Landcom

Fennell Bay

Biodiversity constraints assessment

February 2019

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1. Introduction

1.1 Background

GHD have been engaged to prepare a biodiversity constraints assessment to support a request for a Gateway Determination to Lake Macquarie City Council (LMCC) to rezone a 240.76 hectare (ha) site (the study area) at 155 Old Main Road, Fennell Bay to allow for the urban development of the site. The majority of the study area is currently zoned RU6 Transition and E3 Environmental Management, with small areas zoned E2 Environmental Conservation and IN1 General Industrial in the northern extent of the study area.

The study area is shown on Figure 1-1 and is legally described as follows:

- Lot 5 DP 575458
- Lot 33 DP 858667
- Lot 70 DP 1078962
- Lot 1 DP 184321
- Lots 1 and 2 DP 1112722

The Planning Proposal would entail a mixed use subdivision comprising residential, open space areas, and mixed use local neighbourhood centre. The proposed concept layout is shown in Figure 1-1. The intended outcome of this Planning Proposal is to amend *The Lake Macquarie Local Environmental Plan 2014* (LMLEP 2014) as follows:

- R2 Low Density Residential: the zone currently used as the standard residential zone in the LMLEP 2014 and applies to large areas of land surrounding the site. It works with clause 4.1A to provide sufficient flexibility to enable a range of lot sizes and includes a number of compatible land uses including community facilities.
- R3 Medium Density Residential: this zone has been applied to the areas designated for smaller lot and affordable housing. It is currently applicable in other areas of the local government area (LGA) and permits additional compatible land uses including 'Neighbourhood Shops'. Clause 4.1A also currently applies to enable the delivery of lots to 200 m^2.
- E3 Environmental Management: this zone would be applied to the environmentally sensitive areas within the proposed urban footprint such as the drainage corridor traversing the proposed residential areas and would enable the adequate management of this land. The proposed E3 zoning is consistent with the zoning of adjacent land to the west, as well as the northern section of the site.

No amendments to the zoning of the IN1 General Industrial, E2 Environmental Conservation and E3 Environmental Management land is proposed.

This report provides an overview of the biodiversity values of the study area with a particular focus on accurately mapping plant community types and ecological communities. Vegetation mapping can be used as a surrogate for biodiversity values generally to inform development and conservation planning through consideration of biodiversity constraints and opportunities.

1.2 Purpose of this report

The purpose of this assessment is to describe the biodiversity value of the study area, with particular emphasis on threatened ecological communities, populations and species listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) and *Fisheries Management Act 1994* (FM Act), and Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The assessment has been prepared with reference to the NSW Biodiversity Assessment Method (BAM; OEH, 2017). The specific objectives of this biodiversity constraints assessment report are to:

- Describe the methodology, including desktop assessment and field surveys and any limitations.
- Describe the existing environment of the study area, plant community types, terrestrial and aquatic habitats and flora and fauna species known or likely to occur (including 'likelihood of occurrence' tables).
- Provide an initial assessment of the extent, condition and conservation significance of native vegetation and habitats at the site and the likelihood of occurrence of threatened biota based on the habitats present and the results of targeted surveys (where applicable).
- To accurately map plant community types, threatened ecological communities, records of threatened species and associated biodiversity constraints at the scale of the study area.
- Provide a preliminary assessment of impacts, addressing potential effects of the proposed activity on native flora and fauna, including threatened biota and their habitats. This would be supported by the constraints mapping.
- Provide a preliminary discussion of commitment to completing a biodiversity assessment as part of the Planning Proposal and the preferred approach to securing biodiversity offsets.

The information contained in this report would also be used to support a detailed biodiversity assessment at a later stage.

1.3 Scope and limitations

This report: has been prepared by GHD for Landcom and may only be used and relied on by Landcom for the purpose agreed between GHD and the Landcom as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Landcom arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

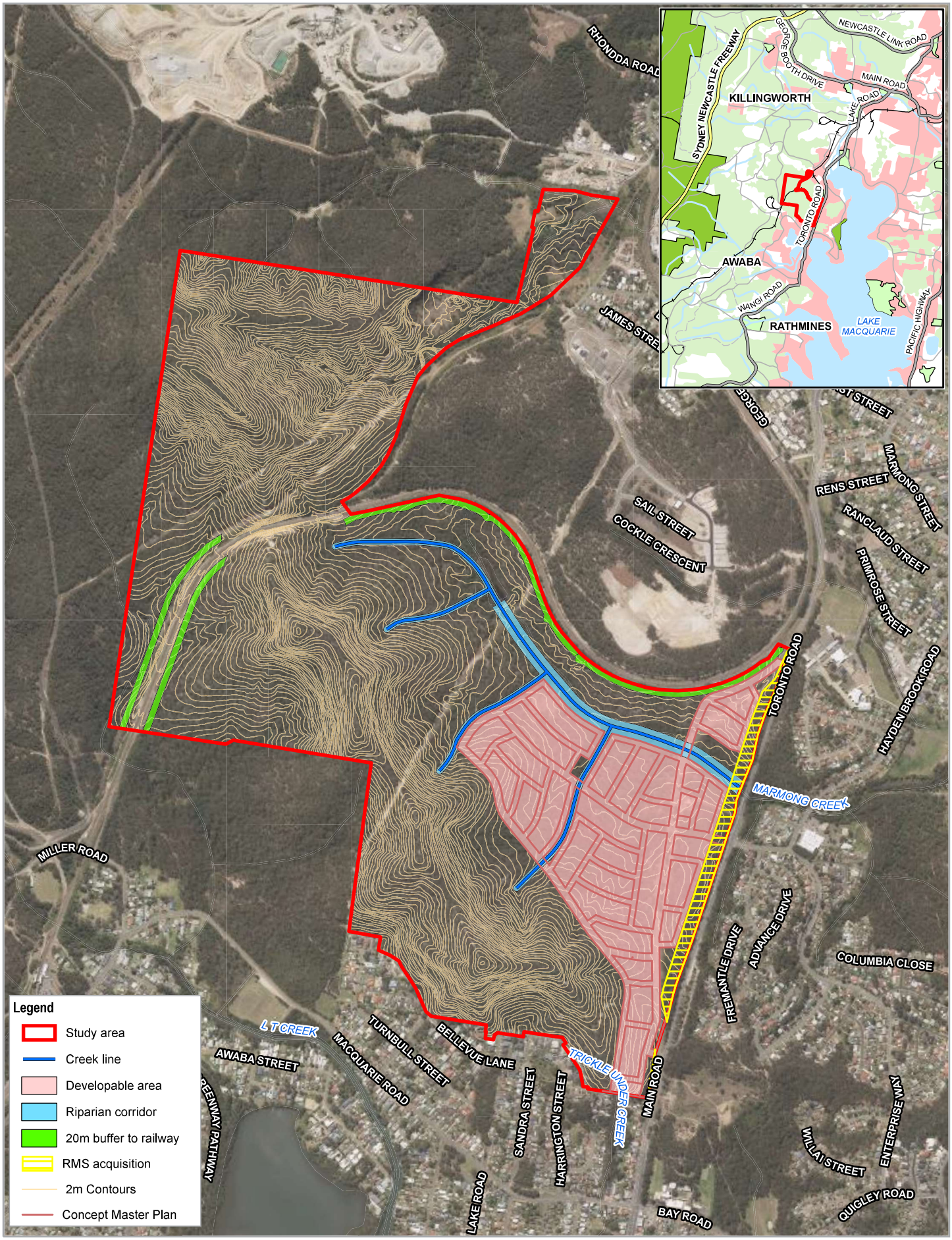
The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Landcom and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points and at the specific time of the field survey. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (such as the condition of vegetation or the presence or detectability of particular species) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.



Paper Size ISO A4

0 110 220 330 440

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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GHD

Urban Growth NSW
Proposed Fennell Bay Residential Development
Biodiversity Constraints

Project No. **22-19132**
Revision No. **0**
Date **31/01/2019**

Site location and concept layout

Figure 1-1

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Data source: LPI: Aerial Imagery, 2017\DTDB, 2017. Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3, 2006. Created by:

2. Methods

2.1 Desktop assessment and literature review

A desktop assessment was undertaken to identify threatened flora and fauna species, populations and ecological communities listed under the BC Act and FM Act, and MNES listed under the EPBC Act that may occur in the study area. Database records pertaining to the study area and locality (i.e. within a 10 km radius of the study area) were reviewed, along with relevant reports and mapping data, including:

- Office of Environment and Heritage (OEH) *NSW BioNet Atlas* database for records of threatened species listed under the BC Act (OEH 2018a)
- OEH *Threatened biodiversity profile search* online database for threatened ecological communities listed under the BC Act (OEH 2018b)
- Department of the Environment and Energy (DEE) *Protected Matters Online Search Tool* for MNES listed under the EPBC Act and predicted to occur in the locality (DEE 2018a)
- DEE online *Species profiles and threats database* (SPRAT) (DEE 2018b)
- DPI maps of Key Fish Habitat (DPI 2007)
- NSW *BioNet Vegetation Classification* (OEH 2018c) to identify matching plant community types (PCTs) in the study area
- Aerial photographs and satellite imagery, 2 m contour data, and creek line data of the study area
- Soil landscapes of the Newcastle 1:100 000 Sheet (Matthei 1995)
- Available regional-scale vegetation mapping of the site (NPWS 2000; LHCCREMS 2003; Bell 2016; Bell & Driscoll 2016)
- Lake Macquarie Large Forest Owl Study – North West City Sector (LMCC 2014a)
- Previous reports relevant to the site (ERM 2005, GHD 2009, and data and references therein)

GHD undertook a preliminary biobanking assessment of the study area in 2009, during which vegetation mapping and plot surveys were completed in accordance with the BioBanking Assessment Methodology (BBAM) 2009. The findings and field data from this assessment were considered in this constraints assessment.

Following collation of database records and species and community profiles, a 'likelihood of occurrence' assessment was undertaken with reference to the broad habitats in the study area. The likelihood of occurrence assessment assisted with focusing field survey techniques and effort and was further refined following the field surveys and the assessment of habitats present. The results of this assessment informed the biodiversity constraints assessment and are presented in Appendix A.

2.2 Field survey

Field surveys was undertaken within the study area to validate desktop information, refine vegetation mapping and to collect baseline species data. This information was used to inform the development of the concept layout.

Field surveys were also undertaken with due consideration of the requirements of the BAM in anticipation of the potential bio-certification of the study area. As the findings of the desktop assessment indicated that the majority of threatened biota constraints would be on the western half of the property, the field survey (particularly baseline targeted species survey) was focussed on the eastern half of the property where it was considered to be less constrained by biodiversity and hence more amenable to bio-certification.

Further targeted surveys would be undertaken across the entire study area as part of detailed assessment for a Biodiversity Biocertification Assessment Report (BCAR) and Biodiversity Stewardship Site Agreement Report (BSSAR).

Field survey effort and techniques used for this biodiversity constraints assessment are summarised in Table 2-1 and described in detail below.

Table 2-1 Survey effort

Survey type	Dates	Survey effort
Fauna survey	26 – 30 March 2018	• Arboreal Elliot Traps • Spotlighting • Call Playback • Harp Trapping • Ultrasonic call recording (Anabat) • Active searches for scats and signs • Camera traps • Habitat assessment • Hollow bearing tree assessments
Flora survey	24 May 2018	• 2 x ecologists for one day • Meander transect survey • Collection of rapid data assessment points • Ground-truthing of vegetation boundaries • Opportunistic fauna and flora observations throughout the study area
Fauna survey	30 July – 1 August 2018	• Large forest owl tree survey • Diurnal bird survey • Nocturnal spotlighting and stag-watching
Flora survey	20 – 22 August 2018	• Targeted survey for *Diuris praecox* • 2 x ecologists for two days, 3 x ecologists for one day • Opportunistic fauna and flora observations
Flora survey	4 & 8 October 2018	• Flora plot sampling • Opportunistic fauna and flora observations
Flora survey	9 – 11 October 2018	• Targeted survey for *Tetratheca juncea* • 2 x ecologists for three days

2.2.1 Terrestrial flora survey

The flora surveys occurred in two stages. The initial focus was to verify the existing vegetation mapping from GHD (2009) and to assess habitat for relevant threatened flora species identified through desktop review. These surveys involved the following techniques.

- Ground-truthing surveys to check mapped vegetation boundaries.
- Rapid data assessment points (RDPs) to collect information on dominant floristics.

- Random meander surveys of each mapped vegetation community to collect information on characteristic floristic assemblages, habitat features present and structure and broad vegetation condition.

Systematic plot and transect sampling in October 2018 was conducted in accordance with prescribed field sampling methods from section 5 of the BAM (OEH, 2017) to assist with the classification of vegetation types to PCTs, focussing on the proposed developable areas.

Following the above assessments, targeted seasonal surveys were conducted in August 2018 and October 2018 for *Tetratheca juncea* (Black-eyed Susan) and *Diuris praecox* (Newcastle Doubletail) respectively, focussing on the proposed developable areas.

The flora surveys are described in more detail below.

Vegetation mapping

Existing vegetation community mapping and plot data from GHD (2009) was used as an initial reference for vegetation mapping and verified during field survey. Fine-scale ground-truthing of the previous vegetation mapping and validation of the location of threatened ecological communities and threatened species habitat was performed with reference to aerial photography and the existing vegetation mapping on ArcGIS Collector. Rapid Data Points (RDPs) were recorded during random meanders of the study area where revisions to the vegetation mapping was identified, collecting data on dominant floristic composition and structure within view (approximate 50 m radius). Linework and attributions were subsequently adjusted based on aerial photographic interpretation within a Geographical Information System (GIS) as guided by the field survey results.

Native vegetation within the study area was classified based on observed species composition and vegetation structure according to the classification of Specht (1970). PCTs were defined according to the *BioNet Vegetation Classification* (OEH, 2018c), with cross references to vegetation community profiles published in NPWS 2000 and Bell (2016).

Vegetation within the study area was assessed against identification criteria for State and Commonwealth listed threatened ecological communities (critically endangered ecological communities (CEECs), endangered ecological communities (EECs) and vulnerable ecological communities (VECs)). Vegetation and habitats were compared with descriptions provided in OEH (2018b) and DEE (2018b) community profiles, as well as against diagnostic species lists for equivalent map units provided in Bell (2016).

Plot sampling

Nine floristic plot and transect surveys were sampled in October 2018. Floristic plot and transect sampling was undertaken in accordance with the prescribed field methods from section 5 of the BAM (OEH, 2017) to identify PCTs and collect vegetation integrity data. The data from these plot surveys is presented in Appendix B.

Plant identifications were made according to nomenclature in RBGT (2018). All vascular plants (i.e. not mosses, lichens or fungi) observed were recorded. Plant specimens that could not be identified rapidly in the field were collected and subsequently identified using standard botanical texts, *PlantNet* (RBGT, 2018), or by the National Herbarium of New South Wales at the Royal Botanic Gardens Sydney.

Plant specimens which were difficult to identify (either insufficient sample collected or buds/fruiting bodies were not available at the time of the survey) were identified to genus level.

Targeted threatened flora surveys

Targeted surveys for threatened flora species *Tetratheca juncea* (Black-eyed Susan) and *Diuris praecox* (Newcastle Doubletail) were conducted over six days in areas of suitable habitat and in accordance with the *NSW Guide to Surveying Threatened Plants* (OEH, 2016) and the LMCC *Tetratheca juncea* Planning and Management Guidelines (LMCC, 2014b). Surveys were timed to coincide with expected flowering times of the species, to maximise the chance of detection for these otherwise cryptic species.

Opportunistic threatened flora surveys

Opportunistic surveys were undertaken for threatened flora species that could potentially occur within the study area given known distributions, previous records in the locality and habitat requirements for each species.

Surveys were conducted on foot while ground-truthing vegetation mapping, and undertaking flora sampling and targeted survey.

2.2.2 Terrestrial fauna survey

Preliminary terrestrial fauna surveys were completed within the study area over two sessions focussing on the proposed developable areas:

- Early autumn - over a five day/four night period.
- Mid-late winter - over a three night/four day period.

A variety of techniques were used to target threatened fauna species and to assess habitat values within the study area. Detailed descriptions of survey techniques are provided below and summarised in Table 2-1. All fauna observations were recorded on proforma field data sheets. Fauna survey locations are shown on Figure 2-1.

Table 2-2 Fauna survey techniques

Survey type	Effort
Arboreal trap lines	A total of 8 transects consisting of 10 traps (five Elliott A and five Elliot B) over 4 day/nights from 26-30 March. 80 trap nights/ night. Total effort = 320 trap nights.
Spotlighting	Four consecutive nights of spotlighting from 26-30 March 2018 (4 person hours each night) were conducted between the hours of 8 – 11 PM. This included walked transects. Total autumn effort = 16 person hours. Three consecutive nights of spotlighting from 30 July-1 August (8 x person hours for the first two nights, 12 person hours for the third night) were conducted between the hours of 6 – 10 PM. During which survey effort included stag- watching of potential Owl hollows and walked transects. Total winter effort = 28 person hours. Total overall effort = 44 person hours.
Call Playback	Conducted over four consecutive nights from 26-30 March in three different locations targeting Koala, Squirrel Glider, Yellow- bellied Glider, Barking Owl, Powerful Owl, Masked Owl and Green and Golden Bell Frog.

Survey type	Effort
Daytime traverses Active reptile/amphibian searches Active searches for scats and signs	Undertook targeted searches in identified preferred habitat for 2 person hours x 4 days (26-30 March 2018). Total effort = 8 person hours. Included dedicated searches for any signs of fauna occupation. Included searching for evidence of feeding (e.g. *Allocasuarina* chewed cones which are signs of Glossy Black-cockatoo (*Calyptorhynchus lathami*) in dense stands of *Allocasuarina*), foraging and signs of bird presence (such as pellets, whitewash, nests etc.) and other biota (scats, scratchings, diggings, nests etc.). Active searches of woody debris and other ground litter were conducted throughout the study area targeting threatened frogs and reptiles.
Owl Tree Surveys	Three consecutive daytime searches from 30 July-1 August (8 x person hours for the first two days, 12 person hours for the third day) Conducted targeted searches for trees containing large hollows, the base of which were inspected for signs of use by roosting owls (whitewash, feathers, bones, scats). All suitable hollows were stag watched. Total effort = 28 person hours.
Harp Traps	4 x harp traps positioned around the study area for a total of four nights (four nights from 26-30 March 2018). Total effort = 24 trap nights.
Ultrasonic call recording	A total of 2 x Anabats positioned in different flyways within the site over four nights (12 hours each/per night from 26-30 March). Total effort = 96 hours.
Camera Traps	10 x baited motion activated camera traps active for four nights (10 traps between 26-30 February) positioned around the site in suitable habitat.
Diurnal bird surveys	Bird surveys were conducted within suitable habitat for target species, between the hours of 6-9 AM in autumn and 6-10 in winter. 4 person hours x 4 days (16 person hours) on 26-30 March 2018 in suitable habitat throughout site. 4 person hours x 3 days (12 person hours) on 30 July-1 August in suitable habitat throughout site. Flowering Eucalypt and Melaleuca were targeted in particular. Total effort = 28 person hours.
Habitat assessments	1 x habitat assessment for each habitat type in autumn. Total effort= 4 assessments.

Fauna habitat assessment

General fauna habitat assessments were undertaken throughout the study area, including active searches for potential shelter, basking, roosting, nesting and/or foraging sites. Each habitat type was assessed. Habitat types were distinguished by differences in habitat resources and changes in resource diversity. Specific habitat features and resources such as water bodies, food trees, the density of understorey vegetation, the composition of ground cover, the soil type, presence of hollow-bearing trees, leaf litter and ground debris were noted. Aquatic habitat was assessed in the field and through desktop assessment of government database searches and guidelines.

Indicative habitat criteria for targeted threatened species (i.e. those determined as having the potential to occur within the study area following the desktop review) were identified prior to fieldwork. Habitat criteria were based on information provided in OEH and DoEE threatened species profiles, field guides, and the knowledge and experience of GHD field ecologists.

Habitat assessments included active searches for the following:

- Trees with bird nests or other potential fauna roosts
- Rock outcrops or overhangs providing potential shelter sites for fauna
- Burrows, dens and warrens
- Distinctive scats or latrine sites (of particular relevance for the Spotted-tailed Quoll), owl white wash and regurgitated pellets under roost sites
- Tracks or animal remains
- Evidence of activity such as feeding scars, scratches and diggings
- Specific food trees and evidence of foraging (e.g. chewed *Allocasuarina* cones)

The locations and quantitative descriptions of significant habitat features were captured with a handheld GPS unit and photographed where appropriate.

Arboreal Elliot trapping

Targeted threatened arboreal mammal trapping was completed within the study area over a four day/four night period. Species targeted include Squirrel Glider (*Petaurus norfolkensis*) and Eastern Pygmy-possum (*Cercartetus nanus*).

A total of eight transects consisting of ten traps (five Elliott A and five Elliot B) were established within the study area. All traps were opened in the late afternoon and checked each morning, closed and then reopened in the afternoon for four consecutive days. The total trapping effort amounted to 320 trap-nights.

Diurnal bird surveys

Targeted surveys for diurnal birds were undertaken throughout the study area within two hours of dawn over two separate periods. Surveys followed the area search method, and birds were identified by observation with binoculars and/or call identification. Diurnal bird surveys also included searches for signs indicative of particular threatened species, including searching for evidence of feeding (e.g. *Allocasuarina* chewed cones which are signs of Glossy Black-cockatoo (*Calyptorhynchus lathami*) foraging and signs of bird presence, such as pellets, whitewash, nests etc.).

Nocturnal amphibian surveys

Active searches for frogs were performed within the study area focussing on areas of suitable habitat, including swampy areas, pools of standing water and drainage lines. Frogs were identified by sight and call.

Microchiropteran bat survey

Four harp traps were set up within the study area over two 4 day/4 night period. The traps were set in potential flyways within and checked twice daily, towards the conclusion of nocturnal surveys (9:00-10:00 pm) and just before dawn (5.30-6:00 am). All trapped bats were identified, weighed, measured, checked for health and released at point of capture.

Bat calls were also recorded during field surveys using Anabat Express detectors and Anabat II coupled with ZCAIMS (Titley Scientific).

Stationary Anabat recordings were undertaken in eight locations over a total of four nights (two recording from 26-30 March within the study area as shown on Figure 2-1. Recording commenced at least half an hour before dusk and continued until the following morning.

Calls were identified using zero-crossing analysis and AnalookW software (version 4.2n) by visually comparing the time-frequency graph and call characteristics (e.g. characteristic frequency and call shape) with reference calls and/or species call descriptions from available reference material.

The *Bat calls of NSW: Region based guide to the echolocation calls of microchiropteran bats* (Pennay *et al*. 2004) was used to assist call analysis. Call identification was also assisted by consulting distribution information for possible species (Pennay *et al.* 2011; Churchill 2008; Van Dyck *et al*. 2013) and records from BioNet (October 2016). No reference calls were collected during the survey.

A call (pass) was defined as a sequence of three or more consecutive pulses of similar frequency and shape. Calls with less than three defined consecutive pulses of similar frequency and shape were not unambiguously identified to a species but were used as part of the activity count for the survey area. Due to variability in the quality of calls and the difficulty in distinguishing some species the identification of each call was assigned a confidence rating (see Mills *et al.* 1996, and Duffy *et al.* 2000) as summarised in Table 2-3.

Due to the absence of reference calls from the study area, high level of variability within a bat call and overlap in call characteristics between some species, a conservative approach was taken when analysing calls.

Species nomenclature follows Van Dyck *et al.* (2013) and Reardon *et al.* (2014).

Table 2-3 Confidence ratings applied to calls

Identification	Description
D - Definite	Species identification not in doubt.
PR - Probable	Call most likely to represent a particular species, but there exists a low probability of confusion with species of similar call type or call lacks sufficient detail.
SG - Species Group	Call made by one of two or more species. Call characteristics overlap making it too difficult to distinguish between species (e.g. *Chalinolobus gouldii*/*Mormopterus ozimops* sp.) *Nyctophilus* sp. - The calls of *Nyctophilus geoffroyi*/*gouldi* cannot be distinguished during the analysis process and are therefore lumped together. *Nyctophilus* sp./*Myotis macropus* - The calls of these species can be easily confused during the analysis process and are therefore often lumped together.

Spotlighting

Spotlight searches were undertaken throughout the study area for nocturnally active mammals, birds and frogs, including dedicated listening periods for fauna vocalisations. Mammals and nocturnal birds were identified by observation under spotlight or by vocalisations heard whilst spotlighting. Transects were conducted on foot over four consecutive nights during field surveys in autumn, and three consecutive nights in winter. Transects were walked for a period of four person-hours each night between the hours of 8:00-11:00 pm, and eight person hours (first and second nights) and twelve person hours (third night) between the hours of 6-10 pm in winter. Species targeted during spotlighting surveys included the Pygmy Possum (*Cercartetus nanus*), Barking Owl, (*Ninox connivens*), Squirrel Glider (*Petaurus norfolcensis)*, Grey-headed Flying Fox (*Pteropus poliocephalus*), and Green and Golden Bell Frog (*Litoria aurea*).

Call playback

Nocturnal call playback surveys were conducted over four consecutive nights during autumn. Species targeted included Koala (*Phascolarctos cinereus*), Squirrel Glider *(Petaurus norfolcensis)*, Yellow- bellied Glider *(Petaurus australis)*, Barking Owl *(Ninox connivens)*, Powerful Owl *(Ninox strenua)*, Masked Owl *(Tyto novaehollandiae)* and Green and Golden Bell Frog *(Litoria aurea)*. Surveys involved an initial listening period of five minutes, followed by call playing for three minutes, followed by a listening period of five minutes (undertaken separately for each species), with a final listening period of approximately 10 minutes. Calls were played through a portable MP3 player connected to a 45-watt megaphone. All potential roost sites in the immediate area were then scanned for 10 minutes using spotlights.

Active searches

Active searches of woody debris and other ground litter were conducted throughout the study area during the survey period targeting threatened frogs and reptiles. Fallen timber and other potential shelter sites such as corrugated iron sheets and rock piles were carefully turned and inspected.

Opportunistic observations

Opportunistic and incidental observations of fauna species were recorded at all times during field surveys. This included a conscious focus on suitable areas of habitat during flora surveys, for instance fallen timber was scanned and/or turned for reptiles and mature trees and stags were scanned for roosting birds.

Camera Traps

Ten baited infra-red motion cameras were set up across the study area for each of the four day survey periods (26-30 March 2018). These cameras were used to target threatened ground-dwelling mammals.

2.2.3 Staff qualifications

This report was prepared by Cecilia Phu with the assistance of Bridie Halse, Philippa Fagan and Felicity Williams. The assessment was peer reviewed by Daniel Williams and Jayne Tipping. Staff qualifications are presented in Table 2-4.

Table 2-4 GHD ecology staff and qualifications

Name	Position/Project Role	Qualifications	Relevant Experience
Jayne Tipping	Principal/Technical Director Ecology Project Director and technical review	B.Sc, M.EnvLaw Accredited BAM Assessor	20+ years
Dan Williams	Associate/Technical Director Biodiversity Offsets Project Manager and technical review	B. App. Sc Accredited BAM Assessor	18+ years
Cecilia Phu	Senior Ecologist Desktop assessment, field surveys and reporting	B.Sc (Hons) Accredited BAM Assessor	11+ years
Philippa Fagan	Ecologist (Botanist) Field surveys and reporting	B. Biod.&Cons. Accredited BAM Assessor	4+ years

Name	Position/Project Role	Qualifications	Relevant Experience
Ben Lewis	Ecologist (Zoologist) Field surveys	B. App. Sc	20+ years
Felicity Williams	Ecologist Field surveys and reporting	B.Sc (Hons)	4+ years
Bridie Halse	Ecologist Desktop assessment, field surveys and reporting	B. EnvSc & Man	2+ years
Alex Williams	Ecologist Field surveys	B. EnvSc & Man	2+ years

2.2.4 Survey limitations

Given the duration, methodology and timing of the field surveys, it is possible that some species that occur in the study area (permanently, seasonally or transiently) were not detected during the survey. These species may include flora species that flower at other times of year or are annual, ephemeral or cryptic species. The climate conditions at the time of survey, particularly in regards to the low rainfall and prevailing drought conditions, may also contribute to cryptic, annual species remaining dormant during the usual flowering period, or flowering earlier and quicker than usual, and therefore not being detected despite comprehensive targeted survey taking place.

