M1 Princes Motorway Mount Ousley Interchange

Review of Environmental Factors

Biodiversity Assessment

Roads and Maritime Services | September 2017

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Roads and Maritime Services

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Biodiversity Assessment

September 2017

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Executive summary

Jacobs has been appointed by Roads and Maritime Services to undertake the concept design and environmental assessment for the upgrade of the M1 Princes Motorway Interchange at the base of Mount Ousley. This report details the methods and results of a biodiversity survey and assessment to identify the distribution and abundance of threatened species, populations and ecological communities in the area of the proposal, to assess the extent and magnitude of ecological impacts and recommend strategies to mitigate and offset these impacts.

An ecological survey was undertaken within the study area over a five-day period, three days in November (28-30 November 2016) and two days in December (1-2 December 2016). While on site, a habitat assessment was undertaken to assess the likelihood of threatened flora and fauna and ecological communities existing in the study area. The field survey aimed to ground-truth the results of the background research and habitat assessment. All threatened species, populations and communities that were considered likely to occur within the study area were targeted during the field surveys. Vegetation surveys were completed in line with chapter 5 of the Framework for Biodiversity Assessment (FBA). Targeted surveys were completed for flora and fauna. The habitat value of each waterway was characterised in accordance with NSW Department of Primary Industries (Fisheries) document *Policy and Guidelines for fish habitat conservation and management (2013 update).*

There are around 10.46 hectares of native vegetation within the study area belonging to two Plant Community Types (PCTs):

- Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (694)
- Sydney Blue Gum x Bangalay – Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (1245)

These PCTs are in moderate to good condition. The remainder of the study area is composed of built-up areas (roadways, footpaths, houses, carparks, university and TAFE buildings) that contain some areas of planted vegetation and disturbed areas dominated by weed growth.

No threatened ecological communities are present in the study area. However, the study area provides suitable habitat for a range of threatened species listed under the *Threatened Species Conservation Act* 1995 (TSC Act) and/or *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) including:

- Rainforest Cassia (*Senna acclinis*)
- Magenta Lilly Pilly (*Syzygium paniculatum*) – four plants recorded in the study area
- *Solanum celatum*
- Gang-gang Cockatoo (*Callocephalon fimbriatum*)
- Varied Sittella (*Daphoenositta chrysoptera*)
- Little Lorikeet (*Glossopsitta pusilla*)
- Swift Parrot (*Lathamus discolor*)
- Powerful Owl (*Ninox strenua*)
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) – recorded in the study area
- Little Bentwing-bat (*Miniopterus australis*) – recorded in the study area
- Grey-headed Flying-fox (*Pteropus poliocephalus*) – recorded in the study area
- Greater Glider (*Petauroides volans*).

The key impacts of the proposal include the removal of up to 7.58 hectares of native vegetation that provides habitat (or potential habitat) for the species listed above. An additional 5.05 hectares of planted trees will also be removed and these trees may be used by threatened fauna species for foraging.

The streams affected by the proposal are in poor condition due to previous development and agricultural activity within their catchments which has resulted in changes to hydrological conditions, increased input of nutrients, sedimentation and weed invasion. No threatened species listed under the *Fisheries Management Act 1994* (FM Act) are likely to occur in these

streams and significant impacts to aquatic ecosystems are unlikely to occur as a result of the proposal.

Fauna injury or death has the greatest potential to occur during construction when vegetation clearing takes place. Indirect and operational impacts including increased habitat fragmentation and new edge effects would occur due to the nature and location of the proposal within native vegetation. Invasion and spread of weeds, invasion and spread of pests, and invasion and spread of pathogens and disease are a risk with a proposal of this type. Noise, light and vibration would be increased during construction and operation. The proposal is likely to result in some changes to hydrological factors including flow velocity, depth, turbulence and flooding regimes of the two first-order streams on the site. As these factors are already different from their natural condition and changes associated with the proposal are only likely to occur over small areas, the impact of the proposal on hydrology is unlikely to be significant. While there may be minor alteration to groundwater conditions in the locality, the proposal is unlikely to result in permanent damage or loss of groundwater dependent ecosystems outside of the proposal footprint.

The study area is situated between two Mitchell Landscapes: the Lake Illawarra Barrier (93% cleared) and the Dapto-Wollongong Coastal Slopes (71% cleared). Both of these landscapes are considered to be over-cleared because of historic activities. In the context of historic vegetation removal, any future vegetation clearing, no matter how small, would result in incremental cumulative impact that would detrimentally affect biodiversity. The proposal would contribute to cumulative biodiversity impacts.

As more than one hectare of habitat in moderate to good condition (ie habitat for *Syzygium paniculatum* and Grey-headed Flying-fox) would be cleared, offsets or supplementary measures must be implemented for the proposal at a 3:1 ratio in accordance with Roads and Maritime environmental offsets policy. The direct impact to habitat for threatened fauna species is likely to be 7.58 hectares. This would result in an offset requirement of 22.74 hectares of habitat for the threatened fauna species identified as being impacted by the proposal and 12 *Syzygium paniculatum* plants.

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Glossary of terms and abbreviations

Definitions	
Cumulative impact	The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Refer to Clause 228(2) of the EP&A Regulation 2000 for cumulative impact assessment requirements.
Direct impact	Where a primary action is a substantial cause of a secondary event or circumstance which has an impact on a protected matter (ref http://www.environment.gov.au/system/files/resources/0b0cfb1e-6e28-4b23-9a97-fdadda0f111c/files/environment-assessment-manual.pdf).
Habitat	An area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic component (OEH 2014).
Indirect impact	Where an event or circumstance is a direct consequence of the action (ref http://www.environment.gov.au/system/files/resources/0b0cfb1e-6e28-4b23-9a97-fdadda0f111c/files/environment-assessment-manual.pdf).
Matters of NES	A matter of national environmental significance (NES) protected by a provision of Part 3 of the EPBC Act
Mitchell landscape	Landscapes with relatively homogeneous geomorphology, soils and broad vegetation types, mapped at a scale of 1:250,000 (OEH 2014).
Mitigation	Action to reduce the severity of an impact. (OEH 2014).
Mitigation measure	Any measure that reduces impact on habitat, facilitates the safe movement of wildlife and/or prevents wildlife mortality.
Population	All the individuals that interbreed within a given area.
Proposal area/ Proposal site	The area of land that is directly impacted on by the Proposal, including access roads, and areas used to store construction materials (OEH 2014).
Study area	The area directly affected by the development and any additional areas likely to be affected by the development, either directly or indirectly (OEH 2014).
Target species	A species that is the focus of a study or intended beneficiary of a conservation action or connectivity measure.

Abbreviations	
BBCC	BioBanking Credit Calculator
BVT	Biometric Vegetation Type
CEMP	Construction Environmental Management Plan
DP&E	Department of Planning and Environment
DPI	Department of Primary Industries
EEC	Endangered ecological community
EIS	Environmental Impact Statement
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999 (Federal).
FBA	Framework for Biodiversity Assessment
FM Act	Fisheries Management Act 1994 (NSW)
GDE	Groundwater dependent ecosystems
IBRA	Interim Biogeographically Regionalisation of Australia
MNES	Matters of National Environmental Significance
OEH	Office of Environment and Heritage
PCT	Plant Community Type
REF	Review of Environmental Factors
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
TECs	Threatened Ecological Communities
TSC Act	Threatened Species Conservation Act 1995 (NSW).
TSPD	Threatened Species Profile Database
VIS	Vegetation information system

1 Introduction

1.1 Proposal background

Jacobs has been appointed by Roads and Maritime Services (Roads and Maritime) to undertake the concept design and environmental assessment for the upgrade of the M1 Princes Motorway Interchange at the base of Mount Ousley.

The M1 Princes Motorway is the primary road link between Sydney and the Illawarra with average daily traffic of more than 50,000 vehicles per day using this link at the base of Mount Ousley near Wollongong. Heavy vehicles represent up to 15% of total daily vehicle movements. The Princes Motorway and Mount Ousley Road currently experience heavy traffic congestion particularly during weekday, weekend and holiday peaks. The intersection of these two roads is the only location on the Princes Motorway between Waterfall and Albion Park Rail (a distance of about 60 kilometres) where vehicles turning right to access the motorway need to give way to oncoming motorway traffic. In addition to poor road network performance, 56 crashes were recorded near the intersection during the five year period between July 2011 and June 2016 (inclusive). Of the 56 crashes, one crash resulted in one fatality and four injuries, and 25 were injury crashes resulting in 28 injuries. The two most common crash types were intersection and rear end crashes.

The southbound carriageway of the motorway has a sign-posted speed limit of 80 kilometres per hour for light vehicles and 40 kilometres per hour for heavy vehicles (trucks and buses). This speed differential creates conflicts between light and heavy vehicles as faster moving light vehicles (travelling in the median lane) are required to cut across groups of slower moving heavy vehicles (travelling in the kerbside lane) to access the exit at Mount Ousley Road, which is the primary access from the north to the Wollongong CBD and surrounding suburbs. Conflicting interactions between light and heavy vehicles create road safety risks as well as contributing to flow breakdowns (stop-start or acceleration and braking) conditions, thus affecting the efficiency of the network in this area. In turn, this reduces the efficiency of access to nearby destinations, such as the Wollongong CBD and University of Wollongong.

Further south on the motorway, the southbound morning traffic queue from University Avenue is observed to extend back toward the motorway with vehicles largely bound for the university. This also creates flow breakdown on the motorway with associated increased risk of vehicle crashes as vehicles intending to exit to University Avenue slow down on the through lanes of the motorway. Modelling shows that in the future years, these queues will regularly extend back onto the motorway in peak hours and past the Mount Ousley Road intersection blocking access into Wollongong.

Additionally, the M1 Princes Motorway creates a barrier for safe pedestrian and cyclist movements between the University of Wollongong and suburbs to the north. Within three kilometres of the university, 23 percent of students live to the north of the campus however only four percent of people who walk to the university come from suburbs to the north.

1.2 The proposal

The proposal is situated at the base of the Illawarra escarpment at Mount Ousley, where the M1 Princes Motorway enters Wollongong via an existing at-grade intersection with Mount Ousley Road, as shown in Figure 1.1. The main features of the proposal include:

- An overpass from Mount Ousley Road to allow northbound traffic to safely access the M1 Princes Motorway
- A dedicated heavy vehicle bypass lane, to separate heavy vehicles from general southbound traffic on the M1 Princes Motorway and light vehicles exiting at Mount Ousley Road
- A dedicated southbound heavy vehicle exit ramp to Mount Ousley Road, to separate heavy and light vehicles exiting the M1 Princes Motorway to Mount Ousley Road

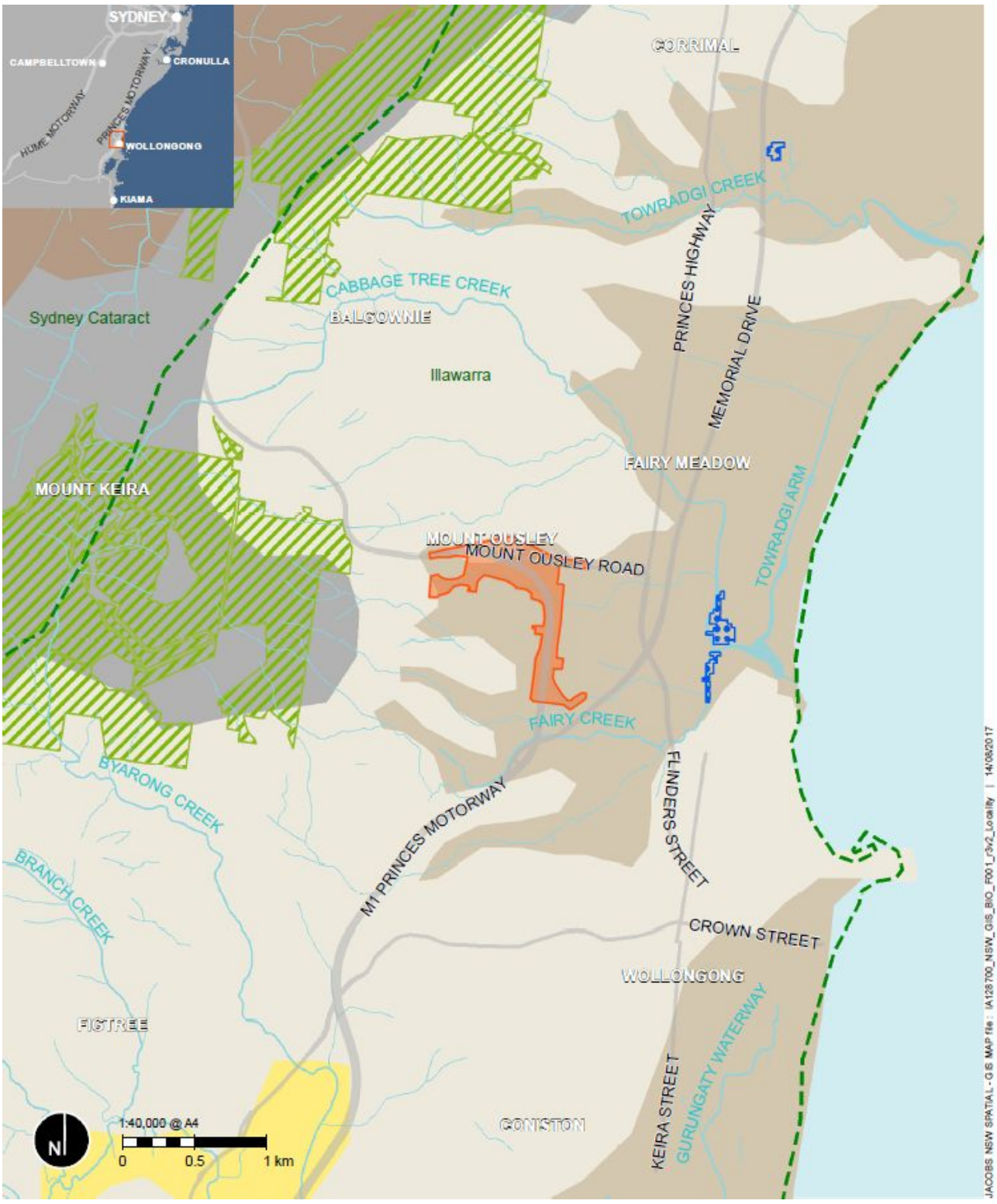
- A new entry to the University of Wollongong from the M1 Princes Motorway, for both northbound and southbound vehicles, via a new overpass from Mount Ousley Road and a new (northbound) motorway exit ramp
- A new exit from the University of Wollongong to the M1 Princes Motorway northbound, and to Mount Ousley Road via the new overpass
- New roundabouts at Mount Ousley Road, servicing the new entrance to the University of Wollongong and for vehicles exiting the Motorway (from northbound and southbound lanes) at Mount Ousley Road
- A new southbound service road, which would replace the existing southbound access from the M1 Princes Motorway to University Avenue
- Two new heavy vehicle safety ramps
- A new pedestrian and cyclist bridge over Mount Ousley Road and the M1 Princes Motorway, and a new shared path connecting suburbs to the north with the University of Wollongong and the TAFE Illawarra Wollongong campus
- Upgrades to the existing pedestrian bridge over the M1 Princes Motorway at Northfields Avenue, comprising modifications to the bridge span and the eastern access ramp
- A new commuter car park, relocated to the southern side of the M1 Princes Motorway, with additional formalised parking spaces
- New noise walls along the M1 Princes Motorway, between the motorway and nearby residential areas
- New noise walls along Mount Ousley Road, between the M1 Princes Motorway interchange and Gaynor Avenue.

