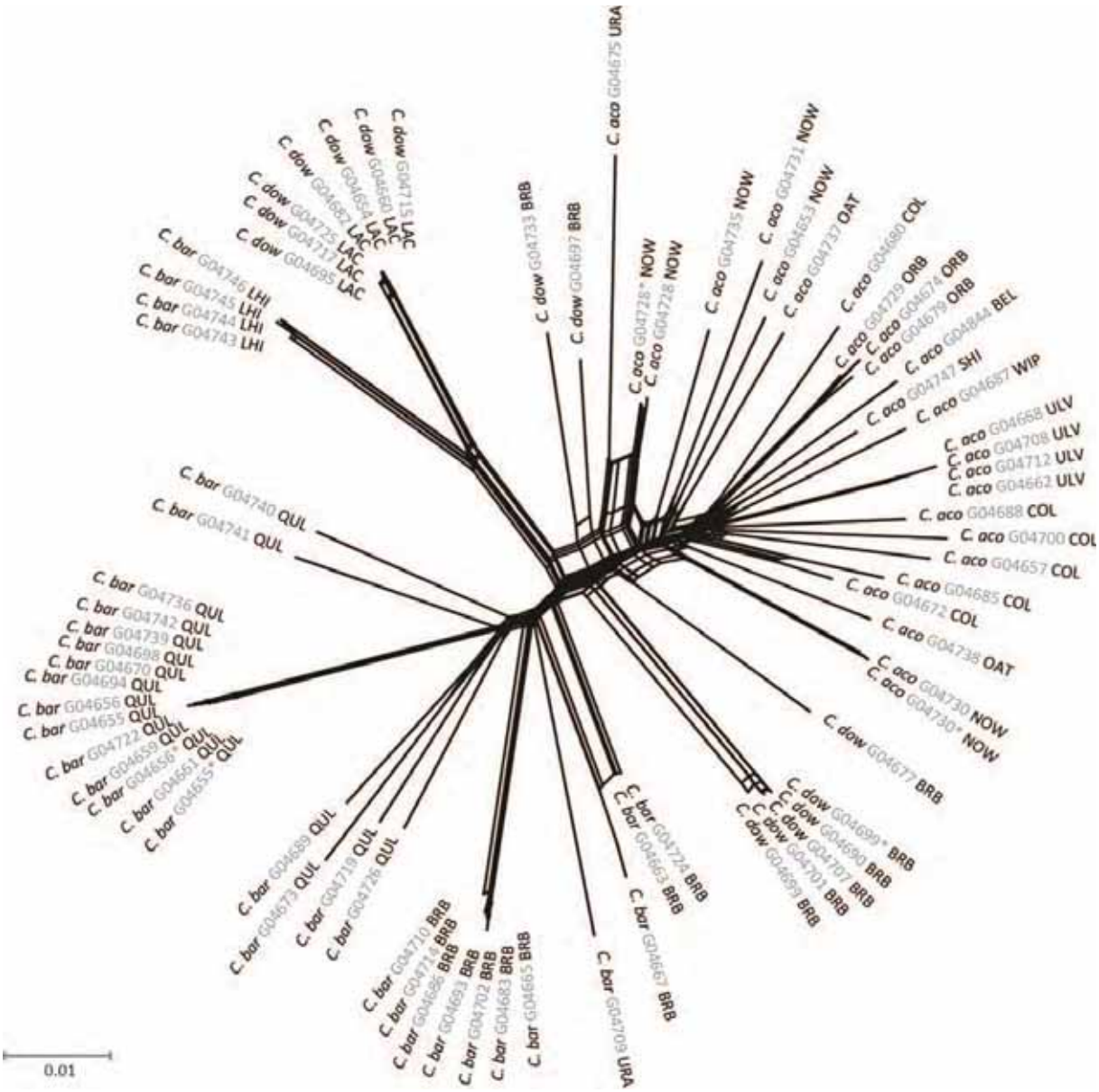

Fig. 3 NeighborNet network for *Corybas aconitiflorus* complex based on 4,293 unlinked SNPs (m20 dataset excluding outgroup). C. aco: *Corybas aconitiflorus*; C. bar: *Corybas barbarae*; C. dow: *Corybas dowlingii*. BEL: Belgrave South; BRB: Broken Bago; COL: Colquhoun; LAC: Lake Cathie; LHI: Lord Howe Island; NOW: Nowra; OAT: Oatly Park; ORB: Orbost; QUL: Queens Lake; SHI: Shallow Inlet; URA: Uralba Nature Reserve; ULV: Ulverstone; WIP: Wilson Promontory. Duplicate samples are marked with an asterisk

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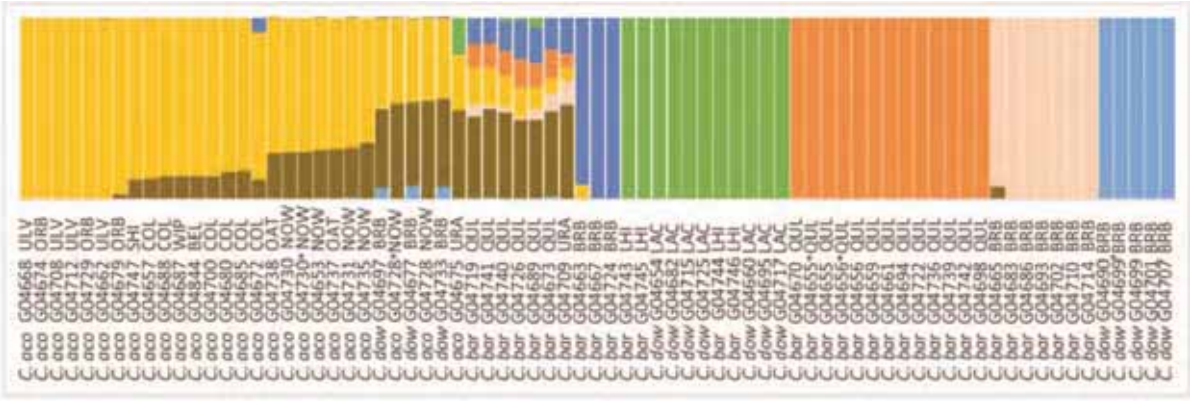

Fig. 4 Genetic structure of *Corybas aconitiflorus* complex based on Structure analysis of 13,708 unlinked SNPs (m70 dataset excluding outgroup) for the optimal K value of seven genetic clusters. C. aco: *Corybas aconitiflorus*; C. bar: *Corybas barbarae*; C. dow: *Corybas dowlingii*. BEL: Belgrave South; BRB: Broken Bago; COL: Colquhoun; LAC: Lake Cathie; LHI: Lord Howe Island; NOW: Nowra; OAT: Oatly Park; ORB: Orbost; QUL: Queens Lake; SHI: Shallow Inlet; URA: Uralba Nature Reserve; ULV: Ulverstone; WIP: Wilson Promontory. Duplicate samples are marked with an asterisk

Tables and table captions

Tab. 1 Material studied. AU: Australia; CNS: Australian Tropical Herbarium; ORG: Orchid Research Group, Centre for Australian Plant Biodiversity Research, Canberra; 1 sample used for ddRADseq establishment phase; duplicate samples are marked with an asterisk

Corybas species	Collection number	DNA number	Provenance	Provenance code
C. aconitiflorus Salisb.	ORG 7362	CNS_G04675	AU: New South Wales, North Coast; property of C & P Charlie, adjoining Uralba Nature Reserve	URA
C. aconitiflorus Salisb.	ORG 7364	CNS_G04732[1]	AU: New South Wales, Central Coast; Bugong near Nowra	NOW
C. aconitiflorus Salisb.	ORG 7365	CNS_G04735	AU: New South Wales, South Coast; Falls Creek near Nowra	NOW
C. aconitiflorus Salisb.	ORG 7366	CNS_G04728 CNS_G04728*	AU: New South Wales, South Coast; Turpentine Rd, near Nowra	NOW
C. aconitiflorus Salisb.	ORG 7367	CNS_G04730 CNS_G04730*	AU: New South Wales, South Coast; Wool Rd near Nowra	NOW
C. aconitiflorus Salisb.	ORG 7368	CNS_G04731	AU: New South Wales, South Coast; Myola near Nowra	NOW

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C. aconitiflorus Salisb.	ORG 7369	CNS_G04653	AU: New South Wales, South Coast; Coonemia Creek, near Nowra	NOW
C. aconitiflorus Salisb.	ORG 7361A	CNS_G04668	AU: Tasmania, North West; Stubbs Rd, near Ulverstone	ULV
C. aconitiflorus Salisb.	ORG 7361B	CNS_G04662	AU: Tasmania, North West; Stubbs Rd, near Ulverstone	ULV
C. aconitiflorus Salisb.	ORG 7361C	CNS_G04712	AU: Tasmania, North West; Stubbs Rd, near Ulverstone	ULV
C. aconitiflorus Salisb.	ORG 7361D	CNS_G04708	AU: Tasmania; North West; Stubbs Rd, near Ulverstone	ULV
C. aconitiflorus Salisb.	ORG 7373B	CNS_G04687	AU: Victoria, Gippsland; Wilson Promontory, Five Mile Rd	WIP
C. aconitiflorus Salisb.	Turner 2063A	CNS_G04680	AU: Victoria, Gippsland; Oil Bore Road in Colquhoun Forest Regional Park, 9.5 km NW of Lakes Entrance	COL
C. aconitiflorus Salisb.	Turner 2063B	CNS_G04657	AU: Victoria, Gippsland; Oil Bore Road in Colquhoun Forest Regional Park, 9.5 km NW of Lakes Entrance	COL
C. aconitiflorus Salisb.	Turner 2063C	CNS_G04700	AU: Victoria, Gippsland; Oil Bore Road in Colquhoun Forest Regional Park, 9.5 km NW of Lakes Entrance	COL
C. aconitiflorus Salisb.	Turner 2064A	CNS_G04672	AU: Victoria, Gippsland; Beside Bruces Road (Bruce Track) in the Colquhoun Regional Park, 9.5 km NW of Lakes Entrance	COL
C. aconitiflorus Salisb.	Turner 2064B	CNS_G04688	AU: Victoria, Gippsland; Beside Bruces Road (Bruce Track) in the Colquhoun Regional Park, 9.5 km NW of Lakes Entrance	COL
C. aconitiflorus Salisb.	Turner 2064C	CNS_G04685	AU: Victoria, Gippsland; Beside Bruces Road (Bruce Track) in the Colquhoun Regional Park, 9.5 km NW of Lakes Entrance	COL
C. aconitiflorus Salisb.	Turner 2065A	CNS_G04729	AU: Victoria, Gippsland; Near Circle Break Track 14.5 km W of Orbost (S of Princes Highway)	ORB
C. aconitiflorus Salisb.	Turner 2065B	CNS_G04679	AU: Victoria, Gippsland; Near Circle Break Track 14.5 km W of Orbost (S of Princes Highway)	ORB
C. aconitiflorus Salisb.	Turner 2065C	CNS_G04674	AU: Victoria, Gippsland; Near Circle Break Track 14.5 km W of Orbost (S of Princes Highway)	ORB
C. aconitiflorus Salisb.	ORG 7374A	CNS_G04738	AU: New South Wales, Central Coast; Oatley Park, George River	OAT
C. aconitiflorus Salisb.	ORG 7374B	CNS_G04737	AU: New South Wales, Central Coast; Oatley Park, George River	OAT
C. aconitiflorus Salisb.	ORG 7381	CNS_G04747	AU: Victoria, Gippsland; Shallow Inlet	SHI
C. aconitiflorus Salisb.	ORG 7376A	CNS_G04844	AU: Victoria, Gippsland; Belgrave South	BEL
C. barbarae D.L.Jones	ORG 7357D	CNS_G04655 CNS_G04655*	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL

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C. barbarae D.L.Jones	ORG 7357F	CNS_G04736	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357G	CNS_G04670	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357G	CNS_G04694	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357H	CNS_G04661	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357I	CNS_G04698	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357J	CNS_G04722	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357K	CNS_G04656 CNS_G04656*	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357L	CNS_G04740	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357M	CNS_G04671ı	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357N	CNS_G04689	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C.barbarae D.L.Jones	ORG 7357o	CNS_G04673	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C.s barbarae D.L.Jones	ORG 7357P	CNS_G04659	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357R	CNS_G04739	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357T	CNS_G04741	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357U	CNS_G04719	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7357V	CNS_G04726	AU: New South Wales, North Coast; Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	ORG 7359A	CNS_G04667	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. barbarae D.L.Jones	ORG 7359B	CNS_G04724	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. barbarae D.L.Jones	ORG 7359C	CNS_G04714	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. barbarae D.L.Jones	ORG 7359D	CNS_G04683	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB

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C. barbarae D.L.Jones	ORG 7359E	CNS_G04686	AU: New South Wales, Central Western Slopes; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. barbarae D.L.Jones	ORG 7359F	CNS_G04665	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. barbarae D.L.Jones	ORG 7359G	CNS_G04702	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. barbarae D.L.Jones	ORG 7359H	CNS_G04693	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. barbarae D.L.Jones	ORG 7359I	CNS_G04663	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. barbarae D.L.Jones	ORG 7359J	CNS_G04710	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. barbarae D.L.Jones	ORG 7363A	CNS_G04709	AU: New South Wales, North Coast; property of C & P Charlie, ajoining Uralba Nature Reserve	URA
C. barbarae D.L.Jones	ORG 7357C	CNS_G04742	AU: New South Wales, North Coast; Edge of Queens Lake, Lakewood	QUL
C. barbarae D.L.Jones	Hutton, I. 946A	CNS_G04743	AU: Lord Howe Island: Ridge between Kim's Lookout and Malabar	LHI
C. barbarae D.L.Jones	Hutton, I. 946B	CNS_G04744	AU: Lord Howe Island: Ridge between Kim's Lookout and Malabar	LHI
C. barbarae D.L.Jones	Hutton, I. 946C	CNS_G04745	AU: Lord Howe Island: Ridge between Kim's Lookout and Malabar	LHI
C. barbarae D.L.Jones	Hutton, I. 946D	CNS_G04746	AU: Lord Howe Island: Ridge between Kim's Lookout and Malabar	LHI
C. dowlingii D.L.Jones	ORG 7358A	CNS_G04699 CNS_G04699*	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Crk & Wauchope	BRB
C. dowlingii D.L.Jones	ORG 7358B	CNS_G04701	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. dowlingii D.L.Jones	ORG 7358C	CNS_G04707	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. dowlingii D.L.Jones	ORG 7358D	CNS_G04727	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. dowlingii D.L.Jones	ORG 7358E	CNS_G04697	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB

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C. dowlingii D.L.Jones	ORG 7358F	CNS_G04733	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. dowlingii D.L.Jones	ORG 7358G	CNS_G04677	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C.dowlingii D.L.Jones	ORG 7358H	CNS_G04690	AU: New South Wales, North Coast; Broken Bago State Forest, between Herons Creek & Wauchope	BRB
C. dowlingii D.L.Jones	ORG 7370A	CNS_G04725	AU: New South Wales, North Coast; Lake Cathie, Lake Innes Nature Reserve, Corduroy fire trail	LAC
C. dowlingii D.L.Jones	ORG 7370B	CNS_G04660	AU: New South Wales, North Coast; Lake Cathie, Lake Innes Nature Reserve, Corduroy fire trail	LAC
C. dowlingii D.L.Jones	ORG 7370C	CNS_G04654	AU: New South Wales, North Coast; Lake Cathie, Lake Innes Nature Reserve, Corduroy fire trail	LAC
C. dowlingii D.L.Jones	ORG 7370D	CNS_G04717	AU: New South Wales, North Coast; Lake Cathie, Lake Innes Nature Reserve, Corduroy fire trail	LAC
C. dowlingii D.L.Jones	ORG 7370E	CNS_G04682	AU: New South Wales, North Coast; Lake Cathie, Lake Innes Nature Reserve, Corduroy fire trail	LAC
C. dowlingii D.L.Jones	ORG 7370F	CNS_G04695	AU: New South Wales, North Coast; Lake Cathie, Lake Innes Nature Reserve, Corduroy fire trail	LAC
C. dowlingii D.L.Jones	ORG 7370G	CNS_G04715	AU: New South Wales, North Coast; Lake Cathie, Lake Innes Nature Reserve, Corduroy fire trail	LAC
C. pruinosus (R.Cunn.) Rchb.f.	ORG 7374H	CNS_G04713	AU: New South Wales, Central Coast; Oatley Park, George River	OAT
C. pruinosus (R.Cunn.) Rchb.f.	ORG 7374M	CNS_G04652	AU: New South Wales, Central Coast; Oatley Park, George River	OAT

Tab. 2. Statistics for the ddRAD dataset for the *C. aconitiflorus* complex a) including the outgroup (*C. pruinosus*, 2 samples) and b) excluding the outgroup resulting from the different filtering thresholds in the ipyrad pipeline for loci shared by minimum number of samples. pis: parsimony informative characters, bp: base pairs, m: minimum number of samples

a) *C. aconitiflorus* complex including outgroup (*C. pruinosus*)
Average # filtered reads: 2.98 Mio (+/- 1.01) per sample

Filtering threshold	m20	m70
#RAD loci	12,420	3,597

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#variable sites	54,177	17,378
#pis	36,486	12,302
#aligned bp	1,682,315	487,474
missing data*	37.66%	4.55%

***Proportion of gaps and undetermined bases in DNA sequence alignment**

b) *C. aconitiflorus* complex (ingroup)
Average # filtered reads: 3,01 Mio (+/-1,01)

Filtering threshold	m20	m70
#RAD loci	14,915	4,293
#variable sites	60,489	18,828
#pis	39,470	12,252
#unlinked SNPs	13,708	4,066
#aligned bp	1,967,151	581,128
missing data*	36.79%	2.30%

***Proportion of gaps and undetermined bases in DNA sequence alignment**

Online Resources

Online Resource 1. Maximum likelihood phylogeny of the *Corybas aconitiflorus* complex based on 3,597 ddRAD loci (m70 dataset including outgroup).