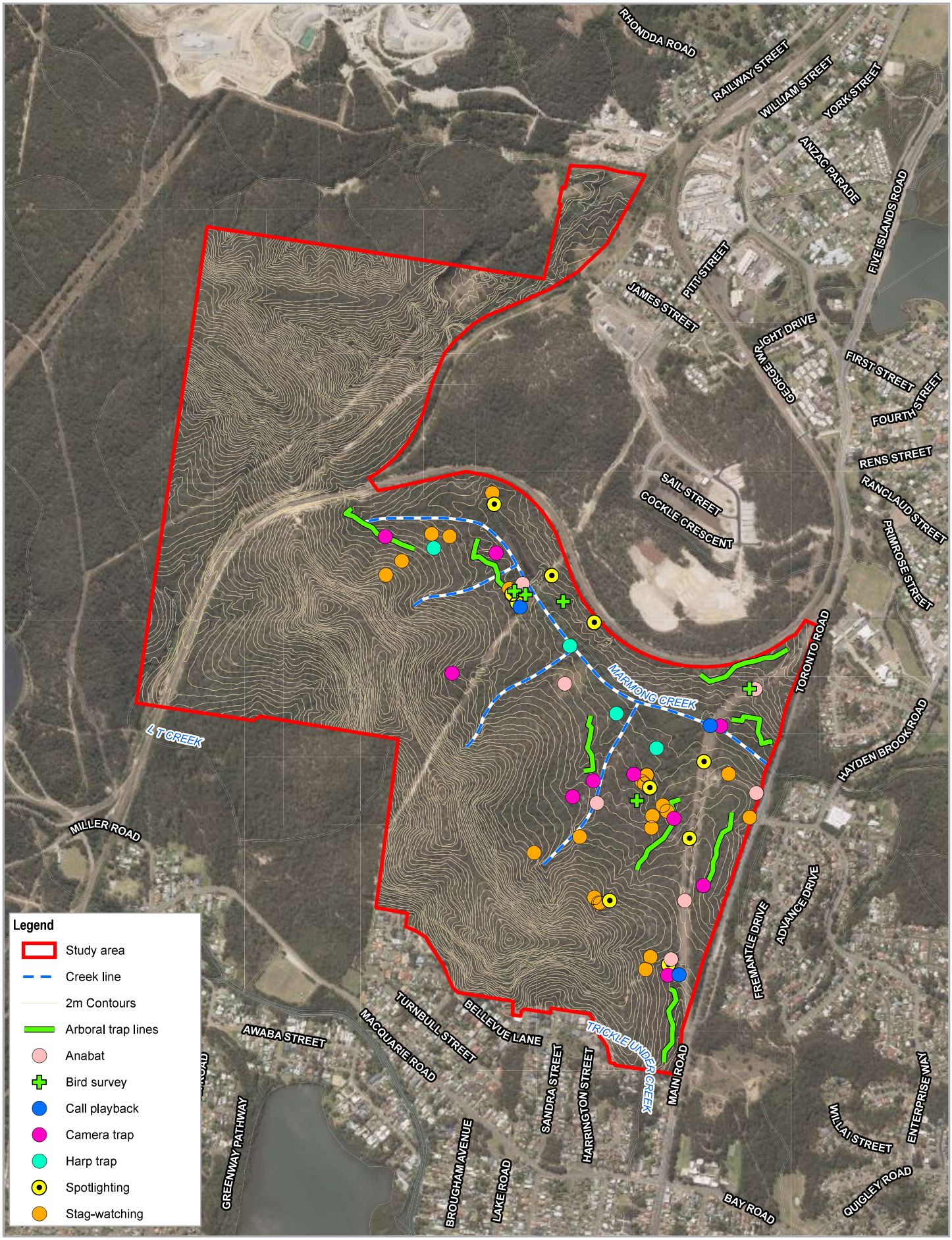
The desktop assessment provided a list of the native flora and fauna and especially threatened biota that could potentially occur in the study area or be affected by the proposal (including seasonal, transient or cryptic species). The habitat assessment conducted for the study area allows for identification of habitat resources for such species and an assessment of their likelihood of occurrence in the study area on this basis. As such, the survey was not designed to detect all species, rather to provide an overall assessment of the biodiversity values in the study area in order to inform the constraints assessment.

2.3 Assessment of likelihood of occurrence

Following collation of database records and species and community profiles, a 'likelihood of occurrence' assessment was prepared with reference to the habitats contained within the study area. Identification of potential habitat for threatened and migratory species was based on information provided in the species profiles (DEE 2018b, OEH 2018b), recovery plans, journal articles, and the GHD staff knowledge of species habitat requirements. The likelihood of occurrence assessment was further refined following field surveys. The likelihood of threatened and migratory biota occurring in the study area was assessed based on presence of records from the locality since 1998, species distribution and habitat preferences, and the suitability of habitat present. The results of this assessment are provided in Appendix A. Threatened and migratory biota considered likely to occur are discussed further in section 3.4. Table 2-5 shows the key used to determine the likelihood of occurrence for threatened biota.

Table 2-5 Key to likelihood of occurrence for threatened biota

Likelihood	Definition
Present	Threatened species, population or community was recorded in the study area.
High	Species, population or community previously recorded within a 10 km radius of the study area and suitable habitat occurs within the study area.
Moderate	Species, population or community previously recorded within a 10 km radius of the study area but only marginally suitable habitat recorded, OR Species, population or community not previously recorded within a 10 km radius of the study area, but the study area is within the species' known distribution and suitable habitat occurs within the study area.
Low	Species, population or community previously recorded within a 10 km radius of the study area but no suitable habitat recorded.
Nil	Species, population or community not previously recorded within a 10 km radius of the study area, suitable habitat not recorded within the study area, and/or the study area is outside the species' known distribution.



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Urban Growth NSW
Proposed Fennell Bay Residential Development
Biodiversity Constraints

Project No. **22-19132**
Revision No. **0**
Date **31/01/2019**

Fauna survey locations

Figure 2-1

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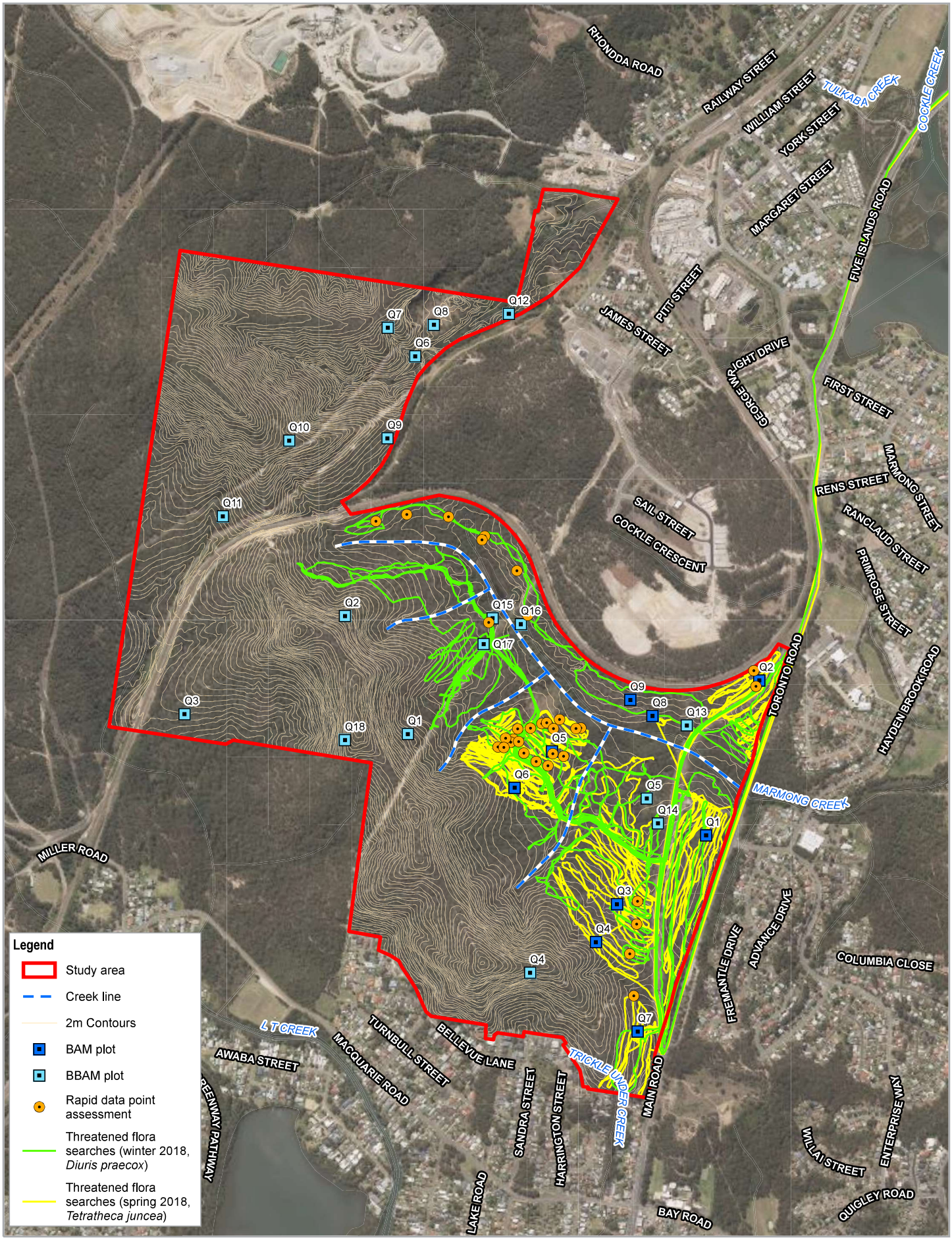
Print date: 31 Jan 2019 - 11:56

Data source: LMCC: Threatened species data, 2017; LPI: Aerial Imagery, 2017. Created by:



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Urban Growth NSW
Proposed Fennell Bay Residential Development
Biodiversity Constraints

Project No. **22-19132**
Revision No. **0**
Date **31/01/2019**

Flora survey locations

Figure 2-2

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Print date: 31 Jan 2019 - 12:23

Data source: LMCC: Threatened species data, 2017; LPI: Aerial Imagery, 2017. Created by:

3. Existing environment

3.1 Site context

3.1.1 Study area

The study area is located in the suburb of Fennell Bay within the Lake Macquarie LGA. The study area has been identified as a suitable location for residential development, with the existing residential areas of Toronto being located directly south, Fassifern to the south west and Woodrising to the east. A rail corridor dissects the study area (see Figure 1-1).

A ridgeline extends northwest across the majority of the study area. The ephemeral streams originating from this feature feed a number of permanent drainage lines, the largest being Marmong Creek in the northeast of the study area. This watercourse has a large open body of water (a dam), within the study area. Two smaller ephemeral first-order tributaries of L T Creek flowing south through the south western portion of the study area. Marmong Creek and L T Creek both flow directly into Lake Macquarie.

With the exception of several small patches of cleared areas and a number of rocky outcrops, the study area is largely covered in remnant native vegetation. It forms part of a more extensive tract of vegetated land to the west of Lake Macquarie connecting to Yengo National Park, including a mix of private lands and forestry or reserve lands (e.g. Sugarloaf State Conservation Area, Awaba and Olney state forests, Watagan National Park, Jilliby State Conservation Area).

Much of the land to the south, south west and east of the study area has been cleared for residential development. To the northwest, the site joins onto a larger vegetation corridor that extends through to Awaba State Forest to the west of the study area. The areas to the north and west are also part of this corridor, though they are interspersed with facilities associated with coal mining.

3.1.2 Landscape context

Mitchell landscape

The majority of the study area is located within the Gosford – Cooranbong Coastal Slopes Mitchell Landscape (DECC 2008a), within the Sydney Basin Bioregion, which is described as follows:

"*Coastal fall of the Sydney Basin, rolling hills and sandstone plateau outliers of Triassic Narrabeen sandstones, extensive rock outcrop and low cliffs along ridge margins, general elevation 0 to 75m. Texture-contrast soils on lithic sandstones and shales. Loamy sand alluvium along creeks. Organic sand and mud in lagoons and swamps. Open forest and woodland of smooth-barked apple (*Angophora costata*), red bloodwood (*Corymbia gummifera*), brown stringybark (*Eucalyptus capitellata*), Sydney peppermint (*Eucalyptus piperita*), spotted gum (*Corymbia maculata*), bastard mahogany (*Eucalyptus carnea*), northern grey ironbark (*Eucalyptus siderophloia*) and grey gum (*Eucalyptus punctata*) on hills and slopes. Small areas of closed forest with; turpentine (*Syncarpia glomulifera*), lilly pilly (*Acmena smithii*), mountain cedar wattle (*Acacia elata*), coachwood (*Ceratopetalum apetalum*), sassafras (*Doryphora sassafras*) and water gum (*Tristaniopsis laurina*) in gullies under high escarpments Prickly-leaved tea-tree (*Melaleuca stypheliodes*) and other shrubs with swamp mahogany (*Eucalyptus robusta*), swamp oak (*Casuarina glauca*), sedges and common reed (*Phragmites australis*) on swampy creek flats. Coastal heath subject to salt spray on headlands.*" (DECC 2008b).

A small portion in the northern tip of the study area is located within the Sydney – Newcastle Coastal Alluvial Plains Mitchell Landscape, which is described as follows:

"*Undulating plains and low rises on Quaternary sand or Permian/Triassic sandstone or shale with swampy valley floors. General elevation 0 to 80m, local relief 20m. Siliceous uniform sands, patches of deep podsol and yellow or brown texture-contrast soils on bedrock. Vegetation varies with soil and drainage. On the sands and podsols coast banksia,* Banksia aemula*, red bloodwood (*Corymbia gummifera*) and smooth-barked apple (*Angophora costata*) are common. On bedrock forest oak (*Allocasuarina torulosa*), grey gum (*Eucalyptus punctata*), forest red gum (*Eucalyptus tereticornis*), and scribbly gum (*Eucalyptus haemostoma*), with a shrubby understorey are common and the swamps are typically surrounded by broad-leaved paperbark (*Melaleuca quinquenervia*), coast banksia (*Banksia integrifolia*), swamp oak (*Casuarina glauca*) and swamp mahogany (*Eucalyptus robusta*) with spike rushes (*Eleocharis *sp.*) and tall swamp sedge (*Gahnia *sp.*). Open water supports a variety of aquatic plants including; common reed (Phragmites australis), floating pondweed (*Potamogeton tricarinatus*), water primrose (*Ludwigia peploides*) duckweed (*Lemna *sp.*), water buttons (*Cotula coronopifolia*) and red azolla (*Azolla filiculoides*).*" (DECC 2008b).

The DECC (2008a, 2008b) description of the geology and geomorphology at the study area was confirmed by GHD ecologists during the site inspection to be consistent with the Gosford – Cooranbong Coastal Slopes Mitchell Landscape. The DECC (2008a, 2008b) description of vegetation for Gosford – Cooranbong Coastal Slopes Mitchell Landscape broadly matches the survey results present in section 3.2, with the exception that the study area generally lacks the more mesic elements that occur in gullies under high escarpments (namely, Lilly Pilly, Sassafras, Coachwood and Water Gum).

Soil landscape

The study area falls within several soil landscapes, which are described below:

- Awaba (aw): rolling hills with short sideslopes and numerous, closely spaced drainage lines. Slope gradients generally 10-25% and local relief 20-80 m. Some southerly facing slopes have slope gradients >25%. Crests are convex and broad; slopes are convex, short and steepen towards narrow incised drainage lines. Rock outcrop is absent. Predominantly uncleared coastal heaths and woodlands (Matthei 1995). Generally a small area within the north eastern corner of the study area.
- Doyalson (do): gently undulating rises on Permian sediments in the Awaba Hills around the Lake Macquarie foreshores. It includes Booragul, Teralba and Blackalls Park. Local relief to 30 m and slope gradients <10%. Broad crests and ridges and long, gently inclined slopes are the major landform elements. Drainage lines are broad and rock outcrop is usually absent (Matthei 1995). Predominantly cleared open forest (Matthei 1995). Generally the eastern fall from the main ridgeline, extending to the north-east off-site.
- Sugarloaf (su): rolling to steep mountains on sandstone and siltstone sediments of the Narrabeen Group in the Sugarloaf Range region. Local relief to 200 m, gradients are >30% on steep sideslopes and 5–20% on summit surfaces. Elevation to 400 m. Steep sideslopes are long and concave, with infrequent narrow (<300 m) sandstone benches and scarps. Drainage lines are numerous, shallow and incipient. Bedrock outcrop is restricted to crests and benches, and floating sandstone boulders are common on sideslopes. Uncleared tall open-forest (Matthei 1995). Generally along the main ridgeline and north of the rail corridor.

- Gateshead (ga): undulating to rolling rises on Permian conglomerate, shale and sandstone in the Awaba Hills. Local relief to 100 m. Slopes 5–15%. Elevation to 130 m. Crests are broad (250-500 m) and slopes are long (500-1000 m). The heads of drainage lines are narrow and deeply incised, but grading into broad flats (up to 5 m wide) downstream. Rock outcrop is rare, less than 2%. Predominantly cleared woodland and open-forest (Matthei 1995). Generally the western fall from the main ridgeline, extending to the north west off-site.

This description of the soil landscapes at the study area was generally confirmed by GHD ecologists during the site inspection.

3.2 Vegetation

3.2.1 Flora species

A total of 171 species from 54 families were identified within the study area during the field survey, including 23 exotic species and 148 native species. The families that are most represented by the species assemblage are Myrtaceae and Poaceae. Species lists are provided in Appendix C.

A number of exotic species listed as priority weeds in the Hunter region, which includes the Lake Macquarie LGA (DPI 2018) occur within the study areas, including:

- Blackberry (*Rubus fruticosus* species aggregate)
- Lantana (*Lantana camara*)
- Pampas Grass (*Cortaderia selloana*)
- Coolatai Grass (*Hyparrhenia hirta*)
- Fireweed (*Senecio madagascariensis*)

These priority weeds occur in generally low densities across the study area, and are more prevalent in areas exposed to disturbance, or edge effects.

Other environmental and windborne weeds include Mickey Mouse Plant (*Ochna serrulata*) and Small-leaved Privet (*Ligustrum sinense*).

3.2.2 Vegetation communities

Overview

The native vegetation within the study area comprises six vegetation types that are intact or near-intact condition. These are:

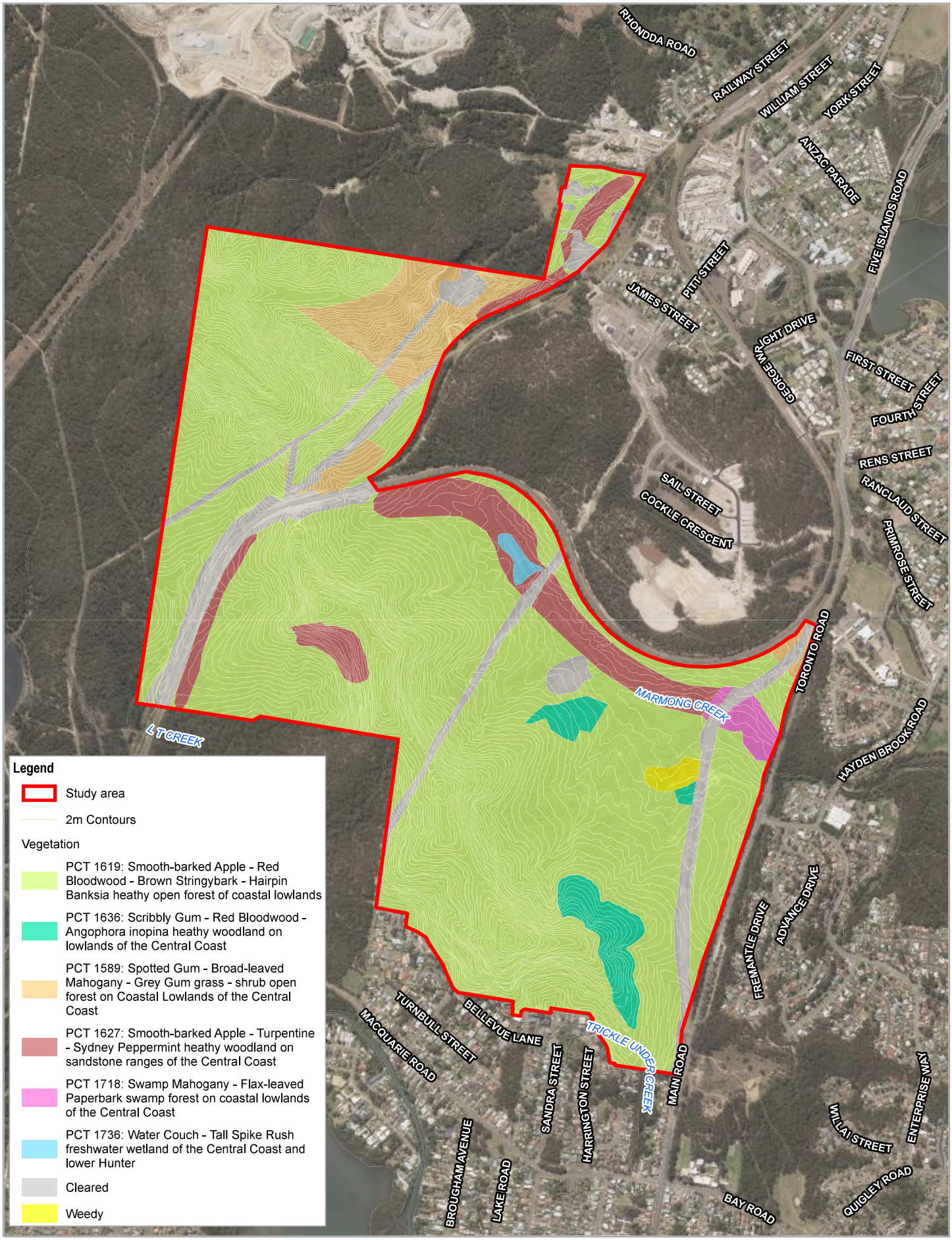
- Coastal Plains Smooth-barked Apple Woodland
- Coastal Plains Scribbly Gum Woodland
- Coastal Foothills Spotted Gum – Ironbark Forest
- Coastal Sheltered Apple – Peppermint Forest
- Riparian Melaleuca Swamp Woodland
- Freshwater Wetland

The study area also includes a small patch of weedy vegetation in the eastern portion of the study area, as well as cleared areas comprising power line and rail corridors, main tracks and small clearings.

The vegetation types and their extent within the study area are detailed below (Table 3-1). The structure, species composition and condition of each of the native vegetation communities within the study area are described in the following section and shown in Figure 3-1.

Table 3-1 Vegetation types and their extent within the study area

Vegetation Type	PCT name	Conservation status	Area (hectare)
Coastal Plains Smooth-barked Apple Woodland	PCT 1619: Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands	Not listed	193.43
Coastal Plains Scribbly Gum Woodland	PCT 1636: Scribbly Gum - Red Bloodwood - Angophora inopina heathy woodland on lowlands of the Central Coast	Not listed	7.05
Coastal Foothills Spotted Gum - Ironbark Forest	PCT 1589: Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast	Not listed	13.21
Coastal Sheltered Apple – Peppermint Forest	PCT 1627: Smooth-barked Apple - Turpentine - Sydney Peppermint heathy woodland on sandstone ranges of the Central Coast	Not listed	17.96
Riparian Melaleuca Swamp Woodland	PCT 1718: Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (endangered, BC Act).	2.24
Freshwater Wetland	PCT 1736: Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (endangered, BC Act)	0.81
Weedy	n/a	Not listed	1.16
Cleared	n/a	Not listed	21.37
		Total in study area (hectare)	**257.23**



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Grid: GDA 1994 MGA Zone 56

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Vegetation communities

Figure 3-1

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Print date: 31 Jan 2019 - 11:56

Data source: LMCC: Threatened species data, 2017; LPI: Aerial Imagery, 2017. Created by:

Vegetation Descriptions

Coastal Plains Smooth-barked Apple Woodland		
PCT (OEH, 2018c)	Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands	
PCT ID	1619	
Equivalent Map Units	MU30 (NPWS 2000); Unit 30 (Bell 2016)	
Survey effort	Plots 1, 2, 3, 9, 10, 11 (2009); 1, 3, 6, 7 (2018)	
Extent in study area (ha)	193.43	
Conservation significance	Not listed under the BC Act or EPBC Act.	
Condition	Moderate to good vegetation, near-intact to intact. • Remnant native vegetation with near-intact over storey • High native species richness and very low exotic species represented in the assemblage • Evidence of previous fire, which may have produced a more open understorey than is typical for this community type	
Evidence used to define vegetation unit	• Dry open forest vegetation structure • Characteristic sedimentary soil types and geomorphology • The dominant plant species described below are consistent with the VIS (OEH, 2018c) and with equivalent regional mapping units (NPWS 2000; Bell 2016)	
Landscape position	Occurs on hillslopes and upper slopes of low coastal ranges on gently undulating topographies. This is the most extensive vegetation type within the study area and is mapped across the majority of the site.	
Structure	Open forest with an open to moderately dense mid storey and a highly diverse understorey comprising grass, fern, rush and forb species. Open forests with a typically shrubby midstorey that includes grass trees and scrambling climbers. The ground layer is typically dominated by grasses along with graminoids and scattered forbs.	
Over storey	Canopy is dominated by Smooth-barked Apple (*Angophora costata*) and Red Bloodwood (*Corymbia gummifera*), with Broad-leaved White Mahogany (*Eucalyptus umbra*), Brown Stringybark *(E. capitellata*) and occasionally Grey Ironbark (*E. paniculata*) and Grey Gum (*E. punctata*). Scribbly Gum (*E. haemastoma*) is present in low numbers at ecotones with Coastal Plains Scribbly Gum Woodland.	
Mid storey	Characterised by species including Black She-oak (*Allocasuarina littoralis*), Hairpin Banksia (*Banksia spinulosa*), Narrow-leaved Geebung (*Persoonia linearis*), and Prickly Shaggy Pea (*Podolobium ilicifolium*).	
Groundcover	Moderately dense and species-rich. Dominated by grass species like Blady Grass (*Imperata cylindrica*), Kangaroo Grass (*Themeda triandra*), and Wiry Panic (*Entolasia stricta*). Also characterised by herbs and sedges including *Dianella revoluta*, *Billardiera scandens*, *Lomandra obliqua*, *Ptilothrix deusta*, *Glycine tabacina*, *Lepidosperma laterale*, *Pomax umbellata*, and *Xanthorrhoea latifolia*.	
Exotic species	Largely weed-free, excepting rare occurrences of exotic species like Dandelion (*Taraxacum officinale*)	

