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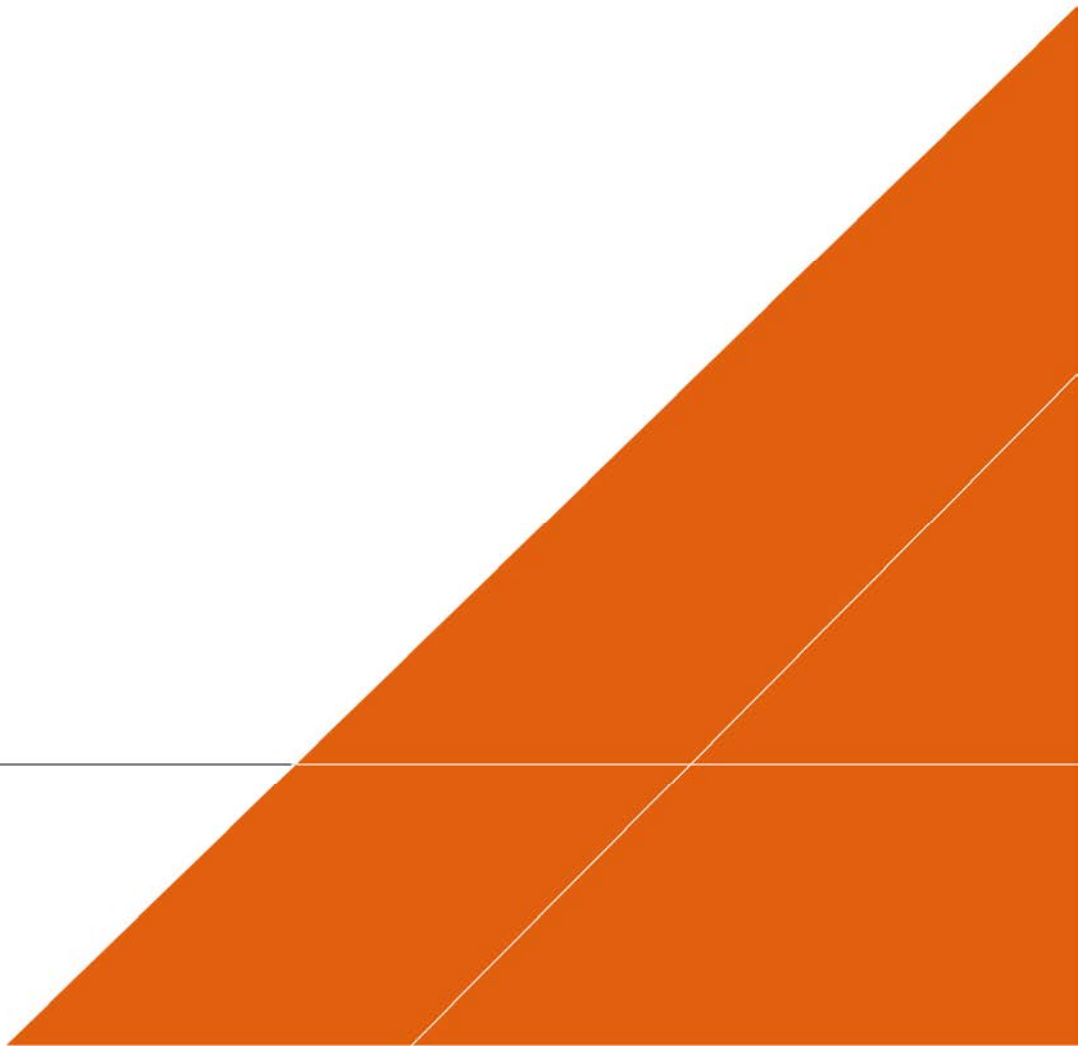
KINGS HILL WATER AND WASTEWATER PIPELINE

Biodiversity Development Assessment Report

FEBRUARY 2020



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KINGS HILL WATER AND WASTEWATER PIPELINE

Biodiversity Development Assessment Report

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REVISIONS

Revision	Date	Description	Prepared by	Approved by
A	2/10/2019	Draft BDAR	Kate Carroll, Jane Rodd, Meredith Leal, Sian Tetther, Carl Corden	Westley Owers
B	17/10/2019	Final draft BDAR	Kate Carroll, Jane Rodd	Westley Owers
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APPENDICES

GLOSSARY

The table below provides a glossary the key acronyms used within this technical report.

Term	Meaning
Acronyms	
BAM	Biodiversity Assessment Method
BAMC	Biodiversity Assessment Method Calculator
BC Act	NSW *Biodiversity Conservation Act 2016*
BC Regulation	NSW *Biodiversity Conservation Regulation 2017*
BDAR	Biodiversity Development Assessment Report
BOS	Biodiversity Offset Scheme
Buffer area	500 m along each side of the centre line of the proposed pipeline
CEEC	Critically Endangered Ecological Community
CEMP	Construction Environmental Management Plan
Development site	The area of land subject to the proposed development (analogous with the term 'Proposal site' in the EIS)
DoEE	Commonwealth Department of Environment and Energy
DP&E	NSW Department of Planning and Environment
DPI	NSW Department of Primary Industries
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FFMP	Flora and Fauna Management Plan
FM Act	NSW *Fisheries Management Act 1994*
GDE	Groundwater dependent ecosystems
IBRA	Interim Biogeographically Regionalisation of Australia
MNES	Matters of National Environmental Significance
OEH	NSW Office of Environment and Heritage
PCT	Plant Community Type
Proposal	The proposed pipelines and associated infrastructure subject to assessment in this report
SAII	Serious and Irreversible Impact
SEARs	Secretary's Environmental Assessment Requirements
SEPP	*State Environmental Planning Policy*
SSI	State Significant Infrastructure

Term	Meaning
TBDC	Threatened Biodiversity Data Collection
TEC	Threatened Ecological Community
VIS	Vegetation information system

EXECUTIVE SUMMARY

Kings Hill Development Pty Ltd is seeking approval for the development of a water supply pipeline 6.7 kilometres long, a wastewater pipeline 4.2 kilometres long and a Wastewater Pumping Station (the Proposal) to support the development of the Kings Hill Urban Release Area (URA), north of Raymond Terrace, NSW. The Proposal is located between Raymond Terrace in the south, and Kings Hill URA in the north.

Approval for the Proposal is sought as Designated Development under Part 4 of the *Environmental Planning and Assessment 1979*. This planning approval pathway is triggered as a result of the Proposal (in part) traversing a mapped Coastal Wetland (ID. 36586) under the *State Environmental Planning Policy (Coast Management) 2018*.

This Biodiversity Development Assessment Report (BDAR) has been prepared to support the Environmental Impact Statement (EIS) for the Proposal.

This BDAR is based on desktop research and detailed field surveys undertaken between November 2018 and August 2019.

The biodiversity impacts and offset requirements for the development site were calculated using the Biodiversity Assessment Method Calculator (BAMC) (Version 1.2.7.2) in accordance with the Biodiversity Assessment Method (OEH 2017).

The vegetation within the development site comprises three Plant Community Types (PCTs) and seven vegetation zones covering two Sydney Basin Interim Biogeographic Regionalisation for Australia (IBRA) regions and subregions. Plant Community Types within the development site, their associated vegetation zones and their calculated vegetation integrity scores are as follows:

Plant Community Type (PCT)	Vegetation zone	Vegetation integrity score	Area within development site (ha)
North Coast bioregion			
Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (PCT 1590)	1590 – Moderate	66.6	0.14
	1590 – Road batter	28.3	0.36
	1590 – Poor	11.8	0.03
Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter (PCT 1600)	1600 – Moderate	33.3	1.32
Sydney basin bioregion			
Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (PCT 1590)	1590 – Poor	14.6	0.07
Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands (PCT 1619)	1619 – Moderate	45.4	0.41
	1619 – Poor	25.8	0.66
	1619 – Planted trees	14.0	2.23
Total			**5.22**

Three non-native vegetation communities that are not equivalent to a PCT are present in the development site: Cleared grassland, Exotic trees and Urban verges. These areas cover about 13.07 hectares of the development site.

None of the vegetation in the development site is equivalent to any Threatened Ecological Community (TEC) listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The BAMC identified 22 candidate threatened flora species credit species associated with the PCTs in the development site. An additional 17 threatened flora species were identified

in database searches as recorded or considered likely to occur within 10 kilometres of the development site. Of the total 39 candidate threatened flora species, only one was considered to have a moderate likelihood of occurrence in the development site based on the presence of suitable potential habitat and nearby recent records, namely *Callistemon linearifolius.* Targeted searches for this species did not identify it as occurring on or near the development site. All other threatened flora species identified in database searches are considered to have a low likelihood of occurrence in the development site. No threatened flora species listed under the EPBC Act and/or BC Act were recorded within the development site.

The BAMC identified 18 predicted threatened fauna ecosystem credit species associated with the PCTs in the development site in addition to 18 candidate threatened fauna species credit species and 14 threatened fauna species to which both species and ecosystem credits may apply. An additional 75 threatened or migratory fauna species were identified in database searches as recorded or considered likely to occur within 10 kilometres of the development site.

Seven threatened fauna species listed under the BC Act were recorded in the development site or immediately adjacent during surveys undertaken for the project: Eastern False Pipistrelle (*Falsistrellus tasmaniensis*), Little Lorikeet (*Glossopsitta pusilla*), Eastern Coastal Free-tailed bat (*Micronomus norfolkensis*), Little Bentwing-Bat (*Miniopterus australis*), Large Bent-winged Bat (*Miniopterus orianae oceanensis*), Grey-crowned Babbler (*Pomatostomus temporalis temporalis*) and Grey-headed Flying-fox (*Pteropus poliocephalus*). Southern Myotis (*Myotis macropus*), also a species credit species, was potentially recorded in the development site.

An additional 11 threatened fauna species credit species are considered to have a moderate or higher likelihood of occurrence in the development site: Regent Honeyeater (*Anthochaera phrygia*), Glossy Black-Cockatoo (*Calyptorhynchus lathami*), White-bellied Sea-Eagle (*Haliaeetus leucogaster*), Little Eagle (*Hieraaetus morphnoides*), Swift Parrot (*Lathamus discolor*), Square-tailed Kite (*Lophoictinia isura*), Powerful Owl (*Ninox strenua*), Masked Owl (*Tyto novaehollandiae*), Squirrel Glider (*Petaurus norfolcensis*), Brush-tailed Phascogale (*Phascogale tapoatafa*) and Koala (*Phascolarctos cinereus*).

Areas of potential habitat have been identified in the development site for four species credit species: Southern Myotis, Brush-tailed Phascogale, Squirrel Glider and Koala.

Four threatened fauna species listed under the EPBC Act are known or considered likely to occur at the development site: Regent Honeyeater, Swift Parrot, Koala and Grey-headed Flying-fox.

The BDAR considered the construction and operational impacts of the Proposal. Where feasible, the design of the Proposal and proposed construction methodology has been refined to avoid or minimise impacts on biodiversity. Some biodiversity impacts are unavoidable. The direct, unavoidable, biodiversity impacts of the Proposal are as follows:

- Clearing of all vegetation within the development site. The total area of PCT vegetation to be cleared is 5.22 hectares none of which is equivalent to any listed TECs under the BC Act or EPBC Act.
- The clearing of 5.22 hectares of PCT vegetation would result in the loss of habitat for ecosystem credit species predicted to occur in the development site.
- The loss of specific habitat for four species credit species that are likely to occur in the development site. Impacts to species credit habitat for these species is as follows:
  - Southern Myotis: 0.1 hectares
  - Squirrel Glider: 1.97 hectares
  - Brush-tailed Phascogale: 1.97 hectares
  - Koala: 1.88 hectares.

- Fauna injury or mortality may occur during vegetation clearing activities.

The indirect impacts of the project on biodiversity include:

- Inadvertent impacts on adjacent native vegetation and habitat
- Reduced viability of adjacent habitat due to edge effects
- Reduced viability of adjacent habitat due to noise, dust or light spill
- Transport of weeds and pathogens from the site to adjacent vegetation.

Prescribed biodiversity impacts in the BAM that are relevant to the Proposal are:

- Impacts of development on the habitat of threatened species or ecological communities associated with non-native vegetation – trees and shrubs associated with non-native vegetation offer foraging, nesting and sheltering habitat to locally occurring threatened birds, arboreal mammals and Grey-headed Flying-fox.
- Impacts of development on the habitat of threatened species or ecological communities associated with human made structures – several nest boxes are present in the development site which may be inhabited by threatened fauna species such as microbats.

Significant Impact Assessments using the EPBC Act Significant Impact Criteria were carried out for the four EPBC listed threatened fauna species known or considered likely to occur in the development site. The assessments determined that the Proposal would not significantly impact any of the threatened species assessed. As such the Proposal is not considered likely to require referral to the Australian Government Minister for the Environment.

Impacts on the identified biodiversity values have been avoided and minimised in the Proposal as far as practicable. Where impacts cannot be avoided, the scale and extent of impacts has been determined, and a range of mitigation measures have been recommended to ameliorate impacts on the biodiversity values during construction and operation including:

- Minimising/avoiding vegetation removal when micrositing the pipeline footprint during detailed design and construction
- Implementing noise mitigation measures near the Grey-headed Flying-fox camp in Raymond Terrace
- Implementing erosion and sediment control measures for works near Irrawang Swamp and watercourses.

The offsets required for the project were calculated using the BAMC; 42 ecosystem credits and 110 species credits are required to offset the impacts of the Proposal, as detailed below.