Online Resource 2. NeighborNet network for *Corybas aconitiflorus* complex based on 4,066 unlinked SNPs (m70 dataset excluding outgroup).

Online Resource 3. Genetic structure of *Corybas aconitiflorus* complex based on Structure analysis of 13,708 unlinked SNPs (m20 dataset excluding outgroup) for the optimal K value of seven genetic clusters.

Appendix L

Dr Frank Lemckert (2020)

Level 3
101 Sussex Street
Sydney NSW 2000
t: (02) 9259 3800

28/2/2020

Our ref: King Hill

RPS Australia

Unit 2A, 45 Fitzroy Street
Carrington NSW 2294, Australia

Attention: Mark Aitkens

Dear Mark,

Review of Management Actions for the Koala at the King Hill site

Below I provide my view on the proposed mitigation measures for Koalas at Kings Hill and its impact more generally on biodiversity values, as described in the proposed Biodiversity Management Plan and Section 7 of the Species Impact Statement, which specifically looks to improve the quality of habitat by increasing the number preferred feed trees for the Koala in the conservation area. In forming a view I have reviewed the works performed by Marsh and Youngentob (2019) and the species that may be affected by these works. I am also calling on my historic experience with forest management through my nearly 20 years of being a forest ecology researcher with the NSW Department of Primary Industries combined with additional working knowledge of fauna management obtained in the role of a senior consultant. This includes works on plantations and in consideration of the value and impacts of thinning and studies on Koala management.

The proposed enrichment works

The approach proposed is relatively novel and very interesting and is simply an extension of the principles of the Biodiversity Assessment Method (BAM). BAM requires the improvement of habitat values in offset sites to produce an overall gain for an ecosystem and so offset its loss as a result of a development. This normally takes the form of actions that reduce more obvious human mediated impacts such as the removal or reduction of feral animals, control of weeds, fencing of stock and erosion mitigation and correction. The works proposed for Kings Hill aim to improve natural aspects of the environment by increasing the number of preferred food trees for the Koala through either natural regeneration, seeding or the planting of tube-stock. Ultimately the aim remains to “improve” the habitat from its current form and so increase the numbers and health of Koalas on the site. So this would be a very logical use of the offset principles followed under BAM.

The science behind the idea of increasing habitat quality through selected growth of trees is well established in that the distribution and breeding success of Koalas is well known to be correlated with foliar nutrient levels. The works by researches such as Andrew Krockenberger and Steve Cork referred to in the Marsh and Youngentob (2019) report record the energy requirements of Koalas in different environments and demonstrate how Koalas actively seek out and forage in select trees within a location that provide the best nutrient outcome, ignoring even adjacent trees of the same species. This results in the typical distribution of Koala populations where populations of breeding Koalas are restricted to specific locations where foliar nutrient content is highest or where toxins are low enough to make their consumption acceptable for the nutrition that they will gain. The quality of the available food is based on the species of trees present, which is why Schedule 2 of State Environmental Planning Policy No 44—Koala Habitat Protection provides an indicative list of locally preferred feed trees for Koalas in different management area. Therefore, if the composition of feed trees at a site has direct bearing on the extent that Koalas are able to use a location it follows that the habitat values of a site will improve for Koalas if more preferred feed trees become available.

Impacts to other aspects of the community

One significant concern raised is the impact of the change in tree composition resulting from the selective promotion of tree species within an area of forest. I do not see that as being a problem as long as the overall composition of trees are maintained within what are recognised as natural levels for the type of forests present (typical benchmark species compositions). The actual distribution of trees within a forest at a local scale is very random and is mainly the result of local disturbances, chance and historic tree composition. This is evident when looking at patches of forest where the trees change in composition over 50-100 m even though there is no obvious difference in the overall environment. Furthermore, patches of forest can be dominated by one species but can be replaced a short distance later by a different species. This is typically a result of local "founder" effects where seeding trees or seed stores for one species are favoured by the type and timing of a disturbance that impacts the forest and allows an area of new growth to occur. This leads to a local dominance that will remain until such time as a further disturbance occurs and allows different species to become more established.

In this instance a very likely impact on tree composition has been historic logging. This results in the removal of the best quality timber trees to leave behind less valuable tree types. Less valuable tree types can also be removed to preferentially allow better quality timber trees to grow through leaving an "artificial" tree composition at a site. The noted lack of Tallowwood present on the site would seem to be highly likely because it has been removed through logging as a high quality timber tree. The same is likely to be true of Grey Gum. So a return of a more typical mix of tree species found in the forest types present on site would be a good ecological outcome and allow a greater diversity of habitat and so niches for species to exploit.

So, if the relative composition of species remains within benchmark levels, and trees of local genetic provenance are used, the presence of trees that provide better nutrient values will be very unlikely to have a negative impact on the local environment as most species would be positively impacted by the presence of more easily obtained nutrients. Common arboreal species such as the Common Ringtail and Common Brushtail Possums eat significant levels of leaf material and can be selective in their foliage browsing (eg. Pahl 1987) and will also benefit from increased foliar nutrient value and reduced toxin levels allowing them to increase growth rates and maintain denser populations. This will be an

advantage to local carnivores that eat arboreal prey including the Powerful Owl and Spotted-tailed Quolls. Furthermore, insect abundance has been found to be positively correlated with leaf nutrient levels (Majer et al. 2006), which will have significant benefits for a large range of species that eat insects including the Squirrel Glider and Bruch-tailed Phascogale and this should equally be valuable to insectivorous bats that concentrate activity where suitable insect prey is more abundant (Adams et al. 2009). So manipulation of the tree composition to increase the overall number of trees with higher nutrient value foliage should have a positive impact on fauna across a range of species.

The prescriptions require that an increase in the number of more nutrient rich species is achieved through regeneration, seeding or direct planting. The rates proposed are only at the lower end of typical planting densities apparently as a means of minimising the extent of disturbance, with more groundwork obviously requiring greater levels of site disturbance. This is not an incorrect approach, but I would recommend considering generating larger numbers of seedlings simply on the basis that it will be more likely to ensure that large enough numbers of higher quality feed trees are grown up to sufficiently improve the habitat for foliage dependent species. More importantly, given that there can clearly be variations in the nutrient value of even adjacent trees (which all looks to be related to genetics), increasing the density of regenerating trees would provide the best chance of growing the most productive individuals in numbers to reach the overall nutrient target levels that will provide a significant improvement in Koala leaf quality (see recommendation on monitoring leaf nutrients).

The growth of any levels of new trees will require thinning operations at some point in time if growth is not only to be maximised, but to actually not be supressed by overcrowding of trees. Such “locked-up” situations can greatly retard growth of younger trees and requires the eventual over-topping by the ultimately dominant trees that leads to natural thinning of the younger trees. In order to avoid any such suppression typically thinning is undertaken within target vegetation where a percentage of the regrowth trees are removed to maintain a high growth rate for the remaining trees. This also provides the opportunity for the removed trees to be used to provide new ground cover elements. I note that ecological thinning is a recognised successful method for improving fauna habitat in the Pilliga Scrub and on the Murray Valley (see Gonsalves et al. 2018). This approach to disturbance is viewed as overwhelmingly positive because it encourages more rapid growth to mature trees and opens up the forest understorey, which provides a much better thermal and foraging environment. Dense tightly locked tree regrowth is generally not considered to be good fauna habitat and is avoided by many species. Thinning of young trees does not remove any critically important habitat elements as there is no removal of significant bark resources nor are there any hollows lost.

If there is concern that thinning might represent a broad disturbance to the environment it is also possible to restrict thinning to only patches of the conservation area. This will provide a mosaic of thinned and “naturally” re-growing areas and could be applied to patches representing 40-60% of the target area. This would not result in the most rapid generation of the targeted preferred tree composition, but it would be accelerated over allowing all of the vegetation to regrow without manipulation. I do not see this as being necessary, but it is an option if there are reservations over having the same impact across the entire conservation area. Regardless of the extent of thinning, because it will result in the removal of only small trees that do not represent important current resources, trees will not be totally removed and the harvesting process does not require the extensive use of heavy machinery, any impacts would be significantly less than typical forest logging.

The only other points I would mention are obvious and already considered in the proposed mitigation. Firstly, new trees should only be generated from local genetic stock to ensure that there is not an impact on the local genetic environment. Secondly, Koalas need not only young trees for their regular needs, but also larger and older trees that provide locations where they can retire too to undertake digestion and are the places that they actually spend the majority of their time. These older and larger trees provide better protection from predators because of their size and height above the ground and their complexity, which provides multiple shelter options. Typically Koalas find a dense shaded point in the tree in which they are very hard to see and most scats are found under these trees even though they are not actually used much as feed trees. They also will form important points for social interactions.

Understanding performance

I have reviewed the proposed research program and this should provide an excellent and well planned opportunity to test the effectiveness of the proposed mitigation works in improving Koala habitat. A properly conducted random and stratified sampling of leaf material will indicate the extent of available nutrient increase and if this falls within the target range to result in the entire conservation area becoming higher quality koala (and other arboreal species) habitat.

Regards,

Frank Lemckert
Principal Scientific Ecologist

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Frank Lemckert **PRINCIPAL SCIENTIFIC ECOLOGIST**

Frank has been a professional scientist since 1992, specialising in understanding and managing the ecology and management of threatened species. Frank has conducted ecological work throughout eastern Australia (NSW, Victoria, Queensland), establishing long-term research and monitoring programs into the management of fauna and developing strategies to mitigate the impacts of human disturbances. He has worked extensively with the NSW state and federal Governments on varying issues of fauna and flora management including the preparation of a draft NSW/National recovery plan for the Giant Burrowing Frog (*Heleioporus australiacus*) and is an accredited expert on the Green and Golden Bell Frog (*Litoria aurea*). Frank has prepared reports on endemism and representation in reserves of flora and fauna for the Commonwealth, represented the NSW Forestry Commission in license negotiations for the Comprehensive Regional Assessment process (2000) and provided expert ecological advice on illegal land clearing for the NSW and Commonwealth Governments. He has authored over 90 peer-reviewed publications. Frank is a research associate with the Australian Museum and University of Newcastle and convenor of the NSW Declining Frog Working Group. He is a recognised expert in frog ecology and management, but has completed management related projects and works on a range of terrestrial vertebrate fauna.

Frank's primary role as a consultant has been to use his expertise and experience in technical writing and threatened species legislation to develop and maintain quality assurance in project reporting including:

- Two Species Impact Statements.
- >100 flora and fauna reports and assessments of significance using the EP&A Act and EPBC Act.
- Biodiversity Assessment Reports for Warragamba Dam Raising, Nowra Bridge, Golden Highway and Eurobodalla Dam.
- Manager for the Oxley Highway to Kempsey and Frederickton to Eungai ecological monitoring program.
- Construction and Environmental Management Plans, Monitoring Plans and Vegetation Management Plans for roads at Port Macquarie, Berry to Bomaderry and South Nowra.
- Nest Box, microbat and Green and Golden Bell Frog management plans for the Berry to Bomaderry and Oxley Highway to Kempsey Highway Upgrades.
- Review of monitoring strategies for the Woolgoolga to Ballina and Warrell Creek to Nambucca Heads programs for the Pacific Highway Upgrade.
- Review of two proposed Coal Seam Gas Impact Assessment methods for Matters of National Environmental Significance (contracted by the Commonwealth Government).
- Provision of species credit species expert reports for the Warragamba Dam raising project and Western Sydney Growth Centres Biocertification.

QUALIFICATIONS

- Bachelor of Science, University of Sydney, 1984 (Terrestrial Ecology and Marine Management)
- Master of Science, University of Sydney, 1991 (Population biology of the Common Froglet)
- PhD, University of Newcastle, 2009 (Management of forest frogs in timber production forests of NSW)

PROJECT EXPERIENCE

Ecological Impact Assessment

- Expert report on the Green and Golden Bell Frog for the Western Sydney Growth Areas BioCertification Project (2018-2019)
- Warragamba Dam Raising Project target surveys, impact assessments, expert reporting (six species) and Q/A for Water NSW (2018-19)
- Shading Impacts for proposed Building Works at Homebush, NSW, Piety PTY LTD (2018)
- Granite Hills Windfarm Bird and Bat Strike Modelling and Ecological Impact Assessment, Nimmitabel, Akuo Energy (2018) and Elysian Windfarm, Nimmitabel, Akuo Energy (2018)
- Vegetation removal and threatened frog management strategies, New Intercity Fleet Management Facility, John Holland Group (2018-19)
- Eurobodalla Dam Biodiversity Assessment Report, Eurobodalla Shire Council (2017-18)
- Nowra Bridge EIS ecological assessments, NSW RMS (2018)
- Heathcote Road Upgrade impact assessment and review of mitigation measures, NSW RMS (2018-2019)
- Mona Vale Road threatened fauna expert survey and impact assessment, Ecosure and NSW RMS (2015-2016)

Government Reviews/Reports

- Biodiversity Assessment Method Frog Survey Guidelines for Species Credit Species (2019)
- Expert review of Biodiversity Impact Assessment Report for the Hornsby Quarry rehabilitation project (2019)
- Review of impact assessment pathways for two LPNG projects, Commonwealth Government (2013)
- Expert advice on impacts of illegal land clearing at Somersby, Commonwealth Government (2015)
- Expert advice on impacts of illegal land clearing at Evans Head, NSW State Government (2016)
- Review of threatened species modelling in forestry areas, Vic Forests (2012)
- Review impacts to threatened reptiles and amphibians in the Southern Brigalow Belt, for WPS (2008)
- Review of monitoring strategies for the Woolgoolga to Ballina and Warrell Creek to Nambucca Heads programs for the Pacific Highway Upgrade, NSW RMS (2014)
- Hornsby Council expert witness for development impacts at Dural, Hornsby Shire Council (2016)
- Expert representing Forests NSW in the Comprehensive Reginal Assessment Program for the Regional Forest Agreement program (1999-2001)
- Review of threatened species modelling in forestry areas, Vic Forests (2012)
- Flora and fauna representation in the Australian Reserve system, Commonwealth Government (2010)
- Flora and fauna endemism patterns across Australia, Commonwealth Government (2009)
- Review impacts to threatened reptiles and amphibians in the Southern Brigalow Belt, for WPS (2008)
- Expert review of fauna and flora impacts for 13 NSW Forestry Commission EIS reports (1992-94).