Coastal Plains Scribbly Gum Woodland		
PCT (OEH, 2018c)	Scribbly Gum - Red Bloodwood - Angophora inopina heathy woodland on lowlands of the Central Coast	
PCT ID	1636	
Equivalent Map Units	MU31 (NPWS 2000); Unit 31 (Bell 2016)	
Survey effort	Plots 4, 14 (2009); 4, 5 (2018)	
Extent in study area (ha)	7.05	
Conservation significance	Not listed under the BC Act or EPBC Act.	
Condition	Moderate to good vegetation, near-intact to intact. • Remnant native vegetation with near-intact over storey • High native species richness and very low exotic species represented in the assemblage • Evidence of previous fire, which may have produced a more open understorey than is typical for this community type	
Evidence used to define vegetation unit	• Tall woodland vegetation structure • Characteristic sedimentary soil types and geomorphology • The dominant plant species described below are consistent with the VIS (OEH, 2018c) and with equivalent regional mapping units (NPWS 2000; Bell 2016)	
Landscape position	Occurs in discrete patches within the study area on upper slopes and hillsides approaching Marmong Creek, where there may be some localised poor drainage. Forms a mosaic of patches within Coastal Plains Smooth-barked Apple Woodland and may be more common than currently mapped.	
Structure	Tall woodland with an open mid storey and a highly diverse understorey comprising grass, fern, rush and forb species. Has a typically shrubby midstorey that includes grass trees and scrambling climbers. The ground layer is typically dominated by grasses along with graminoids and scattered forbs.	
Over storey	Canopy is clearly dominated by Scribbly Gum (*Eucalyptus haemastoma*), with Red Bloodwood (*Corymbia gummifera*) and Brown Stringybark *(E. capitellata*), and occasionally Smooth-barked Apple (*Angophora costata*) where the community transitions to Coastal Plains Smooth-barked Apple Woodland.	
Mid storey	Characterised by species including Hairpin Banksia (*Banksia spinulosa*), Narrow-leaved Geebung (*Persoonia linearis*), Broad-leaved Geebung (*Persoonia levis*), Mountain Devils (*Lambertia formosa*), Sydney Golden Wattle (*Acacia longifolia*), Slender Tea-tree (*Leptospermum trinervium*) and Tantoon (*Leptospermum polygalifolium*).	
Groundcover	Moderately dense and species-rich. Dominated by grass species like Blady Grass (*Imperata cylindrica*), Kangaroo Grass (*Themeda triandra*), Three-awn Speargrass (*Aristida vagans*) and Wiry Panic (*Entolasia stricta*). Also characterised by herbs, sedges and ferns including *Dianella caerulea* var. *producta*, Wombat Berry (*Eustrephus latifolius*), *Lomandra obliqua*, *Ptilothrix deusta*, *Glycine tabacina*, *Lepidosperma laterale*, *Xanthorrhoea latifolia* and Common Bracken (*Pteridium esculentum*).	
Exotic species	Largely weed-free, excepting rare occurrences of exotic species like Wild Aster (*Aster subulatus*)	

Coastal Foothills Spotted Gum – Ironbark Forest		
PCT (OEH, 2018c)	Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast	
PCT ID	1589	
Equivalent Map Units	MU15 (NPWS 2000); Unit 15 (Bell 2016)	
Survey effort	Plots 6, 7 (2009); 2 (2018)	
Extent in study area (ha)	13.21	
Conservation significance	Not listed under the BC Act or EPBC Act.	
Condition	Moderate to good vegetation, near-intact to intact. • Remnant native vegetation, largely intact across the majority of the onsite extent • Patch size and canopy density reduced in the eastern corner due to clearing for the power line easement • Moderate native species richness and very low exotic species represented in the assemblage • Evidence of previous fire, which may have produced a more open understorey than is typical for this community type	
Evidence used to define vegetation unit	• Dry open forest vegetation structure • Characteristic sedimentary soil types and geomorphology • The dominant plant species described below are consistent with the VIS (OEH, 2018c) and with equivalent regional mapping units (NPWS 2000; Bell 2016)	
Landscape position	Occurs on coastal foothills; typically crests and slopes of ridgelines around the northern rim of Lake Macquarie. Within the study area, it is mapped to the north of the rail track and also occurs on a small patch in the eastern corner just to the north of Marmong Creek.	
Structure	Open forest with a sparse shrubby understorey. The groundcover is typically dominated by grasses with scattered graminoids and forbs.	
Over storey	The canopy is dominated by Spotted Gum (*Corymbia maculata*). Other canopy species that commonly co-occur include Broad-leaved White Mahogany (*Eucalyptus umbra*), White Mahogany (*E. acmenoides*), Grey Gum (*E. punctata*), Grey Ironbark (*E. siderophloia*), and Red Ironbark (*E. fibrosa*).	
Mid storey	Characterised by Black She-oak (*Allocasuarina littoralis*), Broad-leaved Geebung (*Persoonia levis*), Prickly-leaved Paperbark (*Melaleuca nodosa*), Prickly Moses (*Acacia ulicifolia*), Silver-stemmed Wattle (*A. parvipinnula*), Hickory Wattle (*A. falcata*), Gorse Bitter Pea (*Daviesia ulicifolia*), Prickly Beard-heath (*Leucopogon juniperinus*), Rough Guinea Flower (*Hibbertia aspera*), Orange Pultenaea (*Pultenaea euchila*) and Prickly Shaggy Pea (*P. ilicifolium*).	
Groundcover	Moderately dense and moderately species-rich. Dominated by grass species like Blady Grass (*Imperata cylindrica*), Kangaroo Grass (*Themeda triandra*), Brown's Lovegrass (*Eragrostis brownii*), Three-awn Speargrass (*Aristida vagans*) and Wiry Panic (*Entolasia stricta*). Also characterised by graminoids and forbs including *Dianella caerulea* var. *producta*, Wombat Berry (*Eustrephus latifolius*), Many-flowered Mat-rush (*Lomandra multiflora*), Variable Sword-sedge (*Lepidosperma laterale*), Whiteroot (*Pratia purpurascens*), False Sarsaparilla (*Hardenbergia violacea*), Hairy Apple Berry (*Billardiera scandens*) and Settler's Twine (*Gymnostachys anceps*).	
Exotic species	Largely weed-free, excepting localised occurrences of Lantana (*Lantana camara*).	

Coastal Sheltered Apple – Peppermint Forest		
PCT (OEH, 2018c)	Smooth-barked Apple - Turpentine - Sydney Peppermint heathy woodland on sandstone ranges of the Central Coast	
PCT ID	1627	
Equivalent Map Units	MU11 (NPWS 2000); Unit 11 (Bell 2016)	
Survey effort	Plots 12, 15, 16, 18 (2009); 8, 9 (2018)	
Extent in study area (ha)	17.96	
Conservation significance	Not listed under the BC Act or EPBC Act.	
Condition	Moderate to good vegetation, near-intact to intact. • Remnant native vegetation with near-intact over storey • Moderate to high native species richness • Some exotic species represented in the species assemblage near the creek where the site has been disturbed	
Evidence used to define vegetation unit	• Open forest vegetation structure • Characteristic sedimentary soil types and geomorphology • The dominant plant species described below are consistent with the VIS (OEH, 2018c) and with equivalent regional mapping units (NPWS 2000; Bell 2016)	
Landscape position	Occurs in sheltered gullies and associated slopes on ridges, upper slopes and mid slopes. Also recorded in dry but sheltered drainage lines on lower slopes. Within the study area, it occurs on the sheltered aspects of the central ridgeline where there is benching, as well as on the lower slopes in association with Marmong Creek.	
Structure	Open forest with a well-developed midstorey. The ground layer is typically dominated by grasses along with graminoids and scattered forbs.	
Over storey	The canopy is dominated by Sydney Peppermint (*Eucalyptus piperita*) and Smooth-barked Apple (*Angophora costata*). Red Bloodwood (*Corymbia gummifera*) and Turpentine (*Syncarpia glomulifera*) is also present along Marmong Creek.	
Mid storey	The midstorey is variable but is characterised by the following species: Cheese Tree (*Glochidion ferdinandi*), Black She-oak (*Allocasuarina littoralis*), Coffee Bush (*Breynia oblongifolia*), Geebung species (*Persoonia linearis*, *P. levis*), Slender Tea-tree (*Leptospermum trinervium*), Crinkle Bush (*Lomatia silaifolia*), Hairpin Banksia (*Banksia spinulosa*), Flax-leaved Paperbark (*Melaleuca linariifolia*)	
Groundcover	Moderately dense and species-rich. Dominated by grass species like Blady Grass (*Imperata cylindrica*), Wiry Panic (*Entolasia stricta*), Barbed-wire Grass (*Cymbopogon refractus*), Kangaroo Grass (*Themeda triandra*), Weeping Grass (*Microlaena stipoides*) and Basket Grass (*Oplismenus aemulus*). Also characterised by herbs, sedges and ferns including Whiteroot (*Pratia purpurascens*), Blueberry Lily (*Dianella caerulea* var. *caerulea*), Wombat Berry (*Eustrephus latifolius*), *Gymnostachys anceps*, Pixie Caps (*Acianthus fornicatus*), Common Maidenhair (*Adiantum aethiopicum*), Rainbow Fern (*Calochlaena dubia*), Gymea Lily (*Doryanthes excelsa*), *Xanthorrhoea latifolia* and Common Bracken (*Pteridium esculentum*).	
Exotic species	Some areas affected by Blackberry (*Rubus fruticosus*), Lantana (*Lantana camara*), Umbrella Sedge (*Cyperus eragrostis*) and Pampas Grass (*Cortaderia selloana*).	

Riparian Melaleuca Swamp Woodland		
PCT (OEH, 2018c)	Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast	
PCT ID	1718	
Equivalent Map Units	MU42a (NPWS 2000); Unit 42a (Bell 2016)	
Survey effort	Plot 13	
Extent in study area (ha)	2.24	
Conservation significance	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions endangered ecological community listed under the BC Act.	
Condition	Moderate condition: • Weed affected; understorey is dominated by woody weed species in large areas of its onsite extent • Reduced native species richness in the understorey • Affected by prior disturbance for track establishment	
Evidence used to define vegetation unit	• Tall swamp paperbark thicket in shallow drainage lines • Characteristic soil type and geomorphology • The dominant plant species described below are consistent with the VIS (OEH, 2018c) and with equivalent regional mapping units (NPWS 2000; Bell 2016)	
Landscape position	Occurs as a discrete patch on Marmong Creek, on the eastern end of the creek's onsite occurrence. Associated with poorly drained sites. Occurs below 50 m elevation	
Structure	Tall paperbark thicket in shallow drainage line. The understorey is densely shrubby and very shaded, resulting in a species-poor ground layer with large areas of bare ground. The species in the ground layer is typically grasses, graminoids and forbs in low abundances.	
Over storey	Emergent canopy layer comprising Sydney Peppermint (*Eucalyptus piperita*), Smooth-barked Apple (*Angophora costata*) or Scribbly Gum (*E. haemastoma*), which are tree species recorded in the surrounding woodland and open forest.	
Mid storey	The midstorey is dominated by Flax-leaved Paperbark (*Melaleuca linariifolia*) and Green Wattle (*Acacia irrorata*), with Cheese Tree (*Glochidion ferdinandi*), *M. sieberi*, Slender Tea-tree (*Leptospermum trinervium*), Tantoon (*L. polygalifolium*) and Sydney Golden Wattle (*Acacia longifolia*). The lower shrub layer is dominated by woody weed species.	
Groundcover	Sparsely vegetated, characterised by Tall Saw-sedge (*Gahnia clarkei*), Spiny-headed Mat-rush (*Lomandra longifolia*), with Wiry Panic (*Entolasia stricta*), Blady Grass (*Imperata cylindrica*), Weeping Grass (*Microlaena stipoides*), Basket Grass (*Oplismenus aemulus*), Brown's Lovegrass (*Eragrostis brownii*), Blueberry Lily (*Dianella caerulea* var. *caerulea*), Whiteroot (*Pratia purpurascens*), Common Maidenhair (*Adiantum aethiopicum*), Wombat Berry (*Eustrephus latifolius*) and Common Bracken (*Pteridium esculentum*).	
Exotic species	The understorey is dominated by woody weeds, namely Small-leaved Privet (*Ligustrum sinense*) and Mickey Mouse Plant (*Ochna serrulata*); other weed species recorded in this vegetation community include Lantana (*Lantana camara*) and Crofton Weed (*Ageratina adenophora*). These are all classified as high threat weeds according to the BAM (OEH 2017).	

Freshwater Wetland		
PCT (OEH, 2018c)	Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter	
PCT ID	1736	
Equivalent Map Units	MU46 (NPWS 2000); Unit 46 (Bell 2016)	
Survey effort	Not sampled	
Extent in study area (ha)	0.81	
Conservation significance	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions endangered ecological community listed under the BC Act	
Condition	Moderate to good vegetation, near-intact to intact. • Low species richness but this is typical of this community • Low exotic species represented in the assemblage Generally treeless or with sparse cover of trees and shrubs	
Evidence used to define vegetation unit	• Emergent wetland vegetation • Landscape position and elevation is consistent with the VIS (OEH, 2018c) and with equivalent regional mapping units (NPWS 2000; Bell 2016) • The dominant plant species described below are broadly consistent with the VIS (OEH, 2018c) and with equivalent regional mapping units (NPWS 2000; Bell 2016), recognising that this is a highly variable unit	
Landscape position	Occurs in association with one dam on Marmong Creek, occurs below 50 m elevation.	
Structure	Freshwater wetlands containing areas of open water. Generally dominated by emergent species such as spike rushes (*Eleocharis* sp.); but also includes grasses or semi-aquatic species depending on the local level and duration of inundation. Myrtaceous shrubs present in very low numbers as emergents.	
Over storey	N/A	
Mid storey	Occasional occurrence of *Melaleuca* shrubs such as Flax-leaved Paperbark (*Melaleuca linariifolia*) observed as emergents or regrowth.	
Groundcover	Dense cover of emergent wetland plants around the edge of the dam, including Spike Rush (*Eleocharis* sp.). Other species that were also abundant include *Juncus* sp. and *Bolboschoenus* sp., with Slender Knotweed (*Persicaria decipiens*) and Broad-leaved Cumbungi (*Typha orientalis*) also present.	
Exotic species	Largely free of weeds.	

3.3 Fauna and fauna habitats

3.3.1 Fauna species

A total of 72 species of fauna were recorded across the study area during the surveys, comprising 48 bird species, 17 mammals, four reptiles and three frogs (see Appendix C). Fauna observed included species that depend on large tracts of woodland vegetation that contain hollows, as well as common species that exist amongst the urban environment. Eight threatened species were identified in the study area – Brown Treecreeper (*Climacteris picumnus* victoriae), Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*), Little Lorikeet (*Glossopsitta pusilla*), Eastern Freetail-bat (*Mormopterus norfolkensis*), Varied Sittella *(Daphoenositta chrysoptera),* Grey-headed Flying Fox *(Pteropus poliocephalus)* and Little Bentwing-bat (*Miniopterus australis*).

3.3.2 Terrestrial fauna habitats

Fauna habitat is generally of moderate or high value throughout the study area, as it is a large tract of relatively undisturbed woodland vegetation that has areas of exotic flora infestations.

A description of fauna habitats is provided in the tables below.

Table 3-2 Fauna habitat: Near intact woodland and forest

Fauna habitats: Near intact woodland and forest	
Description	Near intact woodland and forest occupies the majority of the site. The vegetation is species rich and would provide habitat resources for a range of native fauna including: • Mature canopy trees that provide nectar, fruits, leaves and foraging, roosting or nesting substrates • Four habitat trees with hollows • Abundant woody debris and leaf litter • A range of fruiting and flowering small trees and shrubs The site is part of an extensive, continuous patch of native vegetation that exists on a ridgeline. Four large hollow-bearing trees were identified in the study area in mature Smooth-barked Apple.
Typical fauna species	A mixture of bird species and guilds were observed including those common to suburban parks and gardens including Australian Raven (*Corvus coronoides*), Rainbow Lorikeet (*Trichoglossus haematodus*), Crimson Rosella (*Platycercus eximius*), Australian Magpie (*Cracticus tibicen*), and Laughing Kookaburra (*Dacelo novaeguineae*). Birds of forest and woodland were also recorded and include Eastern Whipbird (*Psophodes olivaceus*), Eastern Spinebill (*Acanthorhynchus tenuirostris*), Striated Pardalote (*Pardalotus striatus*), Lewin's Honeyeater (*Meliphaga lewinii*), Golden Whistler (*Pachycephala pectoralis*), Grey Shrike-thrush (*Colluricincla harmonica*), and Grey Fantail (*Rhipidura albiscapa*). Nocturnal arboreal mammals were identified utilising this vegetation, including Sugar Gliders (*Petaurus breviceps*) and Ringtail Possums (*Pseudocheirus peregrinus*). A Lace Monitor (*Varanus varius*) was observed using the fork of a Smooth-barked Apple to rest in the middle of the day.
Threatened or migratory biota	Little Lorikeets were observed flying over the woodland vegetation in the study area, and Varied Sittellas were recorded in the canopy. A Powerful Owl and Masked Owl were heard during nocturnal surveys. Four large tree hollows suitable for roosting forest owls were observed on the edge of the development footprint in the study area, although there were no owl droppings or other evidence of owl habitation at the foot of these trees. These trees were also stag-watched during winter, with no owls seen emerging.

	Two threatened microbats; Little Bentwing-bat and Eastern Freetail Bat were also identified through Anabat detection and harp netting techniques. These species may use decorticating bark or hollow-bearing trees as roosting habitat in woodland vegetation.
Photographs	 **Plate 3-1 Woodland habitat**  **Plate 3-2 Large hollow in Smooth-barked Apple**

Table 3-3 Fauna habitat: disturbed areas

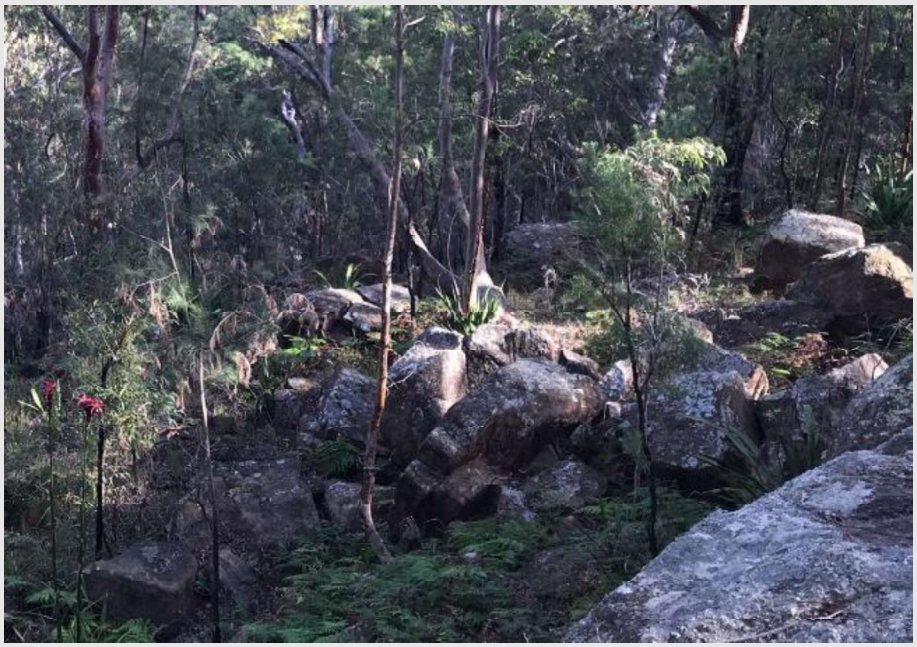
Fauna habitats: Disturbed vegetation	
Description	There are a number of cleared access tracks throughout the site, including a cleared bitumen road (Old Main Road) with power lines running parallel. Vegetation in these areas is exotic and disturbed, and the vegetation adjacent to Old Main Road is maintained for access to electrical services. Disturbed vegetation as a result of cleared access tracks exist amongst areas of better quality woodland habitat and forest in the study area. Disturbed areas contain more sparse vegetation and also include the edge of woodland near Old Main Road and adjacent to the rail line in the north. These areas contain a moderate diversity of vegetation and only provide the following habitat resources for native fauna including: • Scarce woody debris and leaf litter • Scattered patches of dense understorey shrubs • Some fruiting and flowering shrubs
Typical fauna species	Fauna species typical of that found in the near- intact woodland and forest, as they typically use the disturbed vegetation as a thoroughfare between patches of better bushland. Disturbed vegetation areas occur in small linear fragments within intact woodland and forest, and fauna would use this habitat as a transition between better quality habitats.
Threatened or migratory biota	Given the connectivity to larger patches of vegetation and habitat resources present in the study area, a wide variety of threatened species could occur. This may include a range of microbats, owls, gliders and small woodland birds. A Grey-headed Flying Fox was recorded flying over Old Main Road in the study area. There is potential for bat species to use these cleared areas as a flyway as it connects to larger tracts of vegetation.
Photographs	 **Plate 3-3 Cleared access track in the study area**

Fauna habitats: Disturbed vegetation	
	

Plate 3-4 Cleared disturbed area

Table 3-4 Fauna habitat: rock-lined gullies

Fauna habitats: rock-lined gullies	
Description	There are a number of rock-lined gullies in the study area. Vegetation associated with these gullies include flora associated with drainage lines like flowering perennials including Gymea Lilies (*Doryanthes excelsa*) and ferns including Rainbow Fern (*Calochlaena dubia*) that provide shelter for small ground dwelling animals. Sandstone rocks line either side of the gullies, with slight overhang. Some of these had fissures and small gaps.
Typical fauna species	Fauna species typical of that found in rock-lined gullies include reptiles including Lace Monitors that may utilise the rocks for shelter and foraging. Forest Owls forage in the gullies and owls like the Masked Owl use gullies as roosting and breeding habitat. Small ground-dwelling mammals like *Antechinus* may use these areas for foraging of insects, or as a roosting area amongst crevices in the rock. These may also act as prey for Forest Owls. Microbats may utilise rock crevices and fissures as roosting habitat, although no guano or other evidence of habitat was identified during field investigations. They may also use the gullies as a flyway for foraging.
Threatened or migratory biota	Threatened large forest owls like the Powerful Owl and the Masked Owl would potentially use these areas as foraging habitat. While microbats were not identified in the habitat, there is potential that rocks may be used as roosting habitat.

Fauna habitats: rock-lined gullies	
Photographs	 **Plate 3-5 Rock-lined gully**  **Plate 3-6 Rock-lined gully with vegetation**

3.3.3 Aquatic habitats

Marmong Creek exists in the study area. This aquatic habitat was assessed and is described below:

Table 3-5 Aquatic habitats

Aquatic habitats: Marmong Creek	
Description	Marmong Creek is a second order stream that exists in the study area. This waterway is classified as minimal fish habitat as it is a named, second order stream that has intermittent flow, and connects to semi-permanent pools of water following rain events. It is not mapped as Key Fish Habitat (DPI 2007). A natural dam has formed in the study area and Marmong Creek drains from here until it runs into Cockle Bay approximately 1.5 km downstream. The dam is vegetated with freshwater grass, sedge and rush species. A number of first order streams (drainage lines) would form in rock lined gullies following rain events, although at the time of field surveys these were dry.
Typical fauna species	Fish would only occur briefly after heavy rain, if at all, due to culvert structures that run beneath several roads. As this waterway is classed as minimal key fish habitat, it is unlikely to permanently support fish, although it may sporadically support them and other aquatic fauna like yabbies. Frogs such as the Common Eastern Froglet (*Crinia signifera*) and the eastern Dwarf Tree Frog (*Litoria fallax*) are likely to use adjacent habitat for breeding.
Threatened biota	Habitat in the study area has the potential to be Green and Golden Bell Frog (*Litoria aurea*) habitat. No Green and Golden Bell Frogs were identified in the study area during field surveys. The drainage line would be used as foraging habitat by threatened microbats identified during field surveys, including Little Bentwing-bat (*Miniopterus australis*) and Eastern Freetail Bat (*Mormopterus norfolkensis*). The drainage line would not be an important habitat component for other threatened species in the locality.
Photograph	 **Plate 3-7 Dam in the study area**

3.4 Conservation significance

3.4.1 Threatened ecological communities

Two threatened ecological communities were recorded within the study area and are associated with the Marmong Creek riparian corridor (Figure 3-2):

- Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (endangered; BC Act)
- Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (endangered; BC Act)

These communities are described in further detail below.

Swamp Sclerophyll Forest on Coastal Floodplains

There is approximately 1.82 ha of Riparian Melaleuca Swamp Woodland within the study area. This vegetation community conforms to the Swamp Sclerophyll Forest on Coastal Floodplains EEC on the following points:

- The community occurs within and next to Marmong Creek, where it would experience periodic inundation and waterlogging.
- The community occurs at approximately 12 m elevation (i.e. below 20 m elevation).
- The community occurs within the Sydney Basin Bioregion and within the local government area of Lake Macquarie, which is within the known distribution of the ecological community.
- The community has a scrub or tall shrub structure, which is a form that the ecological community can take.
- Characteristic species are present in this community, including *Acacia irrorata*, *A. longifolia*, *Adiantum aethiopicum*, *Dianella caerulea*, *Entolasia stricta*, *Gahnia clarkei*, *Glochidion ferdinandi*, *Lomandra longifolia*, *Melaleuca linariifolia*, *M. sieberi*, *Oplismenus aemulus* and *Pratia purpurascens.*
- Although the community does not feature *Eucalyptus robusta*, *Melaleuca quinquenervia* or *E. botryoides*, it does feature a dense midstorey of *M. linariifolia*. *Melaleuca linariifolia* is referred to as a characteristic tree species (i.e. >6 m) in the identification guidelines for Swamp Sclerophyll Forest on Coastal Floodplains (DECC 2007).

Freshwater Wetland on Coastal Floodplains

There is approximately 0.81 ha of Freshwater Wetland within the study area. This vegetation community conforms to the endangered ecological community Freshwater Wetlands on Coastal Floodplains on the following points:

- The community occurs on Marmong Creek and is permanently inundated with freshwater.
- The community occurs below 20 m elevation.
- The community occurs within the Sydney Basin Bioregion and within the local government area of Lake Macquarie, which is within the known distribution of the ecological community.
- The community forms a sedgeland/reedland around a waterbody, and woody species are scarce.
- Although systematic sampling has not yet been undertaken in this community, broadly characteristic species are present in this community including *Bolboschoenus* sp., *Eleocharis* sp., *Juncus* sp., *Persicaria decipiens* and *Typha orientalis.*

- The community is not associated with an artificial wetland created previously on land specifically for purposes such as sewerage treatment, stormwater management and farm production.

3.4.2 Threatened flora species and endangered populations

Twenty-one threatened flora species have been previously recorded, or are predicted to occur, within 10 km of the study area (see Appendix A). Of these, the following species were recorded within the study area:

- *Tetratheca juncea* (Black-eyed Susan)
- *Grevillea parviflora* subsp. *parviflora* (Small- flower Grevillea)

Tetratheca juncea was previously recorded in the study area by GHD (2009) during systematic plot surveys. Approximately 200 individuals were predicted by GHD (2009) to occur within the study area based on the extent of occupation mapped by ERM (2005). The areas of occupation were largely predicted to be on the western fall of the central ridgeline and to the north of the rail corridor (see Figure 3-2). Incidental observations and targeted surveys during peak flowering in accordance with recommended survey methodologies (LMCC 2014b; OEH 2016; DEE 2018c) for *Tetratheca juncea* recorded 168 individuals, generally within the developable portion of the study area. These surveys found the species to be outside the range predicted by the ERM (2005) mapping, suggesting the area of suitable habitat on site may be higher than originally predicted.

Approximately 82 stems of *Grevillea parviflora* subsp. *parviflora* were also detected by GHD during both incidental observations and targeted surveys during 2018. Future detailed ecological assessments associated with development applications and approvals should continue to consider these species due to the potential for prevailing climate conditions (i.e. drought), to have caused the current survey effort to underestimate the population size and extent.