Biodiversity value	Credit requirement
Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (PCT 1590)	7 ecosystem credits
Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter (PCT 1600)	22 ecosystem credits
Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands (PCT 1619)	13 ecosystem credits
Myotis macropus Southern Myotis	1 species credit

Biodiversity value	Credit requirement
Petaurus norfolcensis Squirrel Glider	37 species credits
Phascogale tapoatafa Brush-tailed Phascogale	37 species credits
Phascolarctos cinereus Koala	35 species credits

1 INTRODUCTION

1.1 The Proposal

Kings Hill Development Pty Ltd (KHD) is seeking approval for the development of a water supply pipeline, a wastewater pipeline and a Wastewater Pumping Station (the Proposal) to support the development of the Kings Hill Urban Release Area (URA), north of Raymond Terrace, NSW. The Proposal is located between Raymond Terrace in the south, and Kings Hill URA in the north.

Approval for the Proposal is sought as Designated Development under Part 4 of the *Environmental Planning and Assessment 1979* (EP&A Act). This planning approval pathway is triggered as a result of the Proposal (in part) traversing a mapped Coastal Wetland (ID. 36586) under the *State Environmental Planning Policy (Coast Management) 2018* (Coastal Management SEPP).

The Proposal includes water and wastewater pipelines of about 6.7 kilometres and 4.2 kilometres in length, respectively, and an associated Wastewater Pumping Station (WWPS) within Kings Hill URA. The water pipeline would connect to existing Hunter Water Corporation (HWC) infrastructure in the south and the Kings Hill URA in the north, while the wastewater pipeline would connect to the proposed WWPS in Kings Hill URA and existing HWC infrastructure in the south.

This Biodiversity Development Assessment Report (BDAR) has been prepared to address the relevant Secretary's Environmental Assessment Requirements (SEARs) (No. 1291) provided for the Proposal in accordance with Section 4.12(8) of the EP&A Act and Schedule 3 the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation).

Water and wastewater infrastructure would be developed to service the first stage of development of Kings Hill URA. Key components of the Proposal include:

- A water pipeline approximately 6.7 kilometres in length that would connect to existing HWC infrastructure in the south and Kings Hill URA in the north
- A wastewater pipeline approximately 4.2 kilometres in length that would connect to existing HWC infrastructure in the south and the wastewater pumping station (WWPS) to be constructed within Kings Hill URA in the north
- A WWPS within Kings Hill URA, including a hardstand area for vehicular access during operation
- Temporary compound areas to be utilised during construction.

The Proposal includes the connection of the URA to the existing water and wastewater services. The proposed pipelines terminate at the south of the URA. Further development of water and wastewater infrastructure (i.e. additional or upgraded infrastructure) would be required to service Kings Hill URA as additional stages are developed. This further development of water and wastewater infrastructure does not comprise part of the Proposal, i.e. is subject to future approval.

1.1.1 Design and construction

1.1.1.1 Wastewater Pumping Station

A WWPS would be designed and constructed in accordance with HWC's specifications within the south-eastern portion of Kings Hill URA.

The exact location of the WWPS would be determined during detailed design. Figure 1-1 identifies the area within which a final location would be chosen.

1.1.1.2 Wastewater pipeline

The wastewater pipeline would be approximately 4.2 kilometres long and would convey wastewater from the WWPS within Kings Hill URA in the north, to HWC's existing network in Raymond Terrace in the south.

Ventilation stacks would be constructed to provide effective odour removal along the wastewater pipeline. A stack is already located where the proposed pipeline would connect to the existing gravity network in the middle of the development site (see Figure 4-10 in the EIS). Additional stacks would be located at the WWPS and, where required, at high points along the alignment. The exact location of the stacks would be determined during detailed design.

1.1.1.3 Water infrastructure

A watermain would convey potable water from HWC's existing network in Raymond Terrace in the south to Kings Hill URA in the north.

The watermain would be connected to an existing water pump station at Raymond Terrace, located near the intersection of Irrawang Street and William Street. Water would flow through the watermain about 6.7 kilometres to the south-eastern portion of Kings Hill URA.

Construction of this water infrastructure would also include adjustment to pump set points, and minor modifications to surrounding pipework at the existing water pump station at Raymond Terrace. Hydrants and stop valves would be installed at regular intervals along the pipeline in easily accessible locations, as per HWC requirements. Fourteen scour valves and 13 air valves would be installed along the alignment at topographic low points and high points.

A chlorine injection point would be required at the northern end of the pipeline adjacent to KHD. The exact location of the point would be determined during detailed design. Figure 1-1 identifies the area within which a final location would be chosen.

1.1.1.4 Construction methodology

Construction for the Proposal would be likely to begin in 1st quarter of 2020 and last approximately nine months. Construction would be likely to occur concurrently in multiple decentralised work zones and as such, work would be at various stages at different points within the Proposal site. Construction in the vicinity of Adelaide St between William Bailey St and the Sleepy Hill Motor Inn, as well as construction through Newbury Park, would occur between March and August only. Construction along the remainder of the alignment would occur year-round.

The final construction program would be determined prior to construction and be subject to the timing of the Kings Hill URA development (separate approvals and market demands).

The proposed working hours for construction activities (including the delivery of plant and equipment) would be limited to the following standard construction hours:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- Sunday and public holidays: No work.

Some additional construction works would be undertaken outside of standard daytime construction working hours. This may include:

- Cut in to existing live water and wastewater networks[1]

[1] This may require the temporary shut-down (at night) of existing services

- Crossing of roads including (but not limited to) Irrawang St, Adelaide St, Tregenna St and Alton Rd
- Relocation of other services, if required.

Extended hours could include the above works and any considered suitable may be undertaken 24 hours, six days a week.

The construction works have been divided into seven ‘works stages’ which are interrelated and would potentially overlap. Subject to confirmation from the construction contractor, the order and staging of these construction works periods may change, but are anticipated to be:

1. Site establishment
2. Vegetation clearing
3. Trenching and underboring
4. Installation of water and wastewater pipelines
5. WWPS construction
6. Connection to existing HWC infrastructure
7. Site restoration

1.1.2 Development site

The development site for the Proposal includes the footprints of the wastewater pumping station, water pipeline and wastewater pipeline, in addition to buffer areas and temporary construction compounds. It totals an area of 25.02 hectares and is shown in Figure 1-1. The area is overestimated to allow for flexibility for unforeseen requirements such as utility relocation.

Figure 1-1 The development site

1.2 Proposal location

The Proposal is located within Port Stephens LGA, approximately four kilometres north of Raymond Terrace, 25 kilometres north of Newcastle and 135 kilometres north of Sydney.

About 80 percent of the Proposal is located within the Hunter sub-region within the Sydney Basin Interim Biogeographic Regionalisation for Australia (IBRA) Bioregion. The remaining 20 percent of the Proposal is located within the Karuah Manning sub-region within the North Coast IBRA Bioregion (Figure 1-2).

The southern portion of the development site is located within Raymond Terrace and traverses urban areas characterised by low density residential development. The northern portion of the Proposal site is located within an overhead electrical easement in otherwise undeveloped “greenfield” land, owned and managed by the HWC. This land also contains a Coastal Wetland (ID. 36586) listed under Coastal Management SEPP. The northern-most extent of the Proposal site is located within the Kings Hill URA, which is currently undeveloped and supports cattle grazing.

Located to the east of the northern portion of the Proposal site is the Pacific Highway, and further east, Grahamstown Dam (approximately 300 metres at its closest point to the Proposal site). Grahamstown Dam covers 2,800 hectares and is the Hunter’s largest drinking water supply dam. Grahamstown Spillway, constructed in 2005, allows for the safe discharge of flows from the dam towards the Coastal Wetland in the west. The smaller Irrawang Spillway (located north of Grahamstown Spillway) is no longer operational. The Proposal would traverse both spillways, on the western side of the Pacific Highway (Figure 1-2).

Figure 1-2 Site Map

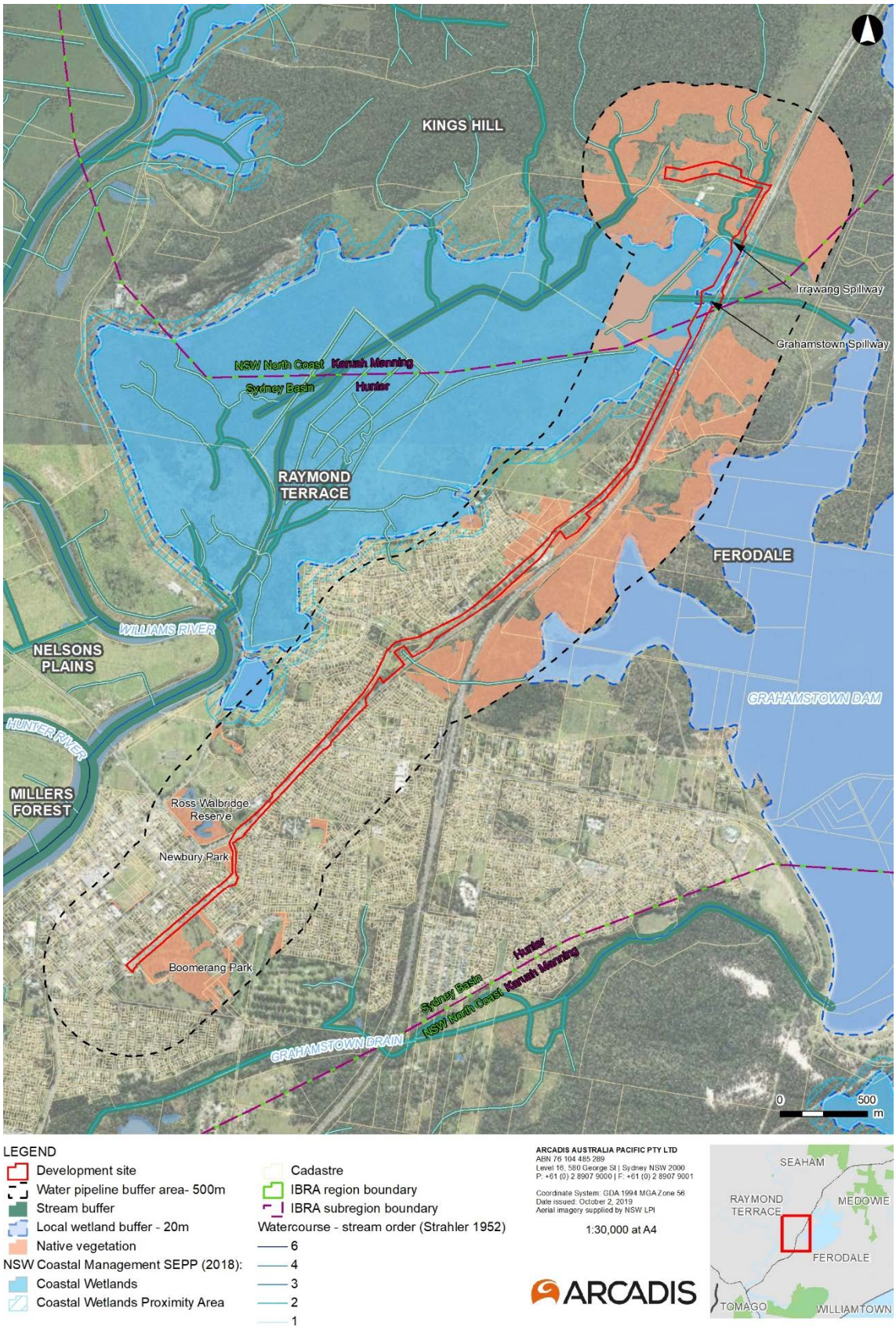
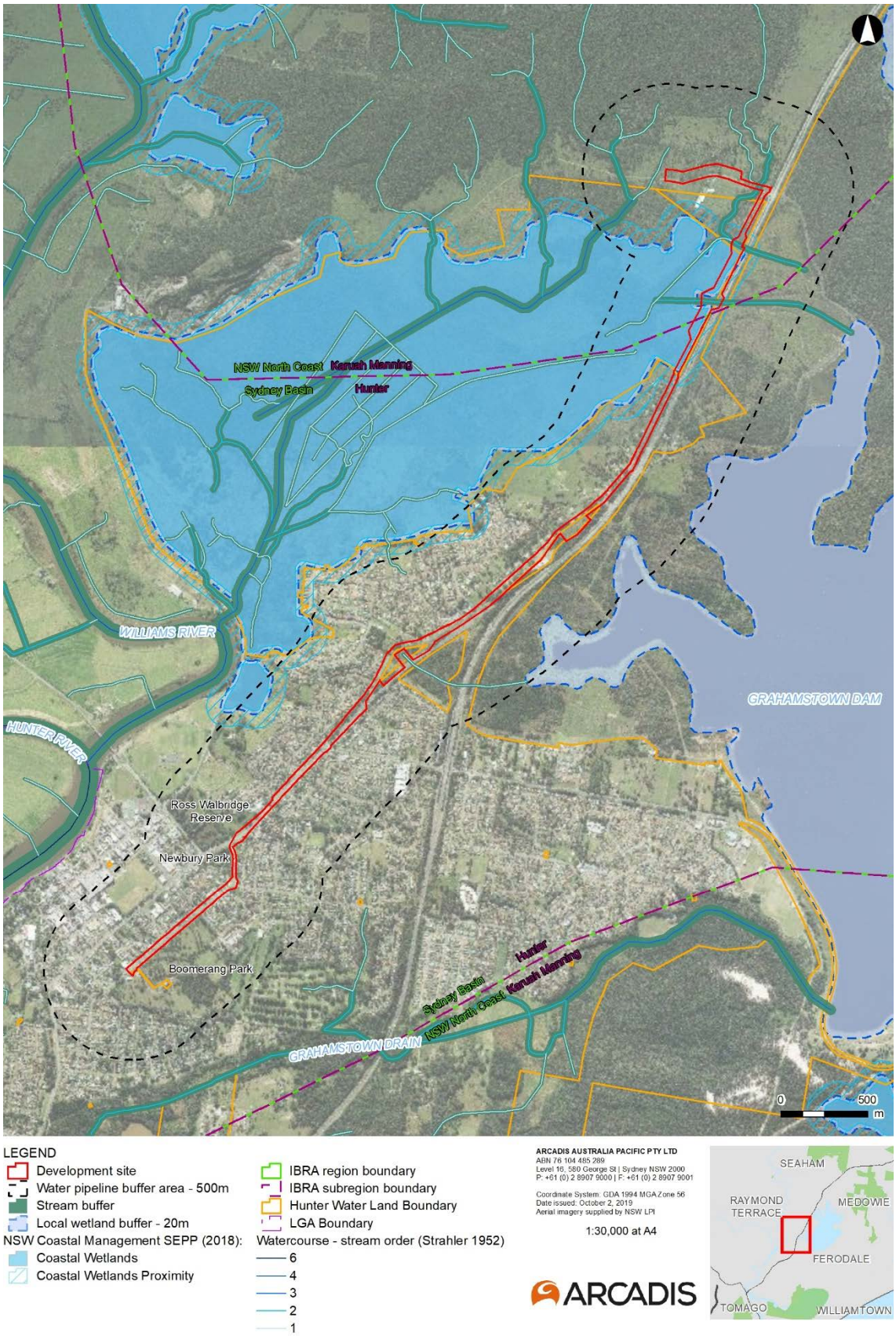


Figure 1-3 Location Map



1.3 Purpose of this report

This Biodiversity Development Assessment Report (BDAR) forms part of the Environmental Impact Statement (EIS) being prepared for the water and wastewater pipelines and WWPS (the Proposal) and assesses the biodiversity impacts of the Proposal.