The proposal extends on the motorway from about 450 metres west to just over 1,000 metres south of the existing intersection with Mt Ousley Road, and about 650 metres east on Mt Ousley Road between the M1 Princes Motorway and Gaynor Avenue, as shown in Figure 1.2. The overall footprint of the proposed interchange extends north of Mt Ousley Road up to the southern edge of Dumfries Avenue, and into the land occupied by the University of Wollongong on the southern side. The proposed works extend south along the M1 Princes Motorway corridor as far as the University Avenue interchange and overpass. Along the eastern side, the proposal's footprint would encroach into a narrow strip of land occupied by the Illawarra TAFE campus. In addition, an existing parcel of Roads and Maritime owned land bounded by the M1 Princes Motorway, Mount Ousley Road, Gowan Brae Avenue and the Illawarra TAFE campus, would be temporarily used as a site construction compound which may be converted into a permanent traffic incident response unit.

1.3 Objectives

This report details the methods and results of a biodiversity survey and assessment to identify the distribution and abundance of threatened species, populations and ecological communities in the area of the proposal to assess the extent and magnitude of ecological impacts associated with the proposal. The report addresses the requirements for assessment of significance under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The report also addresses the requirements of the *Fisheries Management Act 1994* (FM Act). Mitigation measures to ameliorate ecological impacts arising from the proposal are also provided. The aims of the biodiversity assessment are to:

- Describe the characteristics and ecological condition of the vegetation communities and habitats within the study area.
- Determine the occurrence, or likelihood of occurrence of threatened species, populations and communities listed under the *Threatened Species Conservation 1995* (TSC Act), EPBC Act and FM Act within the study area.
- Describe the potential impacts on biodiversity in the study area because of the proposal.
- Undertake an Assessment of Significance for threatened species and communities that are confirmed or considered likely to occur within the study area.
- Propose measures to mitigate impacts on ecological values.
- Conduct a condition assessment using the BioBanking assessment methodology to identify the condition of the vegetation to be impacted for use in determining future offset options.



Legend

- Ecology study area
- Illawarra Escarpment State Conservation Area (LPI 2016)
- Wetlands of NSW (OEH 2017)
- IBRA subregion (OEH 2017)

Mitchel landscapes

- Bulli Coastal Escarpment
- Dapto - Wollongong Coastal Slopes
- Lake Illawarra Alluvial Plains
- Lake Illawarra Barrier
- Woronora Plateau (OEH 2017)

- Waterway
- Water body (LPI 2016)

Figure 1.1 Proposal context

Legend

Ecology study area

Proposal footprint

Design (white line)

Figure 1.2 The proposal

1.4 Study area

The study area for the purposes of this biodiversity assessment includes the Princes Motorway road reserve from 500 metres west of its intersection of Mt Ousley Road to the University Avenue road reserve in the south. The study area extends along University Avenue and includes the Mt Ousley Road reserve from its intersection with the Princes Motorway to Gaynor Avenue. The study area also includes University of Wollongong properties being part of Lot 1 DP 1188267 and Lot 3 DP214022 and TAFE NSW Wollongong Campus Lots 4 & 5 DP843929.

The following areas are discussed throughout the report and are defined as:

- Proposal footprint: this area comprises the limits of the construction design and compound site locations (see Figure 1.2)
- Study area: includes the proposal footprint and surrounding area (see Figure 1.2) that may be used for site access
- Locality: This is defined as the area within a 10 kilometre radius surrounding the proposal footprint
- Bioregion: The study area is located in the Sydney Basin bioregion (Thackway and Cresswell, 1995) and within Illawarra sub-region. The study area is located in the Southern Rivers catchment area.

1.5 Legislative context

A Review of Environmental Factors (REF) is prepared to satisfy Roads and Maritime Services duties under s.111 of the EP&A Act to "examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity" and s.112 in making decisions on the likely significance of any environmental impacts. This biodiversity impact assessment forms part of the REF being prepared for the M1 Mt Ousley interchange proposal, and assesses the biodiversity impacts of the proposal to meet the requirements of the EP&A Act.

Under s.111 of the EP&A Act, Roads and Maritime Services must consider the effect of an activity on:

- any conservation agreement entered into under the *National Parks and Wildlife Act 1974* (NP&W Act)
- any plan of management adopted under the NP&W Act for the conservation area to which the agreement relates,
- any joint management agreement entered into under the *Threatened Species Conservation Act 1995* (TSC Act)
- any BioBanking agreement entered into under Part 7A of the TSC Act
- any wilderness area (within the meaning of the *Wilderness Act 1987*) in the locality
- critical habitat
- threatened species, populations and ecological communities, and their habitats and whether there is likely to be a significant effect
- any other protected fauna or protected native plants within the meaning of the NP&W Act.

Sections 5A and 5C of the EP&A Act require that the significance of the impact on threatened species, populations and endangered ecological communities listed under the TSC Act or FM Act is assessed using a seven-part test. Where a significant impact is likely to occur, a species impact statement (SIS) must be prepared in accordance with the Director-General's requirements.

In September 2015, a "strategic assessment" approval was granted by the Federal Minister in accordance with the EPBC Act. The approval applies to Roads and Maritime activities being assessed under Part 5 of the EP&A Act with respect to potential impacts on nationally listed threatened species, ecological communities and migratory species.

As a result, Roads and Maritime proposals assessed via an REF:

- must address and consider potential impacts on nationally listed threatened species, populations, ecological communities and migratory species, including application of the "avoid, minimise, mitigate and offset" hierarchy
- do not require referral to the Federal Department of the Environment for these matters, even if the activity is likely to have a significant impact.

Roads and Maritime must consider impacts to nationally listed threatened species, ecological communities and migratory species as part of the approval process under the strategic assessment. To assist with this, assessments are required in accordance with the *Matters of National Environmental Significance: Significant impact guidelines 1.1. Environment Protection and Biodiversity Conservation Act 1999* (DoE 2013).

2 Methods

2.1 Personnel

This biodiversity assessment was undertaken and prepared by appropriately qualified and experienced ecologists (refer to Table 2.1).

Table 2.1 Personnel, role and qualifications

Name	Role	Qualifications
Chris Thomson	Technical review	GCertNatRes BAppSc
Lukas Clews	Technical lead, ecology surveys, reporting, GIS analysis	MScStud BSc
Paul Rossington	aquatic ecology reporting, technical review of revisions relating to detailed design	Master of Wildlife Management BSc (biology)
Jonathan Carr	ecology surveys, reporting, GIS analysis	BEnvScMgt

2.2 Background research

A background review of existing information was undertaken to identify the existing environment of the proposal within a search area of 10 kilometres (radius). The review focussed on database searches, relevant ecological reports pertaining to the study area, the Preliminary Environment Investigation (PEI), property boundaries, and relevant GIS layers. Searched databases are listed in Table 2.2. The review was used to prepare a list of threatened species, populations and communities as well as important habitat for migratory species and critical habitat with a likelihood of occurrence in the study area and locality.

Table 2.2 Date and search area of relevant databases searched during desktop review

Database	Date accessed	Search area
Atlas of NSW Wildlife and OEH BioBanking Threatened Species Profile Database	24 November 2016	10 km
EPBC Act Protected Matters Search Tool	9 January 2017	10 km
Critical habitat register	24 November 2016	N/A
OEH vegetation information system (VIS) and Vegetation Types Database databases	24 November 2016	N/A
Bureau of Meteorology's Atlas of Groundwater Dependent Ecosystems (GDE):	9 January 2017	10 km
Directory of important wetlands SEPP 14 wetlands	9 January 2017	10 km
Department of Primary Industries Aquatic TECs and freshwater threatened species distribution maps	24 November 2016	N/A

2.3 Habitat assessment

The following habitat assessment identifies the list of threatened flora and fauna species known or predicted in the Illawarra IBRA subregion and recorded within a 10 kilometre radius of the proposal, identified from databases and literature as well as past surveys. It compares the preferred habitat features for these species with the habitats identified in the study area. This was completed to make an assessment of the likelihood of the species being present in the study area (i.e. subject species). The criteria used in the habitat assessment are detailed in Table 2.3. The results of this assessment are provided in Appendix B.

Table 2.3 Likelihood of occurrence classification and criteria

Likelihood	Criteria
Recorded	The species was observed in the study area during the current survey
High	It is highly likely that a species inhabits the study area and is dependent on identified suitable habitat (i.e. for breeding or important life cycle periods such as winter flowering resources), has been recorded recently in the locality (10km) and is known or likely to maintain resident populations in the study area. Also includes species known or highly likely to visit the study area during regular seasonal movements or migration.
Moderate	Potential habitat is present in the study area. Species unlikely to maintain sedentary populations, however may seasonally use resources within the study area opportunistically or during migration. The species is unlikely to be dependent (i.e. for breeding or important life cycle periods such as winter flowering resources) on habitat within the study area, or habitat is in a modified or degraded state. Includes cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
Low	It is unlikely that the species inhabits the study area and has not been recorded recently in the locality (10km). It may be an occasional visitor, but habitat similar to the study area is widely distributed in the local area, meaning that the species is not dependent (ie. for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the study area or the species are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
None	Suitable habitat is absent from the study area.

2.4 Field survey

2.4.1 Vegetation surveys

The vegetation survey was completed using field survey methods in line with Chapter 5 of the Framework for Biodiversity Assessment (FBA) – NSW Biodiversity Offsets Policy for Major Projects (*NSW Office of Environment and Heritage, 2014*). The survey was undertaken over a five-day period (28-30 November and 1-2 December 2016) in order to complete the required number of transects and plots for each vegetation zone in the study area in accordance with the FBA (refer to **Table 2.4**).

Table 2.4 Minimum number of transects/plots required per vegetation zone area

Minimum number of transects/plots	Vegetation zone area (ha)
0–4	1 transect/plot per 2 ha (or part thereof) or 1 transect/plot if vegetation is in low condition
> 4–20	3 transects/plots or 2 transects/plots if vegetation is in low condition
> 20–50	4 transects/plots or 3 transects/plots if vegetation is in low condition
> 50–100	5 transects/plots or 3 transects/plots if vegetation is in low condition

Minimum number of transects/plots	Vegetation zone area (ha)
> 100–250	6 transects/plots or 4 transects/plots if vegetation is in low condition
> 250–1000	7 transects/plots or 5 transects/plots if vegetation is in low condition More transects/plots may be needed if the condition of the vegetation is variable across the zone
> 1000	8 transects/plots or 5 transects/plots if vegetation is in low condition or in a homogenous landscape in the Western Division More transects/plots may be needed if the condition of the vegetation is variable across the zone

The preliminary vegetation mapping reviewed existing vegetation mapping from the PEI (Biosis, 2014) and used aerial photography to identify vegetation extent. Broad-scale soil and vegetation mapping adapted from Soil Landscapes of the Wollongong-Port Hacking 1:100,000 Map Sheet (Hazelton and Tillie, 1990) and Native Vegetation of the Illawarra Escarpment and Coastal Plain (NSW National Parks and Wildlife Service, 2003b). Contour and waterway data were also used to stratify vegetation across the study area. The preliminary vegetation mapping was then ground-truthed using a mobile GPS unit and later converted into polygons and mapped as Plant Community Types (PCTs) according to OEH Vegetation Information System (VIS) Classification Database (Office of Environment and Heritage, 2014b).

Surveys assessed the environmental variation within the Study area and any areas with gaps in existing mapping and site information to determine vegetation zones. The condition of PCTs for the Proposal was then assessed in accordance with Chapter 5 of the FBA and vegetation zones assigned by comparing the dominant canopy species, the general description of location, soil type and other attributes as described in the Threatened Species Profile Database and VIS classification database.

Vegetation polygons assigned as 'moderate-good' vegetation zones were classified into a sub-condition class of Poor, Medium, Good or Other using the following criteria:

1. Poor condition vegetation had a high abundance of exotic species in the mid storey and ground cover layers
2. Medium condition vegetation had predominantly native species in the mid storey and ground cover layers but included a moderate abundance and cover or exotic species
3. Good condition vegetation was predominantly native, had high native species diversity, and had very few exotic species in any stratum
4. Other a small area of vegetation dominated by regrowth and Acacia overstorey (likely to be regrowth of a PCT).

A plot-based full floristic survey focused on indicative vegetation zones using a series of 20 by 20 metre quadrats nested inside a 20 by 50 metre transect. In total 12 plots / transects were completed to record the following information:

- Stratum and layer – in which each species occurs
- Growth form – for each recorded species
- Species name – above ground vascular plant species were identified to the lowest taxonomic order possible using nomenclature consistent with PlantNet NSW
- Cover – a measure or estimate of the appropriate cover measure for each recorded species; recorded from one to five percent and then to the nearest five percent. If the cover of a species is less than one percent and the species is considered important, then the estimated cover should be entered (e.g. 0.4)
- Abundance rating – a relative measure of the number of individuals or shoots of a species within the plot. The following intervals were used; numbers above about 20 and 1,000 are estimates only: 1,2,3,4,5,6,7,8,9,10,20,50,100,500,1000.

Areas of roadside landscape plantings and disturbed vegetation dominated by weeds were sampled in plots and mapped to identify the composition and abundance within the study area. These areas were not assigned vegetation zones as they are not naturally occurring and cannot be matched to a PCT.

A summary of vegetation survey effort, outlining the number of vegetation zones and respective number of floristic plots / transects sampled in the field is presented in Table 2.5.

Table 2.5 Summary of PCT / vegetation zones survey effort

Vegetation Zone Number	Plant Community Type (PCT)	Condition	Area (ha)	No. plots required	No. plots sampled
1	Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (PCT 694)	Moderate/Good	5.6	3	3
2		Moderate/Good _Medium	0.8	1	1
3		Moderate/Good _Other	0.8	1	1
4	Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (PCT 1245)	Moderate/Good	2.9	2	2
5		Moderate/Good _Poor	0.2	1	1
6		Moderate/Good _Other	0.1	1	1
		Total	**10.46**	**9**	**9**

Legend

Ecology study area

Anabat

Survey site

Transect

Figure 2.1 Field survey locations

2.4.2 Targeted flora surveys

Targeted flora surveys were undertaken for all identified candidate flora species following the methods described in *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft* (Department of Environment and Conservation, 2004c). A combination of random meander surveys using paired parallel transects as described in the *NSW Guide to Surveying Threatened Plants* (Office of Environment and Heritage, 2016) and floristic plot surveys (described in section 4.1.2) was undertaken to identify, search and record any candidate species.