The following species are considered likely to occur within the study area based on previous records and presence of suitable habitat:

- *Angophora inopina* (Charmhaven Apple)
- *Callistemon linearifolius* (Netted Bottle Brush)
- *Cryptostylis hunteriana* (Leafless Tongue-orchid)

There are records for *Cryptostylis hunteriana* and *Angophora inopina* within the study area but these species were not detected during the current survey effort (previous records not shown on Figure 3-2 in accordance with licence conditions). All three of the above species should continue to be considered in future detailed ecological assessments associated with the Planning Proposal and development approvals given past records and the suitability of the habitat.

Based on the results of the desktop assessment and field habitat assessments, an additional four species have a ‘moderate’ likelihood of occurrence in the study area:

- *Caladenia tessellate* (Thick Lip Spider-orchid)
- *Corunastylis insignis* (Wyong Midge Orchid)
- *Diuris praecox* (Newcastle Doubletail)
- *Rutidosis heterogama* (Heath Wrinklewort)

Targeted survey for *Diuris praecox* confirmed the presence of suitable habitat within the site. Although the species was not recorded, the prevailing drought conditions could have inhibited emergence for the season and a lack of detection does not necessarily indicate that the species is absent from the study area. Under more favourable conditions, future surveys may detect this species.

All four of these species are considered cryptic, and suitable habitat was present on site. Although these species were not recorded during the current survey effort, future detailed ecological assessments associated with the Planning Proposal and development approvals should continue to consider these species.

3.4.3 Threatened fauna species

Fifty-five threatened fauna species have been previously recorded, or are predicted to occur, within 10 km of the study area. These comprise 28 bird, 18 mammal, six frog, one fish, one reptile and one invertebrate species (see Appendix A). Of these, the following species were recorded within the study area (see Figure 3-2):

- Brown Treecreeper (*Climacteris picumnus victoriae*)
- Varied Sittella (*Daphoenositta chrysoptera*)
- Little Lorikeet (*Glossopsitta pusilla*)
- Little Bentwing Bat (*Miniopterus australis*)
- Eastern Freetail Bat (*Mormopterus norfolkensis*)
- Grey-headed Flying-fox (*Pteropus poliocephalus*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)

These species were largely detected on the eastern side of the central ridgeline as most of the survey effort was concentrated in the proposed development areas (see Figure 3-2). However, it is likely that these species would utilise most of the site for foraging and potentially for breeding.

The following species are considered likely to occur, based on previous records and the presence of suitable habitat within the study area (previous records within the study area not shown on Figure 3-2 in accordance with licence conditions):

- Birds:
  - Dusky Woodswallow (*Artamus cyanopterus*)
  - Barking Owl (*Ninox connivens*)
  - Sooty Owl (*Tyto tenebricosa*)
- Arboreal mammals:
  - Eastern Pygmy Possum (*Cercartetus nanus*)
  - Squirrel Glider (*Petaurus norfolcensis*)
- Microchiropteran bats:
  - Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
  - Southern Myotis (*Myotis macropus*)

Based on the results of the desktop assessment and field habitat assessments, an additional 13 species have a 'moderate' likelihood of occurrence in the study area. These species include:

- Small woodland birds:
  - Scarlet Robin (*Petroica boodang*)
- Medium woodland birds (Parrots and honeyeaters:
  - Regent Honeyeater (*Anthochaera phrygia*)
  - Swift Parrot (*Lathamus discolor*)
- Cockatoos:
  - Gang-gang Cockatoo (*Callocephalon fimbriatum*)
  - Glossy Black-Cockatoo (*Calyptorhynchus lathami*)
- Wetland birds:
  - Australasian Bittern (*Botaurus poiciloptilus*)
  - White-bellied Sea-eagle (*Haliaeetus leucogaster*)
- Hollow-roosting microbats:
  - Greater Broad-nosed Bat (*Scoteanax rueppellii*)
- Cave-breeding microbats:
  - Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)
  - Large-eared Pied Bat (*Chalinolobus dwyeri*)
  - Eastern Cave Bat (*Vespadelus troughtoni*)
- Spotted-tailed Quoll (*Dasyurus maculatus*)
- Green and Golden Bell Frog (*Litoria aurea*)

3.4.4 Migratory species

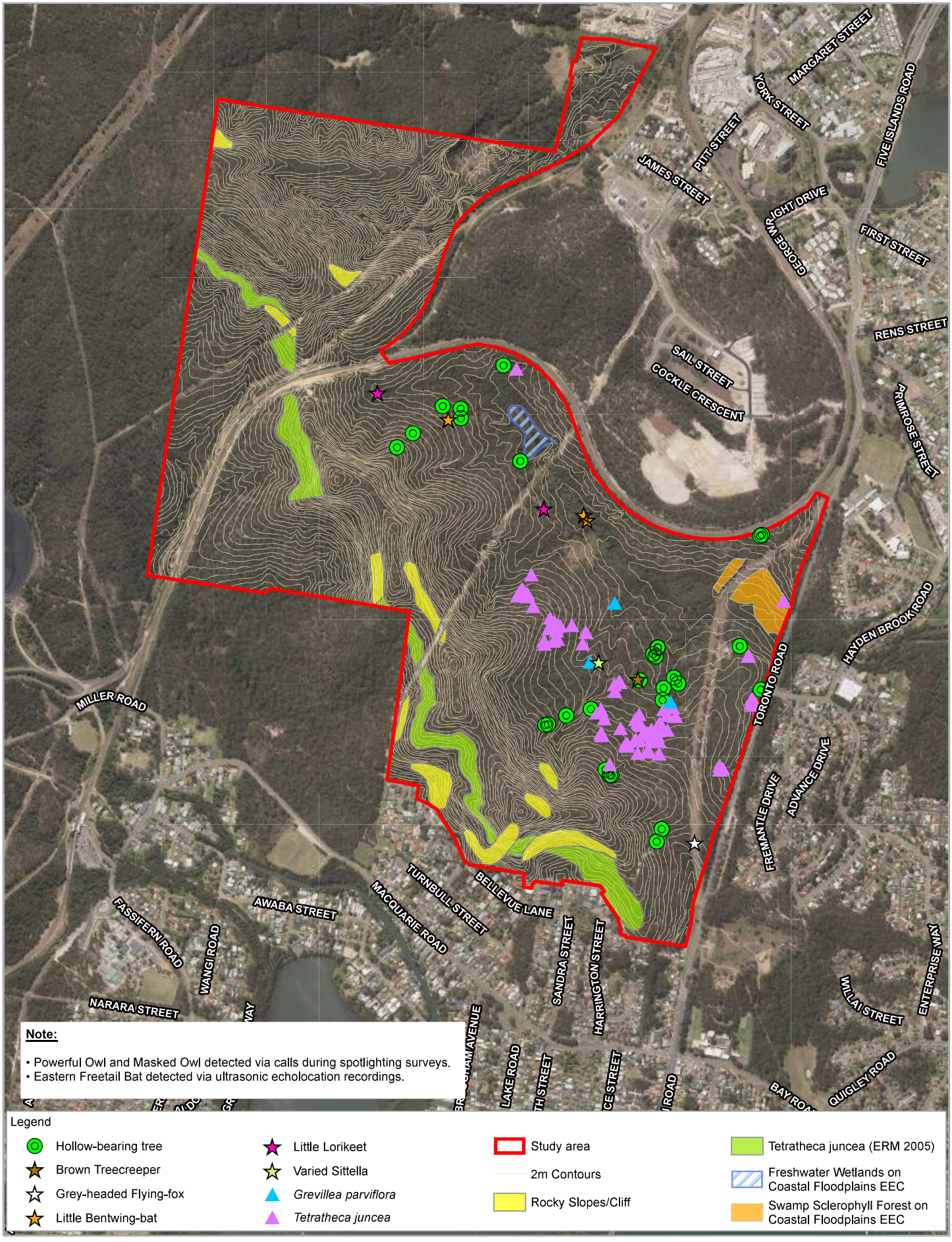
Two migratory bird species may occur on occasion over the study area: White-throated Needletail (*Hirundapus caudacutus*) and Oriental Cuckoo (*Cuculus optatus*).

Important habitat for these and other migratory birds is defined in the significance criteria for listed migratory species (DotE 2013) as follows:

- Habitat utilised by a migratory species occasionally or periodically within the region that supports an ecologically significant proportion of the population of the species.
- Habitat that is of critical importance to the species at particular life-cycle stages.
- Habitat utilised by a migratory species which is at the limit of the species range.
- Habitat within an area where the species is declining.

The study area is not considered important habitat for any of the species known to occur or that may utilise the site on occasion, according to the significant impact criteria for migratory species (DotE 2013). This is due to the habitat in the study area not supporting an ecologically significant proportion of the population of these species, is not of critical importance to these species at particular life-cycle stages, is not at the limit of these species ranges, and is not within an area where these species are declining.

No migratory wetland birds were recorded in the study area or are likely to occur given the absence of suitable wetland habitat.



Paper Size ISO A4

0 110 220 330 440

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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GHD

Urban Growth NSW
Proposed Fennell Bay Residential Development
Biodiversity Constraints

Threatened biota and habitat resources

Project No. **22-19132**
Revision No. **0**
Date **31/01/2019**

Figure 3-2

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Data source: LMCC: Threatened species data, 2017; LPI: Aerial Imagery, 2017. Created by:

4. Biodiversity constraints

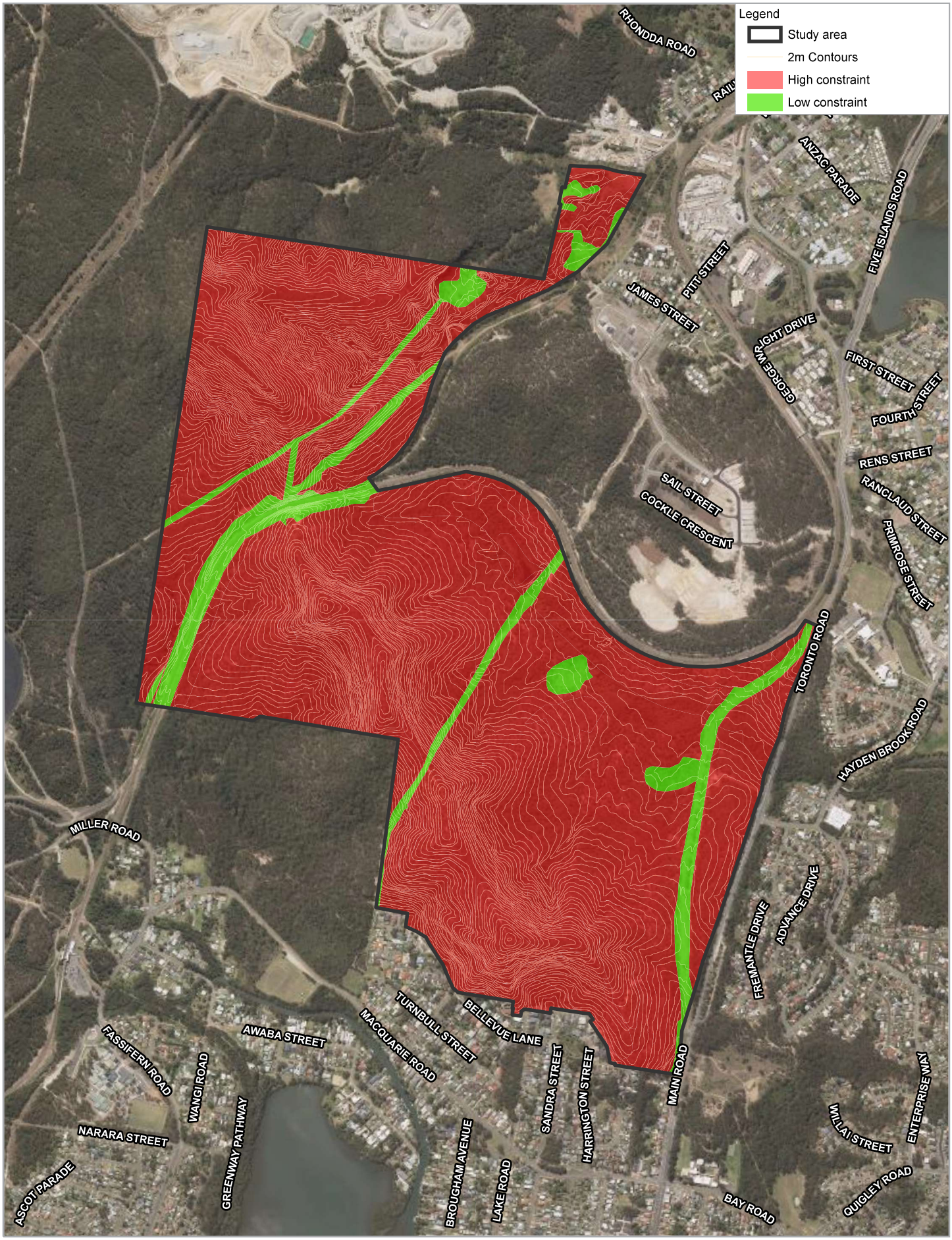
4.1 Constraint classes

Biodiversity constraints were classified into classes based on conservation significance and sensitivity to impacts arising from development.

Table 4-1 outlines the biodiversity features that have been used to define these classes and recommended land use and management. Biodiversity constraints are mapped on Figure 4-1.

Table 4-1 Biodiversity constraint classes

Biodiversity constraints class	Description and Recommended Management
Low	Low biodiversity value comprising, in general, cleared land and exotic vegetation. *There are a few small areas representing low biodiversity constraint, comprising weedy areas and clearings (including substantial tracks and power line easements).*
Moderate	Moderate biodiversity value, comprising: • Native vegetation in poor to moderate condition that is not a threatened ecological community, or • Suitable habitat for native flora and fauna Targeted flora and fauna surveys would be required during later phases of the Biocertification assessment and approval process to verify biodiversity values and inform the final subdivision design. *Development activities may occur in these areas subject to appropriate environmental impact assessment under relevant approval processes and provision of biodiversity offset as required.* *These areas also have the potential to support development though would require further detailed biodiversity impact assessment during the completion of the Biocertification stage.*
High	High biodiversity value, comprising: • Moderate/good (high) condition vegetation that is an endangered ecological community or critically endangered ecological community listed under the BC Act and/or EPBC Act, or • Areas of habitat for a population of the threatened *Tetratheca juncea* and suitable potential habitat for a range of other threatened fauna and flora species known from the locality • Areas of habitat for the threatened *Grevillea parviflora* subsp. *parviflora* *Limited development potential. Development in these areas may result in a significant impact on threatened biota.* *These areas also have the potential to support some development provided the Planning Proposal includes consideration of measures to avoid or mitigate impacts on these areas as far as practical. Impacts in these areas would require further biodiversity assessment and approval at the development application stage and the provision of biodiversity offsets.*



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0 110 220 330 440

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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GHD

Urban Growth NSW
Proposed Fennell Bay Residential Development
Biodiversity Constraints

Project No. **22-19132**
Revision No. **0**
Date **31/01/2019**

Biodiversity constraints

Figure 4-1

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Data source: LMCC: Threatened species data, 2017; LPI: Aerial Imagery, 2017. Created by:

5. Concept design and potential impacts of development

5.1 Concept design

A Planning Proposal has been prepared for the study area, based on a concept design that has been developed with consideration of the results of this biodiversity constraints assessment and other specialist studies.

The concept design is shown on Figure 1-1 and comprises a developable area that will contain residential subdivision, industrial land use, open space areas, mixed use local neighbourhood centre and associated asset protection zones and environmental lands. The proposed development and all associated asset protection zones, services and utilities, construction compounds, laydown areas and surface water management features would be located entirely within the proposed development area shown on the concept layout.

The concept design also provides for the requisite vegetated buffers on first and second order streams within the developable area, as well as the requisite buffer to the railway corridor. Other vegetated spaces will include all retained vegetation outside of the developable areas (generally the western half of the study area).

Considering the substantial biodiversity constraints of the study area, future detailed design and the Biocertification assessment will need to consider various matters when completing detailed impact assessment of the final development/conservation footprint, such as:

- Retention of significant habitat trees, including hollow-bearing trees with large hollows, within lots and throughout streetscape.
- Appropriate protection of threatened ecological communities along Marmong Creek, including the provision of sufficient buffers from development within adjoining lots.
- Appropriate protection of threatened plant species occurring within the proposed development areas where retained.
- Biodiversity offsetting to compensate for unavoidable loss to biodiversity values and threatened biota.

The Planning Proposal includes:

- Potential development areas that could be assessed for development under relevant environmental legislation and approval pathways. As most of the study area is categorised as high biodiversity constraint class, development would require additional approval under relevant approval processes. These would include completion of a BCAR in accordance with the BAM (OEH, 2017) and a 'referral' in accordance with the EPBC Act. It is likely the project would be considered a 'Controlled Activity' meaning additional assessment would be required for impacts on MNES. Impacts would need to be offset and offsets would need to satisfy both state and federal policies.
- Retained native vegetation that would be set aside and managed for conservation to improve or maintain biodiversity values. The majority of the retained vegetation also represents high biodiversity constraint class areas.

The Planning Proposal would achieve an appropriate balance between development and conservation across the study area should the provision of biodiversity offsets be secured using an objective assessment methodology (e.g. BAM). This involves adopting the principles of the 'avoid, mitigate and offset' approach. In summary, this entails avoiding development in areas of highest biodiversity value and retaining these for conservation, focussing development in areas of lower biodiversity values and offsetting any residual impacts in accordance with relevant legislation.

5.1.1 Potential development areas

The majority of the site is mapped as high biodiversity constraint due to the presence of threatened biota and habitat for threatened biota. The areas of development potential is limited to the parts of the study area that are within the vicinity of existing development and which have been identified as having (comparatively) lower biodiversity constraints, noting that the provision of biodiversity offsets would still be required.

The areas that have comparatively lower constraints are broadly those areas that avoid high concentrations of threatened plant species (as they are unable to physically relocate or move in response to disturbance) that were identified through survey and desktop information, namely *Tetratheca juncea*. However, the proposed development area will also still impact on individuals of *Tetratheca juncea* and *Grevillea parviflora* subsp. *parviflora* as well as approximately 38.12 hectares of native vegetation (see Table 5-1), which includes 0.69 ha of Swamp Sclerophyll Forest endangered ecological community associated with Marmong Creek and habitat for a number of threatened fauna species. Although riparian buffers must be observed along Marmong Creek and its first order tributaries, the occurrence of this endangered community extends beyond the riparian corridors and a proportion of its onsite occurrence may be directly impacted by any future development.

5.1.2 Conservation of native vegetation

The proposed vegetation for conservation within the study area broadly occurs on all land from the central ridgeline extending to the west, and all land to the north of the rail corridor, but also includes vegetated riparian corridors that will need to be maintained along Marmong Creek and its tributaries (Figure 5-1).

The conserved land comprises 190.35 hectares of native vegetation (in addition to the 8.97 ha of cleared vegetation within the conservation area) and contains a large proportion of the occurrences of threatened species that were identified on the site through survey and desktop information. The retained native vegetation is mapped as high biodiversity constraint and would help to maintain important connectivity to offsite vegetation to the north, west and south west of the study area. Conservation of this area would also provide a buffer between the development and other areas of native vegetation and habitat to the west.

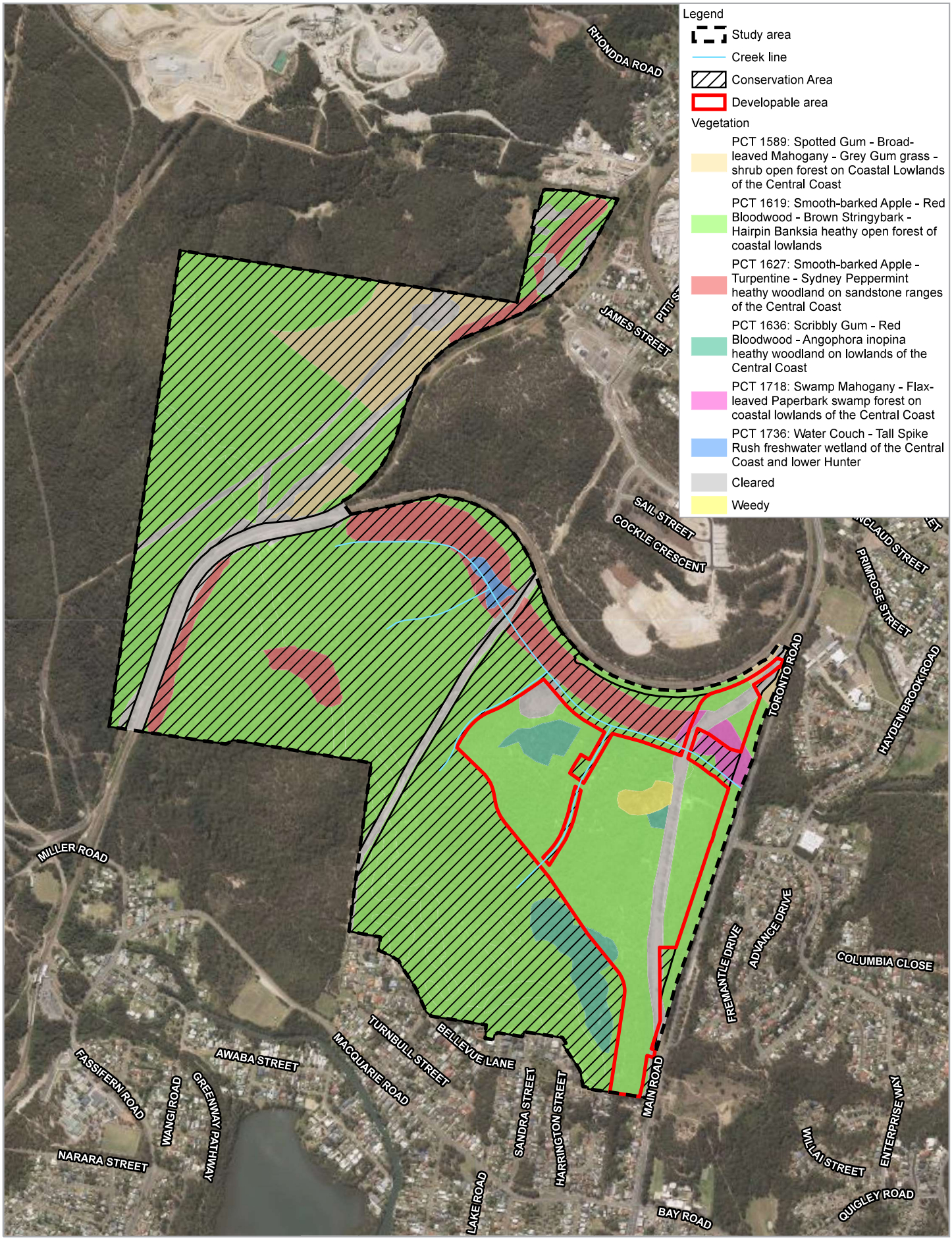
Given the substantial area of retained native vegetation within the study area, it is proposed to manage and conserve these lands via a Biodiversity Stewardship Agreement (BSA) under the BC Act. The conservation of the retained native vegetation under a BSA would be formally included as a biodiversity offset for the development.

While the retention of 190.35 hectares of vegetation on the site is considered to be substantial, development of the study area may still require biodiversity offsets to be secured in accordance with the Biodiversity Offset Scheme (BOS), most likely from BSA sites outside the study area, to deliver a biodiversity offset for the Planning Proposal that would 'improve or maintain' biodiversity values in accordance with the BAM (OEH, 2017).

Table 5-1 Areas of native vegetation within preferred development/conservation

Vegetation Type	PCT name	Conservation status	Extent in study area (ha)	Within proposed conservation area (ha)	Within proposed development area (ha)	Retained outside conservation and development areas (ha)
Coastal Plains Smooth-barked Apple Woodland	PCT 1619: Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands		193.43	153.53	34.78	5.12
Coastal Plains Scribbly Gum Woodland	PCT 1636: Scribbly Gum - Red Bloodwood - Angophora inopina heathy woodland on lowlands of the Central Coast		7.05	4.52	2.53	0.00
Coastal Foothills Spotted Gum - Ironbark Forest	PCT 1589: Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast		13.21	12.57	0.12	0.52
Coastal Sheltered Apple – Peppermint Forest	PCT 1627: Smooth-barked Apple - Turpentine - Sydney Peppermint heathy woodland on sandstone ranges of the Central Coast		17.96	17.78	0.00	0.18
Riparian Melaleuca Swamp Woodland	PCT 1718: Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (endangered, BC Act).	2.24	1.14	0.69	0.41

Vegetation Type	PCT name	Conservation status	Extent in study area (ha)	Within proposed conservation area (ha)	Within proposed development area (ha)	Retained outside conservation and development areas (ha)
Freshwater Wetland	PCT 1736: Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (endangered, BC Act)	0.81	0.81	0.00	0.00
Weedy	Weedy		1.16	0.00	1.16	0.00
Cleared	Cleared		21.37	8.97	5.09	7.31
		Total areas (ha)	**257.23**	**199.32**	**44.37**	**13.54**



Paper Size ISO A4

0 110 220 330 440

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Urban Growth NSW
Proposed Fennell Bay Residential Development
Biodiversity Constraints

Preferred development and conservation footprint

Project No. **22-19132**
Revision No. **0**
Date **31/01/2019**

Figure 5-1

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Print date: 31 Jan 2019 - 13:18

Data source: LMCC: Threatened species data, 2017; LPI: Aerial Imagery, 2017. Created by:

5.1.3 Assessment approach

The majority of the areas proposed for development are of high biodiversity constraint. As part of putting forward a concept design for the study area and achieving a suitable balance between development yield and biodiversity conservation, a considerable area containing high biodiversity values is proposed to be conserved on site. Areas of high constraint include occupied *Tetratheca juncea* and *Grevillea parviflora* subsp. *parviflora* habitat, a number of habitat trees bearing large hollows that are suitable for large forest owls, sandstone rocky outcrops on the upper slopes which provide shelter habitat for reptiles and other small terrestrial animals and potential habitat for a number of threatened fauna previously recorded in proximity of the study area (such as Squirrel Glider and eastern Pygmy Possum). This constraints assessment aims to inform project planning to retain the areas of highest biodiversity value and focus development in areas of comparatively lower biodiversity value adjoining existing development, and offset the residual impacts.

Should LMCC support an application for a Gateway Determination following review of the request for Gateway application, future development in the study area would require additional biodiversity assessments to support the rezoning. At this stage of the planning process, it is assumed that this would comprise preparation of a BCAR in accordance with the BAM (OEH 2017). Approval of a BCAR would mean that all matters associated with NSW threatened biota have been addressed at the rezoning stage and no further assessments would be required to accompany future Development Applications (DAs).

The implications of the EPBC Act and its offsets policy would still require consideration and assessment at the DA stage in accordance with this Act.

5.2 Preliminary impact assessment

5.2.1 Overview

A preliminary assessment of potential impacts resulting from development within the study area is included below. This assessment is based on the assumption that development would be restricted to the proposed development concept (Figure 5-1) and is intended to provide an initial overview of the potential impacts associated with the Planning Proposal. A more comprehensive biodiversity impact assessment, based on the final development footprint and informed by more extensive survey effort and Biocertification assessment, would be undertaken to support the approval of the Planning Proposal. As described above, this would comprise preparation of a BCAR in accordance with the BAM (OEH, 2017) including:

- A review of the current plot sampling effort and potential further sampling of BAM plots to ensure compliance with the BAM.
- A review of the threatened species targeted surveys undertaken to date and potential supplementary surveys for species credit species to ensure compliance with the BAM.
- Confirmation of the conservation significance of the development site, including the presence of any threatened biota and MNES and their habitats.
- Detailed consideration of measures to avoid and mitigate impacts.
- Detailed impact assessment including consideration of secondary and operational impacts.
- Credit calculations to determine the quantum of biodiversity offset required for residual impacts.