1.4 Legislative context and SEARS

The Secretary's Environment Assessment Requirements (SEARs) which set out the requirements of the EIS were issued on 19 February 2019 (No. 1291). SEARs relating to biodiversity, and where they are addressed, are listed in Table 1-1.

Table 1-1 SEARs relating to biodiversity

Biodiversity assessment	Section addressed
NSW Department of Planning, Industry and Environment (DPIE)	
Accurate predictions of any vegetation clearing on site.	Section 8.1.1
An assessment of the proposal in accordance with the Biodiversity Assessment Method (BAM) including the potential impacts on any threatened species, populations, endangered ecological communities or their habitats and groundwater dependent ecosystems. This document	This document
A detailed description of the measures to avoid, minimise, mitigate and offset biodiversity impacts.	Sections 7.1, 1 and 0
The EIS must assess the proposal against the relevant environmental planning instruments, including but not limited to: … • *State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017* • *State Environmental Planning Policy (Coastal Management) 2018* • *…State Environmental Planning Policy No 44–Koala Habitat Protection*	Sections 1.4.4, 1.4.5, 1.4.6, 4.9, 5.2.1, 8.5
NSW Office of Environment and Heritage (OEH)	
The EIS should include an assessment of the following: a. The EIS must assess the impact of the proposed development on biodiversity values to determine if the proposed development is "likely to significantly affect threatened species" for the purposes of Section 7.2 of the Biodiversity Conservation Act 2016 (BC Act), as follows: a. The EIS must demonstrate and document how the proposed development exceeds, or does not exceed, the biodiversity offsets scheme threshold as set out in Section 7.4 of the BC Act 2016 and Clause 7.1 of the Biodiversity Conservation Regulation 2017 (BC Regulation) by determining whether the proposed development involves:	Section 1.4.1, this document

Biodiversity assessment	Section addressed
i. **The clearing of native vegetation exceeds the thresholds** listed under Clause 7.23 of the BC Regulation, **or** ii. The clearing of native vegetation, or other action, **on land included on the Biodiversity Values Map** published under Clause 7.23 of the BC Regulation (this map includes areas of outstanding biodiversity value, as declared under Section 3.1 of the BC Act). b. If the proposal does not trigger any of the criteria in (a) above, then the EIS must determine whether the proposed development is likely to have a significant impact based on '*the test for determining whether proposed development likely to significant affect threatened species or ecological communities'* in Section 7.3 of the BC Act. c. Where there is reasonable doubt regarding potential impacts, or where information is not available, then a significant impact upon biodiversity should be considered likely when applying the test in Section 7.3 of the BC Act. Where it is concluded that there is no significant impact, the EIS must justify how the conclusion has been reached. d. If the development exceeds the thresholds in (a) or (b), then the EIS must be accompanied by a biodiversity development assessment report (BDAR) prepared in accordance with Part 6 of the BC Act. That is, the Biodiversity Assessment Methodology applies.	
Where development is considered "likely to significantly impact on threatened species" and a Biodiversity Development Assessment Report is required, the following requirements apply: • Biodiversity impacts related to the proposal are to be assessed in accordance with the Biodiversity Assessment Method and documented in a Biodiversity Development Assessment Report (BDAR). The BDAR must include information in the form detailed in the *Biodiversity Conservation Act 2016* (s6.12), *Biodiversity Conservation Regulation 2017* (s6.8) and Biodiversity Assessment Method.	This document
• The BDAR must document the application of the avoid, minimise and offset hierarchy including assessing all direct, indirect and prescribed impacts in accordance with the Biodiversity Assessment Method.	Sections 7 and 8
• The BDAR must include details of the measures proposed to address the offset obligation as follows: – The total number and classes of biodiversity credits required to be retired for the proposal. – The number and classes of like-for-like biodiversity credits proposed to be retired.	Section 0

Biodiversity assessment	Section addressed
– The number and classes of biodiversity credits proposed to be retired in accordance with the variation rules. – Any proposal to fund a biodiversity conservation action. – Any proposal to make a payment to the Biodiversity Conservation Fund.	
• If seeking approval to use the variation rules, the BDAR must contain details of the reasonable steps that have been taken to obtain requisite like-for-like biodiversity credits.	Section 0
The BDAR must be prepared by a person accredited to apply the Biodiversity Assessment Method under s6.10 of the *Biodiversity Conservation Act 2016*.	Section 2.1
Where a BDAR is not required and a threatened species assessment is prepared to support a conclusion of "no significant impact", the EIS must include a field survey of the site, conducted and documented in accordance with the relevant guidelines including the Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians (DECCW, 2009), Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities - Working Draft (DEC, 2004) and Guidelines for Threatened Species Assessment (Dept Planning, July 2005). The approach should also reference the field survey methods and assessment information on the OEH website including the Bionet Atlas, Threatened Species Profile and Bionet Vegetation Classification (see Attachment 2).	Not applicable

1.4.1 Biodiversity Conservation Act 2016

The purpose of the *Biodiversity Conservation Act 2016* (BC Act) is to maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development. The BC Act replaced and repealed the TSC Act on 25 August 2017. The BC Act incorporates broadly similar objectives to those identified the TSC Act, and additionally seeks to establish a framework for assessment and offsetting of development impacts as well as investment in biodiversity conservation. The NSW Biodiversity Offsets Scheme (BOS) is established under Part 6 of the BC Act and the Biodiversity Assessment Method (BAM) is established under Section 6.7 of the BC Act. The purpose of the BAM is to prescribe requirements for the assessment of certain impacts on threatened species and Threatened Ecological Communities (TECs), and their habitats, and the impact on biodiversity values, where required under the BC Act.

For proposals assessed under Part 4 of the EP&A Act, the application for development consent must be accompanied by a BDAR as required by the BAM if it is likely to 'significantly impact on threatened species'. The thresholds for determining whether the Proposal is likely to significantly impact on threatened species are defined in Clause 7.1(1b) of the *Biodiversity Conservation Regulation 2017* and include:

- The clearing of native vegetation on land included on the Biodiversity Values Map; or

- The clearing of native vegetation exceeding the following thresholds:
  - 0.25 hectares or more for minimum lot size less than 1 hectare
  - 0.5 hectares or more for minimum lot size less than 40 hectares but not less than 1 hectare
  - 1 hectare or more for minimum lot size less than 1,000 hectares but not less than 40 hectares
  - 2 hectares or more for minimum lot size 1,000 hectares or more.

The Proposal occurs on land identified on the Biodiversity Values Map which triggers the threshold for entry into the BOS. Accordingly, a BDAR must be prepared by an accredited assessor under the BAM (this report). This BDAR was prepared by two accredited assessors: Kate Carroll and Jane Rodd, and was reviewed by Ed Cooper, also an accredited assessor. Their qualifications and accreditation numbers are provided in Section 2.1. Kate Carroll holds the BAM calculator files.

1.4.2 Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) provides for the identification, conservation and recovery of threatened fish, aquatic invertebrates and marine vegetation. The Act also covers the identification and management of key threatening processes which affect threatened species or could cause other species to become threatened.

If a planned development or activity is likely to have any impact on a threatened species listed under the FM Act, an Assessment of Significance must be undertaken. If the impacts are likely to be significant, or if critical habitat is affected, a species impact statement must be prepared.

Irrawang Spillway and its tributaries are mapped as Key Fish Habitat by NSW DPI (2007) (Figure 3-1). Key Fish Habitat is not defined in the FM Act, however one of the objectives of the FM Act is to conserve key fish habitats.

Under Clause 201 of the FM Act, a permit is required for dredging and reclamation. The Proposal would require dredging and reclamation at the Kings Hill URA watercourse, where trenching is required for pipeline installation triggering the requirement for a permit.

Under Clause 219 of the FM Act, fish passage must not be blocked.

1.4.3 Biosecurity Act 2015

The NSW *Biosecurity Act 2015* requires any person who deals with any biosecurity matter, include or 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. Biosecurity matters include weeds and pathogens. Weeds are managed in accordance with control regions. Within each of the regions are listed priority weeds. These priority weeds are allocated different measures based on their threat level.

1.4.4 State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017

In accordance with Clause 5(b), the *State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017* applies to land with the following zones that are found in the development site:

- Zone E2 Environmental Conservation
- Zone R1 General Residential
- Zone R2 Low Density Residential

- Zone R3 Medium Density Residential
- Zone RE1 Public Recreation
- Zone SP1 Special Activities (Hunter Water)
- Zone SP2 Classified Road

Approval from the Native Vegetation Panel is required for clearing of native vegetation that exceeds the BOS threshold. As noted in Section 1.4.1, the BOS threshold is triggered by the Proposal. In determining an application for approval, the Native Vegetation Panel is to take into consideration the following:

- the likely impact of the proposed clearing on biodiversity values as set out in the BDAR
- whether the clearing of the native vegetation is likely to cause or increase soil erosion, salination, acidification, land slip, flooding, pollution or other adverse land or water impacts
- any future clearing of native vegetation on the land that has been duly authorised or notified but not yet carried out
- any biodiversity or heritage matter that an applicable environmental planning instrument or development control plan requires the Panel to take into consideration in relation to the impact of the proposed clearing

Biodiversity impacts and impacts to soil and water as a result of vegetation clearing for the Proposal are outlined in Section 8.

No approval for future vegetation clearing on the development site is currently known. The Proposal's consistency with the *Port Stephens Development Control Plan 2014* (Port Stephens DCP) is outlined in Section 5.5.2 of the EIS.

1.4.5 State Environmental Planning Policy (Coastal Management) 2018

The aim of Coastal Management 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.

b) establishing a framework for land use planning to guide decision-making in the coastal zone.

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 mapping associated with the Coastal Management SEPP shows that about 700 metres of the water and wastewater infrastructure alignment transects the eastern margin of Coastal Wetland (I.D. 36586) and its associated Proximity Area.

Under Clause 10(2), development (including vegetation clearing and earthworks) within a mapped Coastal Wetland (other than development for the purpose of environmental protection works), is declared to be Designated Development for the purposes of the EP&A Act.

Under Clause 10(4) development consent must not be given unless the consent authority is satisfied that sufficient measures have been, or will be, taken to protect, and where possible enhance, the biophysical, hydrological and ecological integrity of the coastal wetland. Section 1 of this report includes measures to minimise impacts to the Coastal Wetland. Under Clause

11 (1) development consent must not be granted to development on land identified as "proximity area for coastal wetlands" unless the consent authority is satisfied that the proposed development will not significantly impact on the biophysical, hydrological or ecological integrity of the adjacent coastal wetland or the quantity and quality of surface and ground water flows to and from the adjacent coastal wetland. Section 8.6 of this report assesses the significance of impact on the coastal wetland in consideration of these factors.

1.4.6 State Environmental Planning Policy No 44–Koala Habitat Protection

State Environmental Planning Policy No.44 - Koala Habitat Protection (SEPP 44) aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for Koalas to ensure that permanent free-living populations are protected in their present range, and to reverse the current trend of population decline. SEPP 44 contains prescriptions for the consideration of "potential Koala habitat" and "core Koala habitat" for developments within LGAs listed in Schedule 1 of the Policy. The policy applies to the Proposal as the Port Stephens LGA is listed in Schedule 1. Port Stephens Comprehensive Koala Plan of Management (2002) (CKPoM) applies to the site and an assessment of Koala habitat in accordance with SEPP 44 and the CKPoM has been undertaken in Section 5.2.1.

1.4.7 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is Commonwealth legislation that provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, defined in the EPBC Act as Matters of National Environmental Significance (MNES). MNES identified in the EPBC Act include:

- World heritage properties
- National heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Threatened species and communities
- Migratory species protected under international agreements
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mines).

Under the EPBC Act, actions that have, or are likely to have, a significant impact on a MNES requires approval from the Australian Government Minister for the Department of the Environment and Energy (DoEE) (the Minister). Assessments have been prepared for potential impacts to MNES in Appendix A in accordance with the *Matters of National Environmental Significance: Significant impact guidelines 1.1* (Commonwealth of Australia, 2013).

2 METHODS

The Proposal is a linear shaped development in accordance with the definition in the Biodiversity Assessment Method (BAM) (OEH 2017a). Linear development assessment requirements outlined in the BAM have been followed in this report.

2.1 Personnel and qualifications

This BDAR has been prepared by a team of Arcadis ecologists. Table 2-1 lists these personnel and their roles in preparation of this BDAR.

All work for this BDAR, including field surveys, was carried out under the appropriate licences, including scientific licences as required under Clause 22 of the *National Parks and Wildlife Regulations 2002*, Section 132C of the *National Parks and Wildlife Act 1974* (License Number: SL100646).