EPBC Referrals

- Green and Golden Bell Frog (*Litoria aurea*) referrals for the Princes Highway Upgrade at South Nowra, NSW RMS
- Austen Quarry (*Eucalyptus pulverulenta*), Hartley, Hy-Tec Industries (2014-15)
- Marys Mount Koala (*Phascolarctos cinereus*) referral, Gunnedah Quarry Products (2015).

Monitoring Programs

- Oxley Highway to Kempsey threatened biodiversity monitoring, NSW RMS (2013-2017)
- Green and Golden Bell Frog baseline monitoring program at Meroo Lakes, NSW OEH (2016-17)
- FCNSW state-wide ecological monitoring program, Forestry Corporation of NSW (2009-10)
- Threatened fauna monitoring Hume Highway, Kapooka, NSW RMS (2018).

Plans of Management / Strategies

- Commonwealth/NSW Giant Burrowing Frog Recovery Plan, DEWHA/DECC (2012)
- Eastern Bentwing-bat Management Plan, Gerringong, NSW RMS (2014)

- Nestbox, Microbat and Green and Golden Bell Frog Management Plans, Berry to Bomaderry Upgrade of the Princes Highway, NSW RMS (2017)
- Green and Golden Bell Frog surveys and monitoring, Princes Highway Upgrades at South Nowra and Berry to Bomaderry, NSW RMS (2012-2017)
- Green and Golden Bell Frog Management Strategy, Princes Highway Upgrade, NSW RMS (2012-2014)
- Green and Golden Bell Frog pre-clearing works Kooragang Island (Daracon 2016 & current)
- Microbat Management Plan for Clarencetown Bridge, NSW RMS (2016)
- Expert review of Threatened Frog Management Plan - Woolgoolga to Ballina Upgrade, NSW RMS (2014)
- Threatened Microbat Management Plan for Warringah Mall, Northern Beaches Council (2014)
- Threatened Frog modelled habitat requirements, Hornsby Shire Council (2016).

Training

- Lead instructor > 50 wildlife training schools run in NSW, ACT and Victoria providing presentations on the survey, identification and management of all flora and fauna. This included detailed instruction on the management of threatened wading and aquatic birds and other aquatic species presented to Queensland, Victorian, NSW and Commonwealth Government staff (1993-2017)
- Private forestry survey requirements, Victorian Timber (2016).

PUBLICATIONS

Book Chapters

Hecnar S. J., & Lemckert, F.L. 2012. Habitat Protection: Refuges and Reserves. Pp 3636-3675 In Biology of the Amphibia Volume 10 - Conservation and Decline of Amphibians: Ecology, Effects of Humans, and Management. H. Heatwole (Ed.). Surrey-Beattey and Sons, Sydney.

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Frank Lemckert **PRINCIPAL SCIENTIFIC ECOLOGIST**

Frank has been a professional scientist since 1992, specialising in understanding and managing the ecology and management of threatened species. Frank has conducted ecological work throughout eastern Australia (NSW, Victoria, Queensland), establishing long-term research and monitoring programs into the management of fauna and developing strategies to mitigate the impacts of human disturbances. He has worked extensively with the NSW state and federal Governments on varying issues of fauna and flora management including the preparation of a draft NSW/National recovery plan for the Giant Burrowing Frog (*Heleioporus australiacus*) and is an accredited expert on the Green and Golden Bell Frog (*Litoria aurea*). Frank has prepared reports on endemism and representation in reserves of flora and fauna for the Commonwealth, represented the NSW Forestry Commission in license negotiations for the Comprehensive Regional Assessment process (2000) and provided expert ecological advice on illegal land clearing for the NSW and Commonwealth Governments. He has authored over 90 peer-reviewed publications. Frank is a research associate with the Australian Museum and University of Newcastle and convenor of the NSW Declining Frog Working Group. He is a recognised expert in frog ecology and management, but has completed management related projects and works on a range of terrestrial vertebrate fauna.

Frank's primary role as a consultant has been to use his expertise and experience in technical writing and threatened species legislation to develop and maintain quality assurance in project reporting including:

- Two Species Impact Statements.
- >100 flora and fauna reports and assessments of significance using the EP&A Act and EPBC Act.
- Biodiversity Assessment Reports for Warragamba Dam Raising, Nowra Bridge, Golden Highway and Eurobodalla Dam.
- Manager for the Oxley Highway to Kempsey and Frederickton to Eungai ecological monitoring program.
- Construction and Environmental Management Plans, Monitoring Plans and Vegetation Management Plans for roads at Port Macquarie, Berry to Bomaderry and South Nowra.
- Nest Box, microbat and Green and Golden Bell Frog management plans for the Berry to Bomaderry and Oxley Highway to Kempsey Highway Upgrades.
- Review of monitoring strategies for the Woolgoolga to Ballina and Warrell Creek to Nambucca Heads programs for the Pacific Highway Upgrade.
- Review of two proposed Coal Seam Gas Impact Assessment methods for Matters of National Environmental Significance (contracted by the Commonwealth Government).
- Provision of species credit species expert reports for the Warragamba Dam raising project and Western Sydney Growth Centres Biocertification.

QUALIFICATIONS

- Bachelor of Science, University of Sydney, 1984 (Terrestrial Ecology and Marine Management)
- Master of Science, University of Sydney, 1991 (Population biology of the Common Froglet)
- PhD, University of Newcastle, 2009 (Management of forest frogs in timber production forests of NSW)

PROJECT EXPERIENCE

Ecological Impact Assessment

- Expert report on the Green and Golden Bell Frog for the Western Sydney Growth Areas BioCertification Project (2018-2019)
- Warragamba Dam Raising Project target surveys, impact assessments, expert reporting (six species) and Q/A for Water NSW (2018-19)
- Shading Impacts for proposed Building Works at Homebush, NSW, Piety PTY LTD (2018)
- Granite Hills Windfarm Bird and Bat Strike Modelling and Ecological Impact Assessment, Nimmitabel, Akuo Energy (2018) and Elysian Windfarm, Nimmitabel, Akuo Energy (2018)
- Vegetation removal and threatened frog management strategies, New Intercity Fleet Management Facility, John Holland Group (2018-19)
- Eurobodalla Dam Biodiversity Assessment Report, Eurobodalla Shire Council (2017-18)
- Nowra Bridge EIS ecological assessments, NSW RMS (2018)
- Heathcote Road Upgrade impact assessment and review of mitigation measures, NSW RMS (2018-2019)
- Mona Vale Road threatened fauna expert survey and impact assessment, Ecosure and NSW RMS (2015-2016)

Government Reviews/Reports

- Biodiversity Assessment Method Frog Survey Guidelines for Species Credit Species (2019)
- Expert review of Biodiversity Impact Assessment Report for the Hornsby Quarry rehabilitation project (2019)
- Review of impact assessment pathways for two LPNG projects, Commonwealth Government (2013)
- Expert advice on impacts of illegal land clearing at Somersby, Commonwealth Government (2015)
- Expert advice on impacts of illegal land clearing at Evans Head, NSW State Government (2016)
- Review of threatened species modelling in forestry areas, Vic Forests (2012)
- Review impacts to threatened reptiles and amphibians in the Southern Brigalow Belt, for WPS (2008)
- Review of monitoring strategies for the Woolgoolga to Ballina and Warrell Creek to Nambucca Heads programs for the Pacific Highway Upgrade, NSW RMS (2014)
- Hornsby Council expert witness for development impacts at Dural, Hornsby Shire Council (2016)
- Expert representing Forests NSW in the Comprehensive Reginal Assessment Program for the Regional Forest Agreement program (1999-2001)
- Review of threatened species modelling in forestry areas, Vic Forests (2012)
- Flora and fauna representation in the Australian Reserve system, Commonwealth Government (2010)
- Flora and fauna endemism patterns across Australia, Commonwealth Government (2009)
- Review impacts to threatened reptiles and amphibians in the Southern Brigalow Belt, for WPS (2008)
- Expert review of fauna and flora impacts for 13 NSW Forestry Commission EIS reports (1992-94).

EPBC Referrals

- Green and Golden Bell Frog (*Litoria aurea*) referrals for the Princes Highway Upgrade at South Nowra, NSW RMS
- Austen Quarry (*Eucalyptus pulverulenta*), Hartley, Hy-Tec Industries (2014-15)
- Marys Mount Koala (*Phascolarctos cinereus*) referral, Gunnedah Quarry Products (2015).

Monitoring Programs

- Oxley Highway to Kempsey threatened biodiversity monitoring, NSW RMS (2013-2017)
- Green and Golden Bell Frog baseline monitoring program at Meroo Lakes, NSW OEH (2016-17)
- FCNSW state-wide ecological monitoring program, Forestry Corporation of NSW (2009-10)
- Threatened fauna monitoring Hume Highway, Kapooka, NSW RMS (2018).

Plans of Management / Strategies

- Commonwealth/NSW Giant Burrowing Frog Recovery Plan, DEWHA/DECC (2012)
- Eastern Bentwing-bat Management Plan, Gerringong, NSW RMS (2014)

- Nestbox, Microbat and Green and Golden Bell Frog Management Plans, Berry to Bomaderry Upgrade of the Princes Highway, NSW RMS (2017)
- Green and Golden Bell Frog surveys and monitoring, Princes Highway Upgrades at South Nowra and Berry to Bomaderry, NSW RMS (2012-2017)
- Green and Golden Bell Frog Management Strategy, Princes Highway Upgrade, NSW RMS (2012-2014)
- Green and Golden Bell Frog pre-clearing works Kooragang Island (Daracon 2016 & current)
- Microbat Management Plan for Clarencetown Bridge, NSW RMS (2016)
- Expert review of Threatened Frog Management Plan - Woolgoolga to Ballina Upgrade, NSW RMS (2014)
- Threatened Microbat Management Plan for Warringah Mall, Northern Beaches Council (2014)
- Threatened Frog modelled habitat requirements, Hornsby Shire Council (2016).

Training

- Lead instructor > 50 wildlife training schools run in NSW, ACT and Victoria providing presentations on the survey, identification and management of all flora and fauna. This included detailed instruction on the management of threatened wading and aquatic birds and other aquatic species presented to Queensland, Victorian, NSW and Commonwealth Government staff (1993-2017)
- Private forestry survey requirements, Victorian Timber (2016).

PUBLICATIONS

Book Chapters

Hecnar S. J., & Lemckert, F.L. 2012. Habitat Protection: Refuges and Reserves. Pp 3636-3675 In Biology of the Amphibia Volume 10 - Conservation and Decline of Amphibians: Ecology, Effects of Humans, and Management. H. Heatwole (Ed.). Surrey-Beattey and Sons, Sydney.

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Hero, J-M, Richards, S, Alford, R., Allison, A., Bishop, P., Gunther, R., Iskandar, D., Kraus, F., Lemckert, F., Menzies, J., Roberts, D. & Tyler, M. 2008. Amphibians of the Australasian Realm. Pp 65-73 In: Threatened Amphibians of the World. S. N. Stuart, M. Hoffman, J. S., Chanson, N. A. Cox, R. J. Berridge, P. J. Ramani & B. E. Young (Eds.). Lynx Edicions, Barcelona.

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Henle, K., Osborne, W., & Lemckert, F. 2014. The herpetofauna of Kioloa, New South Wales: baseline observational data collected 30 years ago and inspired by R. E. Barwick. Australian Journal of Zoology 62:100–107.

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Daly, G. and Lemckert, F.L. 2012. Herpetofauna of the Tenterfield area. Australian Zoologist.

Lemckert, F.L. 2011. Managing pond breeding anurans in the selectively harvested forests of coastal New South Wales, Australia. Forest Ecology and Management 262:1199–1204.

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Kavanagh, R.P., Law, B., Lemckert, F., Stanton, M., Chidel, M., Towerton, A., 2001. Birds, mammals, reptiles and amphibians in eucalypt plantations near Albury-Wodonga: a pilot study of variables influencing biodiversity. State Forests of New South Wales. Pennant Hills, Sydney.

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Appendix M

Flora List

Family	Scientific Name	Common Name	Exotic	High Threat Weeds	TSC Act	EPBC Act
Acanthaceae	*Brunoniella australis*	Blue Trumpet			-	-
Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower			-	-
Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair			-	-
Adiantaceae	*Adiantum formosum*	Giant Maidenhair			-	-
Adiantaceae	*Adiantum hispidulum*	Rough Maidenhair			-	-
Adiantaceae	*Pellaea paradoxa*				-	-
Anthericaceae	*Arthropodium milleflorum*	Pale Vanilla-lily			-	-
Anthericaceae	*Arthropodium spp.*				-	-
Anthericaceae	*Caesia parviflora var. vittata*				-	-
Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily			-	-
Aphanopetalaceae	*Aphanopetalum resinosum*	Gum Vine			-	-
Apiaceae	*Centella asiatica*	Indian Pennywort			-	-
Apiaceae	*Daucus glochidiatus*	Native Carrot			-	-
Apiaceae	*Hydrocotyle peduncularis*				-	-
Apocynaceae	*Asclepias spp.*		*		-	-
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	*		-	-
Apocynaceae	*Marsdenia australis*	Doubah			-	-
Apocynaceae	*Marsdenia rostrata*	Milk Vine			-	-
Apocynaceae	*Marsdenia viridiflora subsp. viridiflora*	Native Pear			-	-
Apocynaceae	*Parsonsia straminea*	Common Silkpod			-	-
Apocynaceae	*Tylophora barbata*	Bearded Tylophora			-	-
Apocynaceae	*Tylophora paniculata*	Thin-leaved Tylophora			-	-
Araliaceae	*Astrotricha spp.*				-	-
Araliaceae	*Polyscias sambucifolia*	Elderberry Panax			-	-
Asparagaceae	*Asparagus aethiopicus*	Asparagus Fern	*	YES	-	-
Asparagaceae	*Asparagus asparagoides*	Bridal Creeper	*	YES	-	-
Asteliaceae	*Cordyline stricta*	Narrow-leaved Palm Lily			-	-
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	*	YES	-	-
Asteraceae	*Brachyscome microcarpa*				-	-
Asteraceae	*Cirsium vulgare*	Spear Thistle	*		-	-
Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	*		-	-
Asteraceae	*Epaltes australis*	Spreading Nut-heads			-	-
Asteraceae	*Euchiton sphaericus*	Star Cudweed			-	-
Asteraceae	*Hypochaeris microcephala var. albiflora*	White Flatweed	*		-	-
Asteraceae	*Hypochaeris radicata**	Catsear	*		-	-
Asteraceae	*Lagenophora gracilis*	Slender Lagenophora			-	-