5.2.2 Direct impacts

The proposed development concept will provide for future development of the study area that may result in the estimated removal of up to 38.12 hectares of native vegetation, the majority of which is classed as high biodiversity constraint. This is shown on Figure 3-2 and will entail:

- Direct removal of an estimated 0.69 hectares of Riparian Melaleuca Swamp Woodland, an endangered ecological community under the BC Act.
- Removal of a known population of *Tetratheca juncea* (Black- eyed Susan).
- Removal of a known population of *Grevillea parviflora* subsp. *parviflora* (Small- flower Grevillea).
- Clearing of known habitat for threatened fauna species, including Brown Treecreeper, Varied Sittella, Powerful Owl, Masked Owl, Little Lorikeet, Grey-headed Flying-fox, and two threatened microbats.
- Clearing of potential habitat for a number of threatened species known to occur outside of the proposed development areas and within the locality of the study area.
- Clearing of native vegetation, which would involve the removal of a moderate diversity of non-threatened native plants, including mature trees. Mature trees have particular value within plant populations because they take longer to replace and are sources of pollen and seed.
- Clearing of native vegetation, which would remove fauna habitat resources including:
  - Flowering myrtaceous trees and shrubs which provide foraging habitat for a range of arboreal mammals and nectivorous birds.
  - Mature trees that provide a complexity of substrates that support a greater invertebrate prey diversity for insectivorous fauna.
  - Hollow-bearing trees which provide denning, roosting, shelter and/or breeding habitat for a range of arboreal mammals, microbats, amphibians and reptiles.
  - Leaf litter and fallen logs, which provide foraging and shelter substrate for small terrestrial animals.

Impacts on threatened and migratory biota are discussed further in section 5.2.4.

5.2.3 Indirect impacts

Indirect impacts associated with future development in the study area may include the following:

- Sedimentation and erosion: Development within the study area has the potential to result in sedimentation and erosion within the study area and adjoining areas through soil disturbance and construction activities. Sediment laden runoff to waterways can alter water quality and adversely affect aquatic life. Erosion may also impact native vegetation.
- Pollution: Future development has the potential to result in pollution and contaminated runoff, in particular as a result of hydrocarbon leaks or spills from vehicles or equipment. Residential gardens may generate contamination through pesticide or herbicide use and pet faeces. This can reduce habitat condition and quality in adjacent vegetation or waterways.

- Introduction or spread of weeds: Exotic flora species, including a number of high threat weeds, are already present in the study area. The proposal has the potential to increase the introduction and spread of exotic plants through increased visitation, fragmentation of vegetation, disturbance of soil and establishment of residential gardens containing exotic plants. Increased weed infestation can lead to decreased diversity of native flora, compromised structural integrity of native vegetation communities and a decrease in habitat quality for native fauna.
- Edge effects: Removal of vegetation causes a number of new environmental conditions to develop along the edges of the cleared environments, in particular in environments that originally contain the upper strata levels (canopy and/or shrub layer) of vegetation. The removal of vegetation generally promotes the invasion of exotic species and/or disturbance tolerant native plants. Edge effects also change habitat conditions (such as degree of humidity and exposure to light or wind) created at or near the boundary between areas. The modified environment can favour overabundant and aggressive native fauna such as Noisy Miners (*Manorina melanocephala*).
- Introduction of pathogens: Construction activities have the potential to introduce or spread pathogens such as Phytophthora (*Phytophthora cinnamomi*), Myrtle Rust (*Uredo rangelii*) and Chytrid fungus (*Batrachochytrium dendrobatidis*) throughout the study area through vegetation disturbance and increased visitation. Phytophthora and Myrtle Rust may result in the dieback or modification of native vegetation and damage to fauna habitats. Chytrid fungus affects both tadpoles and adult frogs and can lead to the extinction of local populations once introduced into an area.
- Noise and vibration: Construction activities would increase noise levels and vibration in the vicinity of the study area during construction, through plant and machinery operation and earth moving activities. Native fauna may temporarily or permanently vacate or avoid areas disturbed by construction activities. Noise and vibration during the operation of the proposal may include traffic and also maintenance activities.
- Light: Lighting from street lights, residential and industrial premises may contribute towards light spill into adjacent native vegetation. Native fauna may temporarily vacate these areas unless they become habituated. Light spill may attract invertebrate prey species for foraging microbats.
- Human activities: The recreational use of adjacent bushland will continue to occur. Local populations of fauna in adjacent could be prone to predation by pets (particularly cats and dogs).

A construction environmental management plan (CEMP) would need to be prepared at the development stage. This would contain environmental safeguards to be implemented to avoid or minimise impacts arising from construction activities.

5.2.4 Impacts on threatened and migratory biota

The proposal would result in impacts on known occurrences of threatened biota, comprising:

- Impacts on an occurrence of Swamp Sclerophyll Forest on Coastal Floodplains endangered ecological community.
- Impacts to a known *Tetratheca juncea* (Black-eyed Susan) population.
- Impacts to a known *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea) population.

- Removal of known habitat for threatened fauna species, including:
  - Brown Treecreeper (*Climacteris picumnus victoriae*)
  - Varied Sittella (*Daphoenositta chrysoptera*)
  - Little Lorikeet (*Glossopsitta pusilla*)
  - Little Bentwing-bat (*Miniopterus australis*)
  - Eastern Freetail-bat (*Mormopterus norfolkensis*)
  - Grey-headed Flying-fox (*Pteropus poliocephalus*)
  - Powerful Owl (*Ninox strenua*)
  - Masked Owl (*Tyto novaehollandiae*)

The proposal also has the potential to impact on further threatened flora, fauna and migratory species through the removal of known or potentially suitable habitat (see Appendix A). Notably the proposal would include the removal of mature, hollow-bearing trees, which provide potential roosting habitat for threatened bats and birds.

As previously discussed, this impact assessment is based on preliminary surveys for the study area. It is anticipated that more extensive survey effort would be undertaken at the development application stage for the proposal, allowing a more detailed assessment of the final proposed footprint and associated impacts on threatened biota using an objective assessment methodology (BAM). It should also be noted that whilst impacts on threatened biota identified in this constraints assessment would not constitute impacts on a SAII entity (species and ecological communities that are likely to be the subject of serious and irreversible impacts). Further detailed surveys as part of future development applications may identify SAII entities and would require detailed consideration and discussion as impacts may be above threshold levels.

Some threatened biota identified in this constraints assessment are listed as threatened under the Commonwealth EPBC Act, including *Tetratheca juncea*, *Grevillea parviflora* subsp. *parviflora* and Grey-headed Flying-fox. An EPBC Act Referral would be required to notify DEE of impacts on these MNES if the impacts are considered to be significant. Additional assessment, approval and potentially biodiversity offsets may be required under the EPBC Act and associated policy.

A summary of potential significance of impacts on threatened and migratory biota is provided in Table 5-2. This is a preliminary assessment based on the results of field surveys undertaken to date. The potential impact, level of impact, and significance of impact may change following the results of further field surveys, proposed development layout and assessment approach.

Table 5-2 Summary of potential impacts on threatened biota and assessment of whether a significant impact is likely

Biota type	Scientific name	Common name	Status		Potential impacts	Level of impact	Significant impact likely?
			BC Act	EPBC Act			
Ecological Community	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	-	EEC	Not listed	Indirect impacts from surrounding development	Low/moderate	No
	Swamp Sclerophyll Forest of Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	-	EEC	Not listed	Reduction in the extent of an occurrence of this community. Indirect impacts from surrounding development	Moderate/High	Possible. Significance of impacts would depend on the area and condition of vegetation to be cleared.
Flora	*Angophora inopina*	Charmhaven Apple	V	V	Removal of potential habitat; potential removal of individuals (unverified records)	Moderate/High	Possible (depends on whether clearing occurs within areas of known habitat).
	Caladenia tessellata	Thick Lip Spider-orchid	E	V	Removal of potential habitat	Low/Moderate	No
	Callistemon linearifolius	Netted Bottle Brush	V	Not listed	Removal of potential habitat	Low/Moderate	No
	Corunastylis insignis	Wyong Midge Orchid 1	CE	CE	Removal of potential habitat	Low/Moderate	No
	Cryptostylis hunteriana	Leafless Tongue-orchid	V	V	Removal of potential habitat; potential removal of individuals (unverified records)	Moderate/High	Possible (depends on whether clearing occurs within areas of known habitat).
	Diuris praecox	Newcastle Doubletail	V	V	Removal of potential habitat	Low/Moderate	No

Biota type	Scientific name	Common name	Status		Potential impacts	Level of impact	Significant impact likely?
			BC Act	EPBC Act			
	Grevillea parviflora subsp. *parviflora*	Small- flower Grevillea	V	V	Removal of potential habitat; potential removal of individuals	Moderate/High	Possible (depends on whether clearing occurs within areas of known habitat).
	Rutidosis heterogama	Heath Wrinklewort	V	V	Removal of potential habitat	Low/Moderate	No
	Tetratheca juncea	Black-eyed Susan	V	V	Removal of potential habitat; potential removal of individuals	Moderate/High	Possible (depends on whether clearing occurs within areas of known habitat).
Small woodland birds	*Artamus cyanopterus*	Dusky Woodswallow	V	Not listed	Removal of potential foraging and breeding habitat	Low/Moderate	No
	Climacteris picumnus victoriae	Brown Treecreeper	V	Not listed			
	Daphoenositta chrysoptera	Varied Sittella	V	Not listed			
	Petroica boodang	Scarlet Robin	V	Not listed			
Medium woodland birds (parrots and honeyeaters)	*Anthochaera phrygia*	Regent Honeyeater	CE	CE	Removal of potential foraging and breeding habitat	Low/Moderate	No
	Glossopsitta pusilla	Little Lorikeet	V	Not listed			
	Lathamus discolor	Swift Parrot	E	CE			
Large birds (cockatoos)	*Callocephalon fimbriatum*	Gang-gang Cockatoo	V	Not listed	Removal of potential foraging and breeding habitat	Low/Moderate	No
	Calyptorhynchus lathami	Glossy Black-Cockatoo	V	Not listed			
Large birds (forest owls)	*Ninox connivens*	Barking Owl	V	Not listed	Removal of foraging habitat; potential removal of breeding habitat	Moderate/High	Possible. Significance of impacts would depend on whether breeding habitat is cleared.
	Ninox strenua	Powerful Owl	V	Not listed			
	Tyto novaehollandiae	Masked Owl	V	Not listed			

Biota type	Scientific name	Common name	Status		Potential impacts	Level of impact	Significant impact likely?
			BC Act	EPBC Act			
	Tyto tenebricosa	Sooty Owl	V	Not listed			
Wetland birds	*Botaurus poiciloptilus*	Australasian Bittern	E	E	Removal of potential foraging habitat	Low/Moderate	No
	Haliaeetus leucogaster	White-bellied Sea-Eagle	V	M			
Migratory woodland birds	*Cuculus optatus*	Oriental Cuckoo	-	M	Removal of potential foraging habitat	Low/Moderate	No
	Hirundapus caudacutus	White-throated Needletail	-	M			
Arboreal mammals	*Cercartetus nanus*	Eastern Pygmy Possum	V	Not listed	Removal of potential foraging and breeding habitat; potential removal of individuals (unverified records)	Moderate/High	Possible (depends on whether clearing occurs within areas of known habitat).
	Petaurus norfolcensis	Squirrel Glider	V	Not listed			
Ground-dwelling mammals	*Dasyurus maculatus*	Spotted-tailed Quoll	V	E	Removal of potential foraging habitat	Low/Moderate	No
Hollow-roosting bats	*Falsistrellus tasmaniensis*	Eastern False Pipistrelle	V	Not listed	Removal of a small area of potential foraging habitat. Removal of potential breeding habitat	Moderate	No
	Mormopterus norfolkensis	Eastern Freetail Bat	V	Not listed			
	Myotis macropus	Southern Myotis	V	Not listed			
	Scoteanax rueppellii	Greater Broad-nosed Bat	V	Not listed			
Cave-breeding bats	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	V	Removal of a small area of potential foraging habitat. No breeding habitat present	Moderate	No
	Miniopterus australis	Little Bentwing Bat	V	Not listed			
	Miniopterus schreibersii oceanensis	Eastern Bentwing Bat	V	Not listed			
	Vespadelus troughtoni	Eastern Cave Bat	V	Not listed			
Fruit bats	*Pteropus poliocephalus*	Grey-headed Flying-fox	V	V	Removal of foraging habitat. No roost camps present	Low	No

Biota type	Scientific name	Common name	Status		Potential impacts	Level of impact	Significant impact likely?
			BC Act	EPBC Act			
Frogs	*Litoria aurea*	Green and Golden Bell frog	E	V	Removal of potential foraging and breeding habitat	High	Possible (depends on whether clearing occurs within areas of known habitat).

Key:
CE *critically endangered*
E *endangered*
V *vulnerable*

6. Mitigation of impacts

6.1.1 Overview

The proposal would result in direct impacts on native biota and their habitats within areas to be developed. There is the potential for indirect impacts on retained areas of native vegetation adjacent to the future development footprint, both during construction and from the resulting residential and industrial development. The following sections provide an overview of recommended mitigation measures likely to be required to avoid or minimise such impacts. These measures are presented according to the hierarchy of avoidance and mitigation of impacts, and the provision of offsets to counter residual impacts of the proposal. It is anticipated that these measures would be revised based on a more detailed and accurate assessment of potential impacts which would be undertaken during the Planning Proposal and Development Application stages.

6.1.2 Avoidance of impacts

Impacts are minimised in the Planning Proposal design concept as far as possible by concentrating development in areas of comparatively lesser constraint, recognising that the majority of the study area is highly constrained.

Key considerations in the development of the concept included avoiding impacts on threatened ecological communities, avoiding impacts on known and estimated occurrences of threatened species, and avoiding impacts on the creek environment. The proposed development footprint has been reduced considerably to avoid impacts to native vegetation and threatened biota. The developable area was reduced considerably to the east to avoid the Freshwater Wetland EEC and to minimise impact on riparian vegetation along Marmong Creek by increasing the width of the riparian corridor and reducing the length of development frontage to the riparian corridor.

The retained native vegetation would help to maintain important connectivity to offsite vegetation to the north, west and south west of the study area. Conservation of this area would also provide a buffer between the development and other areas of native vegetation and habitat to the west.

6.1.3 Mitigation of impacts

A range of mitigation measures will be required to minimise impacts on biodiversity values. These should include, but not be limited to the following:

- Management of retained native vegetation to reduce impacts of human activities and weed infestation including novel impacts arising from the proposed residential development.
- Retention of large old hollow-bearing trees and woody debris as a feature of the development where possible, through a sustainable ecologically focused design. This would be made possible through retention of trees in residential gardens and asset protection zones and by ecologists working closely with the design team during the detailed design phase.
- The residential development provides an opportunity for greater retention of things such as significant habitat trees and hollow-bearing trees within lots and throughout the streetscape during the detailed design of the subdivision. The future detailed design of the subdivision would include a tree retention plan or similar to protect these biodiversity resources where possible.
- Engaging a suitably qualified ecologist prior to any clearing works to clearly demarcate vegetation protection areas.

- Implementing hygiene protocols to prevent the introduction and spread of pathogens such as Phytophthora, Myrtle Rust and Chytrid Fungus.
- Implementing procedures for clearing habitat, including hollow-bearing trees and logs, to minimise fauna injury or mortality including the preparation of a vegetation and fauna management plan.
- Implementing fauna handling and release protocols during any clearing works.

6.1.4 Biodiversity offsets

The proposal is likely to result in unavoidable impacts on native vegetation, threatened species and threatened species habitat, should the Planning Proposal and associated BCAR be approved and parts of the study area be developed. It is possible that clearing of native vegetation could result in a significant impact on threatened biota, particularly one threatened ecological community, large forest owls, and populations of *Tetratheca juncea* (Black-eyed Susan) and *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea).

Biodiversity offsetting is a tool for decision makers who have to balance the relative environmental, social and economic merits of development proposals. As described above, approval of the rezoning application would require the preparation of a BCAR in accordance with the BAM (OEH, 2017). Under the BAM, biodiversity offsets would be required for the removal of native vegetation and threatened species habitat. Offsets in the form of ecosystem credits would be required for removal of PCTs and associated habitat for certain threatened fauna that can be predicted by vegetation. Additional offsets in the form of species credits would be required for removal of threatened plants and habitat for specific threatened fauna (referred to as candidate threatened species) that cannot be predicted by vegetation type and associated habitats. Additional offsets may also be required for impacts on SAII entities should these be confirmed on site and there is a risk that impacts on these entities may not be supported by approval authorities. Offsetting in accordance with the BOS would be subject to the offsetting rules (i.e. credit matching) outlined in the BAM (OEH, 2017) and the *Biodiversity Conservation Regulations 2017.*

Under the BOS, several options for meeting offsetting obligations are available for the proposal and are briefly outlined below:

- Retiring matching credits. The retirement of credits represent the funding of management of offset sites that have been secured for biodiversity conservation. Matching credits can be acquired either:
  - Through purchase from the credit market, or
  - By establishing a Biodiversity Stewardship Site Agreement (BSSA) that can generate matching credits to offset the development.
- Payment to the Biodiversity Conservation Trust Fund (BCT Fund). The BCT Fund is administered by the Biodiversity Conservation Trust (BCT) to ensure that landowners have the funds needed to carry out management actions on Stewardship sites and provides a financial incentive to landowners to carry out those actions. Under certain circumstances, a payment can be made directly into the BCT Fund by proponents to offset the impacts of a proposed development in lieu of purchasing and retiring biodiversity credits. The BCT must then use the funds invested to purchase and retire appropriate biodiversity credits. The value of the payment is determined using the Offset Payments Calculator, which incorporates the credit price as well as a risk premium and administrative costs.

- Funding a Biodiversity Action. Proponents can opt to fund conservation actions that benefit threatened entities other than securing an offset site. The action must be a listed action in the ancillary rules. To use a biodiversity conservation action, it must be imposed as a condition of consent or approval.

There is opportunity to establish a BSSA over the conservation area to generate matching credits for the proposed development. This is the preferred approach to delivering biodiversity offsets required for the project. The conservation area is likely to provide matching credits for a number of ecosystem and species credit entities that would be required to offset the proposed development. To estimate the potential ecosystem credit liability and credit yield of the development and conservation areas respectively, the outcomes of the previous BBAM assessment of the study area were reviewed (GHD, 2009) as well as BAM assessment results interpreted from recent projects in the locality.

Based on the 2009 credit outcomes assessed under BBAM (2009), the concept design is likely to deliver a biodiversity outcome whereby the conservation area can meet the majority of the offsetting obligations (for ecosystem credits) of the development area (Table 6-1), with a difference of only nine ecosystem credits that would be required to be met via an alternative offsetting option as outlined above.

Based on the outcomes of recent projects where a BAM assessment was applied, the concept design is again likely to provide the majority of credits required, however it appears the credit shortfall would be greater than that under the BBAM (see Table 6-2), with 254 ecosystem credits potentially required via an alternative offsetting option as outlined above.

The final layout of the proposed conservation area (i.e. the Biodiversity Stewardship Site) would be completed in consultation with OEH and the BCT. Should small amendments to the configuration of the conservation area be required, this would lead to a small reduction in biodiversity credits generated on site. No impact on the development assessment would be expected. It should be noted however that this analysis is based on interpretation of the results of other BAM assessments GHD has completed in the locality and is likely not to as accurate as the BBAM analysis. The final credit balance for the site can only be determined once the BCAR (development area) and the BSSAR (conservation area) have been completed and approved.

The Commonwealth DEE may also require biodiversity offsets for residual impacts on *Tetratheca juncea* (Black-eyed Susan), *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea) and/or other MNES if impacts were assessed to be significant. Such offsets would need to be determined in accordance with the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* (DSEWPaC, 2012). Additional consultation with DEE at the development application stage and/or assessment would be required to determine if EPBC Act offsets are required.

Table 6-1 Predicted credit liability and yields, based on BBAM 2009 assessment (GHD, 2009)

Plant Community Type	Conservation area		Developable area	
	Area applied (ha)	Credits generated	Area applied (ha)	Credits required
Scribbly Gum - Red Bloodwood - Angophora inopina heathy woodland on lowlands of the Central Coast [PCT1636]	4.52	43	2.53	119
Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands [PCT1619]	153.53	1747	34.78	2002
Smooth-barked Apple - Turpentine - Sydney Peppermint heathy woodland on sandstone ranges of the Central Coast [PCT1627]	17.78	171	0	0
Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast [PCT1589]	12.57	117	0.12	5
Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast [PCT1718] - EEC	1.14	8	0.69	33
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter [PCT1736] - EEC*	0.81	6	0	0
Cleared	8.97	58	5.09	0
Weedy	0.00		1.16	
Grand Total	**199**	**2,151**	**44**	**2,160**

*unknown but assume 8 credits / ha generated, and 50 credits / ha required

Note:

1. Calculations above exclude cleared or highly disturbed lands, rocky outcrops and water bodies

2. The calculations have not sought to achieve a credit balance for each vegetation type, rather for the overall development/conservation footprint

3. The calculations are based on the BBAM (2009). These may differ slightly to BBAM (2014)

4. GHD have adjusted the vegetation types listed in the 2009 assessment to match the PCT's under current vegetation classification system

5. Estimates are provided for development and project planning only. Exact credit generation rates are determined by completing full BAM assessment only

6. Only presents ecosystem credit estimates. No estimation of species credits has been undertaken

Table 6-2 Predicted credit liability and yields, based on outcomes of recent BAM assessments as examples

Plant Community Type	Conservation area		Developable area	
	Area applied (ha)	Credits generated	Area applied (ha)	Credits required
Scribbly Gum - Red Bloodwood - Angophora inopina heathy woodland on lowlands of the Central Coast [PCT1636]	4.52	16	2.53	58
Smooth-barked Apple - Red Bloodwood - Brown Stringybark - Hairpin Banksia heathy open forest of coastal lowlands [PCT1619]	153.53	614	34.78	939
Smooth-barked Apple - Turpentine - Sydney Peppermint heathy woodland on sandstone ranges of the Central Coast [PCT1627]	17.78	62	0	0
Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast [PCT1589]	12.57	44	0.12	3
Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast [PCT1718] - EEC	1.14	3	0.69	19
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter [PCT1736] - EEC*	0.81	3	0	0
Cleared	8.97	22	5.09	0
Weedy	0.00		1.16	
Grand Total	**199**	**765**	**44**	**1,019**

*unknown but assume 3.5 credits / ha generated, and 23 credits / ha required

Note:

1. Calculations above exclude cleared or highly disturbed lands, rocky outcrops and water bodies

2. The calculations have not sought to achieve a credit balance for each vegetation type, rather for the overall development/conservation footprint

3. Estimates are provided for development and project planning only. Exact credit generation rates are determined by completing full BAM assessment only

4. Only presents ecosystem credit estimates. No estimation of species credits has been undertaken

7. Conclusion

A concept plan has been developed to support the Planning Proposal which has considered the study area's constraints, including biodiversity, traffic and bushfire. The majority of the land proposed for development consists of native vegetation in intact or near-intact condition, supporting threatened biota as well as known and potential habitat for threatened biota.

The Planning Proposal comprises the following:

- Potential development areas – that could be assessed for development activities under relevant environmental legislation and approval pathways.
- Proposed conservation areas - that would be retained and managed to improve or maintain biodiversity values and accommodate a balanced future development of the study area.

The majority of the study area is mapped as high biodiversity constraint. Potential development is concentrated in areas of comparatively lesser biodiversity constraint, due to their close proximity to the powerline easement and the main road. These areas will be subject to a range of mitigation measures including retention of hollow-bearing trees, and the implementation of appropriate hygiene, clearing and fauna handling protocols prior and during construction works.

The proposal would retain native vegetation in the western portion of the study area, which would help to maintain important connectivity to offsite vegetation to the north, west and south west. This portion of the site would be conserved under a BSA and managed accordingly. It would also provide a buffer between the development and other areas of native vegetation and habitat to the west.

Should the application for a Gateway determination be supported by LMCC, further assessments of biodiversity impacts would be required most likely comprising a BCAR prepared in accordance with the BAM to support the rezoning. The proposed development may also require assessment and approval under the Commonwealth EPBC Act for impacts on threatened biota listed under the EPBC Act. A referral of the proposed development would likely be required during the development application phase.

This Planning Proposal aims to retain the areas of highest biodiversity value, focus development in areas of comparatively lower biodiversity value, and provide for the offsetting of residual impacts. The potential conservation areas would make a valuable contribution to local and regional biodiversity and help mitigate development impacts. As such, there is scope within the study area to provide an appropriate balance between development and conservation lands.

Residual impacts on native biodiversity, including threatened biota listed under the BC Act would be balanced by the provision of a suite of biodiversity offsets as determined by an objective methodology (i.e. the BAM and BOS). The preferred approach to securing the projects is to place the conservation lands under a BSSAR and retire biodiversity credits accordingly. Any shortfall in credits would be offsets in accordance with the offset options and trading rules associated with the BAM and BOS. This approach would ensure that a suitable development/conservation footprint is delivered for the study area. For MNES, the provision of biodiversity offsets would need to be determined in accordance with the EPBC Act environmental offset policy in consultation with the Commonwealth agency.

8. References

Bell, S.A.J. (2016). *Volume 2: Vegetation Community Profiles, Lake Macquarie Local Government Area. Working Draft v2*. Unpublished Report to Lake Macquarie City Council. March 2016. Eastcoast Flora Survey.

Bell, S.A.J. & Driscoll, C. (2016). *Volume 1: Vegetation Mapping Report, Lake Macquarie Local Government Area. Stages 1 - 6.* Unpublished Report to Lake Macquarie City Council. March 2016. Eastcoast Flora Survey.

Churchill, S (2008). *Australian Bats*. Allen and Unwin, Australia.

Daly, G, (1995). 'Observations on the Green and Golden Bell-Frog *Litoria aurea* (Anura: Hylidae)'. *Herpetofauna*, **25**:2-9

DEE (2018a). *Protected Matters Online Search Tool*. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/arcgis-framework/apps/pmst/pmst.jsf

DEE (2018b). Species profiles and threats database (SPRAT). Department of the Environment and Energy. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

DEE (2018c). '*Tetratheca juncea* – Black-eyed Susan', in *Species Profile and Threats Database.* Department of the Environment and Energy. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=21407

DEE (2018d). '*Grevillea parviflora* subsp. *parviflora* – Small-flower Grevillea', in *Species Profile and Threats Database*. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64910

Department of Environment and Climate Change (DECC) (2007) *Identification Guidelines for Endangered Ecological Communities: Swamp Sclerophyll Forest on Coastal Floodplains*. NSW DECC Hurstville, NSW. Accessed at http://www.environment.nsw.gov.au//resources/threatenedspecies/EEC_Swamp_Sclerophyll_Forest_241207_Low_Res.pdf

Department of Environment and Climate Change (DECC) (2008a) *NSW (Mitchell) Landscapes Version 3* (2008). NSW DECC Hurstville, NSW.

Department of Environment and Climate Change (DECC) (2008b) *Descriptions for NSW (Mitchell) Landscapes*. NSW DECC Hurstville, NSW.

Department of Environment and Climate Change (DECC) (2009) *BioBanking Assessment Methodology*. NSW DECC Sydney, NSW.

DotE (2013). *Matters of National Environmental Significance Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth of Australia.

DPI (2007). Key fish habitat maps. Department of Primary Industries. Accessed at https://www.dpi.nsw.gov.au/fishing/habitat/publications/pubs/key-fish-habitat-maps

DPI (2018) Priority weeds for the Hunter; NSW WeedWise. Accessed by: http://weeds.dpi.nsw.gov.au/WeedBiosecurities?AreaId=80

DSEWPaC (2012) *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy*.