Table 2-1 Relevant personnel

Personnel	Qualifications	Role
Kate Carroll	Bachelor of Science (Honours) Accredited BAM Assessor (BAAS17070)	Lead report author Lead field zoologist
Jane Rodd	Bachelor of Science Accredited BAM Assessor (BAAS17030)	Report author Lead field botanist
Carl Corden	Bachelor of Environmental Management	Report author
Ed Cooper	Bachelor of Science (Honours) Accredited BAM Assessor (BAAS18047)	Technical report reviewer
Meredith Leal	Bachelor of Environmental Management	Report author Field support
Sian Tetther	Bachelor of Science Masters of Science Communication	Report author

2.2 Desktop assessment

The following reports and literature relevant to the Proposal and development site were reviewed:

- Port Stephens Council Comprehensive Koala Plan of Management (CKPoM) (Port Stephens Council 2002)
- Assessment of wetland vegetation and habitats within Irrawang Swamp to inform REF for proposed storm water Channel, Kings Hill NSW (BIOCM 2017)
- Preliminary assessment of the Kings Hill URA impacts on Irrawang Swamp ecology (Alluvium 2019)
- Kings Hill Development – Species Impact Statement (RPS 2019)

- The Bioregions of New South Wales their biodiversity, conservation and history (NPWS 2003)
- Vegetation Information System Classification database (DPIE 2019b)
- Raymond Terrace Flying-fox Camp Management Plan (Port Stephens Council, 2018)
- Referral guideline for management actions in grey-headed and spectacled flying-fox camps (Commonwealth of Australia 2015)
- Key Fish Habitat Mapping – Port Stephens LGA (DPI 2007)
- *State Environmental Planning Policy (Coastal Management) 2018* - maps and shapefile dataset (DPIE)

The following vegetation mapping datasets have been reviewed and considered in determining native vegetation present:

- Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS) (VIS map 2225) (OEH 2010)
- Greater Hunter Native Vegetation Mapping (OEH 2012)
- Hunter Native Vegetation Mapping Geodatabase Guide (Siversten *et al.* 2011).

Additional spatial datasets also considered as a part of the desktop assessment include:

- *State Environmental Planning Policy (Coastal Management) 2018* - maps and shapefile dataset (DPIE)
- Key Fish Habitat Mapping – Port Stephens LGA (DPI 2007)
- Koala habitat planning map (Port Stephens Council 2002)
- Biodiversity Values Map and Threshold Tool (Department of Finance, Services & Innovation 2018)

Additionally, database searches were undertaken to identify State and Commonwealth records of threatened entities and Commonwealth MNES that occur or have the potential to occur within 10 km of the development site. These are listed in Table 2-2.

Table 2-2 Database searches

Database	Search area	Date conducted
NSW BioNet Species Sightings data collection, managed by the NSW Office of Environment and Heritage (OEH)	10 km of the development site	19 November 2018, 29 August 2019
Protected Matters Search Tool, managed by the Commonwealth Department of the Environment (DoE)	10 km of the development site	19 November 2018, 30 August 2019
BioNet Vegetation Classification data collection managed by OEH	Development site and locality	Referenced throughout
BioNet Threatened Species data collection, managed by OEH	Development site and locality	Referenced throughout
NSW WeedWise, managed by DPI	Development site and locality	Referenced throughout
Fisheries NSW Spatial Data Portal	Development site and locality	9 January 2019

Database	Search area	Date conducted
Groundwater Dependent Ecosystems Atlas (BOM)	Development site and locality	9 January 2019

Ecosystem and Species Credit candidate species for this assessment were identified using the Biodiversity Assessment Method calculator (BAMC) and supplemented with database searches as outlined in Table 2-2.

2.3 Field surveys

The area subject to biodiversity field surveys included the development site and adjacent areas potentially subject to indirect impacts. Survey effort, including the locations of vegetation plots and targeted threatened species surveys, is mapped in Figure 2-1.

2.3.1 Timing

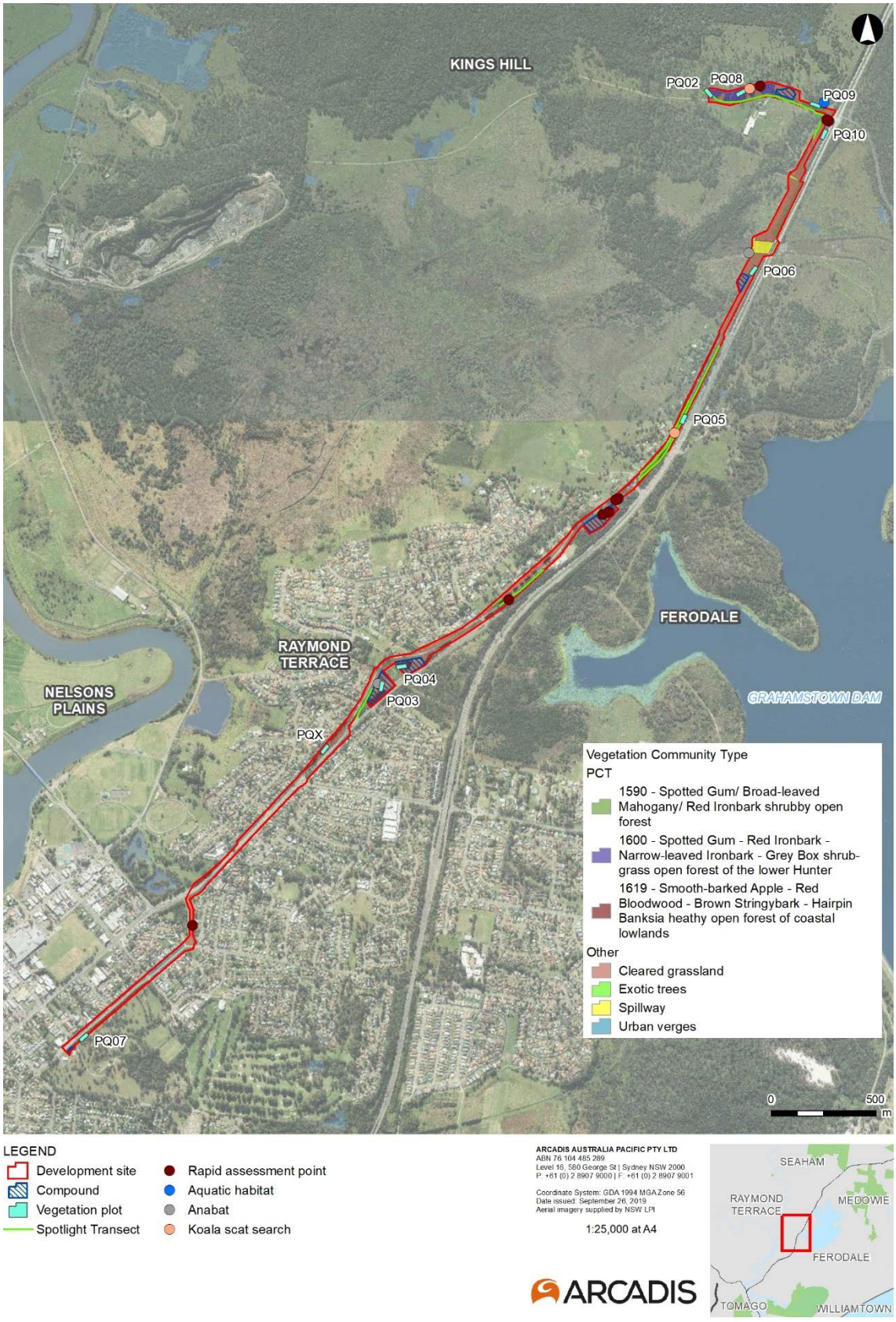
Flora and fauna surveys were conducted across the development site over six days in November and December 2018 and August 2019. Surveys included vegetation surveys to classify vegetation into vegetation zones and assess condition as well as targeted flora and fauna surveys for any species which were determined to have a moderate or high likelihood in the development site.

Weather conditions during the time of surveys were warm and dry. The weather records from Williamtown RAAF (station 061078), approximately eight kilometres from the development site, for the dates of the field surveys are detailed in Table 2-3.

Table 2-3 Weather conditions during survey periods (BOM, 2019)

Date	Surveyors	Temperature		Rain	Maximum wind gust	
		Min (°C)	Max (°C)	(mm)	Direction	Speed (km/h)
26 November 2018	Jane Rodd, Kate Carroll	13.1	24.8	0	S	33
27 November 2018	Jane Rodd, Kate Carroll	13.0	25.5	0	E	26
04 December 2018	Jane Rodd, Kate Carroll, Meredith Leal	15.0	26.2	0	ESE	33
05 December 2018	Jane Rodd, Kate Carroll, Meredith Leal	19.4	22.9	0	ESE	22
19 August 2019	Jane Rodd, Kate Carroll	11.1	18.8	0	WSW	56
20 August 2019	Jane Rodd, Kate Carroll	6.4	20.8	0	WNW	54

Figure 2-1 Survey effort



2.3.2 Native vegetation

Ten 0.1-hectare vegetation plots were used to sample the vegetation of the development site. The vegetation plot was undertaken in accordance with the guidelines in Section 5.3 of the BAM, as summarised in Table 2-4 Data collected from vegetation integrity plots below. Figure 2-2 Flora quadrat layout illustrates the plot layout, comprising a 20-metre x 50-metre plot with a nested 20-metre x 20-metre plot and five one by one metre litter sub-plots.

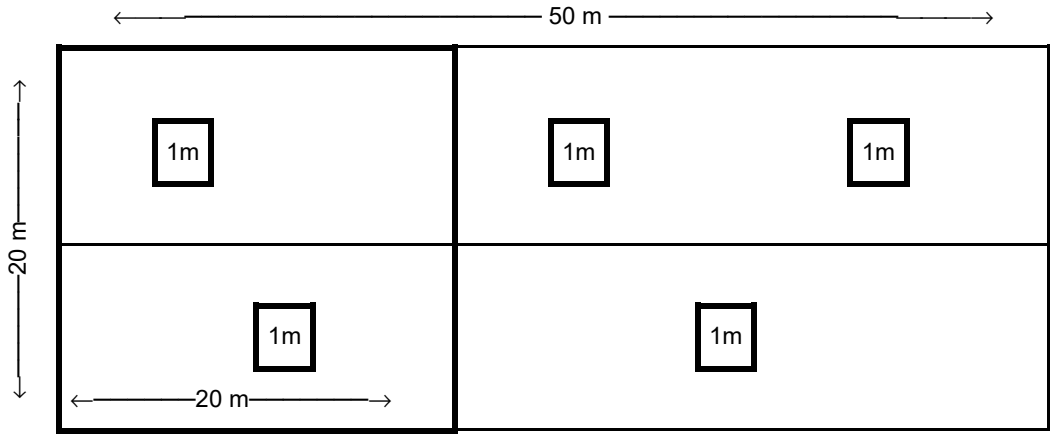


Figure 2-2 Flora quadrat layout

Table 2-4 Data collected from vegetation integrity plots

Attribute	Data collected
Location	Geographic co-ordinates (easting and northing; grid type MGA 94, Zone 56) – collected using GPS
Native and exotic species richness and cover	All plant species identified within the 20-metre x 20-metre nested quadrat were recorded. The cover (percentage of area of quadrat covered) and abundance of each species present was estimated. The growth form, stratum/layer and whether each species was native, exotic, or a high threat weed was recorded.
Number of trees with hollows	The number of living and dead trees with hollows within the 50-metre x 20-metre quadrat was recorded. A hollow was only recorded if: (a) the entrance could be seen; (b) the estimated entrance width was at least five centimetres; (c) the hollow appeared to have depth; (d) the hollow was at least one metre above the ground; and the (e) the centre of the tree was located within the sampled quadrat.
Tree stem size diversity and number of large trees	Tree stem size diversity was recorded by measuring the diameter at breast height (dbh) (i.e. 1.3 metres from the ground) of living trees (greater than five centimetres dbh) within each 50-metre x 20-metre quadrat. For multi-stemmed living trees, only the largest stem was included in the count. The number of large trees was determined by counting all trees with a dbh greater than the specified dbh of large trees for each vegetation formation, as noted in the VIS Classification Database (DPIE 2019b).

Attribute	Data collected
Evaluation of regeneration:	Presence/absence of overstorey species present at the site that were regenerating (defined as seedlings or saplings with a dbh less than or equal to five centimetres.
Total length of fallen logs	Cumulative total of logs within each 50-metre x 20-metre quadrat with a diameter of at least 10 centimetres and a length of at least 0.5 metres.
Litter cover	Estimation of the average percentage groundcover of litter (i.e. leaves, seeds, twigs, branchlets and branches with a diameter less than 10 centimetres which is detached from a living plant) from within five sub-plots that measured one metre x one metre square spaced evenly on either side of the 50 metre central transect.

Flora species identified in each vegetation plot are listed in the flora species inventory provided in Appendix B. BAM plot data is also provided in Appendix C. The locations of vegetation plots are shown in Figure 2-1. The plot requirement per vegetation zone, as determined in reference to Table 4 of the BAM, and number of plots completed are outlined in Table 2-5 Comparison of number of plots required and completed per vegetation zone .

Table 2-5 Comparison of number of plots required and completed per vegetation zone

Vegetation zone	Vegetation zone area (ha)	BAM plots required	BAM plots completed	Plots
1590_Moderate	0.14	1	1	PQ09
1590_Poor	0.09	1	1	PQ06
1590_Road_batter	0.36	1	1	PQ10
1600_Moderate	1.32	1	2	PQ02, PQ08
1619_Moderate	0.41	1	1	PQ05
1619_Poor	0.66	1	2	PQ03, PQ04
1619_Parkland	2.22	2	2	PQ07, PQX

2.3.3 Threatened species survey

Terrestrial flora

The vegetation in the development site generally has low habitat values for threatened flora species, with the exception of the areas in the north of the development site where vegetation moderate condition occurs. These areas were subject to detailed targeted threatened flora species searches during assessment of the Kings Hill URA, as documented in RPS (2019).