The random meander technique is used in preference to systematic, plot-based surveys when attempting to detect threatened plants. Random meander in suitable habitat is more likely to detect threatened species than plot or transect based survey used in floristic surveys. This technique is considered preferable in terms of searching large areas of potential habitat and generally allows for greater area coverage than a plot-based survey. Walked meanders are illustrated in Figure 2.1. A summary of flora survey techniques employed is provided in Table 2.6.

Table 2.6 Summary of flora survey timing, methods and survey effort

Survey date (timing)	Method	Effort
28-30 November and 1-2 December	Targeted searches and random meanders in preferred habitats	Undertaken on all days during the survey - 10 person days
	Floristic plots and transects	12 plots (24 person hours)

The threatened flora species targeted and details of surveys undertaken are outlined in Table 2.7.

Table 2.7 Targeted species survey technique for threatened flora with a potential to occur in the study area

Threatened flora species	Status		Survey technique
	TSC Act	EPBC Act	
White-flowered Wax Plant (*Cynanchum elegans*)	V	V	Targeted surveys and random meanders undertaken throughout the site did not identify this species. A reference population was confirmed on steep eastern slopes of Mt Keira 560 metres west of the study area.
Illawarra Socketwood (*Daphnandra* johnsoni)i	E	E	Targeted surveys and random meanders undertaken in moist eucalypt forest throughout the site did not identify this species.
Gossia acmenoides population	EP	-	Targeted surveys and random meanders undertaken throughout the site did not identify this species.
Solanum celatum	E	-	Targeted surveys and random meanders undertaken throughout the site did not identify this species. Surveys targeted disturbed forest edges and clearings.
Rainforest Cassia (*Senna acclinis*)	E	-	Targeted surveys and random meanders undertaken throughout the site did not identify this species. Surveys targeted disturbed forest edges and clearings. A reference population was confirmed on eastern upper slopes of Mt Keira 610 metres west of the study area.

Threatened flora species	Status		Survey technique
	TSC Act	EPBC Act	
Magenta Lilly Pilly *Syzygium paniculatum*	E	E	Two individuals of this species were recorded in riparian Blue Gum Forest with a rainforest mid-storey in the north east of the University of Wollongong Campus. One plant was recorded in the vegetation off the end of Mt Ousley Road. One plant was recorded in planted vegetation near the heavy vehicle safety ramp. Targeted surveys comprised general traverses throughout areas of suitable habitat.

2.4.3 Targeted fauna surveys

The location and method of the terrestrial fauna surveys were guided by the survey guidelines in the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft* (Department of Environment and Conservation, 2004c) and the *Threatened species survey and assessment guidelines: field survey methods for fauna – Amphibians* (Department of Environment and Climate Change, 2009). The following Commonwealth survey guidelines were also consulted:

- *Survey Guidelines for Australia's Threatened Bats* (Department of the Environment Water Heritage and the Arts, 2010a).
- *Survey Guidelines for Australia's Threatened Birds* (Department of the Environment Water Heritage and the Arts, 2010b).
- *Survey Guidelines for Australia's Threatened Frogs* (Department of the Environment Water Heritage and the Arts, 2010c).
- *Survey Guidelines for Australia's Threatened Mammals* (Department of Sustainability Environment Water Population and Communities, 2011).

The fauna survey was conducted over five field days (28-30 November and 1-2 December). Anabat recording was undertaken from the 31st January to 2nd of February 2017. Surveys were conducted across the entire study area. The study area was stratified into PCTs / habitat types in order to focus survey effort on targeted species. Targeted and opportunistic surveys were conducted in all habitat types. Survey methods and effort per habitat strata are provided in Table 2.8. The following is an overview of the fauna survey methods and effort.

Table 2.8 Summary of fauna methods, target species, survey effort and timing

Survey method	Target species	Effort in habitat strata (PCT area)	
		Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (6.8 ha)	Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (3 ha)
Bat call recording	All bats	1 Anabat for 3 nights	1 Anabat for 3 nights
Time and area based bird surveys	All birds	120 person minutes over two consecutive days	60 person minutes over one day
Walked spotlighting transects and call playback (includes Owl call playback and search)	All fauna	Four person hours Two call playback sites	Four person hours Four call playback sites

Survey method	Target species	Effort in habitat strata (PCT area)	
		Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (6.8 ha)	Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (3 ha)
Area-based frog searches / spotlighting / call playback	All frogs	Nil	Two person hours

2.4.4 Fauna habitat assessment survey

Fauna habitat assessments were completed to assess the likelihood of threatened fauna occurring in the study area. Fauna habitats were assessed by examining characteristics such as the structure and floristics of the canopy, understorey and ground vegetation; the structure and composition of the litter layer; and other habitat attributes important for feeding, roosting and breeding. The criteria used to evaluate the condition of general fauna habitat values are outlined in Table 2.9.

2.4.5 Aquatic habitat assessment

Habitat assessment for threatened aquatic species was undertaken for the two first-order streams which are found in the site. Aquatic habitats were assessed by examining characteristics such as the structure and floristics of aquatic vegetation, channel width, the presence of surface water, water flow, water depth, turbidity, visible pollutants, erosion, the presence of shelter (rocks, submerged vegetation and woody debris) and channel substrate.

The characteristics observed did not match the habitat characteristics of any threatened aquatic species known or predicted to occur in the locality hence targeted surveys for aquatic species were not required.

Table 2.9 General fauna habitat condition assessment criteria

Condition	Characteristics	Patch size/connectivity	Naturalness	Floristic diversity	Groundcover	Habitat feature	Weed abundance
High	Vegetation still retains the majority of native species and structural characteristics of the pre-European equivalent. Such vegetation is usually in a near natural state and displays resilience to weed invasion due to intact ground cover, shrub and canopy layers and lack of soil disturbance. Some limited weed cover is present in edge habitats.	>2 hectares and well connected to other areas of vegetation outside the study area	Remnant woodland / forest	High	Intact	Habitat for threatened fauna, mature trees abundant and tree hollows, dead trees and natural logs	Low
Moderate	Vegetation generally still retains most of its structural integrity but has been partially disturbed and has lost some component of its original species complement. Weed invasion varies from slight to high.	>2 hectares and tentative links to other vegetation outside the study area	Disturbed woodland / forest	Moderate	Intact with few or no invasive grasses	Some habitat for threatened fauna, mature trees low density, few hollows and logs	Moderate - High
Low	Modified areas where most of the native diversity and vegetation structure has been lost. Includes thin strips of roadside vegetation, areas of derived grassland and shrubby vegetation. Environmental weeds are often co-dominant with the original indigenous species, particularly invasive grasses.	< 1-2 hectares and with fragmented connectivity with areas of habitat outside the study area	Derived native grassland, scattered shrubs, isolated paddock trees, and landscape plantings	Low-Moderate	Partial with high proportion of invasive grasses and forbs	Limited habitat for threatened fauna, mature trees absent, very few hollows or logs	High - Moderate
Very Low	Includes cleared paddock areas and clearings dominated by exotic species including noxious weeds. Some regenerating shrubs and native groundcovers may be present in low abundance.	< 1-2 hectares and isolated from other areas of habitat outside the study area	Exotic pasture and cleared areas	Low	None dominated by invasive grasses	Minimal habitat for threatened fauna, mature trees absent, no hollows or logs	High

2.4.6 Summary of survey effort

A summary of the survey method used to target threatened fauna species is presented in Table 2.10. This includes information on the species targeted, the survey technique and minimum effort documented in survey guidelines and a summary of the technique used at the study area.

Table 2.10 Targeted threatened fauna species (potential to occur in the study area) survey details and minimum survey requirements and completed survey effort.

Target species	Minimum survey requirements	Completed survey effort
Dusky Woodswallow Varied Sittella Gang-gang Cockatoo Little Eagle Square-tailed Kite Rose-crowned Fruit-Dove Superb Fruit-Dove Barred Cuckoo-shrike	20-30 minute surveys of 1 ha per stratification unit.	Three 30 minute dedicated surveys of approximately 1 ha by two ecologists. 180 person hours (one early morning, two evening surveys over the 28-30 November and 1 December 2016) Surveys also included opportunistic sightings in remnant and disturbed sites.
Powerful Owl Masked Owl Sooty Owl	Spotlighting and call play back at least 5 site visits per site on different nights for Powerful Owl, 6 visits per site for Sooty Owl and 8 visits per site for Masked Owl.	Due to the small size of the study area, lack of habitat connectivity with large contiguous vegetated areas and unsuitable breeding habitat (lack of large hollowing bearing trees), owl survey effort was limited to six nocturnal call playback sites with four spotlighting transect searches over three consecutive nights. Survey undertaken by two ecologists comprising eight person hours during the late evenings of 28-30 November 2016.
Eastern Bentwing-bat Eastern False Pipistrelle Eastern Freetail-bat Little Bentwing-bat Southern Myotis	Call detection - Two sound activated recording devices utilised for the entire night (a minimum of four hours), starting at dusk for two nights per 100 hectares of stratification unit	Two Anabat detectors for three nights each from 31st January to 3rd February
Grey-headed Flying-fox Greater Glider	Spotlighting searches (walked transect)	Four spotlighting searches over three consecutive nights. Undertaken by two ecologists comprising eight person hours during the late evenings of 28-30 November 2016.

2.5 Limitations

The vegetation field survey was able to provide adequate spatial coverage and survey effort for the entire study area. This was achievable in the timeframe given the small size of the study area. Detailed floristic survey was undertaken to provide a near comprehensive list of flora species for that point in time. Other undetected flora species may appear in other times of the year, particularly cryptic orchids. A period of several seasons or years is often needed to identify all the species present in an area, and specific weather conditions are required for optimum detection (e.g. breeding and flowering periods). The conclusions of this report are therefore based upon available data and limited field survey and are indicative of the environmental condition of the study area at the time of the survey. It should be recognised that site conditions, including the presence of threatened species, can change with time. To

address this limitation, the assessment has aimed to identify the presence and suitability of the habitat for threatened species as discussed in the following section.

The late November, early December survey was suitably timed for most predicted targeted species, except for Illawarra Irene (*Irenepharsus trypherus*) which is best surveyed between February and June. However suitable habitat for this species (i.e. steep rocky slopes near cliff lines and ridge tops) was not observed in the study area.

The mapping included in this report shows the inferred distribution of plant community types and habitat within the study area. In many cases, the boundaries between plant community types and habitats are not well defined and the mapping provides an approximation of on-ground conditions. The maps represent a snapshot in time.

3 Existing environment

3.1 Landscape context

3.1.1 Locality and land use

The study area is located in the Wollongong City Council LGA of the Southern Rivers Catchment, wholly within the Illawarra IBRA sub-region of the Sydney Basin IBRA Bioregion. The majority of the study area is zoned as SP2 infrastructure and surrounded by low-density residential dwellings (R2) in the north, northeast and far south. Educational institutions such as University of Wollongong and TAFE Illawarra Wollongong campus surround the southwest and east. The Illawarra Escarpment State Conservation Area is about 580 metres to the west of the study area.

3.1.2 Landscape features

The site is situated within two Mitchell landscapes. The flat southern portion of the study area comprises the Lake Illawarra Barrier landscape and the sloping northern portion comprises the Dapto – Wollongong Coastal Slopes landscape. The main characteristics of these landscapes are described in Table 3.1.

Table 3.1 Descriptions of Mitchell Landscapes with estimated proportion of cleared land and proportion of land reserved and managed by NPWS

Mitchell Landscape	Landscape characteristics	Percentage of reserved land (managed by NPWS)	Percentage cleared
Lake Illawarra Barrier	This landscape is substantially altered by urban and industrial development but would originally have had very similar structure and composition to the Seven Mile Barrier Landscape. General elevation 0 to 25m, local relief 5m. Eel grass (*Zostera capricorni*) on the lake floor, Common reed (*Phragmites australis*) in fresh swamps and lakes margins, limited Grey Mangrove (*Avicennia marina*) and saltmarsh near lagoon mouths and in more open estuaries.	0 %	93 %
Dapto – Wollongong Coastal Slopes	Hilly forestland lying between the steep rubble slopes of the escarpment and valley floors or coastal barriers. A narrow landscape lying between the coast and the escarpment. Formed on Permian sandstone and shale with areas of interbedded basalt. Slopes range from 3 to 270 with thin stony soils on crests and upper slopes. Deeper well-structured red and red brown loam and clay loam with some areas of mellow texture-contrast soils of high fertility high and good water holding capacity on mid and lower slopes. Yellow solodic soils with bleached A2 horizons common on the lowest slopes and stream terraces. Open forest dominated by Forest Red Gum (*Eucalyptus tereticornis*), Yellow Stringybark (*Eucalyptus muelleriana*), Gully Gum (*Eucalyptus smithii*), stringybark with rainforest elements along streamlines. Extensively cleared, former areas of coastal brush may be indicated by remnant Cabbage-tree Palms (*Livistona australis*) and Port Jackson figs (*Ficus rubiginosa*).	4.4 %	71 %

3.1.3 Native vegetation extent

Regional vegetation mapping and studies undertaken in the PEI represent the most recent distribution and extent of vegetation communities within the study area. Correlation of three vegetation communities in the locality with regional biometric datasets is provided in Table 3.2. These vegetation communities are known to intergrade where increases in soil fertility of PCT 694 will grade into PCT 1245, which may be replaced by greater rainforest components of PCT 1529, particularly in prolonged bushfire protected areas (Tozer et al., 2006).

Table 3.2 Comparison of vegetation community classification with regional datasets within the study area and surrounding area

PCT	BVT code	Tozer (2006)	NPWS (2002a)
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (PCT 694)	SR516	Illawarra Gully Wet Forest (WSF p99)	Escarpment Blackbutt Forest (MU16)
Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (PCT 1245)	SR652	Warm Temperate Layered Forest (WSF p110)	Escarpment Moist Blue Gum Forest (MU8)
Lilly Pilly-Coachwood Warm Temperate Rainforest on Moist Sheltered Slopes and Gullies, Sydney Basin and South East Corner (PCT 1529)	SR567	Coastal Warm Temperate Rainforest (RF p113)	Coachwood Warm Temperate Rainforest (MU2)

3.1.4 Waterways, key fish habitat and wetlands

The hydrological environment is limited to two unnamed creeks (Strahler 1). One creek (a tributary of Cabbage Tree Creek) traverses the centre of the study area on the northern portions of the University of Wollongong campus, and the second creek (a tributary of Fairy Creek) traverses the southern extent of the study area on the border of the TAFE. These streams flow into Cabbage Tree Creek and Fairy Creek which are larger waterways likely to contain more extensive and higher quality, albeit degraded, habitat for aquatic species.

There are no wetlands of significance (State Environmental Protection Policy 44 wetlands or wetlands listed in the Directory of Important Wetlands) within eight kilometres of the study area.