Duffy, AM, Lumsden, LF, Caddle, CR, Chick, RR & Newell, GR (2000). 'The efficacy of Anabat ultrasonic detectors and harp traps for surveying microchiropterans in southeastern Australia', *Acta Chiropterologica* 2: 127-144.

Eby, P. and Law, B. (2008). *Ranking the feeding habitats of Grey-headed flying foxes for conservation management.* A report for a report for The Department of Environment and Climate Change and Water (NSW) & The Department of Environment, Water, Heritage and the Arts.

ERM (2005). *Project 7777 Fennell Bay, Ecological Constraints and Opportunities Assessment – Additional Information*.

GHD (2009). *Report on Fennell Bay, Biobanking Site Assessment, February 2009.* Prepared for Landcom.

LHCCREMS (2003). *Lower Hunter & Central Coast Regional Biodiversity Conservation Strategy: technical report 2003, digital aerial photo interpretation & updated extant vegetation community map, May 2003.* Lower Hunter & Central Coast Regional Environmental Management Strategy, Callaghan, NSW.

Lake Macquarie City Council (LMCC) (2014a). *Lake Macquarie Large Forest Owl Study 2014 – North West City Sector*. Lake Macquarie City Council, Speers Point.

Lake Macquarie City Council (LMCC) (2014b). *Lake Macquarie* Tetratheca juncea *Planning and Management Guidelines*. Lake Macquarie City Council, Speers Point.

Matthei, L.E. (1995). *Soil Landscapes of the Newcastle 1:100 000 Sheet* Report. Department of Land and Water Conservation, Sydney.

Mills, DJ, Norton, TW, Parnaby, HE, Cunningham, RB & Nix, HA (1996), 'Designing surveys for microchiropteran bats in complex forest landscapes – a pilot study from south-east Australia'. *Forest Ecology and management* 85 (1-3):149-161.

NPWS (2000). *Vegetation survey, classification and mapping: Lower Hunter and Central Coast region. A project undertaken for the Lower Hunter and Central Coast Regional Environmental Management Strategy by CRA Unit, Sydney Zone, NPWS. April 2000.* NSW Legislative Council Hansard, 25 June 1996, article 13. Spoken by the Hon. R. S. L. Jones.

OEH (2014). *The BioBanking Assessment Methodology*. NSW Office of Environment and Heritage, Sydney.

OEH (2016). *NSW Guide to Surveying Threatened Plants.* NSW Office of Environment and Heritage, Sydney.

OEH (2017). *Biodiversity Assessment Method*. Published by the Office of Environment and Heritage on behalf of the NSW Government.

OEH (2018a). *NSW BioNet Atlas*. http://www.bionet.nsw.gov.au/

OEH (2018b). T*hreatened biodiversity profile search* http://www.environment.nsw.gov.au/threatenedspecies/

OEH (2018c) NSW *BioNet Vegetation Classification*. http://www.environment.nsw.gov.au/NSWVCA20PRapp/default.aspx

Pennay, M., Law, B. and Reinhold, L. (2004) *Bat calls of NSW: Region based guide to the echolocation calls of microchiropteran bats.* Department of Environment and Conservation, NSW.

Pennay, M., Law, B., and Lunney, D. (2011). 'Review of the Distribution and status of the bat fauna of NSW and the ACT' *The Biology and Conservation of Australian Bats*. Pp. 226-256 Department of Environment and Climate Change, Hurstville.

Pyke, G.H., A.W. White, P.J. Bishop & B. Waldman, (2002). 'Habitat use by the Green and Golden Bell Frog *Litoria aurea* in Australia and New Zealand'. *Australian Zoologist*, **32**(1):12-31.

RBGT (2018). *PlantNET - The Plant Information Network System of The Royal Botanic Gardens and Domain Trust, Sydney, Australia*. Royal Botanic Gardens and Domain Trust. Accessed at http://plantnet.rbgsyd.nsw.gov.au

Reardon, T. B., McKenzie, N. L., Cooper, S.J.B., Appleton., B., Carthew, S. and Adams, M (2014) 'A molecular and morphological investigation of species boundaries and phylogenetic relationships in Australian free-tailed bats Mormopterus (Chiroptera : Molossidae)'. *Australian Journal of Zoology* 62: 109-136.

Reinhold, L, Law, B, Ford, G & Pennay, M (2001) *Key to the bat calls of south-east Queensland and north-east New South Wales*, NRM, NRIM, Indooroopilly.

Van Dyke. S, Gynther. I, and Baker. A. (2013). *Field Companion to the Mammals of Australia.* New Holland Publishers.

White, A.W, (2001). *Green and Golden Bell Frog Surveys on the mid north coast of New South Wales*, Report to NSW National Parks and Wildlife Service.

Appendices

Appendix A – Likelihood of occurrence

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
Ecological Community								
1	Central Hunter Valley eucalypt forest and woodland	-	Parts listed separately	CE	The Central Hunter Valley eucalypt forest and woodland ecological community is an open forest or woodland—typically with a tree canopy dominated by eucalypt species; an open to sparse mid-layer of shrubs; and a ground layer of native grasses, forbs and small shrubs. Typically occurs on lower hillslopes and low ridges, or valley floors in undulating country; on soils derived from finer grained sedimentary rocks. The woodland or forest canopy is dominated1 by one or more of the following four eucalypt species: Narrow-leaved Ironbark (*Eucalyptus crebra*), Spotted Gum (*Corymbia maculata*), Slaty Gum (*Eucalyptus dawsonii*) and Grey Box (Eucalyptus moluccana).Under certain circumstances a fifth species, Bulloak or Buloke (*Allocasuarina luehmannii*), may be part of the mix of dominants—i.e. in sites previously dominated by one or more of the four eucalypt species.	Predicted from PMST	-	Nil. Not recorded within the study area.
2	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	-	EEC	Not listed	Occurs in coastal areas subject to periodic flooding with standing fresh water for at least part of the year. Typically on silts, muds or humic loams below 20m elevation in low-lying parts of floodplains, alluvial flats, depressions, drainage lines, backswamps, lagoons and lakes. Structure and composition varies spatially and temporally depending on the water regime, though is usually dominated by herbaceous plants and has few woody species.	-	-	**Present.** Recorded within the study area.
3	Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	-	EEC	CEEC	Littoral rainforest is generally a closed forest, the structure and composition of which is strongly influenced by its proximity to the ocean. The plant species of this community are predominantly rainforest species. Several species have compound leaves, and vines may be a major component of the canopy. These features differentiate littoral rainforest from forest or scrub, but while the canopy is dominated by rainforest species, scattered emergent individuals of sclerophyll species, such as *Angophora costata, Banksia integrifolia, Eucalyptus botryoides* and *Eucalyptus tereticornis* occur in many stands. The community occurs only on the coast. Occurs on sand dunes and on soil derived from underlying rocks.	Predicted from PMST	-	Nil. Not recorded within the study area.
4	Swamp Sclerophyll Forest of Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	-	EEC	Not listed	Typically occurs below 20m above sea level (sometimes up to 50 metres). Associated with humic clay loams and sandy loams, on waterlogged or periodically inundated alluvial flats and drainage lines associated with floodplains. Characterised by open to dense tree layer of eucalypts and paperbarks, with trees up to or higher than 25m. Includes areas of fern land or tall reed or sedge land, where trees are sparse or absent.	-	-	**Present.** Recorded within the study area.
Flora								
1	*Acacia bynoeana*	Bynoe's Wattle	E	V	Found in central eastern NSW, from the Hunter to the Southern Highlands to west of the Blue Mountains. Occurs in dry sclerophyll forest or heathlands on sandy soils. Associated with Red Bloodwood *Corymbia gummifera* , Scribbly Gum *Eucalyptus haemastoma and* Parramatta Red Gum *Eucalyptus parramattensis* .	Predicted from PMST	-	Low. Not previously recorded within 10 km of the study area. Although dry sclerophyll forest habitat is present in the study area, the preferred habitat for the species is on sandier sites.
2	*Angophora inopina*	Charmhaven Apple	V	V	Endemic to the Central Coast of NSW, from Karuah to Charmhaven. Occurs in wet heath with Scribbly Gum *Eucalyptus haemastoma* and Red Bloodwood *Corymbia gummifera* , sedge woodland with River Bottlebrush *Melaleuca sieberi* and Red Mahogany *Eucalyptus resinifera* , and woodland/forest with Brown Stringybark *Eucalyptus capitellata* and Red Bloodwood *Corymbia gummifera* . Flowers between mid-December and mid-January.	Predicted from PMST	554 bionet records within 10 kms of study area, most recently during 1999	**High.** One record within the study area from 1999, although this record has not been verified by the current study. Suitable habitat occurs within the study area.
3	*Asterolasia elegans*	-	E	E	Distributed from north of Sydney in Baulkham Hills, Hawkesbury and Hornsby. Found in closed forests in lower slopes and valleys. Occurs in forests with a canopy of Turpentine *Syncarpia glomulifera* , Smooth-barked Apple *Angophora costat* a, Forest Oak *Allocasuarina torulosa* and Christmas Bush *Ceratopetalum gummiferum* . Distributed from on Hawkesbury sandstone.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area. The site is not on Hawkesbury Sandstone and is not within the known distribution of the species.
4	*Caladenia tessellata*	Thick Lip Spider-orchid	E	V	Known to exist within the Sydney and Central Coast area of NSW. It is found in grassy sclerophyll woodland. Found on clay loam or sandy soils. Flowers from September to November (this is reduced from late september to early october for southern populations).	Predicted from PMST	-	Moderate. Not previously recorded within 10 km of the study area. The site is within the northern limits of the species known distribution; potentially suitable habitat is present within the study area.
5	*Callistemon linearifolius*	Netted Bottle Brush	V	Not listed	Distributed from Sydney on the NSW south coast to mid north coast of NSW. Occurs in dry sclerophyll forests near the coast. Flowers in spring and summer.	-	104 records from within 10 kms of study area	**High.** Many records within 10 km of the study area, although no records on site. Dry sclrophyll forest habitat occurs within the study area, which could provide habitat for the species.
6	*Corunastylis insignis*	Wyong Midge Orchid 1	CE	CE	Distributed from Wyong, on the Central Coast of NSW. Found in patches of Kangaroo Grass *Themeda australis* in heathland and forest. Associated with dry sclerophyll woodland dominated by Scribbly Gum *Eucalyptus haemostoma* , Red Bloodwood *Corymbia gummifera* and Smooth-barked Apple *Angophora costata* . Flowers between August and November.	Predicted from PMST	-	Moderate. Not previously recorded within 10 km of the study area; however, suitable habitat present within the study area.

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
7	*Cryptostylis hunteriana*	Leafless Tongue-orchid	V	V	Distributed from East Gippsland in Victoria throughout coastal NSW, and up to the Tin Can Bay area in Southern QLD. Habitats include heathlands, heathy woodlands, sedgelands, dry sclerophyll forests, forested wetlands, freshwater wetlands, grassland and wet sclerophyll rainforests. Associated with Scribbly Gum *Eucalyptus haemastoma*, Silvertop Ash *Eucalyptus sieberi*, Red Bloodwood *Corymbia gummifera* and Black Sheoak *Allocasuarina littoralis*. Preferred soils are moist sands, moist to dry clay loam soils. Species flowers from November to February.	Predicted from PMST	One record from 2014 within the study area	**High.** One record within the study area from 2014, although this record has not been verified by the current study. Suitable habitat occurs within the study area.
8	*Cynanchum elegans*	White-flowered Wax Plant	E	E	Distributed from Gerroa (Illawarra) to Brunswick Heads and west to Merriwa in the upper Hunter. Usually occurs on the edge of dry rainforest or littoral rainforest, but also occurs in Coastal Banksia Scrub, open forest and woodland, and Melaleuca scrub. Occurs in association with Small-fruited mock-olive *Notelaea microcarpa* and *Acacia* species inland, and coastally with Coast Banksia *Banksia integrifolia*, Morton Bay Fig *Ficus macrophylla* and Coast Tea-tree *Leptospermum laevigatum* and Rough-fruit Pittosporum *Pittosporum revolutum*. Soil and geology types are not limiting.	Predicted from PMST	Two records within 10 kms of study area, the most recent is from 2005 approximately 5 km away near Belmont.	Low. Species previously recorded within 10 km of the study area; however, this record is not recent and is located on the eastern side of Lake Macquarie. The habitat within the study area is not sufficiently mesic to be suitable or preferred.
9	*Diuris praecox*	Newcastle Doubletail	V	V	Distributed between Ourimbah and Nelson Bay, NSW. Grows on hills and slopes near the coast, in heathy open forests that have a dense grassy understorey. Distributed on well drained soil. Known to be associated with exposed ridgelines with sufficient sunlight reaching the forest floor, rather than being associated with a specific vegetation type or aspect. Produces leaves and flowering stems in winter, with flowers previously recorded in July to early September.	Predicted from PMST	-	Moderate. Not previously recorded within 10 km of the study area but potential suitable habitat is present in the study area along the ridgeline.
10	*Eucalyptus camfieldii*	Camfield's Stringybark	V	V	Distributed from Raymond Terrace to Waterfall NSW. Exists in coastal heath on exposed sandy ridges. Associated species frequently include stunted species of Narrow-leaved Stringybark *Eucalyptus oblonga*, Brown Stringybark *Eucalyptus capitellata* and Scribbly Gum *Eucalyptus haemastoma*. It grows in shallow sandy soils overlying Hawkesbury sandstone.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and no suitable habitat present.
11	*Eucalpytus parramattensis* subsp. *decadens*	Earp's Gum	V	V	Endemic to the Hunter Region of NSW. Occurs in low-lying, swampy areas. Found with Narrow-leaved Scribbly Gum *Eucalyptus racemosa*, Narrow-leaved Apple *Angophora bakeri* and White Stringybark *Eucalyptus globoidea*. Prefers deep low-nutrient sands.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and no suitable habitat present.
12	*Grevillea parviflora* subsp. *parviflora*	Small-flower Grevillea	V	V	Distributed between Moss Vale/Bargo and lower Hunter Valley. Broad habitat range including heath, shrubby woodland and open forest and often in distributed areas on the fringes of tracks or roads. Associated species include Earp's Gum *Eucalyptus parramattensis subsp. decadens*, Narrow-leaved Apple *Angophora bakeri*, Swamp Wattle *Acacia elongata* and Thyme Honey-myrtle *Melaleuca thymifolia*. Distributed on light clay or sandy soils.	Predicted from PMST	39 records from within 10 kms of study area	**Present.** Recorded within the study area.
13	*Melaleuca biconvexa*	Biconvex Paperbark	V	V	Distributed from coastal areas in NSW, from Jervis Bay to Port Macquarie (Harden, 1991). Associated with Eucalypt open forest with Sydney Blue Gum *Eucalyptus saligna,* Swamp Mahogany *Eucalyptus robusta* and Mountain Cedar Wattle *Acacia elata*. Grows in damp areas, often near watercourses, on alluvium soils over shale. Flowers in Summer.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and no suitable habitat present.
14	*Pelargonium* sp. Striatellum	Omeo Stork's-bill	E	E	Only known in four populations in NSW, three of which exist on basalt plains of the Monaro and one at lake Bathurst. Habitat is just above the high-water level of ephemeral lakes in a zone between grasslands or pasture, wetland or aquatic communities. Flowers from October to March.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and no suitable habitat present.
15	*Prasophyllum* sp. Wybong (C.Phelps ORG 5269)	-	Not listed	CE	Distributed within the Border Rivers (Gwydir, Namoi, Hunter), Central Rivers and Central West Natural Resource Management Regions. The species is known to occur in open eucalypt woodland and grassland. The species can be found in the EPBC listed threatened ecological community White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and no suitable habitat present.
16	*Pterostylis gibbosa*	Illawarra Greenhood	E	E	Found in the Hunter Region, Illawarra Region and the Shoalhaven Region. Occurs in open forest or woodland, with a flat or gently sloping topography. Habitat associations include Forest Red Gum *Eucalyptus tereticornis,* Woollybutt *Eucalyptus longifolia* and White Feather Honey Myrtle *Melaleuca decora*. Only visible above ground between late summer and spring.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and no suitable habitat present.
17	*Rhizanthella slateri*	Eastern Underground Orchid	V	E	Distributed from the mid-north coast to the south coast of NSW. Habitat is sclerophyll forest with a deep layer of organic litter. The species has been found in EPBC listed threatened ecological communities of Littoral Rainforest and Coastal Vine Thickets of Eastern Australia, Turpentine-Ironbark Forest in the Sydney Basin Bioregion, Shale/Sandstone Transition Forest and Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and no suitable habitat present.

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
18	*Rutidosis heterogama*	Heath Wrinklewort	V	V	Distributed on the North Coast and Northern Tablelands of NSW. Recorded from near Cessnock to Kurri Kurri with an outlying occurence at Howes Valley. On the Central Coast it is located north from Wyong to Newcastle. Mostly inhabits heathland/sedgeland within shrubby open forest and woodland, and is often recorded in disturbed areas along a road. Distributed with the EPBC listed threatened ecological community White Box- Yellow Box- Blakely's red Gum Grassy Woodland and Derived Native Grassland.	Predicted from PMST	-	Moderate. Not previously recorded within 10 km of the study area; however, potentially suitable habitat present within the study area.
19	*Syzygium paniculatum*	Magenta Lilly Pilly	E	V	Found only in NSW, from Lansdowne to Conjola State Forest. Found in littoral rainforest on sand or subtropical rainforest. Associated species include Small-leaved Fig *Ficus obliqua,* Plum Pine *Podocarpus elatus* and Lilly Pilly *Syzygium smithii.* Preferred soils are sandy and derived from sandstone.	Predicted from PMST	Three records within 10 kms of study area; the most recent is from 2007.	Low. Species previously recorded within 10 km of the study area; however, the habitat within the study area is not suitable.
20	*Tetratheca juncea*	Black-eyed Susan	V	V	Restricted to north of the Sydney Basin bioregion, in the Local Government Areas of Newcastle, Wyong, Lake Macquarie, Port Stephens and the Great Lakes. Usually found in low open forest and woodland, with a mixed shrub understorey and grassy groundcover. Associated species include Smooth-Barked Apple *Angophora costada,* Red Bloodwood *Corymbia gummifera,* Scribbly Gum *Eucalyptus haemastoma* and Brown Stringybark *Eucalyptus capitellata*. Mostly occur on low nutrient soils.	Predicted from PMST	Recorded during surveys. Over 1,500 records from within 10 kms of study area	**Present.** Recorded within the study area.
21	*Thesium australe*	Austral Toadflax	V	V	Found in small, scattered populations along the east coast, northern and southern tablelands. Occurs in grassland or grassy woodland. Found in association with Kangaroo Grass *Themeda australis*. Flowers in spring and summer.	Predicted from PMST	-	Nil. Not recorded within 10 km of the study area; the study area does not provide suitable grassy woodland or grassland habitat
BIRDS								
1	*Anthochaera phrygia*	Regent Honeyeater	CE	CE	Distribution extends from south-east Queensland to central Victoria. Preferred habitat is dry open forests and woodlands, particularly box-ironbark eucalypt woodland and riparian forests of River Sheoak, with an abundance of mature trees, high canopy cover and abundance of mistletoes. Also uses remnant patches including travelling stock routes and roadside reserves when moving between habitat and areas of flowering eucalypt. Feeds on invertebrates and nectar from mistletoe and eucalypts. Breeding corresponds with flowering *Eucalypts.* Regent Honeyeaters usually nest in horizontal branches or forks in tall mature eucalypts and Sheoaks. Also nest in mistletoe haustoria. Nest is an open cup-shaped nest is constructed of bark, grass, twigs and wool by the female.	Predicted from PMST	-	Moderate. Species not recorded within 10 km of the study area but suitable foraging habitat is present within the study area.
2	*Artamus cyanopterus*	Dusky Woodswallow	V	Not listed	Distributed across mainland Australia, ranging from Queensland to South Australia and Tasmania. Preferred habitat is open eucalypt forests and woodlands. Associated with Eucalypt saplings and *Acacia* species, and a ground cover of sedges and woody debris. Feeds on insects and occasionally nectar, fruit and seed. Breeding and nesting occurs in shrubs or low trees, living or dead in branch forks, hollows or behind loose bark.	-	Two records within 10 kms of study area. The most recent is from 2013, and was recorded in Warners Bay.	**High.** Species recorded within 10 km of the study area and suitable foraging habitat is present within the study area.
3	*Botaurus poiciloptilus*	Australasian Bittern	E	E	When in Australia, distributed from Queensland to South Australia and Tasmania. Preferred habitat is permanent freshwater wetlands with tall, dense reedbeds particularly *Typha* spp. and *Eleocharis* spp., with adjacent shallow, open water for foraging. Feeds on wetland animals including fish, eels, crayfish and frogs. Roosts amongst dense reeds or rushes. Breeds from spring to summer in solitary and territorial pairs.	Predicted from PMST	-	Moderate. Species not recorded within 10 km of the study area but suitable foraging habitat is present within the study area.
4	*Calidris canutus*	Red Knot	Not listed	E, M	The Red Knot is commonly found in most parts of coastal Australia except in the Great Australian Bight. Typical habitat includes intertidal mudflats, sandflats and sandy beaches on the coast, estuaries, bays, inlets and harbours. Forage on substrate near the edge of the water on low tide. Have been recorded foraging on eelgrass. Breeds in Arctic areas.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.
5	*Calidris ferruginea*	Curlew Sandpiper	E	CE, M	Distributed around the Australian coast and widespread inland during their non-breeding season. Mainly reside on intertidal mudflats in sheltered coastal areas, like estuaries, bays, inlets and lagoons. Forage on mudflats, and amongst vegetation like saltmarsh and feeds on seagrass, seaweed, algae and waterweed. Roost on dry shingle, shell or sand beaches, sandspits and islets around wetlands or lagoons. Breeding occurs in Siberia.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.
6	*Callocephalon fimbriatum*	Gang-gang Cockatoo	V	Not listed	Distributed from southern Victoria to central-eastern NSW. Occurs in tall highland forests and woodlands, particularly wet sclerophyll forests throughout summer and in drier, more open eucalypt forests- like box-gum and box-ironbark communities in winter. Forages in eucalypt trees and acacia shrubs as it feeds on eucalypt or wattle seeds. Nesting occurs in hollows in trunks, limbs or dead spouts of tall living trees, often near water.	-	One record within 10 kms of study area but from 2004 and located 3 km away.	Moderate. Previously recorded within 10 km of the study area but only marginal habitat present.