Terrestrial fauna

The following fauna surveys were undertaken within the development site:

- Terrestrial fauna habitat assessment. All areas of native and introduced vegetation were assessed for the presence of:
  - vegetation cover and structure
  - hollow-bearing trees, including stags (dead standing trees)
  - bush rock and rocky outcrops
  - burrows
  - large trees with basal cavities
  - logs
  - nests and roosts
  - feed trees and foraging resources
  - flying-fox camps
  - microchiropteran bat tree roosts
  - areas that can act as corridors for plant or animal species
  - wetlands, streams, rivers, dams and other water bodies
  - permanent soaks and seepage.
- Microchiropteran bat surveys. Passive recording of echolocation calls of microchiropteran bats (microbats) was carried out at two locations shown in Figure 2-1. Ultrasonic Anabat bat detection using Anabat Express units (Titley Electronics) was used to record continuously over one night in December 2018 and one night in August 2019 from dawn till dusk. Bat call analysis was completed by Graduate Ecologist Jessica Rooke and Senior Ecologists Carl Corden and Kate Carroll of Arcadis. Bat call of New South Wales Sydney Basin region (Pennay et al., 2004) was used as a reference collection for bat call identification. Level of confidence in the identification was variable and three categories assigned to indicate this: Confident, Probable and Possible, as noted in Appendix B.
- Spotlighting. Spotlighting was undertaken over a single night for a total of 10 person hours at five locations (Figure 2-1). Spotlight surveys targeted threatened nocturnal mammals, birds, reptiles and amphibians. Spotlighting was completed after dusk. Surveys were completed on foot using high-powered hand torches. Any animals observed were identified to the species level.
- Searches of for Koala scats in locations where feed trees were abundant. Searches were untimed and focused on the base of feed tree species when opportunistically encountered.

- Opportunistic sightings. Any animals opportunistically encountered were recorded. Evidence of animal activity, such as scats, diggings, scratch marks, nests/dreys, burrows etc., was also noted.

Aquatic habitat

The aquatic habitat value of the unnamed drainage line at the north of the development site (tributary of Irrawang Spillway) was assessed (Figure 2-1). Aquatic habitat was assessed against the NSW Department of Primary Industries (DPI) *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI 2013).
At the aquatic survey location, the following was recorded:

- Channel width
- Substrate
- Riparian and instream vegetation
- Instream features such as coarse woody debris, pools, riffles (where present)
- Stream order
- Waterway classification (Fairfull & Witheridge, 2003).

2.4 Limitations

This assessment is based on the condition of the development site at the time of field investigations. The conclusions of this report are based upon available data and field surveys and are therefore indicative of the environmental condition of the development site at the time of the survey. It should be recognised that conditions, including the presence of threatened species, could change with time. To address this limitation, a precautionary approach has been used which aimed to identify the presence and suitability of the habitat for threatened species.

Microbat surveys using an Anabat detector were undertaken in December and August 2019. August is outside the recommended survey window for Southern Myotis (*Myotis macropus*) in the *'Species credit' threatened bats and their habitats: NSW survey guide for the Biodiversity Assessment Method* (OEH 2018b) the only species credit species bat with the potential to occur on site. Survey effort was less than the recommended four nights, however as the species was likely detected (Anabat recording may be confused with a *Nyctophilus* sp. whose call profile is very similar), presence has been assumed.

3 LANDSCAPE FEATURES

3.1 Native vegetation extent

In accordance with Section 4.2.1.2 of the BAM, as a linear shaped development, a buffer of 500 metres either side of the proposed pipeline was applied, herein referred to as the **buffer area**. Native vegetation extent within the buffer area was then determined using the most recent vegetation mapping relevant to the development site and locality, Greater Hunter Mapping (Siversten et al., 2011). Native vegetation was found to cover 185 hectares of the buffer area of 730 hectares, which is 25%.

3.2 IBRA Bioregions and subregions

18.29 hectares of the development site lies within the Sydney Basin Interim Biogeographic Regionalisation for Australia (IBRA) Bioregion, largely to the south of Grahamstown Dam spillway. The northern 6.73 hectares of the development site lies within the North Coast IBRA Bioregion. Within the Sydney Basin and North Coast bioregions, the development site is situated within the Hunter and Karuah Manning sub-regions respectively (Figure 1-2). Morgan (2001) provides the following descriptions for these sub-regions.

The Hunter sub-region consists of a wide flood plain with rolling hills, wide valleys and a meandering river system (Morgan, 2001). River terraces are evident, as are numerous small swamps and extensive estuarine swamps. The underlying geology is a complex of Permian shales, sandstones, conglomerates, coal measures and volcanics, resulting in a variety of harsh texture soils on slopes and deep sandy loam alluvium on the valley floors (Morgan, 2001).

The Karuah Manning sub-region consists of patterns of ridges and valleys running to the Great Escarpment as well as extensive coastal beach, dune and lagoon barrier systems (Morgan, 2001). The geology is a complex faulted terrain with a number of underlying rocks present including slates, volcanics, mudstones and sandstones. The main soils present are red brown structured loams on basalt (Morgan, 2001).

In accordance with Section 6.4.1.7 of the BAM, separate habitat suitability assessments have been undertaken for threatened species in each IBRA subregion. Consequently, two BAMC files have been established and species and PCTs have been split and assessed according to PCT/IBRA subregion association of Hunter and Karuah Manning.

3.3 NSW Landscape Regions (Mitchell landscapes)

The development site is largely situated within the Newcastle Coastal Ramp Mitchell landscape, covering an area of 24.52 hectares. The very southern 0.50 hectares of the development site extends into the Sydney – Newcastle Barriers and Beaches Mitchell landscape as mapped by Eco Logical Australia (2008).

The Newcastle Coastal Ramp has a landscape of undulating lowlands and low to steep hills on Carboniferous conglomerate, lithic sandstone, felspathic sandstone, and mudstone (Eco Logical Australia, 2008).

The Sydney – Newcastle Barriers and Beaches landscape consists of quartz sand beaches between rocky headlands which back onto sand dunes and intermittently closed and open lagoons. Vegetation changes as soil development increases from the beaches to the inland dunes (Eco Logical Australia, 2008).

3.4 Cleared areas

Of the 25.02 hectares of land on the development site, 19.58 hectares is cleared. Cleared land comprises mostly of grassy road verge in the Raymond Terrace township and cleared grassland on HWC-owned land.

3.5 Rivers and streams

Several second order streams occur in the development site: the Kings Hill URA watercourse, and watercourses associated with Irrawang Spillway and Grahamstown Spillway. Streams and their associated riparian buffer areas are mapped on Figure 3-1. Key fish habitat is also mapped at all three streams (DPI 2007) (Figure 3-1).

In addition to the second order streams, there is a first order stream immediately downslope of the central compound that drains to Grahamstown Dam.

Figure 3-1 Watercourses and wetlands in the locality

3.6 Wetlands

Part of the development site is within a mapped Coastal Wetland – Irrawang Swamp (I.D. 36586), listed under the *State Environmental Planning Policy (Coastal Management) 2018* (Coastal Management SEPP) (Figure 3-1). About 700 metres of the water and wastewater infrastructure alignment transects the north-eastern margin of Irrawang Swamp Coastal Wetland. The Coastal Wetland covers an approximate area of 450 hectares, of which 2.01 hectares is located within the development site.

Mapping of Coastal Wetlands include the following vegetation types (DPIE 2018):

- Mangroves
- Saltmarshes
- Melaleuca forests
- Casuarina forests
- Sedgelands
- Brackish and freshwater swamps
- Wet meadows.

The vegetation in the area within the development site mapped as the Coastal Wetland is almost entirely cleared grassland dominated by exotic grass species such as *Axonopus fissifolius, Paspalum dilatatum* and the cosmopolitan native grass *Cynodon dactylon.* There are two small (0.08 ha) patches of the Plant Community Type (PCT) Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (PCT 1590) – one in poor condition (0.02 ha) and one planted road batter (0.06 ha) identified in this area – see section 4.2.1 for descriptions of this PCT.

The vegetation within the section of the development site mapped as Coastal Wetland does not align with the vegetation types that define a Coastal Wetland. These vegetation types lie further to the west of the development site. It is likely that the eastern boundary of the Coastal Wetland is mapped inaccurately within the development site.

3.7 Connectivity features

Vegetation across the development site is highly fragmented and disturbed. Connectivity to adjoining and nearby vegetation is limited and likely to allow movement for species tolerant of disturbed environments, fragmentation and low vegetative cover. The southern half of the development site is located in Raymond Terrace township, an urban residential area with sparsely scattered remnant and planted vegetation in the streetscape and gardens. Vegetation connectivity is limited across residential areas. Boomerang Park, Ross Walbridge Reserve and Newbury Park lie within Raymond Terrace township and are adjacent to the development site (Figure 1-3). Boomerang Park is a public park about 20 hectares in size with scattered trees and mown grassland. A patch of native vegetation lies in the middle of the park and further east is Muree Golf Course. The mosaic of scattered vegetation across Boomerang Park and Muree Golf Course has an element of connectivity to large tracts of native vegetation further south and east of the Raymond Terrace township.

Ross Walbridge Reserve and Newbury Park are public reserves that sit either side of Adelaide Street. Ross Walbridge Reserve is about 10 hectares in size and Newbury Park about 2 hectares (Port Stephens Council 2018). Connectivity to vegetation beyond these reserves is minimal as roads, cleared land and residential properties surround them.

Remnant native and highly disturbed vegetation of the development site further north of the Raymond Terrace township lies nearby extensive patches of native vegetation in Irrawang Swamp, Kings Hill URA and Grahamstown Dam. The northern 4 kilometres of the development site lie west of the native vegetation of the foreshore of Grahamstown Dam, a

large waterbody that supplies water for the Lower Hunter, managed by HWC. To the west of the development site lies Irrawang Swamp, a Coastal Wetland, approximately 490 hectares to the west with a mosaic of wetland marsh and woodland communities. The Pacific Motorway, service roads (Adelaide Street and James Rees Road) and fencing, including fauna fencing, lie between Grahamstown Dam foreshore and the development site and present a significant east-west barrier to connectivity between the dam and Irrawang Swamp. Large tracts of native vegetation lie to the north of the development site and connect through to Wallaroo National Park. However, approximately 211 hectares of connecting vegetation immediately to the north will be cleared for the URA and connectivity across the landscape will be reduced as a result, including between the URA and the development site. Corridors of native vegetation will be retained and conserved to offset the Kings Hill URA biodiversity impacts from the north of the Kings Hill URA down to the south east and south west. This will maintain some level of connectivity across the landscape in this location.

3.8 Areas of geological significance and soil hazard features

No caves, karsts, crevices or cliffs were observed in the development site during field surveys. No observable soil hazard features were present, though there is potential for acid sulphate soils (ASS). The road reserve of Adelaide Street adjacent to Ross Walbridge Reserve has been mapped in eSPADE (OEH 2018a) as having a high probability of ASS 1 – 3 metres below ground surface. There is a high probability of ASS in Irrawang Swamp, mapped about 30 metres west of the development site (OEH 2018a).

Four soil landscapes occur within the development site. The hazardous features, erosion risk of each soil landscape and locations are listed in Table 3-1. Erosion risk of the soil landscapes range from low to very high and hazardous features include waterlogging and acidic soils.

Table 3-1 Soil landscapes of the development site (OEH 2018a)

Soil landscape	Hazardous features	Erosion risk	Location within development site
Bolwarra Heights	Moderate foundation hazard, water erosion hazard, high run-on (localised), seasonal waterlogging (localised), localised steep slopes with mass movement hazard.	Low to high	All areas except those listed below
Shoal Bay	Wind erosion hazard, ground water pollution hazard, steep slopes (localised), foundation hazard (localised, swamps), permanent waterlogging (localised, swamps), permanent high watertables (localised, swampy depressions), seasonal waterlogging (localised, low lying swales), acid sandy	Slight to very high	Northern corner of Boomerang Park

Soil landscape	Hazardous features	Erosion risk	Location within development site
	non-cohesive soils with very low fertility.		
Wallalong	High water erosion hazard, foundation hazard, high run-on (localised), seasonal waterlogging (localised) and shallow soils (localised) with very high acidity and very low fertility.	Moderate to high	HWC land and Riding for the Disabled/Kings Hill URA at northern end of development site
Millers Forest	High foundation hazard due to flood hazard, also permanently high watertables, seasonal waterlogging and localised waterlogging.	Low to moderate	Small areas in the middle of the development site
Disturbed Terrain	Highly variable hazards depending on the site. Limitations may include mass movement hazard, steep slopes, foundation hazard, unconsolidated low wet bearing strength materials, potential acid sulphate soils, impermeable soils, poor drainage, erosion hazard, very low fertility and toxic materials.	Highly variable	Ross Walbridge Reserve on the corner of Adelaide Street and William Bailey Street

3.9 Areas of outstanding biodiversity value (AOBVs)

There are no Areas of Outstanding Biodiversity Value (AOBVs) at the development site or surrounding land. Draft important areas for the Swift Parrot have been mapped by DPIE in Boomerang Park and Newbury Park (supplied from DPIE via email on 3/10/2019). These are discussed further in Section 6.

4 NATIVE VEGETATION

4.1 Vegetation mapping datasets

Lower Hunter & Central Coast Environmental Management Strategy (LHCCREMS) (OEH, 2010) (VIS map 2225) map five different vegetation map units in the development site:

- Coastal Plains Smooth-barked Apple Woodland (Map Unit 30)
- Hunter Lowland Redgum Forest (Map Unit 19)
- Lower Hunter Spotted Gum – Ironbark Forest (Map Unit 17)
- Seaham Spotted Gum/Ironbark Forest (Map Unit 17)
- Swamp Mahogany – Paperbark Forest (Map Unit 37).