3.2 Plant community types

The majority of native vegetation is confined to the central and northern portions of the study area. Remaining areas consist of urban tree plantings (roadside landscape plantings) and disturbed or cleared land that is dominated by weed growth. Past and present land use activities such as land clearing, weed and pest invasion, rubbish dumping and human interaction have modified the extent and condition of native vegetation. The disturbed areas are heavily weed infested with a cover of Lantana (>75% in some areas) as well as a high cover of Coral Tree (*Erythrina* x *sykesii*), Box-elder Maple (*Acer negundo*), Panic Veldtgrass (*Ehrharta erecta*) and Kikuyu (*Cenchrus clandestinus*).

A total of 234 flora species were recorded in the study area, including 124 local native species, 31 planted non-indigenous species and 79 exotic plant species, 6 of which are noxious species. The list of flora species recorded in the study area is provided in Appendix A.

The vegetation survey identified moderate to good condition PCTs within the study area based on plot data and landscape features matched against the regional biometric datasets. Vegetation condition was assessed using site attributes compared with benchmark values. The PCTs identified are listed in Table 3.3 and described in detail below. The distribution of PCTs is mapped in Figure 3.1. Non-native vegetation type extents are summarised in Table 3.6.

Table 3.3 Summary of PCT condition, conservation status and extent in the study area

Plant community type (PCT)	Vegetation zone	Condition class	Threatened ecological community?	Area (ha) in study area
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (694)	1	Moderate / Good	No	5.6
	2	Moderate / Good_Medium		0.8
	3	Moderate / Good_Other		0.8
Sydney Blue Gum x Bangalay – Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (1245)	4	Moderate / Good	No	2.9
	5	Moderate / Good_Poor		0.2
	6	Moderate / Good_Other		0.1
Total				10.46

Table 3.4 Summary of non-native vegetation and extent in the study area

Type	Area (ha) in study area
Roadside and landscape plantings	9.61
Disturbed areas dominated by weeds	1.4

Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion

Vegetation zone: 1, 2, and 3

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

Vegetation class: North Coast Wet Sclerophyll Forests

PCT: 694

BVT: SR516

Conservation status: None

Mapping source: OEH (2013), Tozer et al (2010), NPWS, (2002a)

Estimate of percent cleared: 50%

Condition: 1 (Moderate / Good), 2 (Moderate / Good_Medium), 3 (Moderate / Good_Other)

Extent in the study area: 7.2 ha

Plots completed: 5

Structure	Average height (m)	Average cover (%)	Average height (m)	Average cover (%)	
Condition	**Moderate / Good**		**Low**		**Typical species**
Trees	22.8	54	17	31	*Eucalyptus pilularis*, *Syncarpia glomulifera*, *Eucalyptus paniculata*
Small trees	6.8	21	2.3	13	*Backhousia myrtifolia, Livistona australis, Acacia maidenii*
Shrubs	3.7	28	1.6	35	*Myrsine variabilis, Notelaea longifolia*, *Acacia binervata, Pittosporum undulatum, Breynia oblongifolia*
Ground covers	0.9	58	1	56	*Microlaena stipoides, Lomandra longifolia, Dichondra repens*, *Pseuderanthemum variable*
Vines & climbers	1.2	4	0.7	5	*Geitonoplesium cymosum, Hibbertia dentata*, *Eustrephus latifolius and Pandorea pandorana*, *Tylophora barbata*
Condition: This PCT ranges in condition. Moderate / Good (Zone 1, 2 and 3) patches scored between 45 to 80. The sub-condition of this community varied as a result of weed abundance (Zone 2 and 3), pest deer damage / soil disturbance (pugging) and past land use.					

Description:

This community is a wet sclerophyll forest varying in structure and floristic diversity which occurs on the lower and mid-slopes of foothills around Mount Keira in the study area. The lower slopes contain a greater richness of rainforest species and greater structural complexity compared to the upper more exposed slopes. The canopy is tall and dominated by Blackbutt (*E. pilularis*) and Turpentine (*S. glomulifera*) up to 30 metres in height. The sub-canopy and mid-storey varies from open to dense with shrubs such as Variable Muttonwood (*Myrsine. variabilis*), Breynia (*Breynia oblongifolia*), Sweet Pittosporum (*Pittosporum undulatum*) and Sandfly Zieria (*Zieria smithii*). The groundcover is dominated with Spiny Mat-rush (*Lomandra longifolia*), Kidney weed (*Dichondra repens)*, Pastel Flower (*Pseuderanthemum variable*), Weeping Grass (*Microlaena stipoides* var. *stipoides*) and Wiry Panic (*Entolasia stricta*). Many areas of this community, particularly Zone 2 and 3 have a dense understorey of exotic species cover such as Asparagus species (*Asparagus scandens* and *Asparagus aethiopicus*) and Lantana (*Lantana camara*) and other garden escapees. A range of vines also occur such as Wong Wonga Vine (*Pandorea pandorana*), Scrambling Lily (*Geitonoplesium cymosum*) and

Wombat Berry (*Eustrephus latifolius*).There was regeneration of most canopy species in Zone 1, 2 and 3.

Landscape features: This community occurs on escarpment foothills and coastal lowlands and is strongly associated with high rainfall (>1200 mm) and deep red-brown clay soils which sustain a moist open understorey with a mix of rainforest species.

Site and Regional Distribution: It is known to extend along the escarpment foothills and coastal lowlands from Batemans Bay to the Hacking River in southern Sydney. In the study area it occurs as three distinct patches, separated by roads, varying in floristic diversity based on topography. Larger contiguous patches occur further north-west of the study area in the Illawarra Escarpment State Conservation Area.

Diagnostic features: This community is characterised by canopy species Blackbutt (*E. pilularis*) and Turpentine (*S. glomulifera*) and uncommon occurrences of Grey Ironbark (*E. paniculata*) with a moist sub-canopy of rainforest species varying in structure and diversity, and a mix of ferns, grasses and climbers.

Threatened flora: One Magenta Lilly Pilly (*Syzygium paniculatum*) plant was recorded within this community.

Fauna habitat condition: This community comprises a moist open forest habitat in moderate condition and has a variety of structural layers and species rich rainforest mid-storey, particularly on lower slopes. Features which may provide shelter, roosting and breeding habitat for a range of fauna are low in abundance. Tall mature trees containing tree hollows are relatively rare; mean 7.5 hollows / ha compared to the benchmark of 20 hollows / ha. Fallen timber is sparse; mean 81.25 m / ha of logs, compared to benchmark of 1000 m / ha. The moist conditions of this habitat often provide decaying wood and attract a range of invertebrates which are preyed on by a diversity of insectivorous birds (70% of birds observed) and bats. One threatened fauna species, Grey-headed Flying-fox was recorded. This community represents core habitat for the species in the Wollongong area. This habitat may provide foraging opportunities for Grey-headed Flying-fox on fruit from Cabbage Palm (*Livistona australis*) and Lilly Pillies (*Acmena* sp. and *Syzygium* spp as well as flowering blossoms from Blackbutt and Turpentine.

Photograph 1: **Plot 4 (Zone 1 moderate / good condition) of Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion**

Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion

Vegetation zone: 5 and 6

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

Vegetation class: North Coast Wet Sclerophyll Forests

PCT: 1245

BVT: SR652

Conservation status: None

Estimate of percent cleared: 45%

Mapping source: OEH (2013), Tozer et al (2010), NPWS, (2002a)

Condition: 5 (Moderate / Good), 6 (Moderate / Good_Poor)

Extent in the study area: 3.3 ha

Plots completed: 4

Structure	Average height (m)	Average cover (%)	Average height (m)	Average cover (%)	
Condition	Moderate / Good		Low		Typical species
Trees	20	42	13	17	*Eucalyptus botryoides, Syncarpia glomulifera, Eucalyptus botryoides x saligna, Eucalyptus amplifolia*
Small trees	10.3	41.3	0	1	*Melaleuca styphelioides, Claoxylon australe*, *Acmena smithii, Livistona australis*
Shrubs	2.7	46.7	2	25	*Eupomatia laurina, Elaeodendron australe, Myrsine variabilis, Guioa semiglauca*, *Notelaea venosa*
Ground covers	1	50	1	60	*Oplismenus imbecillis, Oplismenus aemulus, Adiantum formosum, Doodia aspera, Pseuderanthemum variabile*
Vines & climbers	2.3	5	0	5	*Parsonsia straminea, Geitonoplesium cymosum, Eustrephus latifolius*
Condition: This PCT ranges in condition. Moderate / Good (Zone 5 and 6) patches scoring 29 to 68. The sub-condition of this community varied as a result of high weed abundance in Zone 6, pest deer damage / soil disturbance (pugging) in Zone 5 as well as other past land uses.					

Description:

This community is a wet sclerophyll forest with multiple structural layers and floristic diversity and occurs on the narrow creek flats and benches at the base of foothills of Mount Keira in the study area. It has higher richness of rainforest and structural layers compared to *Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion*. The canopy is tall and dominated by Bangalay (*E. botryoides*) and *Eucalyptus botryoides x saligna* and Turpentine (*S. glomulifera*) up to 25 metres in height. The sub-canopy and mid-storey is often tall and dense with rainforest shrubs such as Bolwarra (*Eupomatia laurina*), Variable Mutton Wood (*Myrsine. variabilis*), Brittlewood (*Claoxylon australe*), Sweet Pittosporum (*Pittosporum undulatum*) and Guioa (*Guioa semiglauca*). The groundcover is sparse with a mix of grasses, forbs and ferns such as Narrow-leaved Beard Grass (*Oplismenus imbecillis*), Giant Maidenhair Fern (*Adiantum formosum*), Prickly Rasp-fern (*Doodia aspera*) and Settler's Flax (*Gymnostachys anceps*). A range of vines also occur such as Common Silkpod (*Parsonsia straminea*), Scrambling Lily (*Geitonoplesium cymosum*) and Wombat Berry (*Eustrephus latifolius*) and Staff Climber (*Celastrus australis*).

Some portions of this community, particularly Zone 6 had a dense understorey of exotic species cover such as Lantana (*Lantana camara*) and Cape Honeysuckle (*Tecoma capensis*). There was no regeneration of canopy species in all zones.

Landscape features: This community occurs on escarpment benches, alluvial flats and protected gullies and is associated with high rainfall (>1400 mm) and deep chocolate clay soils which sustain a moist understorey with a mix of rainforest species.

Site and Regional Distribution: It is known to extend along the escarpment benches, alluvial flats protected gullies from Nowra to the Hacking River in southern Sydney. In the study area it occurs as distinct isolated patch restricted to the creek flat and benches within the University of Wollongong. Larger contiguous patches occur further west of the study area in the Illawarra Escarpment State Conservation Area.

Diagnostic features: This community is characterised by canopy species *Eucalyptus botryoides x saligna* and Turpentine (*S. glomulifera*) with a moist sub-canopy of rainforest species. It has a sparse groundcover generally composed of ferns and Settlers Flax (*G anceps*).

Threatened flora: Two Magenta Lilly Pilly (*Syzygium paniculatum*) individuals were recorded on the creek flat at the eastern extent of this community.

Fauna habitat condition: This community comprises a moist open forest with a dense sub-canopy in low to high condition and diverse structural layers and species rich rainforest mid-storey. Features which may provide shelter, roosting and breeding habitat for a range of fauna are low to moderate in abundance. Tall mature trees containing tree hollows are relatively sparse; mean 12.5 hollows / ha compared to the benchmark of 20 hollows / ha. Fallen timber is relatively sparse; mean 247.5 m / ha of logs, compared to benchmark of 1000 m / ha. The moist conditions of this habitat provide decaying wood and attract a range of invertebrates that are preyed on by a diversity of insectivorous birds (70% of birds observed) and bats. One threatened species, Grey-headed Flying-fox, were recorded in this community. Foraging habitat is provided for threatened fauna species Grey-headed Flying-fox (Vulnerable TSC Act and EPBC Act) where it may feed on fruit from Cabbage Palm (*Livistona australis*) and Lilly Pillies (*Acmena* sp. and *Syzygium* spp as well as flowering blossoms from Turpentine and *Eucalyptus botryoides x saligna*.

Photograph 2: **Plot 9 (Zone 5 moderate / good condition) of Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion**

Legend

- Ecology study area PCT
- Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion - Moderate/Good
- Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion - Moderate/Good_Medium
- Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion - Moderate/Good_Other
- Disturbed areas dominated by weeds
- Roadside and landscape plantings
- Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion - Moderate/Good
- Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion - Moderate/Good_Other
- Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion - Moderate/Good_Poor

Figure 3.1 Plant community types

3.3 Threatened ecological communities

None of the PCTs identified in the study area qualified as threatened ecological communities (TEC) listed under the TSC Act or the EPBC Act.

3.4 Groundwater dependent ecosystems

The level of groundwater dependence of vegetation communities in the study area has been identified using the Atlas of GDE (Bureau of Meteorology, 2017) and the *Risk Assessment Guidelines for Groundwater Dependant Ecosystems* released by the NSW DPI (Kuginis et al., 2012).

3.4.1 Classification of groundwater dependant ecosystems

The degree of groundwater dependence of ecosystems is classified in three broad categories:

- Non-dependent ecosystems; ecosystems that occur mostly in recharge areas and have no connection with groundwater
- Facultative GDEs; require groundwater in some locations but not in others, particularly where an alternative source of water can be accessed to maintain ecological function
- Obligate GDEs; ecosystems that are restricted to locations of groundwater discharge (e.g. mound springs) and ecosystems located within aquifers (e.g. subterranean cave and stygofauna communities (Kuginis *et al*. 2012).

Facultative GDEs have varying degrees of groundwater dependence and are described under three dependence subcategories:

- Highly dependent; some locations within the ecosystem likely to require continual access to groundwater; likely to be damaged or destroyed if groundwater attributes fall below a critical threshold
- Proportional; exhibit proportional responses to changes in groundwater attributes; do not generally exhibit the threshold type response of the more dependent ecosystems
- Opportunistic; ecosystems which use groundwater as required when surface water / soil moisture is unavailable, such as at the end of a dry period.

Minor changes to the groundwater regime in facultative GDEs with proportional or opportunistic groundwater dependence may not have any adverse impacts but these ecosystems can be damaged or destroyed if a lack of access to groundwater is prolonged (Kuginis *et al*. 2012).

Groundwater dependant ecosystems have been classified into seven types under two broad categories as follows (Kuginis *et al*. 2012):

- Subsurface ecosystems – Underground ecosystems
  - Karst systems and caves (limestone geology)
  - Subsurface aquifer (phreatic) ecosystems
  - Baseflow streams (hyporheic or subsurface component)
- Surface ecosystems – Above ground ecosystems
  - Groundwater dependent wetlands
  - Baseflow surface streams (surface/free-water component)
  - Estuarine and near shore marine ecosystems
  - Groundwater dependent terrestrial ecosystems; dependent on subsurface groundwater (phreatophytic)

3.4.2 Groundwater dependant ecosystems on the proposal site

The level of groundwater dependence and potential for interaction is identified for terrestrial ecosystems in the study area is identified in Table 3.7.

Figure 3.1 shows the distribution of these vegetation communities in the study area.