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
7	*Calyptorhynchus lathami*	Glossy Black-Cockatoo	V	Not listed	Distributed from the east coast to the southern tablelands and central western plains. Occurs in woodland and open forests, rarely away from *Allocasuarina* . Feeds almost exclusively on the seeds of *Allocasuarina* species. Requires sufficient extent of forage within home range to support breeding. Roosts in leafy canopy trees, preferably eucalypts, usually <1km from feeding site. Nests in large (approximately 20cm) eucalypt hollows.	-	One record within 10 kms of study area from 2016. Located over 7 km away.	Moderate. Previously recorded within 10 km of the study area and suitable foraging habitat present in the form of moderate abundance of *Allocasuarina* trees. Some suitable hollow-bearing trees present for roosting.
8	*Charadrius mongolus*	Lesser Sand Plover	V	E, M	Distributed throughout northern and eastern Australia. When not breeding, the species occurs in coastal littoral and estuarine environments. Inhabits large intertidal sandflats or mudflats in sheltered bays, harbours and estuaries. Can occur in saltmarsh and mangroves. Species feeds on freshly exposed intertidal mud and sand flats. Roosts near foraging areas.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.
9	*Climacteris picumnus victoriae*	Brown Treecreeper	V	Not listed	Endemic to eastern Australia and occurs in eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges. Mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and River Red Gum (Eucalyptus camaldulensis) Forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses. Sedentary, considered to be resident in many locations throughout its range; present in all seasons or year-round at many sites; territorial year-round. Up to 80% of the diet is comprised of ants; other invertebrates (including spiders, insects larvae, moths, beetles, flies, hemipteran bugs, cockroaches, termites and lacewings) make up the remaining percentage; nectar from Mugga Ironbark (Eucalyptus sideroxylon) and paperbarks, and sap from an unidentified eucalypt are also eaten. Hollows in standing dead or live trees and tree stumps are essential for nesting. Breeds in pairs or co-operatively in territories which range in size from 1.1 to 10.7 ha (mean = 4.4 ha).	-	-	**Present.** Recorded within the study area.
10	*Daphoenositta chrysoptera*	Varied Sittella	V	Not listed	Sedentary, occurs across NSW from the coast to the far west. Inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and *Acacia* woodland. Sensitive to habitat isolation and loss of structural complexity, and adversely affected by dominance of Noisy Miners. Cleared agricultural land is potentially a barrier to movement. Feeds on arthropods gleaned from crevices in rough or decorticating bark, dead branches, standing dead trees and small branches and twigs in the tree canopy. Builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years	-	Seven records from 2013 within the study area	**Present.** Recorded within the study area.
11	*Dasyornis brachypterus*	Eastern Bristlebird	E	E	Three main populations, in south-eastern Queensland, Central NSW and southern NSW. The species prefers open forest with dense tussocky grass understorey and sparse mid-storey near rainforest ecotone; all of these vegetation types are fire prone. Feeds on a variety of insects, particularly ants. Nests are elliptical domes constructed on or near the ground amongst dense vegetation and eggs are laid between August to Februrary.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.
12	*Erythrotriorchis radiatus*	Red Goshawk	CE	V	The Red Goshawk is endemic to Australia, ranging from the western Kimberley region, to North-eastern NSW. Occurs in coastal and sub-coastal areas in forest and woodland of tropical and warm-temperate Australia. Preferred vegetation types include eucalypt woodland, open forest, tall open forest, gallery rainforest, swamp sclerophyll forest, and rainforest margins.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area and sub optimal habitat present; species is likely to be a vagrant to the area if present as they are typically more of an inland species.
13	*Glossopsitta pusilla*	Little Lorikeet	V	Not listed	Wide distribution across coastal and Great Divide regions of eastern Australia, from South Australia to Cape York. Forages in the canopy of open eucalypt forest and woodlands. Sometimes found foraging in *Angophora* , *Melaleuca* and other tree species. Riparian habitats used for high soil fertility.	-	Six records within 10 kms of study area	**Present.** Recorded within the study area.
14	*Grantiella picta*	Painted Honeyeater	V	V	Nomadic, occurring in low densities across most of NSW. Highest concentrations and almost all breeding occur on inland slopes of the Great Dividing Range. Inhabits Boree, Brigalow and Box Gum woodlands and Box-Ironbark forests. Specialist forager on the fruits of mistletoes, preferably of the *Amyema* genus. Nests in outer tree canopy.	Predicted from PMST	-	Nil. Not recorded within 10 km of the study area and sub-optimal habitat present. Also more likely to be present further inland on the western slopes of the Great Dividing Range.
15	*Haematopus longirostris*	Pied Oystercatcher	E	Not listed	Occurs along the Australian coastline. Mostly on intertidal mudflats of inlets and bays, as well as sand flats and sandbanks. Forages on exposed sand, mud and rock at low tide.	-	Four records withing 10 kms of study area	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
16	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	V	M	Distributed along the Australian coastline and well inland along rivers and wetlands, it's widespread in eastern NSW. Foraging habitat consists of coastal seas, rivers, fresh and saline lakes, lagoons, reservoirs and terrestrial habitats such as grasslands. Diet consists of waterbirds, turtles and fish. Resident pairs are territorial and occupy nesting territories of hundreds of hectares. Breeding habitat consists of large trees within mature open forest, gallery forest or woodland and reported that they avoid nesting near urban areas. Nest trees are typically large emergent eucalypts and often have emergent dead branches or large dead trees nearby which are used as 'guard roosts'. Nests are large structures built from sticks and lined with leaves or grass.	-	27 records within 10 kms of study area, with the most recent from 2017	Moderate. Species recorded within 10 km of the study area but most likely to occur in association with Lake Macquarie itself. If observed in the study area, most likely to be a flyover as the species is typically associated with large bodies of water.
17	*Ixobrychus flavicollis*	Black Bittern	V	Not listed	Wide distribution, from southern NSW, to cape York and along the coast to the Kimberley region. Inhabits terrestrial and estuarine wetlands with permanent water and dense vegetation. May occur in flooded grassland, forest, woodland, rainforest and mangroves.	-	One record within 10 kms of study area	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.
18	*Lathamus discolor*	Swift Parrot	E	CE	Migratory, travelling to the mainland from March to October. Breeds in Tasmania from September to January. On the mainland, it mostly occurs in the southeast foraging on winter flowering eucalypts and lerps, with records of the species between Adelaide and Brisbane. Principal over-winter habitat is box-ironbark communities on the inlad slopes and plains. *Eucalyptus robusta* , *Corymbia maculata* and *C. gummifera* dominated coastal forests are also important habitat.	Predicted from PMST	Nine records within 10 kms of study area	Moderate. Species recorded within 10 km of the study area and suitable foraging habitat is present within the study area. However, species is migratory and does not breed on the mainland and are likely to occur occasionally as influenced by seasonal migratory pathways and in response to seasonal and geographical variation in flowering.
19	*Limosa lapponica baueri*	Western Alaskan Bar-tailed Godwit	Not listed	V	Occurring on all coastal areas of Australia. Roosts on sandy beaches, sandbars, sandspits and near coastal saltmarsh.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.
20	*Limosa lapponica menzbieri*	Northern Siberian Bar-Tailed Godwit	Not listed	CE	Occurring on all coastal areas of Australia. Roosts on sandy beaches, sandbars, sandspits and near coastal saltmarsh.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.
21	*Ninox connivens*	Barking Owl	V	Not listed	Distribution is throughout New South Wales and Australia. Occurs in woodland and open forest, including fragmented remannts and cleared farmland. Roosts in *Acacia* and *Casuarina* species. Feeds on small arboreal mammals including gliders and possums. Nesting occurs in tree hollows form August to November.	-	Three records within 10 kms of study area, the most recent record is from 2008	**High.** Species has been recorded within 10 km of the study area and suitable habitat is present within the study area.
22	*Ninox strenua*	Powerful Owl	V	Not listed	Endemic to eastern and south-eastern Australia, from Mackay to south-western Victoria. Resides in a wide range of vegetation types, from woodland and open sclerophyll forest, to tall open wet forest and rainforest. Solitary and sedentary species. Prefers large tracts of vegetation. Nests in large tree hollows (> 0.5 m deep), in large eucalypts (dbh 80-240 cm) that are at least 150 years old. Roosts in species like Turpentine, Black Sheoak, Blackwood, Rough-barked Apple and Cherry Ballart. Pairs have high fidelity to a small number of hollow-bearing nest trees and defend a large home range of 400 - 1,450 ha. Forages within open and closed woodlands as well as open areas. Very large territory.	-	78 records within 10 kms of study area, with the most recent record from 2018	**Present.** Recorded within the study area.
23	*Pandion cristatus*	Eastern Osprey	V	Not listed	Found around the Australian coastline, except Victoria and Tasmania. They are common around the northern coast, especially on rocky shores. Favour areas along the coast like river mouths, lagoons and lakes. Feed on fish in clear, open water. Nests in crowns of dead trees a kilometre from the ocean.	-	Five records within 10 kms of study area	Low. Previously recorded within 10 km of the study area but there is no suitable habitat within the study area.
24	*Petroica boodang*	Scarlet Robin	V	Not listed	Found from south-east Queensland to to South Australia, from the coast to the inland slopes. They live in dry and eucalypt forests and woodlands, with an open and grassy with little scattered shrubs. Lives in mature and regrowth vegetation.	-	One record within 10 kms of study area, from 2006.	Moderate. Species recorded within 10 km of the study area; however, the record is rare and over 10 years old. There is suitable habitat within the study area.
25	*Numenius madagascariensis*	Eastern Curlew	Not listed	CE	The species is found in all states, particularly the north, east, and south-east regions including Tasmania. Breeds in Russia and north-eastern China. Most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass. Forages on crabs and molluscs on mudflats. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. The birds are often recorded among saltmarsh and on mudflats fringed by mangroves, and sometimes use the mangroves. The birds are also found in saltworks and sewage farms.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
26	*Rostratula australis*	Australian Painted Snipe	E	E	In NSW many records are from the Murray-Darling Basin, including the Paroo wetlands, Lake Cowal, Macquarie Marshes, Fivebough Swamp and more recently, swamps near Balldale and Wanganella. Other important locations with recent records include wetlands on the Hawkesbury River and the Clarence and lower Hunter Valleys. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area and no suitable habitat present.
27	*Tyto novaehollandiae*	Masked Owl	V	Not listed	Ranges from east coast of NSW to the western plains. Its range makes up 90% of NSW. The species lives in dry eucalypt forests and woodlands. Hunts along the edge of forests and roadsides. Eats tree-dwelling and ground mammals. Pairs have a large home-range of 500 to 1000 hectares. Roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting.	-	12 records within 10 kms of study area, with the most recent record from 2017	**Present.** Recorded within the study area.
28	*Tyto tenebricosa*	Sooty Owl	V	Not listed	Occurs along the east of NSW, along the coast and eastern tablands. Occupies dry, subtropical and warm temperate rainforest, and moist eucalypt forests. Roosts in hollows of tall forest trees, or in heavy vegetation. Feeds on small mammals like the Common Ringtail Possum (*Psuedocheirus peregrinus*) and the sugar glider (*Petaurus breviceps*).	-	Two records within 10 kms of study area	**High.** Species has been recorded within 10 km of the study area. Previously recorded within the study area although this has not been verified in the current study. Suitable foraging and roosting habitat is present in the study area.
MIGRATORY BIRDS								
1	*Cuculus optatus*	Oriental Cuckoo	-	M	This species migrates to northern and eastern Australia in the warmer months. Occurs south to the Shoalhaven area. Occurs in a range of habitats, including monsoon forest, rainforest edges, leafy trees in paddocks, river flats, roadsides and mangroves.	Predicted from PMST	-	Moderate. Species has not been recorded within 10 km of the study area but as the species is known to utilise a range of habitat types, suitable habitat is present within the study area. Not expected to be a frequent visitor to the site or to be dependent on the habitat within the study area.
2	*Hirundapus caudacutus*	White-throated Needletail	-	M	Recorded along NSW coast to the western slopes and occasionally from the inland plains. Breeds in northern hemisphere. Almost exclusively aerial while in Australia. Occur above most habitat types, but are more frequently recorded above more densely vegetated habitats (rainforest, open forest and heathland) than over woodland or treeless areas.	Predicted from PMST	-	Moderate. Species not previously recorded within 10 km of the study area but may flyover on occasions.
3	*Monarcha melanopsis*	Black-faced Monarch	-	M	Found along the coast of eastern Australia, becoming less common further south. Found in rainforests, eucalypt woodlands, coastal scrub and damp gullies. It may be found in more open woodland when migrating. Resident in the north of its range, but is a summer breeding migrant to coastal south-eastern Australia, arriving in September and returning northwards in March. It may also migrate to Papua New Guinea in autumn and winter.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area; the species is associated with wetter habitats than is provided by the study area and is unlikely to be occur.
4	*Motacilla flava*	Yellow Wagtail	-	M	This species breeds in temperate Europe and Asia. They occur within Australia in open country habitat with disturbed ground and some water. Recorded in short grass and bare ground, swamp margins, sewage ponds, saltmarshes, playing fields, airfields, ploughed land and town lawns.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area; no suitable habitat present.
5	*Myiagra cyanoleuca*	Satin Flycatcher	-	M	In NSW widespread on and east of the Great Divide, sparsely scattered on the western slopes, very occasional records on the western plains. Inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, often near wetlands and watercourses. On migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests. Generally not in rainforests.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area; the species is associated with wetter habitats than is provided by the study area and is unlikely to be occur.
6	*Rhipidura rufifrons*	Rufous Fantail	-	M	Occurs in coastal and near coastal districts of northern and eastern Australia. Has breeding populations in NSW. Two subspecies intergrade in a zone between the Queensland-NSW border ranges and the Clarence-Orara rivers in NSW. The species mainly inhabits wet sclerophyll forests, often in gullies dominated by *Eucalyptus microcorys*, *E. cypellocarpa*, *E. radiata*, *E. regnans*, *E. delegatensis*, *E. pilularis* or *E. resinifera*; usually with a dense shrubby understorey, often including ferns. They also occur in subtropical and temperate rainforests. They occasionally occur in secondary regrowth, following logging or disturbance in forests or rainforests. When on passage, they are sometimes recorded in drier sclerophyll forests and woodlands, including *Corymbia maculata*, *E. melliodora*, ironbarks or stringybarks, often with a shrubby or heath understorey.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area; the species is associated with wetter habitats than is provided by the study area and is unlikely to be occur.
7	*Symposiachrus trivirgatus*	Spectacled Monarch	-	M	The Spectacled Monarch is found in coastal north-eastern and eastern Australia, including coastal islands, from Cape York, Queensland to Port Stephens, New South Wales. It is much less common in the south. Prefers thick understorey in rainforest, wet gullies and waterside vegetation as well as mangroves.	Predicted from PMST	-	Nil. Species not recorded within 10 km of the study area; the species is associated with wetter habitats than is provided by the study area and is unlikely to be occur.

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
MAMMALS								
1	*Cercartetus nanus*	Eastern Pygmy Possum	V	Not listed	Found in south-eastern Australia, from southern Queensland to eastern South Australia and in Tasmania. In NSW it extents from the coast inland as far as the Pilliga, Dubbo, Parkes and Wagga Wagga on the western slopes. Found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest.Feeds largely on nectar and pollen collected from banksias, eucalypts and bottlebrushes and insects. Shelters in tree hollows, rotten stumps, holes in the ground, abandoned bird-nests, Ringtail Possum (*Pseudocheirus peregrinus*) dreys or thickets of vegetation, (e.g. grass-tree skirts); nest-building appears to be restricted to breeding females; tree hollows are favoured but spherical nests have been found under the bark of eucalypts and in shredded bark in tree forks.	-	Two records within 10 kms of study area. The most recent was from 2013, located less than 50 m from the study area.	**High.** Recorded within 10 km of the study area and suitable habitat occurs within the study area.
2	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	V	Found mainly in areas with extensive cliffs and caves, from Queensland south to the NSW Southern Highlands. Roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (*Petrochelidon ariel*), frequenting low to mid-elevation dry open forest and woodland close to these features. Females have been recorded raising young in maternity roosts (20-40 females) from November through to January in roof domes in sandstone caves and overhangs. Found in well-timbered areas containing gullies. Feeds on insects in the forest canopy or over water. Breeding occurs in winter or spring. Likely to hibernate through the coolest months.	Predicted from PMST	Nine records within 10 kms of study area	Moderate. Previously recorded within 10 km of the study area. The study area does not provide extensive cliff and cave features for roosting and breeding but does provide foraging habitat.
3	*Dasyurus maculatus*	Spotted-tailed Quoll	V	E	Inhabits a range of environments including rainforest, open forest, woodland, coastal health and inland riparian forest, from the sub-alpine zone to the coastline. Den subject sites are in hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces. Females occupy home ranges of up to 750 ha and males up to 3,500 ha, which are usually traversed along immensely vegetated creek lines.	Predicted from PMST	Three records within 10 kms of study area	Moderate. Previously recorded within 10 km of the study area, with the most recent record from 2011 in urban areas (near Eleebana). As the species occurs in very low densities and has very large home ranges, the species is not predicted to be a frequent visitor to the site.
4	*Falsistrellus tasmaniensis*	Eastern False Pipistrelle	V	Not listed	Occurs on the south east coast of Australia, from southern QLD to Tasmania. Prefers moist habitats with trees taller than 20m. Roosts in eucalypt hollows, and hunts small flying insects like moths and beetles just below the tree canopy.	Predicted from PMST	Two records within 10 kms of study area	**High.** Recorded within 10 km of the study area and suitable habitat occurs within the study area, particularly on the western side of the ridgeline in the deeper gully.
5	*Miniopterus australis*	Little Bentwing-bat	V	Not listed	East coast distribution from Cape York to Wollongong. Prefers moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub. Roosts in confined spaces such as caves, tunnels and tree hollows.	Predicted from PMST	Recorded during field surveys. 89 records within 10 kms of study area	**Present.** Recorded within the study area.
6	*Mormopterus norfolkensis*	Eastern Freetail-bat	V	Not listed	Found along the east coast of Australia between southern QLD and southern NSW. Occurs in dry sclerophyll forest, woodland, mangroves and swamp forests. Roosts in tree hollows, but will also roost in man-made structures.	Predicted from PMST	Recorded during field surveys. 26 records within 10 kms of study area	**Present.** Recorded within the study area.
7	*Miniopterus schreibersii oceanensis*	Eastern Bentwing-bat	V	Not listed	Occurs along the east coast and north-west coast of Australia. Inhabits various habitats from open grasslands to woodlands, wet and dry sclerophyll forests and rainforest. Essentially a cave bat but may also roost in road culverts, stormwater tunnels and other man-made structures. Only 4 known maternity caves in NSW, near Wee Jasper, Bungonia, Kempsey and Texas. Females may travel hundreds of kilometres to the nearest maternal colony. Hunts in forested areas for insects like moths and flying insects.	Predicted from PMST	52 records within 10 kms of study area	Moderate. Numerous within 10 km of the study area. The study area does not provide extensive cliff and cave features, or abundant man-made structures for roosting and breeding but does provide foraging habitat.
8	*Myotis macropus*	Southern Myotis	V	Not listed	Mainly coastal but may occur inland along large river systems. Usually associated with permanent waterways at low elevations in flat/undulating country, usually in vegetated areas. Forages over streams and watercourses feeding on fish and insects from the water surface. Roosts in a variety of habitats including caves, mine shafts, hollow-bearing trees, stormwater channels, buildings, under bridges and in dense foliage, typically in close proximity to water. Breeds November or December.	Predicted from PMST	Eight records within 10 kms of study area	**High.** Recorded within 10 km of the study area and suitable habitat occurs within the study area near the dam along Marmong Creek.
9	*Petauroides volans*	Greater Glider	Not listed	V	The species is restricted to eastern Australia, from north QLD to central Victoria. This nocturnal marsupial lives in a variety of eucalypt-dominated habitats, ranging from low open forests on the coast to tall forests in the ranges and low woodland westwards of the Dividing Range. It feeds on eucalypt leaves and flowers. It uses large tree hollows in old, large trees.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and more typically distributed west of the Great Dividing Range.

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
10	*Petaurus australis*	Yellow-bellied Glider	V	Not listed	Found along the eastern side of the Great Dividing Range from southern QLD to Victoria. Resides in tall, mature eucalypt forest in areas with high rainfall and nutrient dense soil. Mostly feeds on plant and insects, including sap, nectar and manna. Den, often in family groups, in hollows of large trees. Very mobile and occupy large home ranges between 20 to 85 ha to encompass dispersed and seasonally variable food resources.	-	Two records within 10 kms of study area	Low. Previously recorded within 10 km of the study area but more typically associated with wet sclerophyll forest habitats.
11	*Petaurus norfolcensis*	Squirrel Glider	V	Not listed	Species widely distributed throughout Australia, from Queensland to western Victoria. Occurs in mature Box-Ironbark woodland, and River Red Gum in areas west of the great dividing range, and in Blackbutt-Bloodwood first with heathy understorey in coastal regions. Prefers mixed species forest composition, with an *Acacia* midstorey. Requires abundant tree hollows for refuge and nest sites. Diet includes *Acacia* gum, eucalypt sap, nectar and manna, as well as invertebrates and pollen.	-	36 records within 10 kms of study area. The most recent records are from 2017 and are between 800 and 1500 m from the study area.	**High.** Many records within 10 km of the study area and suitable habitat occurs within the study area. Two records within the study area from 2013, although these records have not been verified by the current study.
12	*Petrogale penicillata*	Brush-tailed Rock-wallaby	E	V	Occurs from the Shoalhaven north to the Queensland border. Now mostly extinct west of the Great Dividing Range, except in the Warrumbungles and Mt Kaputar. Occurs on rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north. Diet consists of vegetation in adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	Predicted from PMST	-	Nil. Not recorded within 10 km of the study area and no suitable cliff line habitat present.
13	*Phascolarctos cinereus*	Koala	V	V	Occurs from coast to inland slopes and plains. Restricted to areas of preferred feed trees in eucalypt woodlands and forests. Home range varies depending on habitat quality, from < 2 to several hundred hectares. Breeds from August to February.	Predicted from PMST	One record within 10 km of study area	Low. There are few records for the species within 10 km of the study area there is sub-optimal habitat for the species, with preferred feed tree species not likely to comprise more than 15% of the canopy.
14	*Potorous tridactylus*	Long-nosed Potoroo	V	V	Found on the south-eastern coast of Australia, from Queensland to eastern Victoria and Tasmania, with some geographically isolated populations in western Victoria. In NSW it is generally restricted to coastal heaths and forests east of the Great Dividing Range, with an annual rainfall exceeding 760mm. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature.	Predicted from PMST	-	Nil. Not recorded within 10 km of the study area and no suitable habitat present.
15	*Pseudomys novaehollandiae*	New Holland mouse	Not listed	V	The species has patchy distribution across Tasmania, New South Wales and Queensland. The species prefers soil types with deeper top soils and softer substrates for digging burrows. Known to inhabit open heathlands, woodlands and forests with a heathland understorey and vegetated sand dunes. Distribution is patchy in time and space, with peaks in abundance during early to mid stages of vegetation succession typically induced by fire. Will inhabit open heathland, open woodland with heathland understorey, and vegetated sand dunes.	Predicted from PMST	-	Nil. Not recorded within 10 km of the study area and no suitable habitat present.
16	*Pteropus poliocephalus*	Grey-headed Flying-fox	V	V	Roosts in camps within 20km of a regular food source, typically in gullies, close to water and in vegetation with a dense canopy. Forages in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths, swamps and street trees, particularly in eucalypts, melaleucas and banksias. Highly mobile with movements largely determined by food availability (Eby & Law, 2008). Will also forage in urban gardens and cultivated fruit crops.	Predicted from PMST	21 records within 10 kms of study area	**Present.** Recorded within the study area; however, no camps were recorded within the study area. The study area is likely to provide foraging habitat for the species but does not support a roosting camp.
17	*Scoteanax rueppelli*	Greater Broad-nosed Bat	V	Not listed	Occurs in gully and river systems that drain into the great dividing range. Found throughout NSW but not in altitudes over 500m. Utilises a variety of habitat from woodland to moist and dry eucalypt forest, but mostly inhabits tall wet forest. Roosts in tree hollows and buildings. Open woodland and dry open forest is used for foraging for beetles and flying insects.	-	Nine records within 10 kms of study area	Moderate. Previously recorded within 10 km of the study area; however, the habitats within the study area do not comprise tall wet sclerophyll forests and are likely to be marginal habitat only for foraging.
18	*Vespadelus troughtoni*	Eastern Cave Bat	V	Not listed	The Eastern Cave Bat is found in a broad band on both sides of the Great Dividing range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. Very little is known about the biology of this uncommon species. A cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals. Occasionally found along cliff-lines in wet eucalypt forest and rainforest.	-	Six records within 10 kms of study area	Moderate. Previously recorded within 10 km of the study area. The study area does not provide extensive cliff and cave features for roosting and breeding but does provide foraging habitat.

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
FROGS								
1	*Heleioporus australiacus*	Giant Burrowing Frog	V	V	Occurs along the eastern slopes of the Dividing Range in hanging swamps on sandstone shelves and beside creeks. Also occurs in ephemeral sand or rock based streams with a sandy silt or clay base. Has a generalist diet and studies to date indicate that they eat mainly invertebrates including ants, beetles, cockroaches, spiders, centipedes and scorpions. Breeding habitat is generally soaks or pools within first or second order streams or 'hanging swamp' seepage lines and where small pools form from the collected water. Breeds mainly in autumn, but has been recorded calling throughout the year. Egg masses are foamy with an average of approximately 500-800 eggs and are laid in burrows or under vegetation in small pools.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and the aquatic/wetland habitat within the study area is not suitable.
2	*Litoria aurea*	Green and Golden Bell frog	E	V	Found in differing habitat throughout NSW and Victoria. Likely to occur in areas where *Juncus kraussii* , *Schoenoplectus litoralis* and *Sporobolus virginicus* are present (Pyke et. al, 2002). Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (*Typha* spp.) or spikerushes (*Eleocharis* spp.). Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow (*Gambusia holbrooki*), have a grassy area nearby and diurnal sheltering sites available but can occupy disturbed habitat. Breeds in permanent or ephemeral ponds during late winter to early autumn, but generally during September–February with a peak around January–February after heavy rain or storms (Daly 1995; White 2001).	Predicted from PMST	-	Moderate. Not previously recorded within 10 km of the study area but suitable habitat is present in association with the dam. The presence of Plague Minnow would significantly diminish the likelihood of occurrence of the species.
3	*Litoria littlejohni*	Littlejohn's Tree Frog	V	V	Distributed from eastern NSW to north-east Victoria. Inhabits forest, coastal woodland and heath from 100 to 950m above sea level.	Predicted from PMST	-	Nil. No records within 10 km of the study area and the study area is located at unsuitably low elevations.
4	*Mixophyes balbus*	Stuttering Frog	E	V	Occur along the east coast of Australia from southern Queensland to north-eastern Victoria. It is typically found in permanent streams in temperate and subtropical rainforests and wet sclerophyll forest. Little known about the ecological requirements of the species, but is more commonly found in undisturbed areas with a thick canopy and simple understorey. Feed on insects and smaller frogs. Breed in streams during summer after heavy rain. Eggs are laid on rock shelves or shallow riffles in small, flowing streams.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and the aquatic/wetland habitat within the study area is not suitable.
5	*Mixophyes iteratus*	Giant Barred Frog	E	E	Distributed along the coast and ranges from Eumundi in south-east Queensland to Warrimoo in the Blue Mountains. Declines appear to have occurred at the margins of the species' range. Found along freshwater streams with permanent or semi-permanent water, generally (but not always) at lower elevation. Moist riparian habitats such as rainforest or wet sclerophyll forest are favoured for the deep leaf litter that they provide for shelter and foraging, as well as open perching sites on the forest floor but also sometimes occur in other riparian habitats, such as those in drier forest or degraded riparian remnants, and even occasionally around dams. Breeds in streams, egg deposition requires banks overhanging the stream or on steep banks of large pools.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and the aquatic/wetland habitat within the study area is not suitable.
6	*Pseudophryne australis*	Red-crowned Toadlet	V	Not listed	The Red-crowned Toadlet has a restricted distribution. It is confined to the Sydney Basin, from Pokolbin in the north, the Nowra area to the south, and west to Mt Victoria in the Blue Mountains. Occurs in open forests, mostly on Hawkesbury and Narrabeen Sandstones. Inhabits periodically wet drainage lines below sandstone ridges that often have shale lenses or cappings. Shelters under rocks and amongst masses of dense vegetation or thick piles of leaf litter.	-	One record within 10 km of study area	Low. Previously recorded within 10 km of the study area but no suitable habitat present.
FISH								
1	*Epinephelus daemelii*	Black Rodcod	V	V	Distributed from southern Queensland, through NSW to northern Victoria. Inhabit near shore rocky and offshore coral reefs. In coastal waters they're found in rock caves, rock gutters and reefs.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and no suitable habitat is present.
REPTILES								
1	*Hoplocephalus bungaroides*	Broad-headed Snake	E	V	The Broad-headed Snake is restricted to the sandstone ranges in the Sydney Basin and within a radius of approximately 200 km of Sydney. It is often found in rocky outcrops and adjacent sclerophyll forest and woodland. The most suitable sites occur in sandstone ridgetops. Common canopy species include *Corymbia eximia* , *C. gummifera* , *Eucalyptus sieberi* , *E. punctata* and *E. piperita*.	Predicted from PMST	-	Nil. Not previously recorded within 10 km of the study area and no suitable habitat is present.

	Scientific Name	Common Name	Status		Habitat Association	Record source		Likelihood of occurrence
			BC Act	EPBC Act		PMST	Bionet	
INVERTEBRATES								
1	*Petalura gigantea*	Giant Dragonfly	E	Not listed	The Giant Dragonfly is found along the east coast of NSW from the Victorian border to northern NSW. It is not found west of the Great Dividing Range. There are known occurrences in the Blue Mountains and Southern Highlands, in the Clarence River catchment, and on a few coastal swamps from north of Coffs Harbour to Nadgee in the south. Lives in permanent swamps and bogs with some free water and open vegetation. Adults emerge from late October and are short-lived, surviving for one summer after emergence. Adults spend most of their time settled on low vegetation on or adjacent to the swamp. They hunt for flying insects over the swamp and along its margins.	-	One record within 10 km of study area from 2011. Record is located approximately 4 km away near Belmont	Low. Previously recorded within 10 km of the study area but no suitable habitat present.