Family	Scientific Name	Common Name	Exotic	High Threat Weeds	TSC Act	EPBC Act
Asteraceae	*Lagenophora stipitata*	Common Lagenophora			-	-
Asteraceae	*Onopordum acanthium subsp. acanthium**	Scotch Thistle	*		-	-
Asteraceae	*Pseudognaphalium luteoalbum*	Jersey Cudweed			-	-
Asteraceae	*Senecio madagascariensis*	Fireweed	*	YES	-	-
Asteraceae	*Sigesbeckia orientalis subsp. orientalis*	Indian Weed			-	-
Asteraceae	*Solenogyne bellioides*	Solengyne			-	-
Asteraceae	*Sonchus oleraceus*	Common Sowthistle	*		-	-
Asteraceae	*Sonchus spp.*	Sowthistle			-	-
Asteraceae	*Vernonia cinerea*				-	-
Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine			-	-
Bignoniaceae	*Tecoma stans*	Yellow Bignonia	*	YES	-	-
Blechnaceae	*Blechnum indicum*	Swamp Water Fern			-	-
Blechnaceae	*Doodia aspera*				-	-
Boraginaceae	*Cynoglossum australe*				-	-
Campanulaceae	*Wahlenbergia gracilenta*	Annual Bluebell			-	-
Campanulaceae	*Wahlenbergia gracilis*	Sprawling Bluebell			-	-
Campanulaceae	*Wahlenbergia spp.*	Bluebell			-	-
Campanulaceae	*Wahlenbergia stricta*	Tall Bluebell			-	-
Casuarinaceae	*Allocasuarina torulosa*	Forest Oak			-	-
Celastraceae	*Denhamia silvestris*	Narrow-leaved Orangebark			-	-
Celastraceae	*Maytenus silvestris*	Narrow-leaved Orangebark			-	-
Clusiaceae	*Hypericum gramineum*	Small St John's Wort			-	-
Colchicaceae	*Burchardia umbellata*	Milkmaids			-	-
Colchicaceae	*Wurmbea biglandulosa*				-	-
Colchicaceae	*Wurmbea dioica subsp. Dioica*	Early Nancy			-	-
Commelinaceae	*Commelina cyanea*	Native Wandering Jew			-	-
Commelinaceae	*Murdannia graminea*				-	-
Commelinaceae	*Tradescantia spp.*		*		-	-
Convolvulaceae	*Dichondra repens*	Kidney Weed			-	-
Convolvulaceae	*Polymeria calycina*				-	-
Cyperaceae	*Carex longebrachiata*				-	-
Cyperaceae	*Carex maculata*				-	-
Cyperaceae	*Carex spp.*				-	-
Cyperaceae	*Cyperus brevifolius*		*		-	-
Cyperaceae	*Cyperus flaccidus*	Lax Flat-sedge			-	-
Cyperaceae	*Cyperus gracilis*	Slender Flat-sedge			-	-

Family	Scientific Name	Common Name	Exotic	High Threat Weeds	TSC Act	EPBC Act
Cyperaceae	*Cyperus polystachyos*				-	-
Cyperaceae	*Cyperus spp.*				-	-
Cyperaceae	*Fimbristylis dichotoma*	Common Fringe-sedge			-	-
Cyperaceae	*Fimbristylis spp.*				-	-
Cyperaceae	*Gahnia aspera*	Rough Saw-sedge			-	-
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge			-	-
Cyperaceae	*Scleria mackaviensis*				-	-
Dennstaedtiaceae	*Pteridium esculentum*	Bracken			-	-
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower			-	-
Dilleniaceae	*Hibbertia aspera subsp. aspera*				-	-
Dilleniaceae	*Hibbertia diffusa*	Wedge Guinea Flower			-	-
Dilleniaceae	*Hibbertia obtusifolia*	Hoary Guinea Flower			-	-
Dilleniaceae	*Hibbertia scandens*	Climbing Guinea Flower			-	-
Dilleniaceae	*Hibbertia serpyllifolia*	Hairy Guinea Flower			-	-
Ericaceae	*Acrotriche divaricata*				-	-
Ericaceae	*Leucopogon juniperinus*	Prickly Beard-heath			-	-
Ericaceae	*Leucopogon lanceolatus*				-	-
Euphorbiaceae	*Croton verreauxii*	Green Native Cascarilla			-	-
Fabaceae	*Senna spp.*		*		-	-
Fabaceae	*Astragalus spp.*		*		-	-
Fabaceae	*Bossiaea heterophylla*	Variable Bossiaea			-	-
Fabaceae	*Daviesia ulicifolia*	Gorse Bitter Pea			-	-
Fabaceae	*Desmodium brachypodum*	Large Tick-trefoil			-	-
Fabaceae	*Desmodium rhytidophyllum*				-	-
Fabaceae	*Desmodium varians*	Slender Tick-trefoil			-	-
Fabaceae	*Dillwynia retorta*				-	-
Fabaceae	*Erythrina crista-galli*	Cockspur Coral Tree	*	YES	-	-
Fabaceae	*Glycine clandestina*	Twining glycine			-	-
Fabaceae	*Glycine tabacina*	Variable Glycine			-	-
Fabaceae	*Hardenbergia violacea*	False Sarsaparilla			-	-
Fabaceae	*Indigofera australis*	Australian Indigo			-	-
Fabaceae	*Kennedia prostrata*	Running Postman			-	-
Fabaceae	*Mirbelia rubiifolia*	Heathy Mirbelia			-	-
Mimosoideae	*Acacia brownii*	Heath Wattle			-	-
Mimosoideae	*Acacia falciformis*	Broad-leaved Hickory			-	-
Mimosoideae	*Acacia longifolia*				-	-

Family	Scientific Name	Common Name	Exotic	High Threat Weeds	TSC Act	EPBC Act
Mimosoideae	*Acacia longifolia subsp. longifolia*	Sydney Golden Wattle			-	-
Mimosoideae	*Acacia spp.*	Wattle			-	-
Mimosoideae	*Acacia ulicifolia*	Prickly Moses			-	-
Geraniaceae	*Geranium homeanum*				-	-
Geraniaceae	*Geranium potentilloides*				-	-
Geraniaceae	*Geranium solanderi*	Native Geranium			-	-
Goodeniaceae	*Goodenia bellidifolia*				-	-
Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia			-	-
Goodeniaceae	*Goodenia heterophylla*				-	-
Hypoxidaceae	*Hypoxis hygrometrica*	Golden Weather-grass			-	-
Iridaceae	*Herbertia lahue subsp. caerulea*		*		-	-
Juncaceae	*Juncus cognatus*		*		-	-
Juncaceae	*Juncus usitatus*				-	-
Juncaceae	*Luzula densiflora*	Woodrush			-	-
Lamiaceae	*Clerodendrum tomentosum*	Hairy Clerodendrum			-	-
Lamiaceae	*Plectranthus parviflorus*				-	-
Lamiaceae	*Scutellaria humilis*	Dwarf Skullcap			-	-
Liliaceae	*Lilium formosanum*	Formosan Lily	*		-	-
Lobeliaceae	*Pratia concolor*	Poison Pratia			-	-
Lobeliaceae	*Pratia purpurascens*	Whiteroot			-	-
Loganiaceae	*Mitrasacme spp.*				-	-
Lomandraceae	*Lomandra confertifolia*	Matrush			-	-
Lomandraceae	*Lomandra cylindrica*				-	-
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush			-	-
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush			-	-
Lomandraceae	*Lomandra multiflora*	Many-flowered Mat-rush			-	-
Lomandraceae	*Lomandra obliqua*				-	-
Loranthaceae	*Amyema spp.*	Mistletoe			-	-
Loranthaceae	*Dendrophthoe vitellina*				-	-
Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry			-	-
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily			-	-
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	*		-	-
Maundianceae	*Maundia triglochinoides*				V	-
Menispermaceae	*Stephania japonica var. discolor*	Snake Vine			-	-
Moraceae	*Maclura cochinchinensis*	Cockspur Thorn			-	-
Myoporaceae	*Eremophila debilis*	Amulla			-	-

Family	Scientific Name	Common Name	Exotic	High Threat Weeds	TSC Act	EPBC Act
Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle			-	-
Myrtaceae	*Callistemon salignus*	Willow Bottlebrush			-	-
Myrtaceae	*Callistemon spp.*				-	-
Myrtaceae	*Corymbia maculata*	Spotted Gum			-	-
Myrtaceae	*Eucalyptus acmenoides*	White Mahogany			-	-
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark			-	-
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark			-	-
Myrtaceae	*Eucalyptus globoidea*	White Stringybark			-	-
Myrtaceae	*Eucalyptus moluccana*	Grey Box			-	-
Myrtaceae	*Eucalyptus propinqua*	Small-fruited Grey Gum			-	-
Myrtaceae	*Eucalyptus punctata*	Grey Gum			-	-
Myrtaceae	*Eucalyptus siderophloia*	Grey Ironbark			-	-
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum			-	-
Myrtaceae	*Eucalyptus umbra*	Broad-leaved White Mahogany			-	-
Myrtaceae	*Melaleuca nodosa*				-	-
Myrtaceae	*Melaleuca styphelioides*	Prickly-leaved Tea Tree			-	-
Ochnaceae	*Ochna serrulat**	Mickey Mouse Plant	*	YES	-	-
Oleaceae	*Jasminum volubile*				-	-
Oleaceae	*Notelaea longifolia*	Large Mock-olive			-	-
Oleaceae	*Notelaea venosa*	Veined Mock-olive			-	-
Oleaceae	*Olea europaea*	Common Olive	*	YES	-	-
Oleaceae	*Olea europaea subsp. cuspidata*	African Olive	*		-	-
Orchidaceae	*Acianthus fornicatus*	Pixie Caps			-	-
Orchidaceae	*Caladenia picta*				-	-
Orchidaceae	*Calochilus spp.*				-	-
Orchidaceae	*Corybas dowlingii*				E	-
Orchidaceae	*Chiloglottis diphylla*				-	-
Orchidaceae	*Dendrobium spp.*				-	-
Orchidaceae	*Microtis parviflora*	Slender Onion Orchid			-	-
Orchidaceae	*Pterostylis chaetophora*				V	-
Orchidaceae	*Pterostylis spp.*	Greenhood			-	-
Orchidaceae	*Thelymitra pauciflora*	Slender Sun Orchid			-	-
Oxalidaceae	*Oxalis perennans*				-	-
Phormiaceae	*Dianella caerulea*	Blue Flax-lily			-	-
Phormiaceae	*Dianella longifolia*	Blueberry Lily			-	-
Phormiaceae	*Dianella revoluta*	Blueberry Lily			-	-

Family	Scientific Name	Common Name	Exotic	High Threat Weeds	TSC Act	EPBC Act
Phormiaceae	*Thelionema spp.*				-	-
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush			-	-
Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree			-	-
Phyllanthaceae	*Glochidion ferdinandi var. ferdinandi*	Cheese Tree			-	-
Phyllanthaceae	*Poranthera microphylla*	Small Poranthera			-	-
Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry			-	-
Pittosporaceae	*Pittosporum multiflorum*	Orange Thorn			-	-
Pittosporaceae	*Pittosporum revolutum*	Rough Fruit Pittosporum			-	-
Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum			-	-
Plantaginaceae	*Plantago debilis*	Shade Plantain			-	-
Plantaginaceae	*Plantago gaudichaudii*	Narrow Plantain			-	-
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	*		-	-
Plantaginaceae	*Plantago spp.*	Plantain			-	-
Plantaginaceae	*Veronica arvensis*	Wall Speedwell	*		-	-
Plantaginaceae	*Veronica plebeia*	Trailing Speedwell			-	-
Poaceae	*Aira cupaniana*	Silvery Hairgrass	*		-	-
Poaceae	*Aristida ramose*	Purple Wiregrass			-	-
Poaceae	*Aristida vagans*	Threeawn Speargrass			-	-
Poaceae	*Austrostipa spp.*	A Speargrass			-	-
Poaceae	*Bothriochloa decipiens var. decipiens*	Pitted Bluegrass			-	-
Poaceae	*Bothriochloa macra*	Red Grass			-	-
Poaceae	*Briza maxima*	Quaking Grass	*		-	-
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass			-	-
Poaceae	*Cynodon dactylon*	Common Couch			-	-
Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass			-	-
Poaceae	*Digitaria parviflora*	Small-flowered Finger Grass			-	-
Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass			-	-
Poaceae	*Echinopogon ovatus*	Forest Hedgehog Grass			-	-
Poaceae	*Ehrharta erecta*	Panic Veldtgrass	*	YES	-	-
Poaceae	*Entolasia marginate*	Bordered Panic			-	-
Poaceae	*Entolasia stricta*	Wiry Panic			-	-
Poaceae	*Eragrostis brownii*	Brown's Lovegrass			-	-
Poaceae	*Eragrostis leptostachya*	Paddock Lovegrass			-	-
Poaceae	*Eragrostis parviflora*	Weeping Lovegrass			-	-
Poaceae	*Imperata cylindrica*	Blady Grass			-	-
Poaceae	*Lachnagrostis filiformis*				-	-

Family	Scientific Name	Common Name	Exotic	High Threat Weeds	TSC Act	EPBC Act
Poaceae	*Microlaena stipoides*	Weeping Grass			-	-
Poaceae	*Oplismenus aemulus*				-	-
Poaceae	*Oplismenus imbecillis*				-	-
Poaceae	*Panicum simile*	Two-colour Panic			-	-
Poaceae	*Paspalidium distans*				-	-
Poaceae	*Paspalum dilatatum*	Paspalum	*	YES	-	-
Poaceae	*Pennisetum clandestinum*	Kikuyu Grass	*		-	-
Poaceae	*Pennisetum spp.*				-	-
Poaceae	*Poa affinis*				-	-
Poaceae	*Poa labillardierei*	Tussock			-	-
Poaceae	*Poa labillardierei var. labillardierei*	Tussock			-	-
Poaceae	*Poa sieberiana var. sieberiana*	Snowgrass			-	-
Poaceae	*Rytidosperma pallidum*	Redanther Wallaby Grass			-	-
Poaceae	*Rytidosperma racemosum var. racemosum*	Wallaby Grass			-	-
Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass			-	-
Poaceae	*Sporobolus elongatus*	Slender Rat's Tail Grass			-	-
Poaceae	*Themeda triandra*				-	-
Poaceae	*Vulpia bromoides*	Squirrel Tail Fesque	*		-	-
Polygonaceae	*Persicaria hydropiper*	Water Pepper			-	-
Polygonaceae	*Rumex crispus*	Curled Dock	*		-	-
Polypodiaceae	*Platycerium bifurcatum*	Elkhorn Fern			-	-
Primulaceae	*Lysimachia arvensis*	Scarlet Pimpernel	*		-	-
Primulaceae	*Myrsine variabilis*				-	-
Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung			-	-
Pteridaceae	*Cheilanthes sieberi*	Rock Fern			-	-
Pteridaceae	*Cheilanthes spp.*	Rock Fern			-	-
Ranunculaceae	*Clematis aristata*	Old Man's Beard			-	-
Ranunculaceae	*Clematis glycinoides var. glycinoides*				-	-
Ranunculaceae	*Ranunculus lappaceus*	Common Buttercup			-	-
Ranunculaceae	*Ranunculus plebeius*	Forest Buttercup			-	-
Rhamnaceae	*Alphitonia excelsa*	Red Ash			-	-
Rosaceae	*Rosa rubiginosa*	Sweet Briar	*	YES	-	-
Rosaceae	*Rubus parvifolius*	Native Raspberry			-	-
Rubiaceae	*Galium leiocarpum*				-	-
Rubiaceae	*Galium liratum*				-	-
Rubiaceae	*Galium propinquum*	Maori Bedstraw			-	-

Family	Scientific Name	Common Name	Exotic	High Threat Weeds	TSC Act	EPBC Act
Rubiaceae	*Morinda jasminoides*	Sweet Morinda			-	-
Rubiaceae	*Opercularia diphylla*	Stinkweed			-	-
Rubiaceae	*Pomax umbellata*	Pomax			-	-
Rubiaceae	*Psydrax spp.*				-	-
Rutaceae	*Boronia parviflora*	Swamp Boronia			-	-
Rutaceae	*Boronia polygalifolia*	Dwarf Boronia			-	-
Rutaceae	*Melicope micrococca*	Hairy-leaved Doughwood			-	-
Sapindaceae	*Alectryon subcinereus*	Wild Quince			-	-
Sapindaceae	*Cupaniopsis anacardioides*	Tuckeroo			-	-
Sapindaceae	*Mischocarpus australis*				-	-
Smilacaceae	*Smilax australis*	Lawyer Vine			-	-
Solanaceae	*Solanum nigrum*	Black-berry Nightshade	*		-	-
Solanaceae	*Solanum prinophyllum*	Forest Nightshade			-	-
Solanaceae	*Solanum spp.*		*		-	-
Solanaceae	*Solanum stelligerum*	Devil's Needles			-	-
Stackhousiaceae	*Stackhousia viminea*	Slender Stackhousia			-	-
Stylidiaceae	*Stylidium spp.*				-	-
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower			-	-
Verbenaceae	*Lantana camara*	Lantana	*	YES	-	-
Verbenaceae	*Verbena spp.*				-	-
Violaceae	*Hybanthus stellarioides*				-	-
Violaceae	*Melicytus dentatus*	Tree Violet			-	-
Vitaceae	*Cayratia clematidea*	Native Grape			-	-
Vitaceae	*Cissus antarctica*	Water Vine			-	-
Vitaceae	*Cissus hypoglauca*	Giant Water Vine			-	-
Vitaceae	*Clematicissus opaca*	Pepper Vine			-	-