Table 3.5 Level of groundwater dependence of ecosystems in study area

Ecosystem	Tozer et al (2010)	Potential for GDE interaction (BoM, 2017)	Type of GDE (Kuginis *et al.* 2012)	Likely type and degree of groundwater dependence (Kuginis *et al.* 2012)
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (PCT 694)	Illawarra Gully Wet Forest	High potential for groundwater interaction	Groundwater dependent terrestrial ecosystem (phreatophytic)	Facultative - Opportunistic Likely to use groundwater where available during times of water stress but to be dependent chiefly on high local rainfall.
Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (PCT 1245)	Warm Temperate Layered Forest	High potential for groundwater interaction	Groundwater dependent terrestrial ecosystem (phreatophytic)	Facultative – Opportunistic Likely to use groundwater where available during times of water stress but to be dependent chiefly on high local rainfall.
Shallow first-order streams with ephemeral flow	Part of communities listed above	Non-dependent ecosystems	N/A	The shallow, disturbed first-order streams of the site have only ephemeral flow, lack baseflow characteristics and are unlikely to be dependent on groundwater.

3.5 Threatened species and populations

The majority of the study area is highly urbanised and may lack habitat features for supporting threatened species. The structure and floristic attributes of vegetation and features of topography and soil types influence the presence and extent of flora and fauna. Past land uses also have a strong influence on species occurrence where habitat groundcover and understorey is removed and sometimes replaced with weeds and pests.

The background review identified 27 threatened flora and 69 threatened fauna species (listed under the TSC Act and EPBC Act) with a potential to occur in the study area. Based on the assessment of habitat features in moist forest and a review of local literature, three threatened flora species and nine threatened fauna species were considered to have a moderate to high likelihood of occurring based on the presence of suitable habitat and recent records from the locality (see Appendix B).

One threatened flora species, *Syzygium paniculatum*, was recorded in the study area in three locations. Four individual plants were recorded. In the absence of evidence to suggest these plants have been planted, they are considered likely to be naturally occurring and may be a result of seed dispersal from the Coalcliff metapopulation. The identification of this species was confirmed by botanists at the Royal Botanic Gardens in Sydney. An additional two threatened plant species: *Eucalyptus nicholii* and *Eucalyptus scoparia* were also recorded in the study area planted adjacent to the M1 Princes Motorway as street trees. These two species are horticultural specimens, planted far from their natural range. These species are not naturally occurring and impacts to these species have not been assessed, as a significant impact is highly unlikely. Two other threatened flora species: *Senna acclinis* and *Solanum celatum* are considered moderately likely to occur based on the presence of suitable habitat (see Appendix B).

Three threatened fauna species were recorded in the study area; the Grey-headed Flying Fox, Eastern Bentwing-bat and Little Bentwing-bat. The Grey-headed Flying Fox was commonly observed at night flying over and foraging in the habitat in the study area. The Eastern Bentwing-bat and Little Bentwing-bat were recorded via Anabat. All PCTs in the study area are considered to provide suitable foraging habitat for these three species. Six more threatened

fauna species are considered moderately likely to occur within the study area due to the presence of suitable habitat (see Table 3.8 for a summary and Appendix B).

Table 3.8: Threatened fauna and fauna habitat in the study area

Species	Ecosystem or species credit species	Status		Habitat or individuals in the study area
		TSC Act	EPBC Act	
Gang-gang Cockatoo (Callocephalon fimbriatum)	Ecosystem credit species	V	-	9.95 ha of potential foraging and roosting habitat in PCTs 9.88 ha of potential foraging habitat in planted vegetation
Varied Sittella (*Daphoenositta chrysoptera*)	Ecosystem credit species	V	-	9.95 ha of potential foraging, roosting and breeding habitat in PCTs 9.88 ha of potential foraging habitat in planted vegetation
Little Lorikeet (*Glossopsitta pusilla*)	Ecosystem credit species	V	-	9.95 ha of potential foraging, roosting and breeding habitat in PCTs 9.88 ha of potential foraging habitat in planted vegetation
Swift Parrot (*Lathamus discolor*)	Ecosystem credit species	E	CE	9.95 ha of potential foraging and roosting habitat in PCTs 9.88 ha of potential foraging and roosting habitat in planted vegetation
Powerful Owl (*Ninox strenua*)	Ecosystem credit species	V	-	9.95 ha of potential foraging and roosting habitat in PCTs 9.88 ha of potential foraging and roosting habitat in planted vegetation
Little Bent-wing Bat (*Miniopterus australis*)	Ecosystem and Species credit (breeding habitat) species	V	-	9.95 ha of potential foraging habitat in PCTs 9.88 ha of potential foraging habitat in planted vegetation
Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)	Ecosystem and Species credit (breeding habitat) species	V	-	9.95 ha of potential foraging habitat in PCTs 9.88 ha of potential foraging habitat in planted vegetation
Grey-headed Flying-fox (*Pteropus poliocephalus*)	Ecosystem credit species	V	V	9.95 ha of potential foraging habitat in PCTs 9.88 ha of potential foraging habitat in planted vegetation
Greater Glider (*Petauroides volans*)	Not applicable	-	V	9.95 ha of potential foraging habitat in PCTs 0.53 ha of potential foraging habitat in planted vegetation

3.6 Fauna richness

The study area is considered to have moderate fauna species richness, typical of a small fragmented forested area. A total of 58 fauna species was recorded, comprising 42 birds, six terrestrial mammals, one bat, five frogs, four reptiles and one fish species. The total includes

six exotic fauna species. Seventy percent of all birds observed (n=29) were insectivorous likely due to the study area supporting a wide range of invertebrates under favourable conditions provided by a wet forest habitat. The low diversity of nectar-feeding bird species (n=3) indicates that many plants were not flowering or producing nectar at the time of the survey. All recorded species are listed in Appendix A. Three threatened fauna species were recorded in the study area, as discussed in Section 3.5.

3.7 Aquatic results

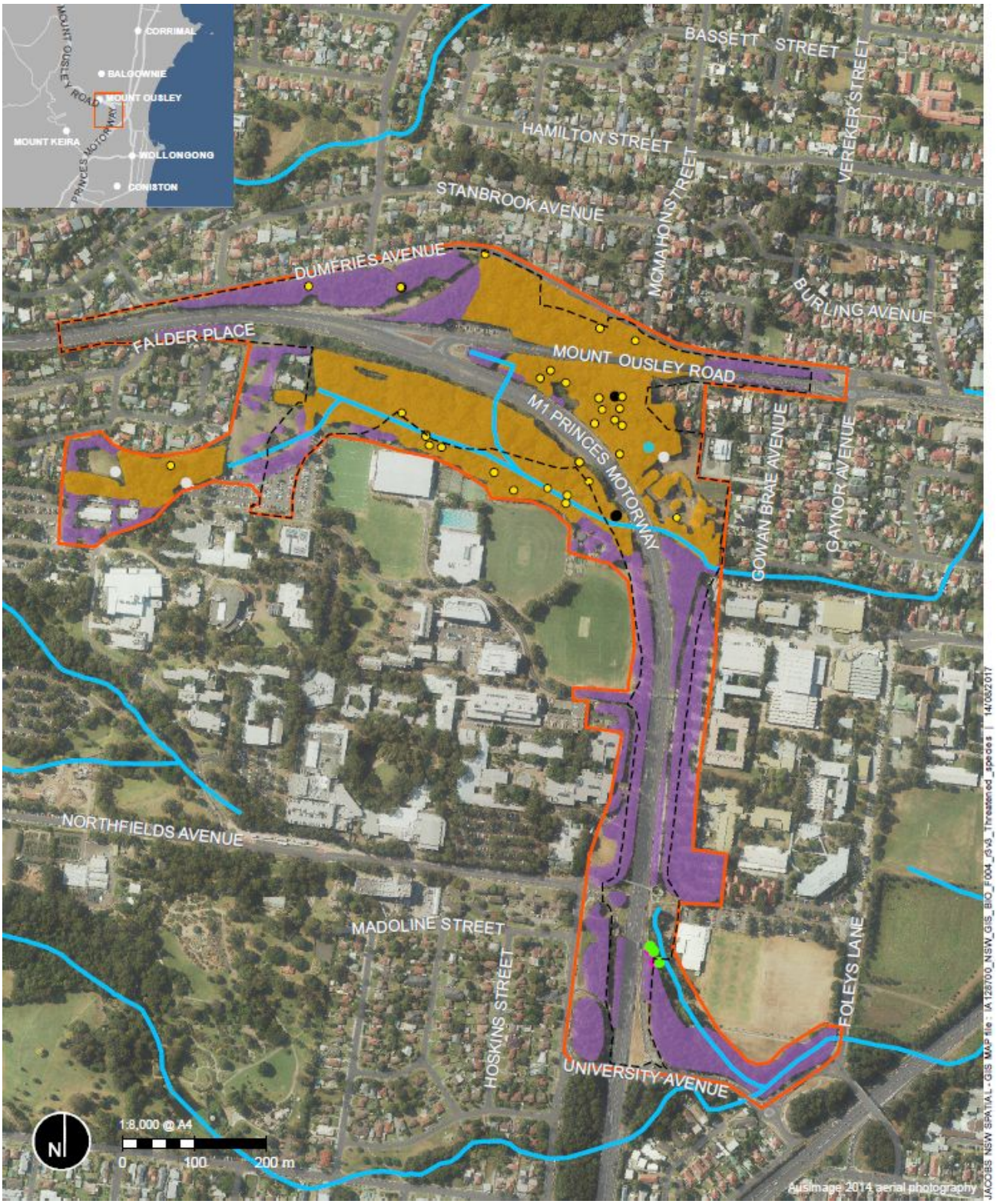
The aquatic habitat in the study area is limited to two unnamed streams (Strahler 1). Stream banks were heavily exposed and moderately unstable in some areas, likely due to excessive stormwater flow volume and velocity and soil disturbance caused by Rusa Deer (*Cervus timorensis*) activity.

The streams lacked visible submerged native aquatic macrophytes and had only occasional patches of disturbance-tolerant native emergent aquatic macrophytes such as Bullrushes (*Typha* spp.) and Knotweeds (*Persicaria* spp). Exotic plant species such as Trad (*Tradescantia fluminensis*), Crofton Weed (*Ageratina adenophora*) and *Brassica* sp. were the dominant stream edge vegetation.

The presence of rubbish, sewerage infrastructure and extensive weed growth indicated that the streams are likely to have been affected by elevated nutrient levels and other forms of pollution. Water in the streams exhibited moderate turbidity and tannin staining and was not flowing although there were signs of past high flows. The stream substrate consisted of patches of mud, accumulated vegetation debris and filamentous green algae.

Due to the lack of permanent flow, rubbish accumulation, increased turbidity, weed proliferation, paucity of native aquatic vegetation, siltation and evidence of physical disturbance of the streams, these streams are considered to be in moderately to highly degraded condition. Due to their small size, lack of complex habitat structure and degraded condition, these streams are only considered likely to provide habitat for very disturbance-tolerant species such as the Longfinned Eels (*Anguilla reinhardtii*) observed near a culvert in Zone 6.

The streams do not have characteristics suitable for any of the threatened aquatic species known or predicted to occur in the locality as shown in Appendix B.



Legend

Ecology study area

Proposal footprint

Threatened species

Eucalyptus nicholii

Eucalyptus scoparia

Grey-headed Flying-fox

Syzygium paniculatum

Eastern Bentwing-bat and Little Bentwing-bat

Habitat

Roadside and landscape plantings

Threatened species habitat

Hollow Bearing Trees

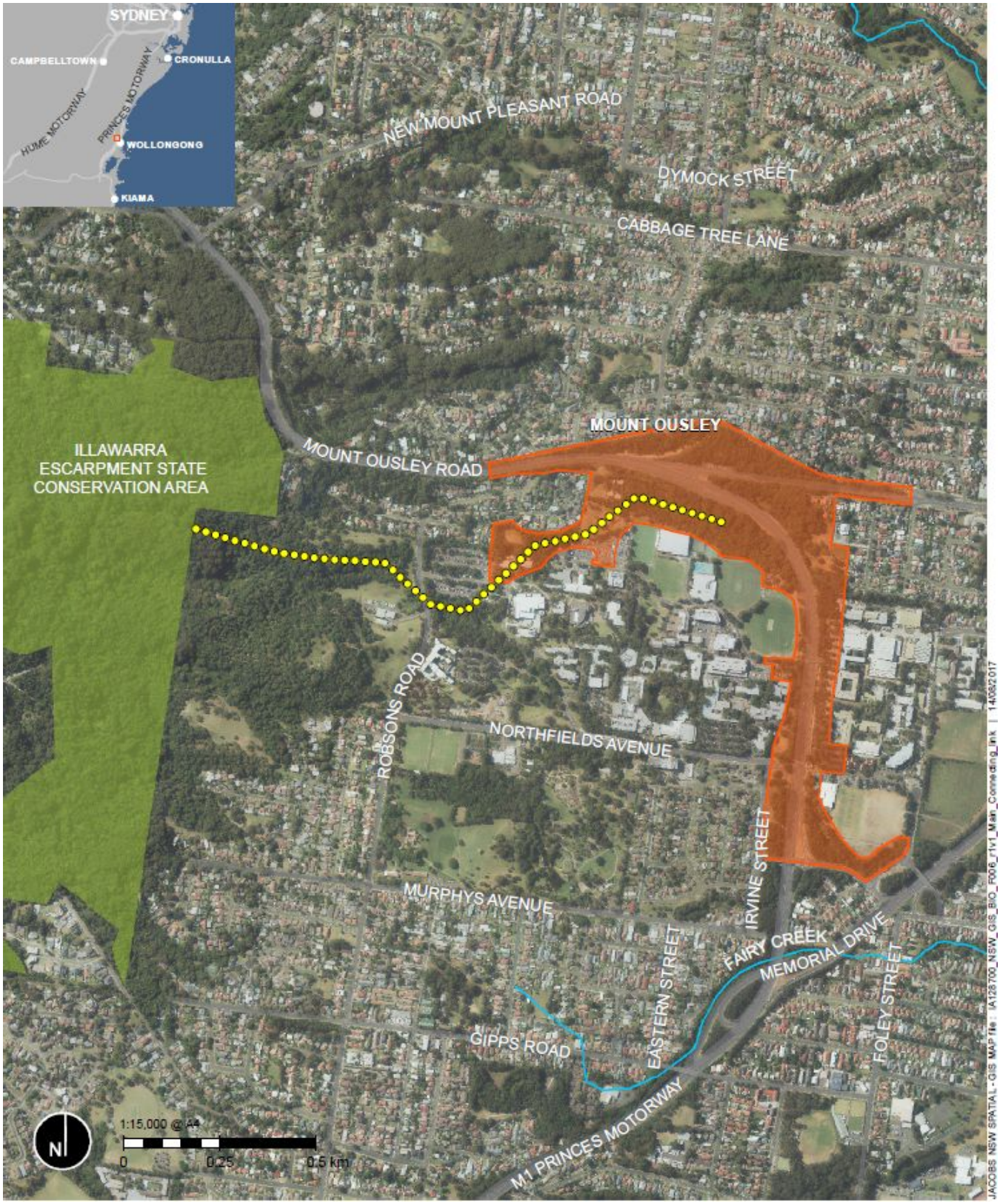
Figure 3.2 Recorded threatened species

3.8 Wildlife connectivity corridors

The study area does not contain viable linkages to larger contiguous vegetation and is highly fragmented by roads and low-density housing. The Escarpment Moist Forest Fauna Linkage is characterised by vegetation that has a rainforest component and connecting bands of moist forest. This link is 500 metres to the west of the study area. While the study area is separated from the Escarpment Moist Forest Fauna Linkage by residential development, roads and cleared land, some connectivity for species which are more tolerant to disturbance does exist.