Key:
CE - critically endangered
E - endangered
V - vulnerable

Appendix B – Plot data (October 2018)

Family	Scientific Name	Common Name	BC Act status	EPBC Act status	Growth Form	Q1		Q2		Q3		Q4		Q5		Q6		Q7		Q8		Q9	
						PCT 1619 Good		PCT 1589 Good		PCT 1619 Good		PCT 1636 Good		PCT 1636 Good		PCT 1619 Good		PCT 1619 Good		PCT 1627 Good		PCT 1627 Good	
						C	Ab	C	Ab	C	Ab	C	Ab	C	Ab	C	Ab	C	Ab	C	Ab	C	Ab
Poaceae	*Andropogon virginicus*	Whisky Grass	*	*	HT					0.1	1	0.1	3										
Poaceae	*Hyparrhenia rufa*	-	*	*	HT	0.1	5	0.1	20	0.1	2												
Rubiaceae	*Richardia brasiliensis*	-	*	*	EX							0.1	1										
Asteraceae	*Conyza bonariensis*	Cobbler's Pegs	*	*	EX																	0.1	1
Asteraceae	*Hypochaeris radicata*	Flatweed	*	*	EX																	0.1	10
Asteraceae	*Solenogyne bellioides*	Solengyne			FG			0.1	20														
Casuarinaceae	*Allocasuarina littoralis*	Black She- oak			TG					0.1	1							0.1	2				
Convolvulaceae	*Convolvulus erubescens*	Blushing Bindweed			OG	0.1	6																
Cyperaceae	*Cyathochaeta diandra*	-			GG	0.1	10			0.1	20					0.1	20						
Cyperaceae	*Gahnia aspera*	Rough Saw-sedge			GG													0.1	10			0.1	7
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge			GG	0.1	10	0.1	50	0.1	10	0.2	50	0.1	20	0.1	20	0.1	20	0.1	10		
Cyperaceae	*Ptilothrix deusta*	-			GG	0.1	3	25	1000	25	500	0.5	200	40	2000	15	1000	5	500			20	500
Dennstaedtiaceae	*Pteridium esculentum*	Bracken			EG			0.1	1							0.1	3			0.1	10		
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower			SG	0.1	1	0.2	50	0.1	20			0.1	2								
Dilleniaceae	*Hibbertia riparia*	Erect Guinea- flower			SG	0.1	2					0.1	20					0.1	5	0.1	5		
Ericaceae	*Epacris pulchella*	Wallum Heath			SG	0.1	15							0.1	3	0.1	3	0.1	10			0.1	10
Ericaceae	*Leucopogon juniperinus*	Prickly Beard-heath			SG			0.1	2														
Ericaceae	*Monotoca scoparia*	-			SG							0.1	1					0.1	2				
Fabaceae (Faboideae)	*Daviesia squarrosa*	-			SG	0.1	12					0	2										
Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea			SG			0.1	10			0.1	3										
Fabaceae (Faboideae)	*Dillwynia retorta*	-			SG	0.1	15	0.1	10	0.1	3	0.1	10	0.1	10	0.1	10	0.1	20				
Fabaceae (Faboideae)	*Glycine clandestina*	-			OG	0.1	5																
Fabaceae (Faboideae)	*Glycine microphylla*	Small - leaf Glycine			OG	0.1	2																
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine			OG			0.1	10			0.1	20	0.1	10			0.1	10	0.1	20	0.1	5
Fabaceae (Faboideae)	*Gompholobium pinnatum*	Pinnate Wedge Pea			SG									0.1	5							0.1	5
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla			OG	0.1	2					0.1	2					0.1	5				
Fabaceae (Faboideae)	*Hovea linearis*	-			FG							0.1	1										
Fabaceae (Faboideae)	*Kennedia rubicunda*	Running Postman			OG	0.1	1																
Fabaceae (Faboideae)	*Mirbelia rubiifolia*	Heathy Mirbelia			SG	0.1	4			0.1	10											0.1	3
Fabaceae (Faboideae)	*Podolobium ilicifolium*	Prickly Shaggy- pea			SG	0.1	1	0.1	1			0.1	2										
Fabaceae (Faboideae)	*Pultenaea euchila*	Orange Pultenaea			SG	0.1	5																
Fabaceae (Faboideae)	*Pultenaea retusa*	Notched Bush- pea			SG	0.1	5					0.1	3										
Fabaceae (Faboideae)	*Pultenaea rosmarinifolia*	-			SG	0.1	20	0.1	100	0.1	20	0.1	50	0.1	20	0.1	20	0.1	50			0.1	10
Fabaceae (Mimosoideae)	*Acacia falcata*	Sickle- leaved Wattle			SG	0.1	6	0.1	1														
Fabaceae (Mimosoideae)	*Acacia longifolia*	Sydney Golden Wattle			SG	0.1	1	0.1	1											0.1	1		
Fabaceae (Mimosoideae)	*Acacia terminalis*	Sunshine Wattle			SG					0.1	1					0.1	2	0.1	3	0.1	2		
Goodeniaceae	*Dampiera stricta*	-			FG													0.1	1				
Goodeniaceae	*Goodenia hederacea*	Geranium			FG			0.1	10														
Haemodoraceae	*Haemodorum planifolium*	Bloodroot			FG			0.1	1	0.1	1					0.1	1					0.1	1
Haloragaceae	*Gonocarpos teucriodies*	Raspwort			FG	0.1	50	0.1	3					0.1	2	0.1	20	0.1	10	0.1	10	0.1	20
Hypericaceae	*Hypericum gramineum*	Small St. John's Wort			FG			0.1	1														
Hypoxidaceae	*Hypoxis hydrometrica*	Golden Weather- grass			FG					0.1	10			0.1	3								
Lauraceae	*Cassytha glabella*	-			OG	0.1	5	0.1	1			0.1	1	0.1	2	0.1	5						
Lindsaeae	*Lindsaea linearis*	Screw Fern			EG											0.1	10			0.1	20		
Lobeliaceae	*Pratia purpurascens*	Whiteroot			FG	0.1	20	0.1	10			0.1	20	0.1	20	0.1	10	0.1	20	0.1	20	0.1	20
Lomandraceae	*Lomandra filiformis*	Wattle Mat- rush			GG			0.1	50			0.2	100			0.1	50			0.1	10	0.1	10
Lomandraceae	*Lomandra glauca*	Pale Mat- rush			GG					0.1	10	0.5	200	0.1	20	0.1	20					0.1	20
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush			GG															30	2000		
Lomandraceae	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush			GG	0.1	20	0.1	20			0.1	5			0.1	10	0.1	20	0.1	20		
Lomandraceae	*Lomandra obliqua*	Fishbones			GG	0.1	20	0.2	100	0.1	50	0.2	200	0.1	20	0.2	100	0.2	500	0.2	200	0.2	200
Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry			OG	0.1	3											0.1	2				
Myrtaceae	*Angophora costata*	Sydney Red Gum			TG	20	14	5	4	10	5	5	5	1	1	1	2	20	8	1	2	0.5	2
Myrtaceae	*Callistemon rigidus*	Stiff Bottlebrush			SG					0.1	1												
Myrtaceae	*Corymbia gummifera*	Red Bloodwood			TG	10	4			5	5	10	6	3	2	3	5	5	5	3	1	5	4
Myrtaceae	*Eucalyptus globoidea*	White Stringybark			TG	15	3	10	28	15	6	15	11	25	11	25	13	10	7				
Myrtaceae	*Eucalyptus haemastoma*	Broad-leaved Scribbly Gum			TG	10	1			10	3	10	1	7	2								
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint			TG															30	13	25	9
Myrtaceae	*Leptospermum polygalifolium*	Tantoon			SG											2	8			5	25	0.2	8
Myrtaceae	*Leptospermum trinervium*	Flaky- barked Tea- tree			SG					0.1	3			0.1	3	2	4	0.1	2	0.10	3	0.1	5
Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark			SG															0.1	1	0.2	1
Myrtaceae	*Melaleuca nodosa*	Prickly- leaved Paperbark			SG	0.1	7																
Myrtaceae	*Melaleuca sieberi*	-			SG									0.1	10								
Myrtaceae	*Melaleuca thymifolia*	Thyme Honey-myrtle			TG																	0.1	10
Orchidaceae	*Calochilus robertsonii*	Bearded Orchid			FG									0.1	1			0.1	1				
Phormiaceae	*Dianella caerulea var. producta*	Blue Flax- lily			FG	0.1	2	0.1	10			0.1	10	0.1	1	0.1	20	0.1	10	0.1	10		
Phormiaceae	*Dianella revoluta*	Blueberry Lily			FG			0.1	2			0.1	10										
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush			SG									0.1	1								
Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree			TG															0.1	2		
Phyllanthaceae	*Phyllanthus hirtellus*	-			SG					0.1	20	0.1	20	0.1	2	0.1	10	0.1	20				
Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry			OG			0.1	5	0.1	5	0.1	5	0.1	3			0.1	5	0.1	20	0.1	20
Poaceae	*Anisopogon avenaceus*	Oat Speargrass			GG					0.2	100					0.1	20	0.1	20	0.1	10		
Poaceae	*Aristida vagans*	Threeawn Speargrass			GG	0.1	10	0.2	100			10	500	0.5	200	0.2	100	0.1	20	0.2	200	0.2	100
Poaceae	*Austrostipa sp.*	-			GG	0.1	10																
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass			GG					0.1	5	0.1	3										
Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass			GG																	0.1	2
Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass			GG			0.1	10											0.1	10		
Poaceae	*Entolasia marginata*	Bordered Panic			GG					0.1	10			0.1	20	0.1	20						
Poaceae	*Entolasia stricta*	Wiry Panic			GG	0.1	20	1	200	20	1000	10	500	10	1000	0.2	200	0.2	200	0.2	200	0.1	20
Poaceae	*Eragrostis brownii*	Brown's Lovegrass			GG	0.1	20	5	500	0.1	10	0.1	50									0.1	10
Poaceae	*Imperata cylindrica*	Blady Grass			GG	0.3	100	0.2	100	0.1	20	1	100			0.3	200	1	100	30	2000	20	200
Poaceae	*Microlaena stipoides*	Weeping Grass			GG			0.1	5											0.1	5		
Poaceae	*Panicum simile*	Two-colour Panic			GG	0.1	10			0.1	20	0	20			0.1	10					0.1	10
Poaceae	*Paspalidium distans*	-			GG					0.1	10									0.1	2	0.1	10
Poaceae	*Rytidosperma pallidum*	Silvertop Wallaby Grass			GG	0.2	100					0.2	20					5	500				
Poaceae	*Rytidosperma sp.*	A Wallaby Grass			GG			0.1	20											0.1	10		

Family	Scientific Name	Common Name	BC Act status	EPBC Act status	Growth Form	Q1		Q2		Q3		Q4		Q5		Q6		Q7		Q8		Q9	
						PCT 1619 Good		PCT 1589 Good		PCT 1619 Good		PCT 1636 Good		PCT 1636 Good		PCT 1619 Good		PCT 1619 Good		PCT 1627 Good		PCT 1627 Good	
						C	Ab	C	Ab	C	Ab	C	Ab	C	Ab	C	Ab	C	Ab	C	Ab	C	Ab
Poaceae	*Themeda triandra*	Kangaroo Grass			GG	60	500	20	1000	20	1000	10	500	0.5	100	15	1000	10	500			20	200
Proteaceae	*Banksia spinulosa*	Hairpin Banksia			TG					0.5	23			0.1	10	0.2	5	0.1	2	0.1	5	3	11
Proteaceae	*Lambertia formosa*	Mountain Devil			SG					0.1	7					0.1	1	0.1	1			0.1	2
Proteaceae	*Persoonia levis*	Broad- leaved Geebung			SG							0.1	1					0.1	1				
Proteaceae	*Persoonia linearis*	Narrow- leaved Geebung			SG															0.1	1		
Pteridaceae	*Cheilanthes sieberi*	Poison Rock Fern			EG			0.1	20			0.1	5										
Restionaceae	*Lepyrodia scariosa*	-			GG															0.1	2	0.1	50
Rubiaceae	*Boronia ledifolia*	-			SG									0.1	2	0.1	2					0.1	5
Rubiaceae	*Opercularia diphylla*	Stinkweed			FG	0.1	3	0.1	20					0.1	10	0.1	10	0.1	10			0.1	5
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush			SG					0.1	10							0.1	5				
Stylidiaceae	*Stylidium graminifolium*	-			FG	0.1	3	0.1	3														
Thymeliaceae	*Pimelea linifolia*	Slender Rice Flower			SG					0.1	5	0.1	2	0.1	5	0.1	3	0.1	10			0.1	10
Violaceae	*Hybanthus monopetalus*	Slender Violet- bush			FG									0.1	10								
Xanthorrhoeaceae	*Xanthorrhoea latifolia*	-			OG	0.2	6	0.1	1	0.1	5	0.5	20	0.2	10	5	20	0.2	8			0.1	2

Key:
C - percentage foliage cover
Ab - abundance
HT - high threat weed species
EX - exotic species
TG - tree
SG - shrub
GG - grasses and grass-like
FG - forbs
EG - ferns and allies
OG - other

Appendix C – Species list

Flora Species List

Family	Species name	Common name	BC Act status	EPBC Act status
TREES				
Casuarinaceae	*Allocasuarina littoralis*	Black She- oak		
Myrtaceae	*Angophora costata*	Sydney Red Gum		
Myrtaceae	*Corymbia gummifera*	Red Bloodwood		
Myrtaceae	*Corymbia maculata*	Spotted Gum		
Myrtaceae	*Eucalyptus acmenoides*	White Mahogany		
Myrtaceae	*Eucalyptus capitellata*	Brown Stringybark		
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark		
Myrtaceae	*Eucalyptus globoidea*	White Stringybark		
Myrtaceae	*Eucalyptus haemastoma*	Broad-leaved Scribbly Gum		
Myrtaceae	*Eucalyptus paniculata*	Grey Ironbark		
Myrtaceae	*Eucalyptus pilularis*	Blackbutt		
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint		
Myrtaceae	*Eucalyptus punctata*	Grey Gum		
Myrtaceae	*Eucalyptus racemosa*	Scribbly Gum		
Myrtaceae	*Eucalyptus resinifera*	Red Mahogany		
Myrtaceae	*Eucalyptus saligna*	Sydney Blue Gum		
Myrtaceae	*Eucalyptus siderophloia*	Grey Ironbark		
Myrtaceae	*Eucalyptus umbra*	Broad-leaved White Mahogany		
Myrtaceae	*Melaleuca thymifolia*	Thyme Honey-myrtle		
Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree		
Proteaceae	*Banksia spinulosa*	Hairpin Banksia		

Family	Species name	Common name	BC Act status	EPBC Act status
SHRUBS				
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower		
Dilleniaceae	*Hibbertia riparia*	Erect Guinea- flower		
Elaeocarpaceae	*Tetratheca juncea*	Black-eyed Susan	V	V
Ericaceae	*Epacris pulchella*	Wallum Heath		
Ericaceae	*Leucopogon juniperinus*	Prickly Beard-heath		
Ericaceae	*Monotoca scoparia*			
Euphorbiaceae	*Homalanthus populifolius*	Bleeding Heart		
Fabaceae (Faboideae)	*Daviesia squarrosa*			
Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea		
Fabaceae (Faboideae)	*Dillwynia retorta*			
Fabaceae (Faboideae)	*Gompholobium pinnatum*	Pinnate Wedge Pea		
Fabaceae (Faboideae)	*Mirbelia rubiifolia*	Heathy Mirbelia		
Fabaceae (Faboideae)	*Podolobium ilicifolium*	Prickly Shaggy- pea		
Fabaceae (Faboideae)	*Pultenaea euchila*	Orange Pultenaea		
Fabaceae (Faboideae)	*Pultenaea retusa*	Notched Bush- pea		
Fabaceae (Faboideae)	*Pultenaea rosmarinifolia*			
Fabaceae (Faboideae)	*Pultenaea sp.*	-		
Fabaceae (Mimosoideae)	*Acacia falcata*	Sickle- leaved Wattle		
Fabaceae (Mimosoideae)	*Acacia irrorata*	Green Wattle		
Fabaceae (Mimosoideae)	*Acacia longifolia subsp. longifolia*	Sydney Golden Wattle		
Fabaceae (Mimosoideae)	*Acacia parvipinnula*	Silver- stemmed Wattle		
Fabaceae (Mimosoideae)	*Acacia terminalis*	Sunshine Wattle		
Fabaceae (Mimosoideae)	*Acacia ulicifolia*	Prickly Moses		
Moraceae	*Ficus coronata*	Sandpaper Fig		

Family	Species name	Common name	BC Act status	EPBC Act status
Myrtaceae	*Callistemon rigidus*	Stiff Bottlebrush		
Myrtaceae	*Kunzea ambigua*	Tick Bush		
Myrtaceae	*Leptospermum polygalifolium*	Tantoon		
Myrtaceae	*Leptospermum trinervium*	Flaky- barked Tea- tree		
Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark		
Myrtaceae	*Melaleuca nodosa*	Prickly- leaved Paperbark		
Myrtaceae	*Melaleuca sieberi*			
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush		
Phyllanthaceae	*Phyllanthus hirtellus*			
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn		
Proteaceae	*Grevillea sp.*	-		
Proteaceae	*Grevillea parviflora subsp. parviflora*	Small-flower Grevillea	V	V
Proteaceae	*Hakea sp.*	-		
Proteaceae	*Lambertia formosa*	Mountain Devil		
Proteaceae	*Lomatia silaifolia*	Crinkle Bush		
Proteaceae	*Persoonia levis*	Broad- leaved Geebung		
Proteaceae	*Persoonia linearis*	Narrow- leaved Geebung		
Rubiaceae	*Boronia ledifolia*			
Santalaceae	*Exocarpos cupressiformis*	Cherry Ballart		
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush		
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower		

Family	Species name	Common name	BC Act status	EPBC Act status
FORBS, FERNS and other groundcovers				
Apiaceae	*Centella asiatica*	Indian Pennywort		
Araceae	*Gymnostachys anceps*	Settlers' Twine		
Araliaceae	*Hydrocotyle sp.*	-		
Asteraceae	*Solenogyne bellioides*	Solenogyne		
Blechnaceae	*Blechnum sp.*	-		
Convolvulaceae	*Convolvulus erubescens*	Blushing Bindweed		
Dennstaedtiaceae	*Hypolepis muelleri*	Harsh Ground Fern		
Dennstaedtiaceae	*Pteridium esculentum*	Bracken		
Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern		
Doryanthaceae	*Doryanthes excelsa*	Gymea Lily		
Droseraceae	*Drosera sp.*	Sundew		
Fabaceae (Faboideae)	*Glycine clandestina*			
Fabaceae (Faboideae)	*Glycine microphylla*	Small - leaf Glycine		
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine		
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla		
Fabaceae (Faboideae)	*Hovea linearis*			
Fabaceae (Faboideae)	*Kennedia rubicunda*	Running Postman		
Goodeniaceae	*Dampiera stricta*			
Goodeniaceae	*Goodenia hederacea*	Geranium		
Goodeniaceae	*Goodenia sp.*			
Haemodoraceae	*Haemodorum planifolium*	Bloodroot		
Haloragaceae	*Gonocarpus teucrioides*	Raspwort		
Hypericaceae	*Hypericum gramineum*	Small St. John's Wort		
Hypoxidaceae	*Hypoxis hygrometrica*	Golden Weather- grass		

Family	Species name	Common name	BC Act status	EPBC Act status
Lauraceae	*Cassytha glabella*			
Lindsaceae	*Lindsaea linearis*	Screw Fern		
Lobeliaceae	*Pratia purpurascens*	Whiteroot		
Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry		
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily		
Menispermaceae	*Stephania japonica*	Snake Vine		
Orchidaceae	*Acianthus fornicatus*	Pixie Caps		
Orchidaceae	*Calochilus robertsonii*	Bearded Orchid		
Phormiaceae	*Dianella caerulea var. caerulea*	Blueberry Lily		
Phormiaceae	*Dianella caerulea var. producta*	Blue Flax- lily		
Phormiaceae	*Dianella revoluta*	Blueberry Lily		
Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry		
Polygonaceae	*Persicaria decipiens*	Slender Knotweed		
Pteridaceae	*Adiantum aethiopicum*	Common Maidenhair		
Pteridaceae	*Cheilanthes sieberi*	Poison Rock Fern		
Rubiaceae	*Opercularia diphylla*	Stinkweed		
Rubiaceae	*Pomax umbellata*	Pomax		
Stylidiaceae	*Stylidium graminifolium*			
Violaceae	*Hybanthus monopetalus*	Slender Violet- bush		
Violaceae	*Viola hederacea*	Ivy- leaved Violet		
Xanthorrhoeaceae	*Xanthorrhoea latifolia*			

Family	Species name	Common name	BC Act status	EPBC Act status
GRASSES AND GRAMINOIDS				
Cyperaceae	*Baumea sp.*	-		
Cyperaceae	*Bolboschoenus fluviatilis*	Marsh Club-rush		
Cyperaceae	*Cyathochaeta diandra*			
Cyperaceae	*Cyperus sp.*	-		
Cyperaceae	*Eleocharis sp.*	-		
Cyperaceae	*Gahnia aspera*	Rough Saw-sedge		
Cyperaceae	*Gahnia clarkei*	Tall Saw-sedge		
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge		
Cyperaceae	*Ptilothrix deusta*			
Juncaceae	*Juncus continuus*	-		
Juncaceae	*Juncus usitatus*	-		
Lomandraceae	*Lomandra filiformis*	Wattle Mat- rush		
Lomandraceae	*Lomandra glauca*	Pale Mat- rush		
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush		
Lomandraceae	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush		
Lomandraceae	*Lomandra obliqua*	Fishbones		
Poaceae	*Anisopogon avenaceus*	Oat Speargrass		
Poaceae	*Aristida ramosa*	Purple Wiregrass		
Poaceae	*Aristida vagans*	Threeawn Speargrass		
Poaceae	*Austrostipa sp.*			
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass		
Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass		
Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass		
Poaceae	*Entolasia marginata*	Bordered Panic		

Family	Species name	Common name	BC Act status	EPBC Act status
Poaceae	*Entolasia stricta*	Wiry Panic		
Poaceae	*Eragrostis brownii*	Brown's Lovegrass		
Poaceae	*Imperata cylindrica*	Blady Grass		
Poaceae	*Microlaena stipoides var. stipoides*	Weeping Grass		
Poaceae	*Oplismenus aemulus*	Basket Grass		
Poaceae	*Panicum simile*	Two-colour Panic		
Poaceae	*Paspalidium distans*			
Poaceae	*Phragmites australis*	Common Reed		
Poaceae	*Rytidosperma pallidum*	Silvertop Wallaby Grass		
Poaceae	*Rytidosperma sp.*	A Wallaby Grass		
Poaceae	*Sporobolos sp.*	-		
Poaceae	*Themeda triandra*	Kangaroo Grass		
Restionaceae	*Lepyrodia scariosa*			
Typhaceae	*Typha orientalis*	Broad-leaved Cumbungi		
EXOTICS, NON-NATIVES				
Asteraceae	*Ageratina adenophora*	Crofton Weed		
Asteraceae	*Aster subulatus*	Wild Aster		
Asteraceae	*Conyza bonariensis*	Cobbler's Pegs		
Asteraceae	*Hypochaeris radicata*	Flatweed		
Asteraceae	*Senecio madagascariensis*	Fireweed		
Asteraceae	*Taraxacum officinale*	Dandelion		
Cyperaceae	*Cyperus eragrostis*	Umbrella Sedge		
Fabaceae (Caesalpinioideae)	*Senna pendula var. glabrata*	-		
Fabaceae (Faboideae)	*Erythrina x sykesii*	Coral Tree		
Ochnaceae	*Ochna serrulata*	Mickey Mouse Plant		

Family	Species name	Common name	BC Act status	EPBC Act status
Oleaceae	*Ligustrum sinense*	Small-leaved Privet		
Poaceae	*Andropogon virginicus*	Whisky Grass		
Poaceae	*Briza minor*	Quaking Grass		
Poaceae	*Cenchrus clandestinus*	Kikuyu Grass		
Poaceae	*Cortaderia selloana*	Pampas Grass		
Poaceae	*Hyparrhenia hirta*	Coolatai Grass		
Poaceae	*Hyparrhenia rufa*			
Poaceae	*Melinis repens*	Red Natal Grass		
Poaceae	*Paspalum urvillei*	Vasey Grass		
Rosaceae	*Rubus anglocandicans (within R. fruticosus complex)*	Blackberry		
Rubiaceae	*Richardia brasiliensis*			
Verbenaceae	*Lantana camara*	Lantana		
Verbenaceae	*Verbena bonariensis*	-		

Fauna Species List

Class	Scientific name	Common name	Exotic	BC status	EPBC status
Amphibia	*Crinia signifera*	Common Eastern Froglet			
Amphibia	*Limnodynastes peronii*	Brown-striped Frog			
Amphibia	*Litoria fallax*	Eastern Dwarf Tree Frog			
Aves	*Acanthiza chrysorrhoa*	Yellow- rumped Thornbill			
Aves	*Acanthiza lineata*	Striated Thornbill			
Aves	*Acanthiza pusilla*	Brown Thornbill			
Aves	*Acanthorhynchus tenuirostris*	Eastern Spinebill			
Aves	*Alisterus scapularis*	Australian King-parrot			
Aves	*Anthochaera carunculata*	Red Wattlebird			
Aves	*Anthochaera chrysoptera*	Little Wattlebird			
Aves	*Cacatua galerita*	Sulphur-crested Cockatoo			
Aves	*Cacatua sanguinea*	Little Corella			
Aves	*Cacomantis flabelliformis*	Fan- tailed Cuckoo			
Aves	*Caligavis chrysops*	Yellow- faced Honeyeater			
Aves	*Climacteris picumnus victoriae*	Brown Treecreeper		V	
Aves	*Colluricincla harmonica*	Grey Shrike-thrush			
Aves	*Cormobates leucophaeus*	White-throated Treecreeper			
Aves	*Corvus orru*	Torresian Crow			
Aves	*Cracticus nigrogularis*	Pied Butcherbird			
Aves	*Cracticus tibicen*	Australian Magpie			
Aves	*Dacelo novaeguineae*	Laughing Kookaburra			
Aves	*Daphoenositta chrysoptera*	Varied Sittella		V	
Aves	*Dicaeum hirundinaceum*	Mistletoebird			
Aves	*Eopsaltria australis*	Eastern Yellow Robin			
Aves	*Falco cenchroides*	Nankeen Kestrel			
Aves	*Falco longipennis*	Australian Hobby			
Aves	*Glossopsitta concinna*	Musk Lorikeet			
Aves	*Glossopsitta pusilla*	Little Lorikeet		V	
Aves	*Grallina cyanoleuca*	Magpie-lark			
Aves	*Malurus lamberti*	Variegated Fairy-wren			
Aves	*Manorina melanocephala*	Noisy Miner			
Aves	*Meliphaga lewinii*	Lewin's Honeyeater			
Aves	*Melithreptus brevirostris*	Brown-headed Honeyeater			

Class	Scientific name	Common name	Exotic	BC status	EPBC status
Aves	*Melithreptus lunatus*	White- naped Honeyeater			
Aves	*Myzomela sanguinolenta*	Scarlet Honeyeater			
Aves	*Neochmia temporalis*	Red-browed Finch			
Aves	*Ninox strenua*	Powerful Owl		V	
Aves	*Pachycephala pectoralis*	Golden Whistler			
Aves	*Pardalotus striatus*	Striated Pardalote			
Aves	*Philemon citreogularis*	Little Friarbird			
Aves	*Phylidonyris niger*	White-cheeked Honeyeater			
Aves	*Platycercus eximius*	Eastern Rosella			
Aves	*Podargus strigoides*	Tawny Frogmouth			
Aves	*Psophodes olivaceus*	Eastern Whipbird			
Aves	*Ptilonorhynchus violaceus*	Satin Bowerbird			
Aves	*Rhipidura albiscapa*	Grey Fantail			
Aves	*Sericornis frontalis*	White-browed Scrubwren			
Aves	*Strepera graculina*	Pied Currawong			
Aves	*Trichoglossus chlorolepidotus*	Scaly-breasted Lorikeet			
Aves	*Trichoglossus haematodus*	Rainbow Lorikeet			
Aves	*Tyto novaehollandiae*	Masked Owl		V	
Mammalia	*Antechinus stuartii*	Brown Antechinus			
Mammalia	*Austronomus australis*	White-striped Freetail-bat			
Mammalia	*Chalinolobus gouldii*	Gould's Wattled Bat			
Mammalia	*Macropus giganteus*	Eastern Grey Kangaroo			
Mammalia	*Macropus rufogriseus*	Red-necked wallaby			
Mammalia	*Miniopterus australis*	Little Bentwing-bat		V	
Mammalia	*Mormopterus norfolkensis*	Eastern Freetail-bat		V	
Mammalia	*Mormopterus ridei*	Eastern Free-tailed bat			
Mammalia	*Nyctophilus* sp.	long-eared bat			
Mammalia	*Petaurus breviceps*	Sugar Glider			
Mammalia	*Pteropus poliocephalus*	Grey-headed Flying Fox		V	V
Mammalia	*Pseudocheirus peregrinus*	Common Ringtail Possum			
Mammalia	*Rattus rattus*	Black Rat	*		
Mammalia	*Rhinolophus megaphyllus*	Eastern Horseshoe-bat			
Mammalia	*Vespadelus sp.*	Unidentified Eptesicus			
Mammalia	*Vespadelus vulturnus*	Little Forest Bat			

Class	Scientific name	Common name	Exotic	BC status	EPBC status
Mammalia	*Wallabia bicolor*	Swamp Wallaby			
Reptilia	*Amphibolurus muricatus*	Jacky Lizard			
Reptilia	*Cacophis squamulosus*	Golden-crowned Snake			
Reptilia	*Tiliqua scincoides*	Eastern Blue-tongue			
Reptilia	*Varanus varius*	Lace Monitor			

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Document Status

Revision	Author	Reviewer		Approved for Issue		
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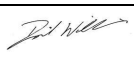
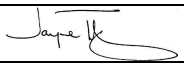
0	C. Phu F. Williams	D. Williams		J. Tipping		1/02/2019

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