The Greater Hunter Native Vegetation Mapping (OEH 2012) (refer to Figure 4-1) built on previously existing field data, mapping, classification and remote sensing interpretation from the Hunter region, augmented with new survey data to produce vegetation community classification and mapping. Three native vegetation map units were mapped in the development site by OEH (2012). The map unit names, number and equivalent PCTs are listed in Table 3 1. Two additional map units, MU000 – identified as 'Non-native vegetation' and MU999 – which has no map unit name or description, were also mapped within the development site.

Table 4-1 Vegetation mapped in the development site by OEH (2012)

Map Unit name	Map Unit number	Equivalent PCT No	Area (ha) in development site
Spotted Gum/ Broad-leaved Mahogany/ Red Ironbark shrubby open forest	MU072	1590	1.47
Smooth-barked Apple/ Red Bloodwood/ Brown Stringybark/ Hairpin Banksia heathy open forest of coastal lowlands	MU101	1619	0.67
Total native vegetation communities			**2.14**
Non Native Vegetation	MU000	N/A	19.13
Blank	MU999	N/A	3.75
Total all map units			**25.02**

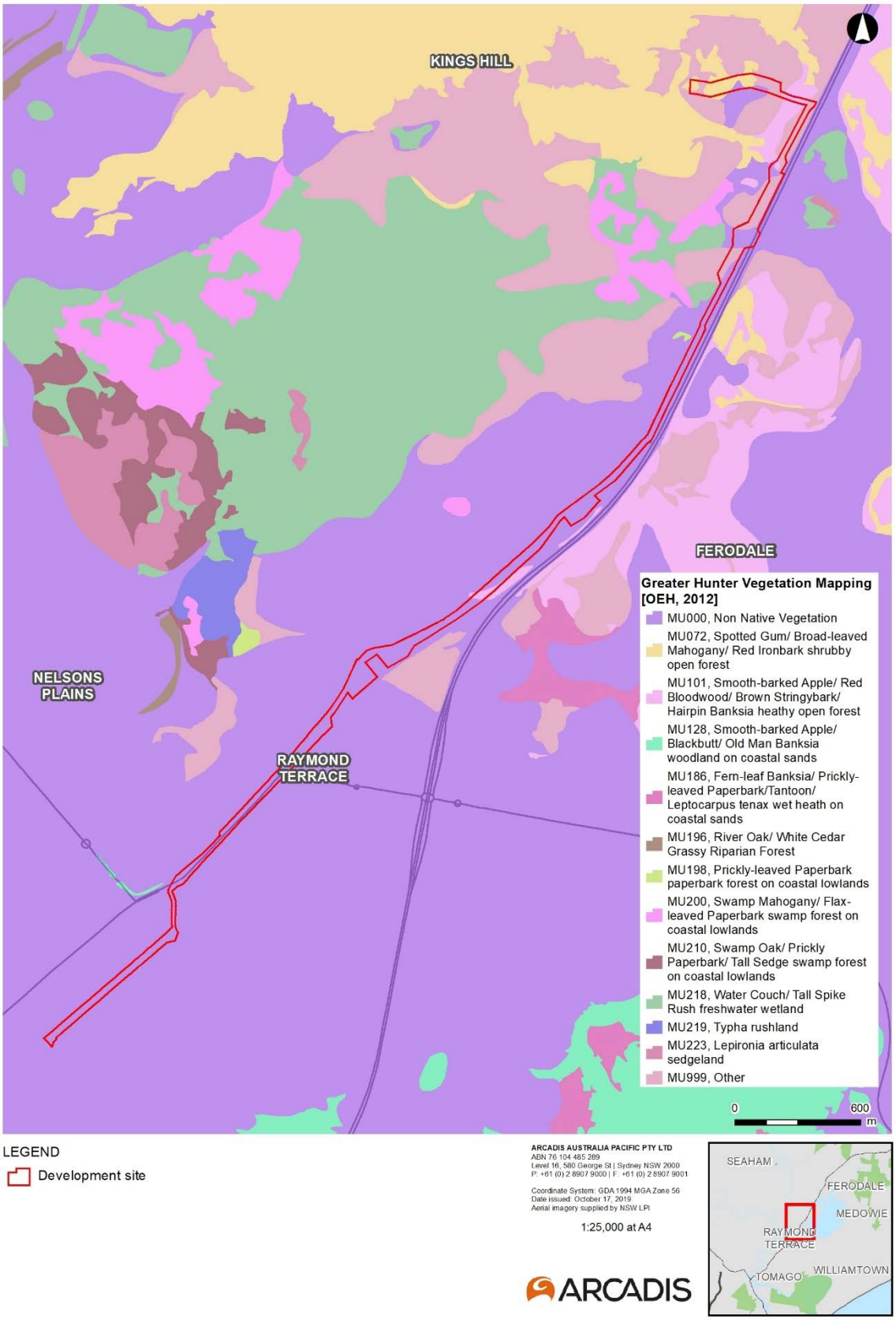
RPS (2019) mapped the vegetation of the Kings Hill URA proposal footprint and additional adjoining lands, with a total development site of about 1,171 hectares, which is located immediately to the west of and partially overlapping the current development site. Seven native PCTs were identified and mapped within the RPS (2019) development site:

- Coastal freshwater swamps of the Sydney Basin Bioregion (PCT 783)
- Sandpaper Fig - Whalebone Tree warm temperate rainforest (PCT 1525)
- White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley (PCT 1584)
- Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (PCT1590)

- Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter (PCT1600)
- Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (PCT 1724)
- Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (PCT 1728).

Of these seven PCTs, two are mapped within the area overlapping the current development site: Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (PCT 1590) and Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter (PCT 1600).

Figure 4-1 Regional vegetation mapping



4.2 Plant Community Types

The regional vegetation mapping (OEH 2012) was ground truthed and the vegetation community boundaries and PCT classifications were refined to reflect the on-ground observations. The PCTs and other vegetation types identified in the development site are listed in Table 4-2 and mapped in Figure 4-2. Detailed descriptions of each PCT are provided below.

Table 4-2 Vegetation types in the development site

Vegetation type		Area (ha)
PCT ID	**Plant Community Types**	
1590	Spotted Gum/ Broad-leaved Mahogany/ Red Ironbark shrubby open forest	0.6
1600	Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter	1.32
1619	Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands	3.3
Total PCTs		**5.22**
Other vegetation types		
Cleared grassland		11.49
Exotic trees		0.22
Urban verges		1.36
Total		**13.07**

Figure 4-2 Plant community types

Figure 4-2 Plant community types

4.2.1 Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest

Vegetation formation: Dry Sclerophyll Forests (Shrub/grass sub-formation)

Vegetation class: Hunter-Macleay Dry Sclerophyll Forests

PCT: 1590

Conservation status: The VIS classification database (DPIE 2019b) states that this PCT is partially a subset of Lower Hunter Spotted Gum - Ironbark Forest in the Sydney Basin Bioregion (listed as endangered under the BC Act). The occurrence of this PCT in the development site is not considered to form part of the TEC (see Section 4.4 for further detail).

Estimate of percent cleared: 48%

Condition: a range of vegetation structure and condition classes have been identified in the development site; these have been classified into vegetation zones as listed in Table 4-3 Vegetation integrity scores for PCT 1590 and described in further detail below.

Extent in the development site: 0.6 hectares

Description: *Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest* (PCT 1590) is described in OEH (2019) as an open forest with a canopy dominated by *Corymbia maculata* and a midstorey consisting of a diverse open shrub layer along with various small climbers. The ground layer is grassy with a mix of forbs, small ferns and other graminoids. The distribution of this PCT is low ranges of the lower Hunter Valley and Central Coast at lower elevations (DPIE 2019b).

The PCT 1590 vegetation in the develeopment site consists of several fragmented patches in varying condition, including regrowth form previous clearing and planted road batters.

PCT 1590: Moderate

This vegetation zone consists of a small area of regrowth vegetation adjoining the northen side of the Riding for the Disabled driveway. The tree canopy inlcudes *Corymbia maculata, Eucalyptus moluccana, Eucalyptus crebra* and *Eucalyptus tereticornis,* with occasional occurrence of *Melaleuca styphelioides* in the midlayer. The understorey is open, with very scattered cover of native shrubs such as *Glochidion ferdinandi, Notelaea longifolia* and *Breynia oblongifolia.* The ground layer is dominated by native grasses and sedges, with *Carex appressa, Imperata cylindrica* and the cosmopolitan species *Cynodon dactylon* together comprising the majority of the ground cover. There is also substantial cover of exotic groundcover species, including *Axonopus fissifolius, Rubus fruticosus, Paspalum dilatatum* and *Plantago lanceolata.*

PCT 1590: Road batter

The development site intersects a very small area within the planted road batter in the north of the alignment. The road batter consists of a steep slope next the Pacific Highway, planted with trees including *Corymbia maculata, Eucalyptus fibrosa, Eucalyptus acmenoides* and *Eucalyptus moluccana,* with scattered shrubs and a ground layer dominated by weedy exotic grasses including *Panicum repens* and *Cenchrus clandestinus*.

PCT 1590: Poor

This vegetation zone consists of small, degraded areas of regrowth trees and shrubs within cleared grassland in the HWC land adjoining Irrawang Spillway. Tree cover is low, reduced to a few *Eucalyptus moluccana* (Grey Box) in small patches adjoining the road batters. Small tree and shrub cover is also very reduced, consisting of scattered plants of *Acacia longifolia, Glochidion ferdinandi* and *Pittosporum undulatum.* The ground layer is dominated by weedy exotic grasses such as *Briza subaristata, Chloris gayana* and *Paspalum dilatatum,* with minor occurrence of natiev grasses and herbs including *Microlaena stipoides, Themeda triandra* and the cosmopolitan species *Cynodon dactylon.*

Plate 1: PCT 1590 - Moderate

Plate 2: PCT 1590 – Road batter

Plate 3: PCT 1590 – Poor

Table 4-3 Vegetation integrity scores for PCT 1590

Vegetation zone	Composition condition score	Structure condition score	Function condition score	Vegetation integrity score
1590 – Moderate	70.7	51.3	81.3	66.6
1590 – Road batter	71.8	7.2	43.9	28.3
1590 - Poor	34.1	2.3	39	14.6

4.2.2 Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter

Vegetation formation: Dry Sclerophyll Forests (Shrub/grass sub-formation)

Vegetation class: Hunter-Macleay Dry Sclerophyll Forests

PCT ID: 1600

Conservation status: The VIS classification database (DPIE 2019b) states that this PCT is largely equivalent to *Lower Hunter Spotted Gum - Ironbark Forest in the Sydney Basin Bioregion* (listed as endangered under the BC Act) and partly equivalent to *Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions* (listed as endangered under the BC Act and EPBC Act). The occurrence of this PCT in the development site is not considered to form part of the TEC (see Section 4.4 for further detail).

Estimate of percent cleared: 66%

Condition: Only one vegetation zone was identified in PCT 1600: Moderate.

Extent in the development site: 1.32 ha

Description: *Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter* (PCT 1600) is found on hillslopes and low rises within the Lower Hunter Valley. It is characterised as an open forest with a canopy dominated by *Corymbia maculata* (Spotted Gum) with *Eucalyptus fibrosa* (Red Ironbark), *Eucalyptus crebra* (Narrow-leaved Ironbark) and *Eucalyptus moluccana* (Grey Box) occurring to a lesser extent. This community has an open shrub layer and a predominately grassy ground layer with graminoids, forbs and small ferns present (DPIE 2019b).

PCT 1600 is located in the very northern extent of the development site. Here, the vegetation is located in semi-intact patches which adjoin large, intact expanses of native vegetation to the north, south and west. The canopy is dominated by *Corymbia maculata* and *Eucalyptus moluccana* with *Eucalyptus tereticornis* and *Eucalyptus crebra* also occurring occasionally.

The shrub layer of PCT 1600 is generally sparse or absent, with *Acacia* spp. and *Daviesia ulicifolia* Gorse Bitter Pea) occasionally present. Exotic shrub species are present in patches, in particular *Rubus anglocandicans.* (Blackberry) and *Lantana camara* (Lantana).

The ground layer is predominantly grassy, with *Cynodon dactylon, Cymbopogon refractus* (Barbed Wire Grass), *Imperata cylindrica* (Blady Grass), *Dichelachne micrantha* (Small Plume Grass), *Microlaeana stipoides* (Weeping Grass) and *Themeda triandra* (Kangaroo Grass) all abundant. Other ground species present include *Desmodium* spp, *Dichondra repens* (Kidney Weed) and *Pratia purpurescens* (White Root).

Exotic species are abundant within PCT 1600. In addition to the *Rubus fruticosus sp. agg.* and *Lantana camara* within the shrub layer, the ground layer has dense cover of *Axonopus fissifolius* (Carpet Grass) and *Paspalum dilatatum* (Paspalum) in some patches. Other exotic species in the ground layer include *Briza subaristata* (Chilean Quaking Grass), *Rosa bracteata* (Macartney Rose), *Hypochaeris radicata* (Catsear) and *Herbertia lahue subsp. caerulea.*

Plate 4: PCT 1600

Plate 5: PCT 1600

Table 4-4 Vegetation integrity scores for PCT 1600

Vegetation zone	Composition condition score	Structure condition score	Function condition score	Vegetation integrity score
1600 – Moderate	47.2	23.7	32.9	33.3

4.2.3 Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands

Vegetation formation: Dry Sclerophyll Forests (Shrubby sub-formation)

Vegetation class: Sydney Coastal Dry Sclerophyll Forests

PCT: 1619

Conservation status: Not listed

Estimate of percent cleared: 45%

Condition: a range of vegetation structure and condition classes have been identified in the development site; these have been classified into vegetation zones as listed in Table 4-5 Vegetation integrity scores for PCT 1619 and described in further detail below.