Appendix N

Bird List

Family	Common Name	Scientific Name	Avifauna Survey	Ground Trapping	Arboreal Trapping	Hair Funnel	Camera Traps	Anabat	Koala SAT	Spotlighting	Nocturnal Call Playback	Diurnal Transect surveys	Opportunistic Observation
Acanthizidae	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*											O
Acanthizidae	Striated Thornbill	*Acanthiza lineata*	O										O
Acanthizidae	Yellow Thornbill	*Acanthiza nana*	O										O
Acanthizidae	Brown Thornbill	*Acanthiza pusilla*											O
Acanthizidae	Buff-rumped Thornbill	*Acanthiza reguloides*	O										
Acanthizidae	White-throated Gerygone	*Gerygone olivacea*											O
Acanthizidae	White-browed Scrubwren	*Sericornis frontalis*	O										O
Accipitridae	Wedge-tailed Eagle	*Aquila audax*											O
Accipitridae	Swamp Harrier	*Circus approximans*											O
Accipitridae	Black-shouldered Kite	*Elanus axillaris*											O
Accipitridae	White-bellied Sea-Eagle	*Haliaeetus leucogaster*											O
Accipitridae	Whistling Kite	*Haliastur sphenurus*											O
Accipitridae	Square-tailed Kite	*Lophoictinia isura*											O
Accipitridae	Black Kite	*Milvus migrans*											O
Acrocephalidae	Australian Reed-Warbler	*Acrocephalus australis*											O
Aegothelidae	Australian Owlet-Nightjar	*Aegotheles cristatus*											O
Alcedinidae	Azure Kingfisher	*Ceyx azureus*											O
Alcedinidae	Laughing Kookaburra	*Dacelo novaeguineae*											O
Alcedinidae	Sacred Kingfisher	*Todiramphus sanctus*											O
Anatidae	Chestnut Teal	*Anas castanea*	O										O
Anatidae	Grey Teal	*Anas gracilis*	O										O
Anatidae	Pacific Black Duck	*Anas superciliosa*	O										O

Family	Common Name	Scientific Name	Avifauna Survey	Ground Trapping	Arboreal Trapping	Hair Funnel	Camera Traps	Anabat	Koala SAT	Spotlighting	Nocturnal Call Playback	Diurnal Transect surveys	Opportunistic Observation
Anatidae	Hardhead	*Aythya australis*											O
Anatidae	Australian Wood Duck	*Chenonetta jubata*	O										O
Anatidae	Black Swan	*Cygnus atratus*	O										O
Ardeidae	Great Egret	*Ardea alba*											O
Ardeidae	Intermediate Egret	*Ardea intermedia*											O
Ardeidae	White-necked Heron	*Ardea pacifica*											O
Ardeidae	Cattle Egret	*Bubulcus ibis*											O
Ardeidae	White-faced Heron	*Egretta novaehollandiae*											O
Artamidae	Dusky Woodswallow	*Artamus cyanopterus*	O										O
Artamidae	White-breasted Woodswallow	*Artamus leucorynchus*											O
Artamidae	Pied Butcherbird	*Cracticus nigrogularis*	O										O
Artamidae	Australian Magpie	*Cracticus tibicen*	O										
Artamidae	Grey Butcherbird	*Cracticus torquatus*	O										O
Artamidae	Pied Currawong	*Strepera graculina*	O										
Cacatuidae	Sulphur-crested Cockatoo	*Cacatua galerita*											O, CO
Cacatuidae	Little Corella	*Cacatua sanguinea*											O
Cacatuidae	Glossy Black Cockatoo	*Calyptorhynchus lathami*	O										
Cacatuidae	Galah	*Eolophus roseicapilla*											O
Cacatuidae	Yellow-tailed Black-Cockatoo	*Zanda funereus*											O
Campephagidae	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	O										
Campephagidae	Cicadabird	*Edolisoma tenuirostris*											O
Campephagidae	White-winged Triller	*Lalage tricolor*	O										O

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Charadriidae	Black-fronted Dotterel	*Elseyornis melanops*											O
Charadriidae	Masked Lapwing	*Vanellus miles*	O										O
Climacteridae	Brown Treecreeper	*Climacteris picumnus picumnus*											O
Climacteridae	White-throated Treecreeper	*Cormobates leucophaea*	O										
Columbidae	Bar-shouldered Dove	*Geopelia humeralis*	O										O
Columbidae	Wonga Pigeon	*Leucosarcia picata*					O						
Columbidae	Topknot Pigeon	*Lopholaimus antarcticus*											O
Columbidae	Crested Pigeon	*Ocyphaps lophotes*	O										O
Columbidae	Spotted Turtle-Dove	*Streptopelia chinensis**	O										
Coraciidae	Dollarbird	*Eurystomus orientalis*											O
Corvidae	Australian Raven	*Corvus coronoides*	O										O
Cuculidae	Fan-tailed Cuckoo	*Cacomantis flabelliformis*											O
Cuculidae	Pheasant Coucal	*Centropus phasianinus*											O
Cuculidae	Horsfield's Bronze-Cuckoo	*Chalcites basalis*											O
Cuculidae	Eastern Koel	*Eudynamys orientalis*	O										O
Cuculidae	Pallid Cuckoo	*Heteroscenes pallidus*	O										O
Dicaeidae	Mistletoebird	*Dicaeum hirundinaceum*											O
Estrildidae	Red-browed Finch	*Neochmia temporalis*	O										
Falconidae	Brown Falcon	*Falco berigora*											O
Falconidae	Australian Hobby	*Falco longipennis*											O
Hirundinidae	Welcome Swallow	*Hirundo neoxena*											O
Hirundinidae	Fairy Martin	*Petrochelidon ariel*											O

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Hirundinidae	Tree Martin	*Petrochelidon nigricans*											O
Locustellidae	Rufous Songlark	*Cincloramphus mathewsi*	O										O
Maluridae	Superb Fairy-wren	*Malurus cyaneus*	O										
Maluridae	Variegated Fairy-wren	*Malurus lamberti*	O										O
Meliphagidae	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	O										O
Meliphagidae	Eastern Spinebill	*Acanthorhynchus tenuirostris*	O										
Meliphagidae	Red Wattlebird	*Anthochaera carunculata*	O										
Meliphagidae	Blue-faced Honeyeater	*Entomyzon cyanotis*											O
Meliphagidae	Yellow-faced Honeyeater	*Lichenostomus chrysops*	O										
Meliphagidae	Noisy Miner	*Manorina melanocephala*	O										
Meliphagidae	Lewin's Honeyeater	*Meliphaga lewinii*	O										
Meliphagidae	Noisy Friarbird	*Philemon corniculatus*	O										
Meliphagidae	Striped Honeyeater	*Plectorhyncha lanceolata*	O										O
Monarchidae	Magpie-lark	*Grallina cyanoleuca*	O										O
Oriolidae	Olive-backed Oriole	*Oriolus sagittatus*	O										O
Pachycephalidae	Grey Shrike-thrush	*Colluricincla harmonica*	O										
Pachycephalidae	Golden Whistler	*Pachycephala pectoralis*											O
Pachycephalidae	Rufous Whistler	*Pachycephala rufiventris*											O
Pardalotidae	Spotted Pardalote	*Pardalotus punctatus*											O
Pardalotidae	Striated Pardalote	*Pardalotus striatus*											O
Pelecanidae	Australian Pelican	*Pelecanus conspicillatus*	O										O
Petroicidae	Eastern Yellow Robin	*Eopsaltria australis*	O										O

Family	Common Name	Scientific Name	Avifauna Survey	Ground Trapping	Arboreal Trapping	Hair Funnel	Camera Traps	Anabat	Koala SAT	Spotlighting	Nocturnal Call Playback	Diurnal Transect surveys	Opportunistic Observation
Petroicidae	Jacky Winter	*Microeca fascinans*											O
Petroicidae	Scarlet Robin	*Petroica boodang*											O
Petroicidae	Rose Robin	*Petroica rosea*											O
Phalacrocoracidae	Little Pied Cormorant	*Microcarbo melanoleucos*											O
Podargidae	Tawny Frogmouth	*Podargus strigoides*											O
Podicipedidae	Australasian Grebe	*Tachybaptus novaehollandiae*	O										O
Pomatostomidae	Grey-crowned Babbler	*Pomatostomus temporalis*	O										O
Psittacidae	Australian King Parrot	*Alisterus scapularis*	O										
Psittacidae	Little Lorikeet	*Glossopsitta pusilla*											O
Psittacidae	Crimson Rosella	*Platycercus elegans*	O										O
Psittacidae	Eastern Rosella	*Platycercus eximius*	O										O
Psittacidae	Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	O										
Psittacidae	Rainbow Lorikeet	*Trichoglossus haematodus*	O										
Psittaculidae	Red-rumped Parrot	*Psephotus haematonotus*	O										O
Psophodidae	Eastern Whipbird	*Psophodes olivaceus*	O										
Rallidae	Eurasian Coot	*Fulica atra*	O										O
Rallidae	Dusky Moorhen	*Gallinula tenebrosa*	O										O
Rallidae	Purple Swamphen	*Porphyrio porphyrio*											O
Rallidae	Black-tailed Native-hen	*Tribonyx ventralis*											O
Recurvirostridae	Black-winged Stilt	*Himantopus leucocephalus*											O
Rhipiduridae	Grey Fantail	*Rhipidura albiscapa*	O										O
Rhipiduridae	Willie Wagtail	*Rhipidura leucophrys*	O										O

Family	Common Name	Scientific Name	Avifauna Survey	Ground Trapping	Arboreal Trapping	Hair Funnel	Camera Traps	Anabat	Koala SAT	Spotlighting	Nocturnal Call Playback	Diurnal Transect surveys	Opportunistic Observation
Rhipiduridae	Rufous Fantail	*Rhipidura rufifrons*	O										
Scolopacidae	Latham's Snipe	*Gallinago hardwickii*	O										O
Strigidae	Powerful Owl	*Ninox strenua*											O
Sturnidae	Common Myna	*Acridotheres tristis*	O										O
Sturnidae	Common Starling	*Sturnus vulgaris*	O										O
Threskiornithidae	Royal Spoonbill	*Platalea regia*											O
Threskiornithidae	Australian White Ibis	*Threskiornis moluccus*	O										O
Threskiornithidae	Straw-necked Ibis	*Threskiornis spinicollis*											O
Tytonidae	Barn Owl	*Tyto alba*											O
Tytonidae	Masked Owl	*Tyto novaehollandiae*								O			
Zosteropidae	Silvereye	*Zosterops lateralis*											O

O – Observed
T - Trapped or netted
R - Road kill
W - Heard call
V - Fox kill
M - Miscellaneous

B - Burnt
H - Hair, feathers, or skin
P - Scat
C - Cat kill
E - Nest/roost
X - In scat

F - Tracks/scratchings
Y - Bone or teeth
D - Dog kill
Z - In raptor/owl pellet
K - Dead
U – Bat Recording

CO – Chewed Casuarina orts

Appendix O

Frog Species List

Family	Species	Common Name	Avifauna Survey	Ground Trapping	Arboreal Trapping	Hair Funnel	Camera Traps	Anabat	Koala SAT	Spotlighting	Nocturnal Call Playback	Diurnal Transect surveys	Opportunistic Observation
Amphibians													
Hylidae	*Litoria dentata*	Bleating Tree frog								W			
Hylidae	*Litoria fallax*	Eastern Dwarf Tree Frog								W			
Hylidae	*Litoria peronii*	Peron's Tree Frog								W			
Hylidae	*Litoria tyleri*	Tyler's Tree Frog								W			
Hylidae	*Litoria verreauxii*	Whistling tree frog								W			
Myobatrachidae	*Crinia signifera*	Common Eastern Toadlet								W			
Myobatrachidae	*Crinia parinsignifera*	Eastern Sign-bearing Froglet								O			
Myobatrachidae	*Limnodynastes peronii*	Striped Marsh Frog								W			
Myobatrachidae	*Limnodynastes tasmaniensis*	Spotted Marsh Frog								W			
Myobatrachidae	*Pseudophryne bibronii*	Brown Toadlet								O			
Myobatrachidae	*Pseudophryne coriacea*	Red-backed Toadlet								O			
Myobatrachidae	*Uperoleia fusca*	Dusky Toadlet											

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W - Heard call
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M - Miscellaneous
B - Burnt
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C - Cat kill
E - Nest/roost
X - In scat
F - Tracks/scratchings
Y - Bone or teeth
D - Dog kill
Z - In raptor/owl pellet
K - Dead
U – Bat Recording
CO – Chewed Casuarina orts

Appendix P

Mammal Species List

Family	Species	Common Name	Avifauna Survey	Ground Trapping	Arboreal Trapping	Hair Funnel	Camera Traps	Anabat	Koala SAT	Spotlighting	Nocturnal Call Playback	Diurnal Transect surveys	Opportunistic Observation
Mammals													
Canidae	Fox	*Vulpes vulpes**					O						
Canidae	Dog	*Canis lupus familiaris**					O						
Dasyuridae	Brown Antechinus	*Antechinus stuartii*		T		H	O						
Dasyuridae	Brush-tailed Phascogale	*Phascogale tapoatafa*											
Dasyuridae	Common Dunnart	*Sminthopsis murina*					O						
Petauridae	Sugar Glider	*Petaurus breviceps*			T								
Phalangeridae	Common Brushtail Possum	*Trichosurus vulpecula*			T	H							
Phascolarctidae	**Koala**	***Phascolarctos cinereus***							F, P				
Pseudocheiridae	Common Ringtail Possum	*Pseudocheirus peregrinus*								O			
Macropodidae	Eastern Grey Kangaroo	*Macropus giganteus*					O						O
Macropodidae	Red-necked Wallaby	*Macropus rufogriseus*								O			O
Macropodidae	Swamp Wallaby	*Wallabia bicolor*					O						
Muridae	Bush Rat	*Rattus fuscipes*		T									
Microbats (suborder Megachiroptera)													
Pteropodidae	Grey-headed Flying Fox	*Pteropus poliocephalus*								O			
Microbats (suborder Microchiroptera)													
Miniopteridae	**Little Bent-winged Bat**	***Miniopterus australis***						U					
Miniopteridae	**Eastern Bent-winged Bat**	***Miniopterus orianae oceanensis***						U					
Molossidae	White-striped free tail bat	*Austronomus australis*						U					
Molossidae	**Eastern coastal Free-tailed Bat**	***Mormopterus norfolkensis***						U					
Molossidae	Ride's Free-tailed Bat	*Mormopterus ridei*						U					

Family	Species	Common Name	Avifauna Survey	Ground Trapping	Arboreal Trapping	Hair Funnel	Camera Traps	Anabat	Koala SAT	Spotlighting	Nocturnal Call Playback	Diurnal Transect surveys	Opportunistic Observation
Rhipiduridae	Eastern Horseshoe Bat	*Rhinolophus megaphyllus*						U					
Vespertilionidae	Gould's Wattled Bat	*Chalinolobus gouldii*						U					
Vespertilionidae	Chocolate Wattled Bat	*Chalinolobus morio*						U					
Vespertilionidae	Eastern Forest Bat	*Vespadelus pumilus*						U					

O – Observed
T - Trapped or netted
R - Road kill
W - Heard call
V - Fox kill
M - Miscellaneous

B - Burnt
H - Hair, feathers, or skin
P - Scat
C - Cat kill
E - Nest/roost
X - In scat

F - Tracks/scratchings
Y - Bone or teeth
D - Dog kill
Z - In raptor/owl pellet
K - Dead
U – Bat Recording

CO – Chewed Casuarina orts

Appendix Q

Reptile Species List

Family	Species	Common Name	Avifauna Survey	Ground Trapping	Arboreal Trapping	Hair Funnel	Camera Traps	Anabat	Koala SAT	Spotlighting	Nocturnal Call Playback	Diurnal Transect surveys	Opportunistic Observation
Reptiles													
Boidae	Carpet & Diamond Pythons	*Morelia spilota*								O			
Scincidae	Land Mullet	*Bellatorias major*					O						

O – Observed	**B - Burnt**	**F - Tracks/scratchings**	**CO – Chewed Casuarina orts**
T - Trapped or netted	**H - Hair, feathers, or skin**	**Y - Bone or teeth**	
R - Road kill	**P - Scat**	**D - Dog kill**	
W - Heard call	**C - Cat kill**	**Z - In raptor/owl pellet**	
V - Fox kill	**E - Nest/roost**	**K - Dead**	
M - Miscellaneous	**X - In scat**	**U – Bat Recording**	

Appendix R

Staff Curriculum Vitae's

Mark Aitkens

Principal Ecologist

Role at RPS
Principal Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Science (Environmental Biology), University of Technology Sydney (UTS)

Accredited Biodiversity Assessment Method Assessor under Section 6.10 of the *Biodiversity Conservation Act* 2016

Rail Industry Safety Induction - RISI

Memberships
Ecological Society of Australia

Why Mark for this role

Mark is a Principal Ecologist with over 23 years experience in the delivery of terrestrial and aquatic ecology services to the private and public sectors. He is experienced in all aspects of project delivery including design and implementation of seasonally based flora and fauna surveys, identification of terrestrial and aquatic species and ecological communities, impact assessments prepared under State and Commonwealth legislation, and design and implementation of monitoring programs.