The habitats within the study area are fragments that have formed since the initial habitat clearing that occurred with the development of the suburbs of Mt Ousley, Keiraville, Gwynneville and North Wollongong. The current alignment of the M1 Princes Motorway and Mt Ousley Road divides the remaining habitats within the study area into four main fragments. The hard hostile barriers posed by the M1 Princes Motorway and Mt Ousley Road serve to restrict fauna movements between the habitat patches for terrestrial and arboreal species. However, the permeability of landscapes for different fauna species varies and habitat connectivity for more mobile species (eg birds, flying-foxes, insectivorous bats, plants) is present with the escarpment to the west. However, connectivity for sedentary species and smaller species such as frogs and reptiles is likely to be minimal.

The current roadways and urban areas do not totally prevent fauna movement between habitat fragments. Fauna can, and likely do, cross the road and disturbed areas but would do so less frequently than in natural habitats and would be at greater risk of mortality during movements. It is likely that animals move between the escarpment habitats and the habitats within the study area. It is also likely that plant pollinators and seed dispersers move pollen and seed (or other vegetative reproductive material) between habitat patches within the study area and the escarpment. Functional connectivity for many species will exist between the study area and the escarpment despite the level of fragmentation that has occurred. The main linkage to the escarpment is illustrated in Figure 3.4.



Legend

Ecology study area

Location of the main connecting link

Figure 3.4 The location of the main connecting link from the study area to the escarpment

3.9 SEPPs

State Environmental Planning Policy 44 (SEPP 44) – Koala Habitat Protection does not apply to proposals that are being assessed under Part 5 of the EP&A Act. However, the Koala (*Phascolarctos cinereus*) is listed as vulnerable under the Commonwealth EPBC Act and in NSW under the TSC Act. There was no evidence of core or potential Koala habitat in the study area.

3.10 Matters of National Environmental Significance

3.10.1 Threatened ecological communities

None of the PCTs identified in the study area qualified as threatened ecological communities (TEC) listed under the EPBC Act.

3.10.2 Threatened species

There was one threatened fauna species recorded in the study area, the Grey-headed Flying Fox (*Pteropus poliocephalus*) which is listed as vulnerable under the EPBC Act and was commonly observed at night flying over and foraging in the habitat in the study area. All PCTs in the study area are considered to provide suitable foraging habitat for the Grey-headed Flying-fox. Two other EPBC Act listed fauna species: the Swift Parrot and Greater Glider are considered moderately likely to occur based on the presence of suitable habitats.

One plant species *Syzygium paniculatum* (Magenta Lilly Pilly), which is listed as endangered under the EPBC Act, was found in the study area during the field survey. Four plants were found in three locations (see Figure 3.2 for the location of *Syzygium paniculatum* plants).

3.10.3 Migratory species

Three migratory species listed under the EPBC Act may potentially occur within the study area. Of these, the White-throated Needletail has a moderate potential of occurring in the study area. This species may fly over the study area on occasion during seasonal migration but is unlikely to land in the study area to utilise the habitats. The full list of migratory species considered in this assessment is provided in Appendix B.

4 Impact assessment

The proposal's likely direct and indirect impacts on biodiversity are summarised in this chapter. The potential for indirect impacts on biodiversity values is considered moderate given that much of the study area is highly fragmented and surrounded by existing roads and barriers. However, the proposal would change the integrity (local scale) of the last remaining vegetation patches in the area due to increased edge effects.

4.1 Construction impacts

4.1.1 Removal of native vegetation

The proposal would have direct and indirect impacts on a range of biodiversity values during construction and operation. Under the current design, the estimated clearing of PCTs is about 7.58 hectares consisting of the following PCTs:

- Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (PCT 694) = 6.69 ha
- Sydney Blue Gum x Bangalay – Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (PCT 1245) = 0.89 ha.

A breakdown of approximate native vegetation removal in each vegetation zone is provided in Table 4.1.

The local occurrence of these two PCTs is mapped within the locality by Tozer *et al.* (2006). PCT 694 corresponding to WSF p99: Illawarra Gully Wet Forest and PCT 1245 corresponding to WSF p110: Warm Temperate Layered Forest.

The local occurrence of each PCT is defined as the area of the PCT that occurs within the study area and adjacent areas that form part of a larger contiguous area of the PCT, in which movement of individuals and exchange of genetic material across the boundary of the study area can be clearly demonstrated. The PCTs within the study area are within 500 metres of the vegetation along the escarpment so are considered to be connected and part of the local occurrence. Movement of individuals and exchange of genetic material from the vegetation on the escarpment to and from the PCTs within the study area can be expected.

The proposal will also result in the removal of approximately 5.05 ha of roadside and urban plantings and approximately 1 ha of weed dominated vegetation. The predicted clearing of landscape plantings and weed-dominated vegetation is outlined in Table 4.2.

Table 4.1 Predicted impacts to PCTs in the study area

Plant community type (PCT)	Veg. zone	Condition class	Threatened ecological community?	Area (ha) in study area	Impact (ha)	Total PCT impact (ha)	Proportional impact to the local occurrence (%)
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (694)	1	Moderate / Good	No	5.59	5.22	6.69	0.6% (mapped local occurrence of 1,058 ha)
	2	Moderate / Good_ Medium		0.83	0.83		
	3	Moderate / Good_ Other		0.76	0.64		

Plant community type (PCT)	Veg. zone	Condition class	Threatened ecological community?	Area (ha) in study area	Impact (ha)	Total PCT impact (ha)	Proportional impact to the local occurrence (%)
Sydney Blue Gum x Bangalay – Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (1245)	4	Moderate / Good	No	2.93	0.55	0.89	0.04% (mapped local occurrence of 2,478 ha)
	5	Moderate / Good_ Poor		0.22	0.22		
	6	Moderate / Good_ Other		0.11	0.11		

Table 4.2 Predicted impacts to non-native vegetation in the study area

Type	Area (ha) in study area	Predicted impact (ha)
Roadside landscape plantings	9.61	5.05
Disturbed areas dominated by weeds	1.44	0.98

4.1.2 Removal of threatened fauna habitat

The extent of vegetation clearing estimated to result from the proposal is outlined above in Section 4.1.1. This vegetation, including planted trees, provides suitable habitat for a range of threatened fauna species listed under the TSC Act and EPBC Act. As such, direct impacts to habitat for threatened fauna species will occur during construction.

The direct impacts of the proposal to habitats for threatened fauna have been estimated based on the current design. A breakdown of the direct impacts to habitat for threatened fauna species is provided in Table 4.3.

Nineteen hollow-bearing trees (including dead trees) are located within the footprint which would be removed during construction. These trees contain small (≤ 5 cm) to medium (> 5 cm to ≤10 cm) sized hollows that may be suitable as habitat for a range of tree roosting insectivorous bats (including threatened species), arboreal mammals including the Brushtail Possum and Sugar Glider, and small to medium sized birds (including threatened species such as the Little Lorikeet). These hollows are present in the larger trees and stags. The size and number of hollows to be removed is estimated as follows:

- Nine small sized hollows ≤ 5cm wide in living trees
- Three small sized hollows ≤ 5cm wide in dead trees
- Six medium sized hollows >5 cm to ≤10 cm wide in living trees
- Two medium sized hollows >5 cm to ≤10 cm wide in dead trees.

Table 4.3: Impacts on threatened fauna and fauna habitat

Species	Status		Habitat or individuals in the study area	Habitat or individuals to be impacted
	TSC Act	EPBC Act		
Gang-gang Cockatoo *(Callocephalon fimbriatum)*	V	-	10.46 ha of potential foraging and roosting habitat in PCTs 9.61 ha of potential foraging habitat in planted vegetation	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation

Species	Status		Habitat or individuals in the study area	Habitat or individuals to be impacted
	TSC Act	EPBC Act		
Varied Sittella (*Daphoenositta chrysoptera*)	V	-	10.466 ha of potential foraging and roosting habitat in PCTs 9.61 ha of potential foraging habitat in planted vegetation	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Little Lorikeet (*Glossopsitta pusilla*)	V	-	10.466 ha of potential foraging and roosting habitat in PCTs 9.61 ha of potential foraging habitat in planted vegetation	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation Removal of 19 hollow bearing trees
Swift Parrot (*Lathamus discolor*)	E	CE	10.466 ha of potential foraging and roosting habitat in PCTs 9.61 ha of potential foraging habitat in planted vegetation	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Powerful Owl (*Ninox strenua*)	V	-	10.466 ha of potential foraging and roosting habitat in PCTs 9.61 ha of potential foraging habitat in planted vegetation	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)	V	-	10.466 ha of potential foraging and roosting habitat in PCTs 9.61 ha of potential foraging habitat in planted vegetation	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Little Bentwing-bat (*Miniopterus australis*)	V	-	10.466 ha of potential foraging and roosting habitat in PCTs 9.61 ha of potential foraging habitat in planted vegetation	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V	10.466 ha of potential foraging and roosting habitat in PCTs 9.61 ha of potential foraging habitat in planted vegetation	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Greater Glider (*Petauroides volans*)	-	V	10.46 ha of potential foraging and roosting habitat in PCTs	7.58 ha of habitat removal from PCTs

4.1.3 Removal of threatened flora

There will be an impact to potential habitat for the following threatened plant species:

- *Syzygium paniculatum* (Endangered – TSC Act, Vulnerable EPBC Act)
- *Senna acclinis* (Endangered – TSC Act)
- *Solanum celatum* (Endangered – TSC Act).

Four *Syzygium paniculatum* plants will be removed by the proposal. Habitat for this species is present throughout PCT 694 and PCT 1245.

Senna acclinis and *Solanum celatum* were not found on site but are considered moderately likely to occur. These two species are known from the locality and have persistent soil stored seed banks. These species may be present as seed in the soil stored seedbank within PCT 694 and PCT 1245.

Table 4.4 Impacts on threatened flora habitat

Threatened species	Ecosystem or species credit species	Status		Habitat or individuals in the study area	Habitat or individuals to be impacted
		TSC Act	EPBC Act		
Rainforest Cassia *(Senna acclinis)*	Species credit species	E	-	No known plants 10.46 ha of potential habitat in the study area	No known plants to be removed 7.58 ha of habitat removal
Magenta Lilly Pilly *(Syzygium paniculatum)*	Species credit species	E	V	4 plants 10.46 ha of potential habitat in the study area	4 plants to be removed 7.58 ha of habitat removal
Solanum celatum	Species credit species	E	-	No known plants 10.46 ha of potential habitat in the study area	No known plants to be removed 7.58 ha of habitat removal

4.1.4 Aquatic impacts

The proposal will result in the modification of some limited aquatic habitat along two first-order streams. The streams affected by the proposal are in poor condition due to previous development and agricultural activity within their catchments which has resulted in changes to hydrological conditions, increased input of nutrients, sedimentation and weed invasion. As shown in Appendix B, no threatened species listed under the FM Act are likely to occur in these streams due to their poor condition and lack of characteristic habitat features associated with listed species.

The potential impacts of the proposal on aquatic habitats are discussed in Table 4.5 below. Through this analysis it has been concluded that significant impacts to aquatic ecosystems are unlikely to occur as a result of the proposal.

Table 4.5 Potential impacts of the proposal on aquatic habitats

Potential impacts of activities in aquatic habitats	Impact of proposal
Activation of acid sulfate soils and associated acid metal pollution of water	Construction activities such as excavation and land clearing pose a risk to water quality when the activity is carried out in areas of actual or potential acid sulfate soils (ASS). Disturbance and exposure of ASS to oxygen from construction activities could generate sulphuric acid and toxic quantities of aluminium and other heavy metals that could be readily released into the surrounding environment, polluting nearby surface waters and potentially resulting in a loss of aquatic flora and fauna. ASS has been identified as likely to be present in the alluvium on site but actual presence of ASS is to be confirmed through detailed investigations. A detailed CEMP would provide mitigation measures if ASS is encountered during construction. ASS is therefore not considered to be a major risk to the proposal.
Changed hydrology; flow velocity, depth, turbulence, flooding regime	The proposal is likely to result in some changes to factors including flow velocity, depth, turbulence and flooding regimes. The extent of these changes would be controlled through design measures and construction environmental management and would therefore be largely restricted to the proposal footprint and immediate surrounds. Given that these factors are already significantly different from their natural condition and that the changes associated with the proposal are only likely to occur over small areas, the impact of the proposal on hydrology is unlikely to be significant.
Changes in shading regime and temperature	In the short term, the proposal would result in a reduction in shading and an increase in water temperature associated with removal of native and exotic riparian vegetation. This impact would only occur over small areas and is likely to be temporary as native riparian vegetation would be restored to streamside areas where feasible at the completion of the proposal. The impact of the proposal on shading and temperature is therefore unlikely to be significant.
Loss of aquatic habitat	The proposal would result in the loss and modification of a small amount of aquatic habitat. This habitat is already degraded and is only likely to be occupied by common disturbance-tolerant species. This small loss and modification of habitat is unlikely to significantly impact the aquatic ecosystems of the affected streams.
Obstruction to fish passage	The affected streams already contain potential obstructions to fish passage in the form of culverts, are degraded and are only likely to contain disturbance-tolerant fish species such as eels. While the proposal will require structures that may affect fish passage, it is unlikely to significantly change fish movements in the waterways which are already likely to be affected by existing structures.

Potential impacts of activities in aquatic habitats	Impact of proposal
Potential impacts of tannins entering waterways from mulch	Riparian revegetation activities associated with the proposal could result in tannins entering the streams. Given that the streams already appear to be moderately polluted, the ecosystems they contain are unlikely to be very sensitive to a moderate increase in tannins. With the exclusion of mulching from areas likely to be inundated and using alternative materials for soil stabilisation such as rocks and erosion matting, the risk of substantial tannin pollution of the streams would be low.
Temporary displacement of fauna.	The proposal will result in the modification of a small area of habitat where it crosses the two first-order streams. As the streams are highly modified and degraded, their aquatic fauna is likely to consist entirely of common disturbance-tolerant species. These species are unlikely to be significantly affected by the temporary displacement that is likely to occur during construction and during the time-lag between construction and the completion of aquatic habitat restoration in these areas.
Turbidity and sedimentation	Proposal construction activities could result in sediment entering the streams. With the installation of standard sediment controls, the risk of substantial amounts of sediment entering the streams would be low. Small amounts of sediment may enter the streams despite the installation of sediments controls. However, due to the very low flow conditions any sediment is likely to settle almost entirely in the immediate vicinity of the proposal footprint and is unlikely to significantly affect habitat downstream which is already subject to elevated turbidity and sedimentation.