Extent in the development site: 3.3 ha

Description: *Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands* (PCT 1619) is associated with the coastal lowlands and low ranges of the lower North Coast and Central Coast. This community generally occurs on coastal hillslopes and upper slopes with sandy substrates. PCT 1619 is characterised by a canopy of *Angophora costata* (Smooth-barked Apple) and *Corymbia gummifera* (Red Bloodwood) with a typically shrubby mid-storey which includes grass trees and scrambling climbers (DPIE 2019b).

The areas mapped as PCT 1619 within and adjoining the development site consist of fragmented patches of disturbed regrowth, roadside vegetation that has likely been planted, and planted street trees in road verges. This vegetation is variable and does not directly correspond to any PCT. Given the dominance of *Angophora costata* in the better condition areas and the mapping of this PCT across the southern parts of the development site in the most recent vegetation map (OEH 2014), this disturbed vegetation has been assigned to PCT 1619.

PCT 1619: Moderate

This vegetation zone comprised narrow strips of regrowth and planted trees, shrubs and groundcover between Rees James Road and the Pacific Highway. The tree canopy was

variable, with many areas dominated by *Angophora costata* with *Eucalyptus signata* also abundant. Other eucalypts commonly recorded include *Corymbia maculata, Eucalyptus acmenoides, Corymbia gummifera* and *Angophora floribunda. Casuarina glauca, Allocasuarina littoralis* and *Pittosporum undulatum* commonly occur in the midlayer, and there are scattered shrubs including *Breynia oblongifolia, Dodonaea triquetra* and *Acacia* spp.

The ground layer is characterised by sparse cover of native grasses and graminoids, including *Entolasia stricta, Microlaena stipoides, Lomandra longifolia, Themeda triandra* and *Cynodon dactylon.* Some areas include ferns such as *Pteridium esculentum* and *Adiantum aethiopicum,* and climbers such as *Parsonsia straminea.* This vegetation zone also contains weedy shrubs such as *Lantana camara* and *Olea europaea* subsp. *cuspidata* and exotic grasses such as *Chloris gayana, Paspalum dilatatum* and *Cenchrus clandestinus,* particularly near the cleared edges of the strips.

PCT 1619: Poor

This vegetation type occurs as small, disturbed patches within larger areas of cleared grassland to the south-east of Rees James Drive. Native cover is reduced to occasional trees of *Angophora costata,* shrubs of *Pittosporum undulatum, Acacia* spp., *Melaleuca quinquenervia* and *Glochidion ferdinandi* and ground cover species including *Microlaena stipoides, Adiantum aethiopicum, Pteridium esculentum* and the cosmopolitan native gras *Cynodon dactylon.* Exotic species are abundant, with trees of *Pinus radiata, Cinnamomum camphora* and *Jacaranda mimosifolia,* shrubs such as *Lantana camara* and *Rubus fruticosus* agg. spp. and weedy exotic grasses such as *Anthoxanthum odoratum, Briza subaristata, Cenchrus clandestinus, Hyparrhenia hirta* and *Paspalum dilatatum* all occurring frequently.

PCT 1619: Planted Trees

The ‘Planted trees’ vegetation zone has been assigned to this community as it is the closest mapped community to these areas of the development site and some characteristic trees are present, however the vegetation in this zone is not consistent with any PCT. This vegetation zone consists of a planted trees of a range of species, mostly eucalypts, in road verges and parklands, over a mown exotic grassy ground layer.

Plate 6: PCT 1619 - Moderate

Plate 7: PCT 1619 - Poor

Table 4-5 Vegetation integrity scores for PCT 1619

Vegetation zone	Composition condition score	Structure condition score	Function condition score	Vegetation integrity score
1619 – Moderate	47.5	25.6	77	45.4
1619 - Poor	12.4	29.2	47.3	25.8
1619 – Planted trees	8.4	22.9	14.1	14.0

4.3 Vegetation zones

Eight vegetation zones were identified within the three PCTs in the development site; these are identified and discussed in sections 4.2.1 to 4.2.3 above, listed in Table 4-6 Vegetation integrity score for each zone and shown in Figure 4-3.

Vegetation integrity is a measure of the condition of native vegetation and is assessed for each vegetation zone by calculating the scores for a range of condition attributes collected in plots, as listed in section 4.1.2, against the benchmark values for each PCT. The assessment of native vegetation under the BAM is not required beyond Section 5.4, and an assessment of threatened species habitat according to Section 6.2 and Paragraph 6.2.1.4 of the BAM is not required for vegetation zones with an integrity of:

- Less than 15 if the PCT is a Critically Endangered Ecological Community (CEEC) or Endangered Ecological Community (EEC)
- Less than 17 if the PCT is threatened species habitat or vulnerable ecological community; or
- Less than 20 if the PCT is not representative of a TEC or associated with threatened species habitat.

Vegetation integrity scores across the development site were mostly low, with vegetation zones assessed to be in moderate condition scoring in a range of 33.3 to 66.6. Two vegetation zones had values lower than 20: PCT 1590 – Poor and PCT 1619 – Planted trees.

The vegetation zones and vegetation integrity scores (as determined using the BAMC) for each PCT are listed in Table 4-6 Vegetation integrity score for each zone. The BAM calculator inputs are provided in Appendix B.

Table 4-6 Vegetation integrity score for each zone

Vegetation zone	Plant Community Type (PCT)	Vegetation integrity score	Area within development site (ha)
North Coast bioregion			
1590 – Moderate	1590	66.6	0.14
1590 – Road batter	1590	28.3	0.36
1590 – Poor	1590	11.8	0.03
1600 – Moderate	1600	33.3	1.32
Sydney Basin bioregion			
1590 – Poor	1590	14.6	0.07
1619 – Moderate	1619	45.4	0.41
1619 – Poor	1619	25.8	0.66
1619 – Planted trees	1619	14.0	2.23

Figure 4-3 Vegetation zones

Figure 4-3 Vegetation zones

4.4 Threatened ecological communities

Database search results identified 26 Threatened Ecological Communities (TECs) listed under the BC Act and/or the EPBC Act as having potential to occur within 10 kilometres of the development site. The probability of each of these locally recorded TECs to occur within the development site was considered using knowledge of each TEC's characteristic species, preferred landscape position, soil associations and structure, with regard to the vegetation present within the development site (Appendix D).

The VIS classification database (DPIE 2019b) states that:

- Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (PCT 1590) is partially a subset of Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin Bioregion, listed as endangered under the BC Act.
- Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter (PCT 1600) is largely equivalent to Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin Bioregion, listed as endangered under the BC Act, and partially equivalent to Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions, listed as endangered under the BC Act and critically endangered under the EPBC Act.

The location, structure and floristics of PCTs 1590 and 1600 in the development site were compared to the Final Determinations for Lower Hunter Spotted Gum Ironbark Forest in the Sydney and NSW North Coast Basin Bioregion gazetted 31 May 2019 (Table 4-7) and Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions gazetted 12 February 2010 (Table 4-8).

Table 4-7 Comparison of the Final Determination for Lower Hunter Spotted Gum Ironbark Forest in the Sydney and NSW North Coast Basin Bioregion with PCTs 1590 and 1600

Extract from Final Determination	Comparison with areas of PCT 1590 and 1600 in the development site	Consistency of PCT 1590 and 1600 in the development site with Final Determination
1.1 Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions (hereafter referred to as the Lower Hunter Spotted Gum Ironbark Forest) is characterised by the assemblage of species listed below [44 species listed]	Of the 44 species listed, a total of 18 (41%) were recorded in the development site, with 13 (30%) recorded in areas of PCT 1590 and 10 (23%) recorded in areas of PCT 1600.	Broadly consistent - between 23% and 30% of listed characteristic species occur within PCTs 1590 and 1600 in the development site.
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 development site intersects the boundary between the NSW North Coast Bioregion and the Sydney basin Bioregion.	Consistent – the development site occurs within the specified bioregions.
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 development site is located outside this geographic range.	Not consistent – the development site is not within the specified geographic range.

Extract from Final Determination	Comparison with areas of PCT 1590 and 1600 in the development site	Consistency of PCT 1590 and 1600 in the development site with Final Determination
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 geology of the northern part of the development site where PCTs 1590 and 1600 occur is mapped as sediments of the Permian Dalwood Group (Rose *et al.* 1966).	Consistent – PCTs 1590 and 1600 in the development site occur on the specified geology.
4.2 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).	The northern part of the development site (north from Irrawang Spillway) is mapped as the Wallalong soil landscape (Matthei 1995).	Not consistent – the development site does not occur on the specified soil type.
4.3 Lower Hunter Spotted Gum Ironbark Forest is usually dominated by *Corymbia maculata* and *Eucalyptus fibrosa*, with *E. punctata* 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. ……	The areas of PCT1590 in the development site are dominated by *Corymbia maculata*, *Eucalyptus moluccana* and *Eucalyptus tereticornis* with *Angophora costata, Eucalyptus crebra* and *Eucalyptus punctata* also present. The areas of PCT 1600 in the development site have a canopy characterised by *Corymbia maculata, Eucalyptus moluccana, Eucalyptus tereticornis* and *Eucalyptus crebra.*	Partially consistent – although many of the specified canopy species are present in the development site, *Eucalyptus fibrosa* is not dominant or co-dominant, occurring infrequently.
4.4 In an undisturbed condition, the structure of the community is typically open forest. If thinning has occurred, it may take the form of woodland or a dense thicket of either shrubs or saplings, depending on post-disturbance regeneration.	The areas of PCTs 1590 and 1600 in the development site are disturbed by clearing and historical land use including grazing. The structure of the PCTs in the development site is woodland or small patches of open forest.	Generally consistent – the structure of the PCTs in the development site is woodland or open forest.

Extract from Final Determination	Comparison with areas of PCT 1590 and 1600 in the development site	Consistency of PCT 1590 and 1600 in the development site with Final Determination
4.4 Somerville (2009a, 2009b) described two communities corresponding to Lower Hunter Spotted Gum Ironbark Forest. The first of these (MU 67 Spotted Gum/Red Ironbark/Large – fruited Grey Gum shrub/grass open forest) is the more widespread and is described as "open forests characterised by a canopy strongly dominated by *Corymbia maculata* and *Eucalyptus fibrosa* often in association with *E. punctata*. The shrubby understorey is characterised by a range of shrubs including *Daviesia ulicifolia, Persoonia linearis, Bursaria spinosa* and *Lissanthe strigosa*. The ground layer is characteristically grassy and dominated by a range of species including *Themeda australis* [syn. *Themeda triandra*], *Entolasia stricta, Aristida vagans* and *Panicum simile*. Various graminoids are also typically present in the ground layer in particular *Lepidosperma laterale, Dianella revoluta* and *Lomandra multiflora*, along with ground ferns, typically *Cheilanthes sieberi,* and scattered herbs" (Somerville 2009b). The second community (MU 68 Red Ironbark/paperbark shrubby open forest) is more restricted in distribution and is described as "open forests with a canopy strongly dominated by *Eucalyptus fibrosa* often in association with *Corymbia maculata*, with a tall shrub layer dominated by *Melaleuca nodosa* and commonly including *M. decora*. The open shrub layer may include various shrubs such as *Bursaria spinosa, Pultenaea spinosa, Acacia parvipinnula* and *Macrozamia flexuosa*, however climbing species are not an abundant feature of the community. The ground layer is typically dominated by grasses, in particular *Entolasia stricta, Microlaena stipoides and Aristida vagans* and ground ferns, predominately *Cheilanthes sieberi*" (Somerville 2009b).	MU 67 of Somerville (2009b) is equivalent to PCT 1592, Spotted Gum – Red Ironbark – Grey Gum shrub – grass open forest of the Lower Hunter. MU 68 of Somerville (2009b) is equivalent to PCT 1593, Red Ironbark – Spotted Gum – Prickly-leaved Paperbark shrubby open forest of the Lower Hunter. The closest mapped area of either vegetation map unit is MU 67 mapped over 12 kilometres to the north of the development site. While there are some common canopy, shrub and groundlayer species in both the descriptions of MU 67 and MU 68 and the vegetation in the development site, the vegetation in the development site is not consistent with these map units. *Eucalyptus fibrosa* is not co-dominant, and *Eucalyptus punctata* only occurs in the planted road batter. The understorey is not shrubby, and there is no tall shrub layer of *Melaleuca* spp. as is typical in MU 68.	Not consistent – PCTs 1590 and 1600 in the development site are not consistent with the descriptions of MU 67 and MU 68 in Somerville (2009b) and neither unit is mapped within 10 kilometres of the development site.

Extract from Final Determination	Comparison with areas of PCT 1590 and 1600 in the development site	Consistency of PCT 1590 and 1600 in the development site with Final Determination
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 two closest meteorological stations to the development site are Raymond Terrace (Wallaroo State Forest) (station 061076), which closed in April 2006 and Williamtown RAAF (station 061078), which remains open (BOM, 2019). Raymond Terrace recorded a mean annual rainfall of 1147.4 mm over 68 years of record and Williamstown RAAF recorded a mean annual rainfall of 1123.8 mm over 77 years of record.	Not consistent – the development site is located in a higher rainfall range than that considered typical for LHSGIF (750-1000mm).
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). 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*. 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). 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,*	PCT1590 is equivalent to MU65 of Somerville (2009). The canopy, shrub layer and ground layer features of the Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest in the development site are generally consistent with the descriptions provided, with *Breynia oblongifolia,* and *Leucopogon juniperinus* recorded in the shrub layer and *Cymbopogon refractus, Desmodium varians, Dichondra repens, Echinopogon ovatus, Geitonoplesium cymosum, Gonocarpus tetragynus, Goodenia heterophylla, Imperata cylindrica* and *Pandorea pandorana* recorded in the ground layer, often frequently.	Not consistent – the vegetation in PCT 1590 is consistent with the description of MU65 of Somerville (2009), which is not considered to form part of the TEC.