Mark is accredited under the newly established Biodiversity Assessment Methodology (BAM) and has conducted a range of BAM assessments for State Significant Infrastructure and State Significant Developments, as well as EPBC offset calculations.

Relevant projects

TAP3 Project, 2017-present

Mark is the project ecologist involved in the preparation of biodiversity assessment documentation for rail station upgrade for inclusion in Review of Environmental Factors. Assessments have included the identification and assessment of threatened species and ecological communities found within the rail corridor for multiple rail stations located within the greater Sydney metropolitan area.

Maitland to Minimbah Third Track Project, 2011-2012

As part of the Hunter8 Alliance, Mark performed integral part of the approvals, post approvals and biodiversity offsetting components of a 30 km section of new rail track constructed adjacent to the existing rail corridor between Maitland and Minimbah, NSW. Prepared and, implemented management plans for microbat exclusion from culverts, pre-clearance surveys and reporting, vegetation clearing audits, biodiversity offset site identification, evaluation and assessment.

Pacific Highway Upgrade: Oxley Highway to Kempsey, RMS, 2012-2014

Assisted in the procurement of approvals under State and Commonwealth legislation including participation in risk assessments, field surveys, reporting, project design and impact assessments (i.e. EPBC Act Preliminary Documentation). Performed monitoring surveys for the State listed *Maundia triglochinoides* and the State and Commonwealth listed Giant Barred Frog (*Mixophyes iteratus*) in accordance with a Before Impact Control After monitoring design. Analysed results and reported findings including an evaluation of Project impacts and performance of mitigation measures.

Relevant projects

Finley Solar Farm EIS, ESCO, 2017

Mark was involved in RPS' preparation of an Environmental Impact Statement (EIS) for the Finley Solar Farm Project. The Finley Solar Farm would produce 170MW over 500 hectares of land. Numerous RPS service lines worked together to prepare the document. To date RPS have successfully liaised with the NSW Department of Planning and Environment, as well as the client, to progress the project smoothly in line with the desired outcomes.

NBN Build, Tata Consulting, 2016-18

Preparation of biodiversity assessments for multiple greenfield NBN cabling installations from Tweed Heads to Merimbula and west to Braidwood (27 sites). Biodiversity constraints were identified and managed within tight assessment timeframes to meet NBN delivery objectives.

NBN Build, Visionstream, 2018-present

Preparation of biodiversity assessments for multiple greenfield NBN Towers from Mullumbimby to Tallong (five sites). Biodiversity constraints were identified and managed within tight assessment timeframes to meet NBN delivery objectives.

Waterloo Road Upgrade, RMS, 2017

Mark prepared a specialist biodiversity assessment report as part of a Review of Environmental Factors for the Upgrade of Waterloo Road, North Ryde. Challenges successfully encountered included the management of roadside impacts on critically endangered ecological communities and threatened species habitat.

Bells Line of Road Upgrade, RMS, 2016-17

Mark prepared a specialist biodiversity assessment report as part of a Review of Environmental Factors for the Upgrade of Bells Line of Road from Lithgow to Bell. Challenges successfully encountered included the management of roadside impacts on endangered ecological communities and threatened species habitat. Investigations included assessments for terrestrial and aquatic matters.

Reconstruction of the Limbri to Weabonga Road, Tamworth Regional Council, 2011

Performed biodiversity surveys and assessment for the reconstruction of the Limbri to Weabonga Road following flood damage from the adjacent Swamp Oak Creek. The endangered Booroolong Tree Frog (*Litoria booroolongensis*) and Eel-tailed Catfish (*Tandanus tandanus*) were detected adjacent to the construction area. Impact minimisation involving the establishment of exclusion zones and frog hygiene (Chytrid control) was successfully used to avoid a significant impact on the species. Works could proceed in accordance with an EPBC Act 'Particular Manner' decision notice.

Rosewood Estate Tamworth, 2014-2015

Project managed and prepared Preliminary Documentation for a 'controlled action' declared under the EPBC Act. Assessment involved a detailed consideration of White Box Yellow Box Blakely's Redgum Grassy Woodland and Derived Native Grasslands, a critically endangered ecological community.

Mary's Mount Blue Metal Quarry, Gunnedah Quarry Products, 2013-2014

Project managed and prepared Preliminary Documentation for a 'controlled action' declared under the EPBC Act for a quarry project linked to the delivery of ballast needed for the inland rail project. Assessment involved the consideration of MNES impacted by the quarry including, but not restricted to Semi-evergreen Vine Thicket EEC and the Koala. Calculated and report biodiversity offset requirements in accordance with Commonwealth Offsets Policy and incorporated into a Biodiversity Offset Strategy.

Western Region Biodiversity Offset Strategy, Centennial Coal, 2018

Preparation of a biodiversity offset strategy for multiple approved coal mining operations in the NSW 'Western Coal Fields' near Lithgow. Involved a post hoc assessment of Project impacts and comparable offsets using the repealed Framework for Biodiversity Offsets (Major Projects) and Part 7A of the *Threatened Species Conservation Act* 1995. Demonstrated a suitable offset strategy for approved projects by gaining approval through the NSW Department of Planning and Environment and Office of Environment and Heritage.

Springvale Coal, Centennial Coal, 2018

Preparation and implementation of Biodiversity Management Plans (BMP) and Swamp Monitoring Programs (SMP) as subplans of Longwall Extractions Plans for the Springvale Coal Extension Project. BMPs and SMPs are reviewed by the Independent Monitoring Panel and State/ Commonwealth regulators prior to the approval of secondary coal extraction. Works involved the synthesis of a growing knowledge base on best practice monitoring and management of endangered upland peat swamps listed on State and Commonwealth legislation.

Albion Park, Tower Holdings, 2015-2016

Prepared Biodiversity Management Plans for the protection of State and Commonwealth listed endangered and critically endangered plant species (*Zieria granulata* and *Cynanchum elegans*) and ecological communities (Illawarra and South Coast Lowland Forest and Woodland). Management prescriptions centred on weed and fire management,

with the latter linked to asset protection zones for the adjoining approved residential subdivision.

Midal Cabling Project, Midal Cabling Company, 2011-2012

The approved Midal aluminium cabling plant is a heavy industrial development involving hot aluminium metal haulage from the Tomago aluminium smelter to the manufacturing plant for the production of high-tension electrical cables. Mark's role in the approvals process involved the preparation of State and Commonwealth assessments centred on the threatened New Holland Mouse and Ramsar Wetlands. An EPBC Act controlled action was avoided as a consequence of the assessment prepared.

Wyong Hospital Enabling Works, Health Infrastructure NSW, 2016

Mark prepared a Flora and Fauna Assessment for the Wyong Hospital Enabling Works to inform a Review of Environmental Factors (REF). The approach adopted for field surveys for the Flora and Fauna Assessment was in accordance with the BioBanking Methodology (OEH 2014), enabling the surveys and results of the assessment to be transferrable to any BioBanking Assessments that may be required if the project became considered a Major Project (i.e. State Significant Infrastructure (SSI) or a State Significant Development (SSD)).

Kings Hill Concept Plan, Kings Hill Developments, 2015-present

Prepared a Species Impact Statement for a 500 ha development site with focal species being the Koala, Brush-tailed Phascogale, woodland birds and threatened orchids. Documentation was based on comprehensive seasonal surveys involving the project management of eight ecologists over a nine . Utilised innovative techniques to assess the projects impacts on the Koala (i.e. use of detection dogs and foliage nutrient analysis). Other commissions included the preparation of Biodiversity Management Plan, Vegetation Management Plan, Aquatic Impact Assessment (Key Fish Habitat).

Water Quality Monitoring Program, Orchard Hills Defence Facility, 2012

Prepared a Water Quality Monitoring Program for a defence facility in western Sydney. Monitoring works included measures of abiotic and biotic indicators for a catchment containing defence activities imbedded within a highly sensitive natural setting containing the critically endangered Cumberland Plan Woodland and nationally listed threatened species. The program included the monitoring of groundwater dependant ecosystems.

ELF Stage 2 Construction Biodiversity Assessment, Singleton Military Area, 2010

Prepared a Biodiversity Assessments for multiple defence training installations associated with the ELF program located within the Singleton Military Area. Included the assessment of development and operational impacts such as 'ballistic pruning' on threatened flora and fauna species including the Slaty Redgum (*Eucalyptus glaucina*) and habitat occupied by threatened woodland birds. Assessments adopted the 'good neighbour policy' (i.e. consideration of impacts on State listed threatened species and ecological communities).

Joe May

Ecologist

Role at RPS
Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Master of Environmental Management

Bachelor of Environmental Science & Management

Accredited BAM Assessor

Memberships
The Ecological Consultants Association of NSW (ECA)

Environment Institute of Australia & New Zealand (EIANZ)

Royal Zoological Society of NSW (RZSNSW)

Birdlife Australia

Why Joe for this role

Joe is an accredited Biodiversity Assessment Method (BAM) Assessor with over 6 years' experience as an ecological consultant.

Joe has been an Ecologist with RPS since 2014 and has experience in the preparation of a variety of report types, including but not limited to:

- Review of Environmental Factors Biodiversity Monitoring Reports;
- Due Diligence Reporting;
- Thresholds Assessments;
- Vegetation Management Plans;
- Biodiversity Management Plans;
- Biodiversity Assessment Development Reports (BDAR); and
- Biodiversity Stewardship Site Assessment Reports (BSSAR).

The preparation of these report types requires understanding of the relevant local, state and federal legislation and policies pertaining to each.

In addition to having skills in report writing and legislation, Joe is accomplished with the following field skills:

- Fauna identification; including birds, reptiles, amphibians and mammals; and
- Flora identification; including plants, vegetation community mapping and the identification of state and federally listed endangered ecological communities.

Relevant projects

NBN Thresholds Assessments, NBN, 2015-2019

Preparation of biodiversity assessments for multiple greenfield NBN cabling installations from Maxville to Moruya (14 sites). Biodiversity constraints were identified and managed within tight assessment timeframes to meet NBN delivery objectives.

Western Region Biodiversity Offset Strategy, Centennial Coal, 2018

Conducted biometric plots, vegetation mapping and targeted flora and fauna surveys for multiple approved coal mining operations in the NSW 'Western Coal Fields' near Lithgow.

Bulga Mine Annual Fauna Monitoring, Glencore, 2015-2019

Joe has been involved in an annual monitoring program that spans two operations and involves seasonal bird surveys, habitat assessments and the full spectrum of fauna monitoring methodologies targeting threatened species as well as comprising an overall species list, and providing technical input and annual report writing.

Springvale Coal, Centennial Coal, 2018

Preparation and implementation of Biodiversity Management Plans (BMP) and Swamp Monitoring Programs (SMP) as subplans of Longwall Extractions Plans for the Springvale Coal Extension Project. BMPs and SMPs are reviewed by the Independent Monitoring Panel and State/ Commonwealth regulators prior to the approval of secondary coal extraction. Works involved the synthesis of a growing knowledge base on best practice monitoring and management of endangered upland peat swamps listed on State and Commonwealth legislation.

Mandalong Offset Assessments, Centennial Coal Mandalong, 2018

Field surveys for a range of flora and fauna assessments, including threatened species searches, nocturnal and amphibian surveys for the proposed Mandalong Offset sites.

Charbon Compensatory Habitat Assessment, Centennial Coal Charbon, 2016 to 2018

Field surveys for annual monitoring of floristics and bird life across Charbons' northern and southern Compensatory Habitat Management Areas.

Lidsdale Biodiversity Development Assessment, Centennial Coal, 2018 to 2019

Flora and fauna field surveys for the preparation of a Biodiversity Development Assessment Report.

Bulga to Broke, Singleton Council, 2019

Impact assessment for the proposed Bulga to Broke Pipeline, with floristics, threatened species searches and vegetation community determinations

Nest Box Monitoring Program, Rose Group, 2012-2019

Conduct biannual monitoring of over 500 nest boxes to comply with Conditions of Consent for residential development at Gwandalan. Prepare annual compliance reports for various approvals.

Neubeck Open Cut Coal Mine, Centennial Coal, 2012-2014

Flora and fauna field surveys were undertaken for the proposed Neubeck open cut coal mine. Surveys involved targeted threatened species surveys, vegetation mapping, flora and fauna identification and habitat mapping.

Huntlee Ecological works, LWP Property Group, 2015

Undertook Ecology works to inform Major Project Approval and negotiations under the EPBC Act for the new Hunter Valley town at Huntlee.

Springvale Blue Mountains Water Skink (BMWS) Monitoring and Research Program, Centennial Coal, 2015-2018

Participated in field research for a multi-year research and monitoring program for the nationally endangered Blue Mountains Water Skink. Roles have included ecological field surveys data management.

Janene Devereux

Senior Ecologist

Role at RPS
Senior Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Science (Marine Science and Sustainable Resource Management)

Senior First Aid Certificate

Introductory 4WD training (off road and sand) - SODRV 302A, SISODRV 302A, SRO OPS 001B and TLIB40

Nationally recognised OH&S White Card

Memberships
Ecological Consultants Association of NSW

Why Janene for this role

Janene is a Biodiversity Assessment Method (BAM) Accredited Assessor with over nine years' experience in Environmental Consulting. During this time, Janene has been involved in several major projects across Australia and New Zealand, utilising her knowledge and experience in Terrestrial Ecology and Marine Ecology.

Janene's experience in Marine Ecology particularly focuses on the offshore Oil & Gas sector, working with teams on multiple projects for the Browse Basin in Western Australia and New Zealand's Taranaki, Canterbury and Great South Basin. Janene assisted in the delivery of Marine Impact Assessments, referrals and safety advice for major clients and was also a team lead on offshore surveys.

Janene has strengths in safety and team management.