4.1.5 Injury and mortality

Fauna injury or death has the greatest potential to occur during construction when vegetation clearing would occur. The extent of this impact would be proportionate to the extent of vegetation that is cleared. Less mobile species (e.g. ground dwelling reptiles), or those that are nocturnal and nest or roost in trees during the day (e.g. arboreal mammals and microchiropteran bat species), may find it difficult to rapidly move away from the clearing when disturbed. The study area contains a number of hollow dwelling species including Brushtail Possums, Ringtail Possums, Sugar Gliders, and birds that may be injured or killed during vegetation removal. Reptiles and frogs may also be injured or killed during construction as habitat is cleared.

Entrapment of wildlife in any trenches or pits that are dug is a possibility if the trenches are deep and steep sided. Wildlife may also become trapped in or may choose to shelter in machinery that is stored in the study area overnight. If these animals were to remain inside the machinery, or under the wheels or tracks, they may be injured or may die once the machinery is in use.

There is a chance of fauna mortality during the operational phase of the proposal through vehicle collision (i.e. roadkill). Vehicle collision is a direct impact that reduces local population numbers and is a common occurrence in Australia (Coffin, 2007, Rowden et al., 2008). Mammals, reptiles, amphibians and birds are all at risk of vehicle strike, particularly those common species (e.g. macropods) that are tolerant of disturbance and/or those species that can utilise roadways for movement pathways or as foraging habitat. As there are no definitive data on current rates of roadkill or fauna population densities in the study area, the consequences of vehicle strike on local populations is unknown. With the creation of a new road the risk of vehicle strike is introduced but the significance of such an impact cannot be predicted. The impact on threatened species however is expected to be minimal. Based on evidence from other roadways in the locality most vehicle strike impacts can be expected to

occur to common mammals such as birds and possums and exotic animals including foxes. Mitigation measures designed to reduce an injury and mortality of fauna are provided in Section 5.

4.2 Indirect/operational impacts

4.2.1 Wildlife connectivity and habitat fragmentation

Habitat fragmentation *per se* relates to the physical dividing up of once continuous habitats into separate smaller 'fragments' (Fahrig, 2002). The habitats created by fragmentation tend to be smaller and separated from each other by a matrix of less suitable habitats. The new dividing habitat type between fragments is often artificial and less suitable to the species remaining within these newly created fragments (Bennett, 1990, Bennett, 1993, Lindenmayer and Fischer, 2006) or is generally only used by adaptive and aggressive generalist species (e.g. Noisy Miners) which further decreases population levels of other species remaining in the fragments.

The habitats within the study area are fragments that have formed since the initial habitat clearing that occurred with the development of the suburbs of Mt Ousley, Keiraville, Gwynneville and North Wollongong. The current alignment of the M1 Princes Motorway and Mt Ousley Road divides the remaining habitats into four main fragments. The hostile barriers posed by the M1 Princes Motorway and Mt Ousley Road serve to restrict fauna movements between the habitat patches. However, functional habitat connectivity for more mobile species (eg birds, flying-foxes, insectivorous bats, insects, plants) is still present with the escarpment to the west. The current roadways do not totally prevent fauna movement between habitat fragments (fauna can and likely do cross the road) but the roads do create a considerable hazard.

The proposal will not break apart continuous habitats into separate smaller 'fragments'. The proposal will however result in an increase in isolation of habitats as the remaining two habitat patches will be separated by a hostile barrier (i.e. the proposed new interchange) by a distance of approximately 200 metres.

The isolation that may be caused by the proposal is not expected to have an appreciable impact on nomadic or migratory species such as birds. However, opportunities for dispersal may be affected and roadkill may be increased due to the increased road area and traffic that will be moving through areas of once continuous habitat. The habitats contain populations of arboreal mammals including Brushtail Possums, Ringtail Possums and Sugar Gliders. Dispersal of these animals between habitat patches is likely to be hindered by increased habitat isolation. The proposal is considered likely to be detrimental to the dispersal of arboreal mammals and other species including frogs and reptiles.

Reduced connectivity can also lead to crowding effects and increased competition within the remaining habitat patches.

The predicted level of isolation from the proposal is not expected to be enough to prevent the breeding and dispersal of plant pollinators or the dispersal of plant propagules (i.e. seed or other vegetative reproductive material) between habitat patches. Functional connectivity for many species will remain in the study area. However, local division of some wildlife populations, isolation of key habitat resources, loss of genetic interchange, and loss of population viability for some species may result.

4.2.2 Edge effects on adjacent native vegetation and habitat

The development of linear infrastructure is known to cause disturbance in terms of reducing habitat quality in adjacent areas. This is due to the greater potential for edge effects and habitat fragmentation and barrier effects due to the high perimeter to area ratio of linear developments. There is potential for a residual impact to occur to some of the intact habitats within the study area from edge effects.

Edge effects refer to the changes in environmental conditions (e.g. altered light levels, wind speed, temperature) that occur along the edges of habitats. These new environmental conditions along the habitat edges can promote the growth of different vegetation types (including weeds), promote invasion by pest animals specialising in edge habitats, or change the behaviour of resident animals (Moenting and Morris, 2006). Edge zones can be subject to higher levels of predation by introduced mammalian and native avian predators. The distance of edge effect influence can vary, with the extent of edge effects having been recorded greater than 1 km from an edge (Forman et al., 2000) and stopping as little as 50 m from an edge (Bali, 2005).

The proposal will be built in an area that is currently subject to a high level of edge effects from the existing roadways, urban development and the TAFE and university. Some of the vegetation patches near the TAFE are suffering from intense weed invasion from *Lantana camara* that is dominating the shrub layer. The planted vegetation patches along the roadways and in the carparks are edge habitats without any undisturbed core due to their thin linear shape. The edges of the larger vegetation patches are affected by edge effects in the form of weed invasion (primarily grass and herbaceous weeds but also *Lantana camara*), increased light levels, increased wind speeds, and greater temperature fluctuations.

The proposal will remove current edge habitats but will also introduce some new edges where habitats are retained. This may create new areas of vegetation subject to edge effects but as the vegetation in the study area does not possess large core areas of undisturbed habitat the introduction of a new edge will be an impact of low magnitude.

4.2.3 Invasion and spread of weeds

Proliferation of weed and pest species is an indirect impact (i.e. not a direct result of proposal activities). Proliferation of weeds is likely to occur during construction and operation, although impacts will be greatest because of vegetation clearing during the construction phase. The effects of weed invasion may not be experienced immediately or even in the short-term, however, will likely commence a few months after the construction phase commences and gradually increase over months and seasons. This impact has potential to have the greatest impact to the quality and integrity of TECs and threatened species habitat.

Without appropriate management strategies, proposal activities have the potential to disperse weeds into areas of remnant vegetation where weed species are currently limited or in low density. Proposal activities also have the potential to import new weed species into the study area. The most likely causes of weed dispersal and importation associated with the proposal include earthworks, movement of soil, and attachment of seed (and other propagules) to vehicles and machinery during all phases. Weed dispersal by vehicles along roads and access tracks is a key source of weed invasion (Birdsall et al., 2012).

Large expanses of the study area have significant weed growth. Therefore, the potential for habitat modification from weed invasion resulting from the proposal is highest where activities take place in relatively intact areas that exhibit low weed diversity and abundance.

Mitigation measures designed to limit the spread and germination of weeds are provided in Section 5.

4.2.4 Invasion and spread of pests

The study area is currently habitat for a range of pest species, most notably Rusa Deer (*Cervus timorensis*), a deer native to the islands of Java, Bali and Timor in Indonesia. The study area forms part of the home range of a group of Rusa Deer that roam widely throughout the Illawarra escarpment to the west.

Male deer rub trees to remove the felt from their antlers and these behaviours have led to a considerable amount of damage to trees and saplings within the study area. Cast antlers were found in the study area during the field survey and abundant evidence of rutting is present throughout the creek beds and areas of bare ground. The local Rusa Deer population is damaging the vegetation and it is likely that these animals pose a traffic hazard. Deer droppings were commonly recorded at the grassy edge of the M1 Princes Motorway and it is

likely that the deer commonly graze the roadside edges and cross the road to move between habitat patches. It is likely that the proposal will reduce the quality of the habitat in the locality for the deer as the core vegetated area will be reduced and sheltering opportunities will become more limited. As such, the deer may be dispersed out of the study area. The increased road area may also result in deer posing a greater risk to motorists if they are to graze on newly created grassed roadside edges.

Mitigation measures designed to discourage habitat use by deer are provided in Section 5.

Photograph 3 and 4: Evidence of Rusa Deer from the study area including tree damage and cast antler

4.2.5 Invasion and spread of pathogens and disease

Several pathogens known from NSW have potential to affect biodiversity as a result of their movement and infection during construction. Of these, three are listed as a key threatening process under either the EPBC Act and/or TSC Act including:

- Dieback caused by Phytophthora (Root Rot; EPBC Act and TSC Act)
- Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis (EPBC Act and TSC Act)
- Introduction and establishment of exotic Rust Fungi of the order Pucciniales on plants of the family Myrtaceae (TSC Act).

While these pathogens were not observed or tested for in the study area the potential for pathogens to occur should be treated as a risk during construction.

Mitigation measures to deal with the potential introduction and spread of pathogens are provided in Section 6.

4.2.6 Changes to hydrology

The proposal is likely to result in some changes to factors including flow velocity, depth, turbulence and flooding regimes of the two small, ephemerally-flowing first-order streams on the site. The extent of these changes would be controlled through design measures and construction environmental management and would therefore be largely restricted to the proposal footprint and immediate surrounds. Given that these factors are already significantly

different from their natural condition and that the changes associated with the proposal are only likely to occur over small areas, the impact of the proposal on hydrology is unlikely to be significant.

4.2.7 Noise, light and vibration

Noise, light and vibration are direct impacts that are likely to result from proposal activities. These impacts are likely to have cumulative effects. Noise, light and vibration are likely to occur during all phases of the proposal from all activities, although will be greatest where activities take place within the vegetated areas and during construction.

During all phases of the proposal, there will be increased noise and vibration levels in the study area and immediate surrounds due to vegetation clearing, ground disturbance, machinery and vehicle movements, and general human presence. The noise and vibration from activities associated with the proposal will potentially disturb resident fauna and may disrupt foraging, reproductive, or movement behaviours. Some night works would be required during construction and lighting will be installed on the roadside. As such, the immediate area surrounding the construction activities, and the roadside during operation, will be subject to artificial lighting, essentially creating permanent 'daylight' like conditions. Ecological light pollution may potentially affect nocturnal fauna by interrupting their life cycle. Some species (ie light tolerant microchiropteran bats) may benefit from the lighting due to increased food availability (insects attracted to lights) around these areas. Due to the frequency and sustained nature of the lighting, it is unlikely that animals will habituate to the light disturbance.

There will be an impact from noise, light and vibration but the level of noise, vibration and light spill into adjacent habitats during construction and operation cannot be quantified. Works will be undertaken in different areas at different times and it is not known where or when machinery will be located within the site. It is not known how many lights there will be during construction, or where the roadside lighting will be placed.

Mitigation measures to deal with the impacts from noise, light and vibration are provided in Section 6.

4.2.8 Groundwater dependent ecosystems

The plant community types which are found on the site are listed as having a high potential for groundwater interaction in the NSW Department of Water *Groundwater Dependent Ecosystem (GDE) Atlas* (BoM, 2017). The plant community types which are found on the site are classified as groundwater dependent terrestrial ecosystems, do not occur solely in association with waterbodies, are not found on floodplains, in association with springs, swamps or other areas of impeded drainage and are located in areas with high annual rainfall. As discussed in section 3.4, they are likely to be in the Facultative - Opportunistic dependence class of GDEs and are unlikely to be heavily dependent on groundwater.

The small, shallow, ephemerally flowing first-order streams (aquatic ecosystems) of the site appear to be fed by rainfall and surface water flows and are unlikely to be groundwater dependent.

The proposal may cause minor local impacts to groundwater such as slight, localised changes to groundwater depth but it is unlikely to cause significant alteration to groundwater conditions outside of the immediate vicinity of the proposal site. While there may be minor alteration to groundwater conditions in the locality, the proposal is unlikely to result in permanent damage or loss of groundwater dependent ecosystems outside of the proposal footprint.

4.3 Cumulative impacts

The potential biodiversity impacts of the proposal must be considered as a consequence of the construction and operation of the proposal within the existing environment. The proposal would not act alone in causing impacts to biodiversity. The incremental effects of multiple sources of impact (past, present and future) are referred to as cumulative impacts and provide an opportunity to consider the proposal within a strategic context.

The accumulating impacts of historic vegetation clearing for agriculture, urban development, and development and maintenance of infrastructure would likely include continued loss of biodiversity in the region. The study area is situated between two Mitchell Landscapes: the Lake Illawarra Barrier (93% cleared) and the Dapto-Wollongong Coastal Slopes (71% cleared). Both of these landscapes are considered to be over-cleared because of historic activities. Due to the likely expansion of the greater Wollongong urban area via the creation of housing and associated infrastructure, further impacts to biodiversity are likely to result in this region.

Suitable data for a quantitative analysis of cumulative impacts from planned future proposals in the Lake Illawarra Barrier or the Dapto-Wollongong Coastal Slopes is not freely available. However, in the context of historic vegetation removal, any future vegetation clearing no matter how small will result in incremental cumulative impact that will detrimentally affect biodiversity. It has been proposed that when a landscape reaches a vegetation retention threshold of ~30 per cent, most species would be lost from the ecosystem (McAlpine et al. 2002). With only 7 per cent of the original vegetation remaining in the Lake Illawarra Barrier landscape, irreversible damage to the biodiversity of this region has already been done and while the proposal will further contribute to the cumulative impacts in this landscape most species have already been lost. The Dapto-Wollongong Coastal Slopes landscape retains only 29 percent of the original vegetation and may be approaching (or may have already crossed) a threshold where irreversible species lost will occur. The proposal will contribute to the cumulative impacts to this landscape and may result in detrimental impacts to biodiversity.

4.4 Assessments of significance

An Assessment of Significance has been conducted for threatened species that have been positively identified within the study area or that are considered to have a moderate or high likelihood of occurring in the study area due to the presence of suitable habitat. The Assessments of Significance are summarised in the tables below and provided in full in Appendix C.

4.4.1 Environmental Planning and Assessment Act 1979

The EP&A Act requires that a seven-part test be undertaken to assess the likelihood of a significant impact occurring to a threatened species, population or ecological community listed under the TSC Act. The document *Threatened Species Assessment Guidelines: The Assessment of Significance* (Department of Environment and Climate Change, 2007) outlines a set of guidelines to help applicants/proponents of a development or activity with interpreting and applying the factors of assessment in the seven-part test. The guidance provided by the Department of Environment and Climate Change (2007) has been used here in preparing these seven-part tests.