Extract from Final Determination	Comparison with areas of PCT 1590 and 1600 in the development site	Consistency of PCT 1590 and 1600 in the development site with Final Determination
Podolobium ilicifolium, and *Pomax umbellata*. Species recorded more frequently in MU 65 include *Cymbopogon refractus, Desmodium rhytidophyllum, 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).		

In conclusion, the vegetation in PCTs 1590 and 1600 in the development site is not consistent with the TEC Lower Hunter Spotted Gum Ironbark Forest in the Sydney and NSW North Coast Basin Bioregion as:

- The development site is not within the geographic range or rainfall range as that specified in the final determination.
- The vegetation in the development site is not dominated or co-dominated by *Eucalyptus fibrosa*, which occurs infrequently, but is specified in the final determination as a characteristic canopy species.
- The vegetation in PCT 1590 is consistent with the description of MU65 of Somerville (2009), which is not considered in the final determination to form part of the TEC.

Table 4-8 Comparison of the Final Determinations for Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions with PCT 1600.

Extract from Final Determination	Comparison with areas of 1600 in the development site	Consistency of PCT 1590 and 1600 in the development site with Final Determination
1. Central Hunter Ironbark - Spotted Gum - Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions is the name given to the ecological community that generally occurs on Permian sediments in the Hunter Valley and is characterised by the assemblage of species in paragraph 2. The community typically forms an open forest to woodland.	The geology of the northern part of the development site, where PCT 1600 occurs, is mapped as sediments of the Permian Dalwood Group (Rose *et al.* 1966).	Consistent – PCTs 1590 and 1600 in the development site occur on Permian sediments, as specified in the final determination.
2. Central Hunter Grey Box – - Spotted Gum - Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions is characterised by the following assemblage of species [41 species listed]	Of the 41 species listed, 17 (41%) were recorded in PCT 1600 in the development site.	Consistent - 41% of listed characteristic species occur within PCT 1600 in the development site.
4. Central Hunter Ironbark - Spotted Gum - Grey Box Forest typically forms an open forest to woodland dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark), *Corymbia maculata* (Spotted	The vegetation in PCT 1600 includes *Corymbia maculata, Eucalyptus moluccana* and *Eucalyptus tereticornis* as	Partially consistent – the characteristic canopy species occur, however ironbarks are not co-dominant. Although many

Extract from Final Determination	Comparison with areas of 1600 in the development site	Consistency of PCT 1590 and 1600 in the development site with Final Determination
Gum) and *Eucalyptus moluccana* (Grey Box). Other tree species may be present and occasionally dominate or co-dominate, and include *Eucalyptus fibrosa* (Broad-leaved Ironbark) and *Eucalyptus tereticornis* (Forest Red Gum). A sparse layer of small trees may be present in some areas, typically including *Allocasuarina luehmannii* (Bulloak) or *Acacia parvipinnula* (Silver Streamed Wattle). The shrub layer is typically sparse or absent in some cases, through to moderately dense. Common shrub species include *Daviesia ulicifolia* subsp. *ulicifolia* (Gorse Bitter Pea), *Pultenaea spinosa* (Grey Bush Pea), *Breynia oblongifolia* (Coffee Bush), *Hakea sericea* (Bushy Needlebush), and *Bursaria spinosa* subsp. *spinosa* (Native Blackthorn) (Peake 2006). Ground cover can be sparse to moderately dense, and consists of numerous forbs, a few grass species, and a limited number of ferns, sedges or other herbs. Common species include *Cheilanthes sieberi* subsp. *sieberi* (Poison Rock Fern), *Cymbopogon refractus* (Barbed Wire Grass), *Pratia purpurascens* (Whiteroot), *Lomandra multiflora* subsp. *multiflora* (Many-flowered Mat-rush), *Pomax umbellata* (Pomax), *Glycine tabacina* (Variable Glycine), *Dianella revoluta* (Blue Flax Lily), *Laxmannia gracilis* (Slender Wire Lily), *Microlaena stipoides* var. *stipoides* (Weeping Rice Grass), *Vernonia cinerea* var. *cinerea, Lissanthe strigosa* (Peach Heath), *Brunoniella australis* (Blue Trumpet), *Desmodium varians* (Variable Tick-trefoil), *Dichondra repens* (Kidney Weed), *Eremophila debilis* (Winter Apple), *Calotis cuneifolia* (Purple burr-daisy), *Hypercium gramineum* (Small St. John's Wort), *Chrysocephalum apiculatum* (Common Everlasting), *Opercularia diphylla* (Stinkweed), *Paspalidium distans* (Tufted Hedgehog Grass) *Themeda australis* (Kangaroo Grass), *Stackhousia viminea* (Slender Stackhousia) and *Wahlenbergia communis* (Tufted Bluebell) (Peake 2006).	co-dominants in the tree canopy. *Eucalyptus crebra* also occurs, but is not dominant. Neither of the small tree species were recorded. One of the six shrub species listed, *Daviesia ulicifolia,* was recorded in PCT 1600 in the development site; the shrub layer is largely absent in this PCT. The ground cover within the patches of PCT 1600 in the development site is grazed, and consists largely of grasses and forbs. Twelve of the 23 listed ground cover species were recorded in the development site.	of the characteristic understory species listed occur, these are common species in the area and are also characteristic of a range of other vegetation communities.
5. Central Hunter Ironbark - Spotted Gum - Grey Box Forest has been described by Peake (2006) as Central Hunter Ironbark - Spotted Gum - Grey Box Forest (Map Unit 27) and as Map Unit 18 (NPWS 2000; DECC 2008). It includes a part of a unit described by Thomas (1998) as Eucalyptus crebra – Eucalyptus	None of the listed map units are mapped within or adjacent to the development site; most of the mapping references listed are outside the locality of the development site. The	Not consistent – the specified map units are not consistent with the vegetation in the development site and are not mapped near the development site.

Extract from Final Determination	Comparison with areas of 1600 in the development site	Consistency of PCT 1590 and 1600 in the development site with Final Determination
moluccana – Eucalyptus glaucina/tereticornis woodland. It shares some characteristics with, but is not part of a community described by Bell (2005) as Narrabeen Residual Spotted Gum Forest from a small area near Bulga. It shares some characteristics with, but is not part of a community described by Peake (2006) as Central Hunter Grey Box – Ironbark Woodland, and also shares some characteristics with but is not part of the Endangered Ecological Community 'Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions (NSW Scientific Committee 2010).	closest area of Map Unit 18 to the development site is mapped over 40 kilometres to the west (OEH 2010), and the closest area of Central Hunter Ironbark - Spotted Gum - Grey Box Forest mapped by Peake (2006) is over 35 kilometres to the west of the development site.	
6. Central Hunter Grey Box – Ironbark Woodland has been recorded from the local government areas of Cessnock, Central Hunter Ironbark - Spotted Gum - Grey Box Forest has been recorded from the local government areas of Cessnock, Singleton and Muswellbrook but may occur elsewhere within the NSW North Coast and Sydney Basin Bioregions (sensu Thackway and Creswell 1995).	The development site is located in the Port Stephens local government area.	Not consistent. The development is not within the specified local government areas. It is noted that the TEC may occur elsewhere within the NSW North Coast and Sydney Basin Bioregions.

In conclusion, the vegetation in PCT 1600 in the development site is not consistent with the TEC Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions as:

- The development site is not within the geographic range specified in the final determination.
- While some of the characteristic canopy and groundcover species occur, these are common species in the area and are also characteristic of a range of other vegetation communities which are not consistent with the TEC.

4.5 Other vegetation types

Three other vegetation types that do not conform to the definition of any PCTs were also recorded in the development site (Table 4-9).

Table 4-9 Non-PCT vegetation types in the development site

Vegetation type	Area (ha)
Cleared grassland	11.49
Exotic trees	0.22
Urban verges	1.36
	13.07

Cleared grassland

Cleared grassland occurs across the development site, in grazed areas in the north of the development site, across most areas within and adjoining access track on HWC land, and

on regularly mown or slashed road verges in the central and southern parts of the development site.

Cleared grasslands are characterised by a groundcover dominated by exotic grasses such as *Andropogon virginicus* (Whisky Grass), *Axonopus fissifolius* (Narrow-leaved Carpet Grass), *Cenchrus clandestinus* (Kikuyu), *Chloris gayana* (Rhodes grass), *Eragrostis curvula* (African Lovegrass), *Sporobolus africanus* (Parramatta Grass) and the planted cosmopolitan native grass *Cynodon dactylon* (Couch). The exotic *Watsonia meriana* dominates some of the larger cleared patches adjoining Rees James Drive, and *Rubus fruticosus* agg. spp. form some large patches among ares of cleared grassland in the north. Some native species are interspersed with the exotic grasses in these areas, particularly in the north of the development site; species observed include *Cymbopogon refractus* (Barbed Wire Grass), *Microlaena stipoides* (Weeping grass) and *Aristida vagans.*

While there are occasionally scattered trees and shrubs in areas mapped as cleared grassland, ongoing maintenance activities such as slashing and mowing prevent the regeneration of trees and shrubs in these areas.

Plate 8: Cleared grassland with *Rubus fruticosus* sp. agg.

Plate 9: Cleared grassland dominated by *Watsonia meriana*

Exotic trees

There are small areas of densely planted exotic trees along Rees James Drive, mainly conifers such as *Pinus radiata* and *Cupressus* spp.

Urban verges

The southern parts of the development site are located within the more urbanised areas of Raymond Terrace. This vegetation type consists of smaller, fragmented patches of mown exotic grass lawns and planted ornamental shrubs, trees and groundcovers in residential gardens and verges. It also includes paved driveways and walking paths.

4.6 Weeds

Of the 59 exotic species were identified in the development site, six are declared as Priority Weeds for the Hunter region under the *Biosecurity Act 2015.* Of these species, four are also included on the Commonwealth list of 32 Weeds of National Significance (WoNS). An additional 19 exotic species recorded in the development site are considered by OEH (OEH, 2017) to be high threat weeds. The presence and cover of high threat weeds influences the vegetation integrity score of a vegetation zone. The names, classification and legal requirements for these species are outlined in

Table 4-10.

Table 4-10 Weed species recorded on the site

Species	WoNS	High Threat Weed	Biosecurity duty under the Biosecurity Act 2015	Legal requirement
Acetosa sagittata Rambling Dock		Yes	-	
Alternanthera pungens Khaki Weed		Yes	-	
Andropogon virginicus Whisky Grass		Yes	-	
Asparagus aethiopicus Asparagus Fern	Yes	Yes	Prohibition on dealings	Must not be imported into the State or sold
Axonopus fissifolius Narrow-leafed Carpet Grass		Yes	-	
Bidens pilosa Cobbler's Pegs		Yes	-	
Briza subaristata		Yes	-	
Cenchrus clandestinus Kikuyu		Yes	-	
Chloris gayana Rhodes Grass		Yes	-	
Cinnamomum camphora Camphor Laurel		Yes	-	
Cyperus eragrostis Umbrella Sedge		Yes	-	
Eragrostis curvula African Lovegrass		Yes	-	
Hyparrhenia hirta Coolatai Grass		Yes	Prohibition on dealings	Must not be imported into the State or sold
Lantana camara Lantana	Yes	Yes	Prohibition on dealings	Must not be imported into the State or sold

Species	WoNS	High Threat Weed	Biosecurity duty under the Biosecurity Act 2015	Legal requirement
Ligustrum sinense Small-leaved Privet		Yes	-	
Ochna serrulata Mickey Mouse Plant		Yes	-	
Olea europaea subsp. cuspidata African Olive		Yes	Regional Recommended Measure	Land managers mitigate the risk of the plant being introduced to their land. Land managers reduce impacts from the plant on priority assets. Land managers prevent spread from their land where feasible. The plant or parts of the plant are not traded, carried, grown or released into the environment
Panicum repens Torpedo Grass		Yes	-	
Paspalum dilatatum Paspalum		Yes	-	
Pinus radiata Radiata Pine		Yes	-	
Romulea rosea Onion Grass		Yes	-	
Rosa rubiginosa Sweet Briar		Yes	-	
Rubus fruticosus species aggregate Blackberry	Yes	Yes	Prohibition on dealings Regional Recommended Measure	Must not be imported into the State or sold The plant should not be bought, sold, grown, carried or released into the environment. Land managers should mitigate the risk of the plant being introduced to their land. Land managers should mitigate spread from their land. Land managers to reduce impacts from the plant on priority assets.
Senecio madagascariensis	Yes		Prohibition on dealings	Must not be imported into the State or sold

Species	WoNS	High Threat Weed	Biosecurity duty under the Biosecurity Act 2015	Legal requirement
Fireweed				
Watsonia meriana		Yes	-	

4.7 Groundwater dependent ecosystems

A search of the *National Atlas of Groundwater Dependent Ecosystems* (BOM, 2019b) identified several groundwater dependent ecosystems (GDEs) with potential reliance on subsurface groundwater within and adjoining the development site, based on regional studies. A total of 1.78 hectares of GDEs were identified in the development site, with potential reliance on subsurface groundwater ranging from high to moderate (Table 4-11, Figure 4-4). All areas of mapped GDEs were in the northernmost portions of the development site, north of Irrawang Spillway. Irrawang Swamp, to the west of the development site, is mapped as a high potential GDE. The closest aquatic GDE, Williams River, is mapped about 700 metres west of the development site.

Table 4-11 Groundwater dependent ecosystems mapped by BOM (2019) in the development site

GDE potential	Mapped vegetation types	Area within development site (ha)
High	Smooth-barked Apple/ Red Bloodwood/ Brown Stringybark/ Hairpin Banksia heathy open forest Spotted Gum/ Broad-leaved Mahogany/ Red Ironbark shrubby open forest	0.36
Moderate	Smooth-barked Apple/ Red Bloodwood/ Brown Stringybark/ Hairpin Banksia heathy open forest Spotted Gum/ Broad-leaved Mahogany/ Red Ironbark shrubby open forest	1.42
Total		1.78