Relevant projects – Marine Ecology

*** Anadarko New Zealand, Post-Drill Monitoring Survey, New Zealand (2015)**

Night shift survey lead for two, 10-day offshore surveys on both the south east coast and north west coast of New Zealand. This survey involved the collection sediment grabs and CTD samples in depths of over 1000m. This also included the preparation of samples for macrobenthic and chemical analysis.

*** Shell Exploration New Zealand, Great South Basin Environmental Baseline Report/ MMIA Report, New Zealand (2013)**

The development of the Baseline Report, including data analysis of water and sediment quality, analysis of macrobenthic data and subsequent reporting of results and conclusions. Technical support for the MMIA Project team including assessment and reporting of baseline data, seismic impacts and the review of available information on sensitive receptors within the Great South Basin.

*** Woodside Energy Limited Browse Upstream LNG Development, WA (2011)**

Browse LNG Development Upstream environmental approvals including development of the EIS report, compilation of a series of comprehensive baseline environment reports encompassing the development areas and the wider northwest marine region. Technical review and editing of EIS sections and preparation of the EIS document for publication and public review.

* Project completed with previous employer

Kieran Marshall

Ecologist

Kieran.marshall@rpsgroup.com.au

Qualifications:	Bachelor of Environmental Science and Management (Honours First Class), University of Newcastle, 2015
Memberships:	Australasian Land and Groundwater Association Hunter Bird Observer's Club
Locations:	Newcastle, NSW, Australia
Project role:	Field Ecologist

Overview

Kieran has acquired a diverse range of ecological experience and skills throughout his career, education and research. He has undertaken extensive flora and fauna surveys and assessments, field monitoring and ecological field surveys during the course of his studies and career.

Kieran's career as allowed him to develop his regional knowledge of threatened species and endangered ecological communities, along with their context in current legislation. In addition to his terrestrial field ecology background, Kieran is highly proficient in the use of ArcGIS.

[Areas of expertise]

- Flora and Fauna Assessment
- Aquatic Ecology (AUSRIVAS)
- Spatial analysis (GIS)

[Sectors]

- Housing
- Government
- Mining

Experience

Temperate Highland Peat Swamp (THPSS) Monitoring, Centennial Coal, 2019

field surveys, including implementation and continuation of a range of extensive seasonal and annual monitoring programs.

Housing Development at Catherine Hill Bay and Gwandalan, Rose Group

Project tasks included the installation and monitoring of nest boxes, revision of hollow recovery procedure, and preparation of compliance correspondence.

Blue Mountains Water Skink (*Eulamprus leurensis*) monitoring, 2016 – 2019
Field monitoring to assess the population dynamics of Blue Mountains Water Skink within swamps of the Newnes Plateau.

Mandalong South Powerline Relocation - Flora and Fauna Impact Assessment, Centennial Coal

Project tasks included targeted field surveys and Biometric plots. Works on this project are also incorporating the Framework for Biodiversity Assessment to inform an offset strategy under the Framework for Biodiversity Assessment.

Shelomi Doyle

Ecologist

Shelomi.doyle@rpsgroup.com.au

Qualifications: Bachelor of Horticulture (Environmental Specialisation) Charles Sturt University, 2013
Graduate Diploma in Science (Biodiversity Science) University of New England, 2019
Rail Industry Safety Induction - RISI

Memberships: Australian Network for Plant Conservation

Locations: Newcastle, NSW, Australia **Project role:** Field Ecologist

Overview

Shelomi is an ecologist with a special focus on botany, developed in her previous positions in the horticulture industry over 10 years. This experience with both native and introduced plants has progressed into a strong knowledge of flora and vegetation communities, along with associated legislation.

Shelomi's studies and career have centred around plant identification and have expanded to include a variety of flora and fauna assessment techniques, data management and reporting.

[Areas of expertise]

- Flora and Fauna assessment and monitoring
- Threatened species surveys
- Ecological community mapping

[Sectors]

- Resources
- Local Government
- Housing

Experience

Black Hill Biodiversity Assessment, Maitland Diocese, 2017
Ecological field surveys including floristic quadrats, bird surveys and biometric data collection to inform reporting under the Framework for Biodiversity Assessment.

Bulga Water Pipe, Singleton Council, 2017
Field surveys and pre-clearance threatened species searches, with associated reporting, impact assessment and design recommendations.

Springvale Temperate Highland Peat Swamp (THPSS) Monitoring, Centennial Coal, 2017 to present
Ecological field surveys and associated monitoring report preparation for flora and fauna assessments within the Newnes Plateau and surrounding areas for the Springvale underground mine. Includes nested transects, floristic quadrats, annual swamp transects and ground truthing of remotely sensed imagery.

Springvale Blue Mountains Water Skink (*Eulamprus leurensis*) monitoring, Centennial Coal, 2017 to present

Field monitoring to assess the population dynamics of Blue Mountains Water Skink within swamps of the Newnes Plateau, including funnel trapping, animal handling and assessment, and DNA collection.

Western Region Biodiversity Offset Strategy (WRBOS), Centennial Coal, 2017
This project involves the assessment of Centennial's offset sites to establish suitability for offsetting project impacts on biodiversity.

Mandalong Offset Site assessment, Centennial Coal, 2018
Including vegetation community analysis, conduction floristic plots using the current Biodiversity Assessment Method.

Shawn Ryan

Ecologist

Role at RPS
Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Environmental Science & Management (Ecology), University of Newcastle, 2010

Diploma in Conservation & Land Management, Hunter TAFE, 2019

Senior First Aid, 2017

4X4 driving Certificate 2018

Defence Driving Certificate, 2014

ChemCert AQF3, 2015
White Card, 2015

Memberships
Ecological Consultants Association (ECA)

Ecological Society of Australia (ESA)

Orchid Society of NSW

Hunter Bird Observers (HBOC)

Australian Association of Bush Regenerators (AABR)

Ocean & Coastal Care Initiative (OCCI)

Hunter Region LandCare Network

Burwood Beach Coast Care

Central Coast & Hunter Region Fungi Group

Why Shawn for this role

Shawn has over 9 years' experience in the environmental field. He has gained extensive experience in undertaking ecological field surveys, flora and fauna surveys, monitoring, and environmental assessments.

Throughout his career, Shawn has attained skills in report writing, professional communication between clients and contractors, project management, day-to-day scheduling and teamwork.

Relevant projects

Stubbo Solar Farm – Preliminary Vegetation surveys and Box-Gum Woodland Mapping, Gulgong, 2019

Lead detailed flora surveys targeting type, condition and distribution of derived native grasslands, with focus on derived Box-Gum woodland vegetation types, as well as targeted surveys for threatened flora and fauna species (as per the candidate species list produced using BAM). Shawn represented RPS in client and landowner meetings which were a major component of the project, with daily meetings and land access scheduling required to complete works within small time frames and over a large study area.

North Star Quarry - BDAR, Boral, 2019

Detailed field surveys quantifying vegetation type and condition classes across the site and performed targeted surveys for threatened flora and fauna species (as per the candidate species list produced using BAM).

Threatened Flora Monitoring: *Prostanthera junonis*, Newcastle University, 2018

Conducted fieldwork to assess the population dynamics and monitor remanent populations.

Airly Coal – Box-Gum Woodland Vegetation Surveys & Mapping, Centennial Coal, 2019

Completed detailed field surveys of previously unmapped areas of Box-Gum Woodland in intact and Derived Native Grassland states. This involved undertaking extensive Rapid data point surveys, BAM plot surveys, background searches, data analysis and interpretation, vegetation mapping analysis & creation of GIS maps.

Kingshill Development – threatened Flora and Fauna surveys & vegetation mapping, 2018-2019

Targeted threatened species searches and extensive vegetation Mapping surveys.

Springvale Colliery – Swamp Monitoring Program, Centennial Coal, 2019

Lead quarterly and annual flora monitoring field programs.

Charbon Colliery – Annual Box-Gum Woodland Monitoring, Centennial Coal, 2019

Assisted RPS Ecology team in undertaking the monitoring program to assess changes in floristics of Box-Gum Woodland and bird diversity within compensatory habitat areas.

Angus Place Colliery – Maximum Offset Vegetation Surveys & Mapping, Centennial Coal, 2019

Assisted the RPS Ecology team in undertaking large scale Vegetation surveys. Field work included extensive Rapid Data Point surveys, BAM surveys and ground truthing of vegetation mapping.

Newstan Colliery, Vegetation Surveys & Mapping, Centennial Coal, 2018-19

Assisted the RPS Ecology team in undertaking Targeted Threatened Species searches, vegetation surveys and assisting in vegetation mapping. Field work included extensive Rapid Data Point and BAM surveys to ground truth existing vegetation mapping, as well as targeted belt transect surveys over several seasons for cryptic flora and fauna species.

Mandalong Colliery, Vegetation Ground Truthing Surveys, Centennial Coal, 2019

Assisted the RPS Ecology team in undertaking large scale vegetation surveys to verify and update existing vegetation mapping as well conducting BAM surveys and Threatened Flora Searches across the entirety of site.

Myuna Colliery, Endangered Ecological Community (EEC) monitoring, Centennial Coal, 2017

Shawn is involved in the annual monitoring of the Swamp Sclerophyll Forest on Coastal Floodplain EEC at Myuna Colliery through landscape and site analysis techniques. Biometric plots, Floristics plots and photo points are used to compare the results against benchmark data to determine change in condition of the EEC. Recommendations are provided with the object of delivering a 'maintain or improve' outcome.

Bush Regeneration & Green Army Team Supervisor, Conservation Volunteers Australia (CVA), 2013-2017

Shawn gained extensive experience in practical conservation and natural areas management, supervising Conservation Volunteers Australia's (CVA) dedicated bush Regeneration team, Volunteer teams, Indigenous teams and supervising a 4th Green Army team partnered with National Parks, Lake Macquarie Council and WetlandCare Australia. He has a well-developed knowledge of native and introduced flora and fauna, vegetation communities of hunter region, species indicative of habitat health and strong on-ground identification. His primary role was delivering units in Conservation and Land Management and directing bush regeneration works within in various sensitive areas of the Hunter estuary. This included planting, primary and secondary weeding and maintenance, erosion control, seed collection and propagation, horticultural works and liaising with National Parks, Hunter Wetland Centre and WetlandCare Australia on management strategies for various sites. Shawn ensured safe practices, adhering to and applying WH&S policies, establishing and maintaining high moral levels and motivation.

Environmental Scientist & Geotechnical Engineer, Douglas Partners Environmental Consultants, 2012-2013

Shawn performed a variety of tasks including geotechnical and environmental fieldwork, laboratory testing & on-site supervision of sub-contractors. Projects included contaminated land management, waste management, salinity & acid sulphate soils assessment and geotechnical investigations. Regular duties included groundwater and soil investigation and monitoring, installing and developing groundwater wells and using various water sampling and monitoring equipment. Operating truck mounted push tube sampler for soil profiling, sampling and geotechnical investigations.

He also conducted numerous routine and advanced soil tests such as; soil classification, aggregate, soil compaction & density, soil strength & consolidation, soil permeability and dispersion, soil reactivity, penetration & deflection, concrete and rock testing. He assisted scientists and engineers with fieldwork, namely development, control & protection of groundwater resources predominantly at Kooragang island, Hexham swamp and Tomago areas.

Field Assistant, Nexus Archaeology Consultancy, 2011

Performed site surveying and recording using geophysical surveys, aerial photography, drafting and detailed notes. Carried out field excavations, orchestrating excavations with various equipment & heavy machinery, prepared preliminary site reports, research and desk-based assessments of sites.

Field Assistant, Eco-biological Consultants, 2011

Assisted in various field work including habitat assessment surveys, various flora and fauna surveys: spotlighting, use of Elliot traps, construction of pitfall traps, harp and mist net traps. Main duties included repairs and maintenance on traps and other field equipment.

Field Technician, Spectrum Acoustics, 2009-11

Duties included client liaison, coordination and implementation of attended and unattended remote compliance noise surveys, plant noise measurements, licensed premises monitoring, traffic and rail noise & vibration measurement, and data analysis and reporting

Alan Midgley

Ecologist

Role at RPS
Ecologist

Location
Newcastle, NSW, Australia

Qualifications
DipCon&LanMan, BEnvMan⪼ BSc (Hons); PhD

BAM Accredited Assessor (BAAS17094)

Memberships
Ecological Consultants Association of NSW (Practicing Member)

Australian Association of Bush Regenerators (AABR)

Why Alan for this role

Alan is an experienced Ecologist with 10 years' experience combined in terrestrial and aquatic ecology, bush regeneration and post-graduate research. He has played an integral role in a number of ecological projects throughout NSW, including in the telecommunication, energy and transport sectors.

Being a Biodiversity Assessment Method Accredited Assessor, Alan has experience conducting field BAM assessments under the new NSW *Biodiversity Conservation Act 2016*.

Relevant projects

Ecology Assessments for National Broadband Network (NBN) and Critical Communications Enhancement Program (CCEP), 2016-2019

Alan has completed numerous ecological assessments and associated site reporting for proposed telecommunication sites, delivered for the National Broadband Network (NBN) and the Critical Communications Enhancement Program (CCEP) throughout NSW. Tasks have included tree impact assessment, threatened species searches and providing advice to inform adaptive establishment of infrastructure to limit ecological impacts. Clients have included Aurecon and Visionstream.

Upgrade Works to Belford to Golden Highway New England Highway, 2016-2018

Alan conducted targeted winter bird surveys for the critically endangered Swift Parrot and Regent Honeyeater, completed BAM (Biodiversity Assessment Method) / BBAM (BioBanking Assessment Method) Plots and co-authored ecological reporting for the Roads and Maritime upgrade works to Belford to Golden Highway New England Highway.

Glen Innes Wind Farm, OneWind, 2016-2017

Alan completed a range of ecological works for the proposed Glen Innes Wind Farm project including conducting BBAM plots, vegetation mapping, extensive hollow-bearing tree survey design and implementation and ecological reporting including preparation of a Flora and Fauna Management Plan (FFMP) and Bird and Bat Adaptive Management Program (BBAMP).

Darlington Point Solar Farm, Riverina Region, Edify Energy, 2017-2018

Alan completed a range of ecological works for the proposed Darlington Point Solar Farm project including conducting BBAM plots, ecological reporting in line with complex site-specific considerations, harp trapping targeting the vulnerable Corben's Long-eared Bat, targeted threatened species surveys for flora and fauna including the critically endangered Plains Wanderer and vulnerable Superb Parrot. The project received development approval in December 2018.

Relevant projects

Speers Point Quarry, Lake Macquarie, de Witt Consulting, 2017

In a small team, Alan completed ecological fieldwork, provided bush regeneration/rehabilitation advice and reporting for a proposed residential development of a decommissioned quarry in Lake Macquarie.

Waterford County Staged Residential Development, County Property Group Pty Ltd, 2016-2017

Alan completed a variety of ecology assessments for the implementation of residential development stages within a housing estate, including targeted threatened species surveys, BBAM plots, hollow-bearing tree surveys and associative reporting.

Batemans Bay Road Bridge Upgrade, Aurecon, 2018

In a small team, Alan completed ecological fieldwork, including conducting BBAM plots for the proposed upgrade to Batemans Bay Road Bridge on the South Coast of NSW. Located in an area of sensitive threatened ecological communities (TECs), information collected was utilised to justify the presence/absence of particular TECs in consideration of complex information already collected in previous site assessments.

Worimi Ecotourism Facility, Worimi Local Aboriginal Land Council, 2017-2019

Alan completed a range of adaptive ecological fieldwork and reporting for a proposed ecotourism facility at Williamtown, NSW for the Worimi Local Aboriginal Land Council, including a range of targeted flora/fauna surveys, BBAM surveys, hollow-bearing tree surveys and trapping surveys. Technical ecological advice was provided in consideration of the threatened species Powerful Owl and White-bellied Sea Eagle.

Gillieston Heights Sewer Main and Water Main Extensions, GCA Engineering Solutions, 2017

Alan completed an ecological assessment along Cessnock Road, Gillieston Heights for proposed sewer main and water main extensions. Consideration of potential ecological impacts from the proposal were considered with a focus on Green and Golden Bell Frog, Grey-crowned Babbler, presence/absence of freshwater wetland TECs and trees requiring removal.

Hayden Beck

Senior Ecologist

Role at RPS
Senior Ecologist

Location
Newcastle, NSW, Australia

Qualifications
BSc (Mar Sc); BEnvSc (Hons); MSc (Res); PhD

BAM Accredited Assessor (BAAS19000)

AUSRIVAS Macroinvertebrate Bioassessment Training

Contaminated Site Assessment, Remediation and Management (CSARM) short course, UTS4X4 driving Certificate

White Card

Rail Industry Safety Induction - RISI

Memberships
Ecological Consultants Association of NSW (Practicing Member)

Why Hayden for this role

Hayden specialises in terrestrial, aquatic and marine ecology. As an Ecologist at RPS, Hayden undertakes fieldwork and prepares reports for diverse projects, including the mining and housing sectors.

Being a Biodiversity Assessment Method (BAM) Accredited Assessor, Hayden has considerable experience preparing Biodiversity Assessment Reports under the NSW *Biodiversity Conservation Act 2016*.

Relevant projects

33kV Power Easement for Mandalong Coal Mine, Centennial Coal, 2019

Hayden prepared a Biodiversity Development Assessment Report (BDAR) to determine the offset liability for this State Significant Development (SSD). This project extended 7.6km easement will extent through multiple Plant Communities. Preparation of this report involved collating multiple years of field data and specialist reports to assess impacts on biodiversity values. As part of this project, Hayden supported the lodgement an EPBC Act referral due to uncertain impacts on threatened flora.

Basalt Quarry, Boral, 2019

Hayden undertook a feasibility assessment for a proposed basalt mine at North Star, NSW. This project involved undertaking flora surveys across Semi-evergreen Vine Thicket EEC to determine the offset liability to develop the site. Three extraction options were assessed. Involvement included fieldwork, preparation of a report and presentation to the client.

NBN tower Installation, Vision Stream, 2019

Hayden prepared a BDAR to determine the offset liability for an infrastructure Project at Tallong, NSW. Impacts to ecosystems and threatened species were assessed for the installation of an access track, NBN tower and associated facilities.

LW22-24a and LW 25-31 Mandalong Coal Mine, Centennial Coal, 2019

Hayden organises annual monitoring of sensitive ecological communities, as well as frogs, to detect impacts of longwall mining. As a project manager, he coordinates teams of up to six ecologists to undertake surveys across a vast area.

Jemalong Solar Farm, Genex Power Pty Ltd, 2019

Hayden prepared an EPBC Act referral document for a proposed Solar Farm (SSD) in Jemalong, NSW. This Project involved assessing impacts of removing hollow-bearing trees on Swift Parrot and Corben's Long-eared Bat.

Relevant projects

Newcastle Light Rail (NLR) Project, Downer, 2019

Hayden prepared the ecological sections of an Infrastructure sustainability rating (ISCA) application for the 'As Built' stage of the NLR Project

Tikitere Quarry, SMK Consultants, 2017

Hayden assisted the ecological assessment of a basalt quarry at North Star, NSW. Tasks included fieldwork and assistance with reporting.

Concrete Batch Plant at Bushells Ridge, Advision, 2017

Hayden prepared a Flora and Fauna impact assessment for the proposed establishment of a concrete batch plant. This facility is currently being used to facilitate widening of the M1. This project involved several survey efforts targeting multiple threatened flora and fauna species, including a critically endangered orchid that was found on site.

Roads and Maritime Services, Road Upgrade Projects, 2016 to 2018

Hayden undertook Biodiversity Assessments for 15 road projects. Examples include:

- Widening of Golden Highway, Castlereagh Junction to Dunedoo;
- Shoulder Widening, Golden Highway (Segments 240 to 260), Denman;
- Culvert rehabilitation (23 sites): Old Pacific Highway, Kariong to Mooney Mooney;
- Manns Road Upgrade, West Gosford; and
- Drainage Upgrades to M1, Mt Pleasant, Roads and Maritime Services.

Dungog Council, Road Upgrade Projects, 2016

Hayden undertook Biodiversity Assessments and preclearance surveys for two road projects in Dungog Shire Council LGA.

Dan Creevey

Field Ecologist

Role at RPS
Field Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Science

Why Dan Creevey for this role

At RPS, Dan is a Field Ecologist with experience in flora survey and monitoring techniques.

Dan Creevey is an adaptable, hardworking team member with a particular interest in botany. His exposure to several survey methods and ability to lead field and coordinate fieldwork suits him to this project.

Relevant projects

Kings Hill Development – Threatened Species and Vegetation Surveys & Mapping, 2018-2019

Assisted the RPS Ecology team in undertaking Targeted Threatened Species Searches and extensive Vegetation Mapping surveys.

LW22-24a and LW 25-31 Mandalong Coal Mine, Centennial Coal, 2019

Dan undertakes annual monitoring of sensitive ecological communities, as well as frogs, to detect impacts of longwall mining. Here, Dan works within a large team to undertake floristic plots and monitor threatened plants across a vast area.

Swamp Monitoring Project, Centennial Coal, 2019

Employing a variety of survey techniques to gather floristic data within Threatened Highland Peat Swamps on Sandstone (THPSS) vegetation community. Survey techniques include; monitoring ground control points, carrying out threatened species surveys and annual transect monitoring. Data was then analysed and reported to the client as part of ongoing monitoring programs.

Newstan Extension Ecology Assessment, Centennial Coal, 2019

Carrying out flora and fauna surveys for threatened species located above a proposed mine extension. These surveys involved walking wandering transects to locate threatened species, installing nest boxes and carrying out bird surveys. Data was then analysed and reported to the client.

Mandalong Annual Monitoring, Centennial Coal, 2019

Assisted in carrying out BAM plots in a variety of vegetation types. Data was then analysed and reported to the client as part of an ongoing monitoring program.

Threatened Flora Monitoring: *Astrotricha crassifolia* and *Prostanthera junonis*, Newcastle University, 2016-2017

Conducted fieldwork to assess the population dynamics of locate then monitor remanent populations.

Relevant projects

Springvale Blue Mountains Water Skink (*Eulamprus leurensis*) monitoring, Centennial Coal, 2019

Field monitoring to assess the population dynamics of Blue Mountains Water Skink within swamps of the Newnes Plateau.

Joe Gibbs

Field Ecologist

Role at RPS
Field Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Environmental Science and Management (Earth Systems and Ecosystems & Biodiversity), University of Newcastle, 2016

ACDC Certification, GAQ, 2017

First aid and CPR training (HLTAID003, HLTAID001)

White Card

Operate and Maintain a 4WD (RIIVEH305E)

Operate and Maintain a Chainsaw (AHCMOM213)

BioCondition and QLD RE training by Oberonia Botanical Services

Fauna Spotter Catcher and Snake Handling training

Crocodile Awareness Training, DES, QLD

Why Joe for this role

Joe has over 7 years' experience in the environmental field. His field experience is complimented with his double major in Earth Systems and Ecosystems & Biodiversity.

As a Field Ecologist for RPS, Joe has developed a detailed knowledge in both field and desktop ecological services including flora and fauna surveys and monitoring.

Relevant projects

Blue Mountains Water Skink monitoring, Centennial Coal, 2019

Joe undertook field monitoring to assess the population dynamics of the Blue Mountains Water Skink *(Eulamprus leurensis)* within swamps of the Newnes Plateau, adjacent to Centennial Coal's Springvale Coal Mine.

Newstan Extension Ecology Assessment, Centennial Coal, 2019

Joe assisted in flora and fauna surveys for threatened species located above a proposed mine extension. These surveys involved walking wandering transects to locate threatened species and installing and checking of Elliot traps. Data was then analysed and reported to the client.

Newnes Plateau post-bushfire monitoring, Centennial Coal, 2020

Joe assisted with the installation and checking of camera traps and water / feed stations for fauna at Newnes Plateau as part of the post-bushfire monitoring program.

Threatened Species and Vegetation Surveys & Mapping, Kings Hill Development, 2019 – 2020

Assisted the RPS Ecology team in undertaking Targeted Threatened Species Searches, extensive Vegetation Mapping surveys and assisted with BAM plots.

Swamp Monitoring Project, Centennial Coal, 2019 – 2020

Employing a variety of survey techniques to gather floristic data within Threatened Highland Peat Swamps on Sandstone (THPSS) vegetation community.

Survey techniques include monitoring ground control points, carrying out threatened species surveys and annual transect monitoring. Data was then analysed and reported to the client as part of ongoing monitoring programs.

Relevant projects

Environmental Officer, Ecosure, February 2018-May 2019*

Joe undertook fauna spotter catcher fieldwork in remote areas for renewable energy, state government and local council clients. This included flora and fauna ID for pre-clearance surveys, clearance surveys, dewatering of culverts for road upgrades, and safe handling/relocation of fauna.

He conducted habitat quality and BioCondition assessments for industry offset programs and threatened ecological community assessments in remote, internationally significant wetlands, coastal vine thickets and litoral rainforest.

In his role, Joe complied with Defence access, clearance and communication protocols for biocondition assessment and regeneration works completed within a Department of Defence training area (Shoalwater Bay, QLD).

Joe undertook monthly, quarterly and annual groundwater quality monitoring at CS Energy's Callide power station. He also conducted water quality monitoring projects in high-ecological significance wetlands to comply with DES and EPA water-quality management plans.

Fitzroy River Turtle and White Throated Snapping Turtle Monitoring, Greening Australia QLD, 2017 – 2019*

Joe undertook the daily monitoring and protection of the nests of two threatened turtle species along the Fitzroy River, Central Queensland.

The collection of population and spatial data for these species was provided to the local Catchment Management Authority and QLD Dept. of Environmental Science.

Amphibian Research Group, University of Newcastle, 2012 – 2015*

Joe undertook over 400 hours of assistance to endangered amphibian conservation and breeding research. He conducted NSW-based field surveys including flora and fauna surveys, along with data collection in physically isolated areas.

Joe has extensive mark release recapture survey experience - amphibians and small mammals/marsupials.

** projects undertaken for previous employers*

Duncan Scott-Lawson

Bush fire Planner / Practitioner

Role at RPS
Bush fire Planner / Practitioner

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Environmental Science, University of Newcastle, 1995

Bachelor of Applied Science (Honours), Southern Cross University, 1996

Level 2 Bush fire Planning and Design (BPAD), Fire Protection Association of Australia (FPAA), 2019

Graduate Diploma in Bush fire Protection, Western Sydney University, Current

Memberships
Fire Protection Association Australia (FPAA)

Australasian Fire & Emergency Services Council (AFAC)

International Association of Wildfire (IAW)

Why Duncan for this role

Duncan has 18 years' experience as a bush fire planner including the development and implementation of strategic Bush fire Management Plans (BMPs), prescribed and cultural burning, and aviation and wildfire suppression operations throughout Australia. He is Level 2 Bush fire Planning and Design (BPAD) accredited and is currently concluding the top tier Level 3 accreditation.

Duncan works across multidisciplinary teams to provide project and client management; undertaking site inspections and the development of bush fire assessment and management plan reports for residential, commercial, industrial and Special Fire Protection Purpose (SFPP) developments throughout Australia.

In addition, Duncan has a background in ecology and land management with National Parks and Wildlife Service. This enables him to link a wide range of landscape attributes and planning processes to bush fire assessment and management programs.

Relevant projects

Special Fire Protection Purpose Development

Age-care facility – Dural, Sunglow RV One Unit Trust c/o Thelem Consulting Pty Ltd, 2018

Completed a Bush fire Threat Assessment for a 74-beds and 145 self-care housing units contained within 8 three storey buildings and a class 9b 'wellness centre'.

Caravan Park – Hallidays Point, Port Nortica, 2019

Increase existing land-use towards bush fire threat with manufactured homes and camping along the eastern boundary. A range of BPM were proposed to ensure compliance.

Eco-tourism – Laguna, VP Holidays Pty Ltd, 2019

Establishment of 3 lodges and residential dwelling that acted as a bush fire refuge adjacent to the Watagan State Forest, high bush fire prone area. Set-becks, and emergency management procedures were critical to this development.

Age-care facility – Bribie Island, Stockwell Development Group Pty Ltd, 2019

Completed a Bush fire management plan for a manufactured home estate comprising 200 individual sites, a recreation facilities, office, and parking, Appropriate set-back and emergency management were recommended for this development.

Relevant projects

Residential and Rural Sub-divisions

North Tuncurry Subdivision, Lendlease, 2019

Rezoning 615ha of land to accommodate low-medium density coastal community with approximately 2123 dwellings (4500 residents) centred around a new centre, reconfigured golf course, open spaces, supermarket and specialty stores.

Barden Ridge Subdivision, WINHO Trading Co, 2019

Completed a Bush fire Assessment Report for a 4-lot subdivision to obtain Bush fire Safety Authority from NSW RFS.

Rocky Springs QLD Subdivision, Lendlease, 2019

Bush fire assessment on a 6ha site undertaken in consideration of DRAFT Planning of Bush fire Resilient Communities (2018) and SPP DRAFT Natural hazards, risk and resilience – Bush fire (2018).

Industrial and commercial developments

Animal shelter / care facility – Fern Gully, Singleton Council, 2018

Completed a Bush fire Treat Assessment for class 8 building, 16 pens, office and carparking facility, which incorporated Taylor (2015) preparedness and evacuation behaviour of pet owners in emergencies and natural disasters.

Quarry – North Star, Boral, 2018

Completed a Bush fire Assessment Report for the development of a Rail loader and quarry throughout grassland hazards in western NSW.

University Accommodation and support infrastructure – Armidale, University of New England, 2018

Bush fire assessment of Robb and Wright college to satisfy the Planning Secretary's Environmental Assessment Requirements (SEARs). The construction included multiple structures, over 300 beds, 240 carparks, central 'hub / amphitheatre' for communal student use that include catering, gymnasium, study areas, and games rooms.

Telecommunication Tower – Currumbin - Visionstream Pty Ltd, 2019

Completed a Bush fire Management Plan in consideration of Gold Coast City Council Planning Scheme, s12 Building Regulation 2006 – local governments to designated bush fire prone areas, Part 2 Planning Regulation 2017 - compliance with the Building Code and AS 3959-2009 Construction of buildings in bush fire-prone areas.

Bush fire Due Diligence and Risk Assessments

Risk Analysis - Maribyrnong VIC, Department of Defence, 2018

Review of Risk Management documentation for the operational activities within Defence estate at Maribyrnong, Implementation of AS/NZS ISO 31000: 2009. Commonwealth and Victorian WHS legislation and Codes of Practice for Bush fire Management on public lands.

Solar Farm – Gulgong, UPC Renewables, 2019

Completed a Due Diligence in consideration of PBP 2018 for a proposed Solar farm at Gulgong. NSW. DPE Hazardous Industry Planning and Assessment Paper N0. 3, 2011 and a range of BPM were recommended to be incorporated into design to facilitate compliance.

Education facilities (school) – Glenfield, Jordan Springs and Alex Avenue, NSW Department of Education, 2018

Completed high level review of proposed school infrastructure in Bush fire prone areas. Assessment identified project risk with poor clarify in previous assessment methodology and lack of understanding of new Planning for Bush fire Protection 2018 processes and mitigation measures.

Residential dwellings and alterations and additions

Completed various Bush fire Threat Assessments in accordance with Planning for Bush fire protection 2006 and AS3959:2009 Construction of buildings in bush fire prone areas and Complying Development Certification in accordance with SEPP (Exempt and Complying Development Codes) 2008 for a range of residential developments, alterations and additions throughout NSW.

Bush fire Management Plans

Office of Environment and Heritage - National Parks and Wildlife Service

Project managed and completed the environmental assessments, data collection, field-based assessments and writing of over 10 Reserve Fire Management Strategies. Also complete the 5-year review and update of over 15 Reserve Fire Management Strategies while Employed as Fire Management Officer.