Full details of assessments of significance under the EP&A Act are presented in Appendix C. The conclusions of the EP&A Act assessment are provided in Table 4.6, which indicates that a significant effect is considered unlikely on any threatened species listed under the TSC Act (no threatened ecological communities are present in the study area).

Table 4.6: summary table of the findings of EP&A Act significance assessments.

Species	Status (TSC Act)	Seven-part test questions							Likely Significant Impact	Potential to occur in the Study area and predicted impact
		a	b	c	d	e	f	g		
Rainforest Cassia *(Senna acclinis)*	E	N	X	X	Y	N	N	Y	No	No known plants to be removed 7.58 ha of habitat removal
Magenta Lilly Pilly *(Syzygium paniculatum)*	E	N	X	X	Y	N	N	Y	No	4 plants to be removed 7.58 ha of habitat removal
Solanum celatum	E	N	X	X	Y	N	N	Y	No	No known plants to be removed 7.58 ha of habitat removal
Gang-gang Cockatoo *(Callocephalon fimbriatum)*	V	N	X	X	Y	N	N	Y	No	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Varied Sittella (*Daphoenositta chrysoptera*)	V	N	X	X	Y	N	N	Y	No	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Little Lorikeet (*Glossopsitta pusilla*)	V	N	X	X	Y	N	N	Y	No	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation Removal of 19 hollow bearing trees
Swift Parrot (*Lathamus discolor*)	E	N	X	X	Y	N	N	Y	No	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Powerful Owl (*Ninox strenua*)	V	N	X	X	Y	N	N	Y	No	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation

Species	Status (TSC Act)	Seven-part test questions							Likely Significant Impact	Potential to occur in the Study area and predicted impact
		a	b	c	d	e	f	g		
Little Bent-wing Bat (*Miniopterus australis*)	V	N	X	X	Y	N	N	Y	No	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)	V	N	X	X	Y	N	N	Y	No	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	N	X	X	Y	N	N	Y	No	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation

* Y= Yes (negative impact), N = No (no or positive impact), X = not applicable,

Significance assessment questions

a In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

b In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

c In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

d In relation to the habitat of a threatened species, population or ecological community:

a. the extent to which habitat is likely to be removed or modified as a result of the action proposed

b. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action

c. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

e Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

f Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

g Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

4.4.2 Environment Protection and Biodiversity Conservation Act 1999

For threatened biodiversity listed under the EPBC Act, significance assessments have been completed in accordance with the *Matters of National Environmental Significance, Significant Impact Guidelines 1.1* (Department of the Environment, 2013). The following species were assessed, as they are considered moderately likely to occur based on the presence of suitable foraging habitat:

- Grey-headed Flying-fox (vulnerable)
- Swift Parrot (endangered).

The summary of the EPBC Act assessment of significance are provided in Table 4.7 which indicates that a significant impact is considered unlikely for any Matter of NES and a referral of the proposal would not be required. Full details of the assessment of significance for threatened species under the EPBC Act are presented in Appendix C.

Table 4.7 Summary of EPBC Act assessments of significance

Species/Ecological Community	*Assessment of significance questions (EPBC Act)									Likely Significant Impact	Important Population+
	1	2	3	4	5	6	7	8	9		
Vulnerable species+											
Magenta Lilly Pilly *(Syzygium paniculatum)*	N	N	N	N	N	N	N	N	N	No	No
Greater Glider *(Petauroides volans)*	N	N	N	N	N	N	N	N	N	No	No
Grey-headed Flying-fox *(Pteropus poliocephalus)*	N	N	N	N	N	N	N	N	N	No	No
Critically Endangered species											
Swift Parrot *(Lathamus discolour)*	N	N	N	N	N	N	N	N	N	No	NA

* Assessment of significance questions

1) Lead to a long-term decrease in the size of a population
2) Reduce the area of occupancy of the species
3) Fragment an existing population into two or more populations
4) Adversely affect habitat critical to the survival of a species
5) Disrupt the breeding cycle of a population
6) Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
7) Result in invasive species that are harmful to a species becoming established in the species' habitat
8) Introduce disease that may cause the species to decline
9) Interfere with the recovery of the species.

+ Important population as determined by the EPBC Act is a population of a vulnerable species that:

- is likely to be key source populations either for breeding or dispersal
- is likely to be necessary for maintaining genetic diversity
- is at or near the limit of the species range

4.5 Impact summary

A summary of the predicted ecological impacts from the proposal is provided in Table 4.8.

Table 4.8: Summary of impacts

Impact	Biodiversity values	Nature of impact	Extent of impact	Duration	Does the proposal constitute or exacerbate a key threatening process?	Confidence in assessment
Removal of native vegetation	Native vegetation	Direct Cumulative	PCT 694 = 6.69 ha (0.6% of the mapped local occurrence) PCT 1245 = 0.89 ha (0.04% of the mapped local occurrence)	Long term	• Clearing of native vegetation	Known Irreversible
Removal of threatened fauna habitat	Gang-gang Cockatoo (*Callocephalon fimbriatum*) Varied Sittella (*Daphoenositta chrysoptera*) Little Lorikeet (*Glossopsitta pusilla*) Swift Parrot (*Lathamus discolor*) Powerful Owl (*Ninox strenua*) Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) Little Bentwing-bat (*Miniopterus australis*) Grey-headed Flying-fox (*Pteropus poliocephalus*) Greater Glider (*Petauroides volans*)	Direct Cumulative	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation Removal of 19 hollow bearing trees	Long term	• Clearing of native vegetation • Loss of hollow-bearing trees • Removal of dead wood and dead trees	Known Irreversible

Impact	Biodiversity values	Nature of impact	Extent of impact	Duration	Does the proposal constitute or exacerbate a key threatening process?	Confidence in assessment
Removal of threatened flora habitat	Rainforest Cassia (*Senna acclinis*) Magenta Lilly Pilly (*Syzygium paniculatum*) *Solanum celatum*	Direct Cumulative	Four plants to be removed 7.5 ha of habitat removal	Long term	• Clearing of native vegetation	Known Irreversible
Aquatic impacts	Only common and disturbance-tolerant species (e.g. eels) likely to be affected	Direct Indirect	Minor habitat to be lost at a single stream crossing point. Indirect; minor and temporary modification to areas immediately adjacent to the proposal footprint.	Long term (direct) Short-term (indirect)	No. Threatened aquatic species affected by relevant key threatening processes are unlikely to occur.	Known Reversible
Injury and mortality of fauna	All fauna species present in the habitat	Direct	Unknown. Impact cannot be quantified.	Long term	No	Unpredictable Irreversible
Fragmentation of identified biodiversity links and habitat corridors	All PCTs and flora and fauna species present in the habitat	Direct/ indirect Cumulative	Minimal, but local habitat isolation will be increased	Long term	No	Known Irreversible
Edge effects on adjacent native vegetation and habitat	All PCTs and flora and fauna species present in the habitat	Indirect Cumulative	Minimal as no core habitat is present	Long term	No	Known Irreversible

Impact	Biodiversity values	Nature of impact	Extent of impact	Duration	Does the proposal constitute or exacerbate a key threatening process?	Confidence in assessment
Invasion and spread of weeds	All PCTs and flora and fauna species present in the habitat	Indirect	Without appropriate management strategies, proposal activities have the potential to disperse weeds into areas of remnant vegetation where weed species are currently limited or in low density	Long term	• Invasion and establishment of exotic vines and scramblers • Invasion, establishment and spread of *Lantana camara* • communities by exotic perennial grasses	Unknown Unpredictable
Invasion and spread of pests	All PCTs and flora and fauna species present in the habitat	Indirect	The study area is currently habitat for a range of pest species, most notably Rusa Deer (*Cervus timorensis*). The deer may be dispersed out of the study area. The increased road area may also result in deer posing a greater risk to motorists if they are to graze on newly created grassed roadside edges	Long term	• Herbivory and environmental degradation caused by feral deer • Predation by the European red fox (*Vulpes vulpes*) • Predation by the feral cat (*Felis catus*) • Predation by Plague Minnow or Mosquito Fish *(Gambusia holbrooki*)	Unknown Unpredictable
Invasion and spread of pathogens and disease	All PCTs and flora and fauna species present in the habitat	Indirect	While pathogens were not observed or tested for in the study area the potential for pathogens to occur should be treated as a risk during construction	Long term	• Infection of native plants by *Phytophthora cinnamomi* • Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae • Infection by psittacine circoviral (beak and feather) disease affecting	Unknown Unpredictable

Impact	Biodiversity values	Nature of impact	Extent of impact	Duration	Does the proposal constitute or exacerbate a key threatening process?	Confidence in assessment
					endangered psittacine species and populations • Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	
Groundwater dependent ecosystems	All PCTs and flora and fauna species present in the habitat	Indirect	Minor local impacts to groundwater such as slight, localised changes to groundwater depth; unlikely to cause significant groundwater conditions outside of the immediate vicinity of the proposal site. While there may be minor alteration to groundwater conditions in the locality, the proposal is unlikely to result in permanent damage or loss of groundwater dependent ecosystems outside of the proposal footprint.	Short-term	No	Known Irreversible
Changes to hydrology	All PCTs and flora and fauna species present in the habitat	Direct/ indirect	Changes to factors including flow velocity, depth, turbulence and flooding regime would be largely restricted to the proposal footprint and immediate surrounds. Given that these factors are already significantly different from their natural condition, the impact is unlikely to be significant.	Long-term	No. Threatened aquatic species affected by relevant key threatening processes are unlikely to occur.	Known Irreversible
Noise, light and vibration	All PCTs and flora and fauna species present in the habitat	Direct/ indirect	There will be an impact from noise, light and vibration but the level of noise, vibration and light spill into adjacent habitats during construction and operation cannot be quantified.	Long term	No	Unknown Unpredictable

5 Avoid, minimise and mitigate impacts

In managing biodiversity, Roads and Maritime aims to achieve a balanced outcome, taking account of environmental considerations together with economic and community objectives. This includes a balanced approach to examining the particular environmental consequences of an activity, recognising that achieving an optimal outcome often requires compromise and decisions regarding environmental values. A key part of Roads and Maritime's management of biodiversity for this proposal is the application of the 'avoid, minimise, mitigate and offset' hierarchy.

Roads and Maritime's current approach with respect to biodiversity is:

1. Avoid and minimise impacts as the highest priority
2. Mitigate impacts where avoidance is not feasible or practicable in the particular circumstance
3. Offset where residual, significant unavoidable impacts would occur.

5.1 Avoidance and minimisation

Avoiding environmental impacts as the first step is consistent with the application of the precautionary principle. Roads and Maritime's first priority is to avoid impacts to the environment. This is can be achieved by early consideration of environmental issues from identification of constraints at project inception through to options analysis and selection of a preferred option, design investigation and assessment of the preferred option, detailed design, and implementation of on-ground safeguards during construction and operation and maintenance of the activity. A PEI was undertaken for the proposal in 2015 (Jacobs, 2015). The information contained in the PEI was used to develop design solutions to address the specific needs of the proposal while minimising the potential adverse effects on the community and environment. The opportunities and constraints identified in the PEI were considered during the design development and also informed the investigations for this biodiversity assessment.

The Mt Ousley Preferred Option Report (Roads and Maritime, 2016) was informed by the PEI which ranked the overall sensitivity of the biodiversity constraints within the study area as low, medium or highly sensitive where the interchange is proposed. A smaller footprint for the interchange would result in a lower impact on biodiversity. The preferred option, Option 4, has the second largest footprint of all the interchange options so some minimisation of biodiversity impacts has occurred at the design stage.

The primary method to avoid impacts is to locate activities away from areas of known or potential high biodiversity value. In identifying suitable work sites, the first preference is to locate existing cleared and disturbed areas that have good access, are not within immediate proximity to waterways, and that support good site management practices (for example, management of material stockpiles and location of the primary site compound in a largely cleared area to avoid impacts).

Where it is not possible to avoid impacts the proposal has been designed to minimise impacts where reasonably practicable. This includes provision of retaining walls rather than cut and fill embankments in a number of locations, particularly on the southern side of the extension of Mount Ousley Road to the southern side of the Princes Motorway. Opportunities to further reduce impacts to vegetation will be investigated during detailed design.

5.2 Mitigation measures

Once all practicable steps to avoid or minimise impacts have been implemented at the detailed design phase, mitigation measures would be implemented to lessen the potential ecological impacts of the proposal. Mitigation measures are to be undertaken during the construction and operational phases. The Roads and Maritime guidelines and procedures identify a range of mitigation techniques to be applied, including managing the vegetation clearing process, re-establishment of native vegetation at the end of a project, weed management, provision of

supplementary fauna habitat (such as nest boxes for appropriate species), and installation of erosion and sediment controls as appropriate.

The following mitigation measures as outlined in the *Biodiversity Guidelines: Protecting and managing biodiversity of RTA projects* (NSW Roads and Traffic Authority, 2011) are recommended for implementation (see Table 5.1). The NSW DPI (Fisheries) document *Policy and Guidelines for fish habitat conservation and management (2013 update)* (Department of Primary Industries, 2013) has also been used.

Table 5.1: Mitigation measures

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
Removal of native vegetation	Native vegetation removal will be minimised where reasonably practicable through detailed design.	Detailed design	Effective	The predicted residual impact to native vegetation is estimated at 7.58 ha
	Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Prior to construction	Effective	
	Vegetation removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bushrock* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	
	Native vegetation will be re-established in accordance with *Guide 3: Re-establishment of native vegetation* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Post construction	Effective	
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened ecological communities that have not been assessed in the biodiversity assessment, are identified in the proposal site.	During construction	Proven	
Removal of threatened species habitat and habitat features	Habitat removal will be minimised where reasonably practicable through detailed design.	Detailed design	Effective	The predicted residual impact to threatened species habitat is estimated at 7.58 ha of PCTs and 5.05 ha of planted vegetation
	Habitat removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bushrock* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
	Where required, habitat will be replaced or re-instated in accordance with *Guide 5: Re-use of woody debris and bushrock* and *Guide 8: Nest boxes* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Proven	
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened fauna that have not been assessed in the biodiversity assessment are identified in the proposal site.	During construction	Proven	
Removal of threatened plants	Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Proven	The four *Syzygium paniculatum* plants will be removed.
	Exclusion zones will be set up at the limit of clearing in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Proven	
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened flora species that have not been assessed in the biodiversity assessment are identified in the proposal site. This procedure is important to identify any threatened species that may germinate in disturbed areas during and after construction. *Senna acclinis* and *Solanum celatum* may be present as seed in the soil seed bank and as these species are disturbance specialists, the work areas must be monitored to check whether these species germinate in areas of disturbed soil or topsoil stockpiles.	During construction	Proven	

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
	An option to be considered during detailed design to reduce the impact to the *Syzygium paniculatum* plants within the study area may be to implement a salvage program. Seed could be harvested from the plants to be removed, grown off site in a nursery, and reused in landscaping required for the proposal. This will retain the genetics of these plants in the habitat and will lead to an overall increase in the size of the local population.	Before construction commences	Likely to be effective	
Aquatic impacts	Aquatic habitat will be protected in accordance with *Guide 10: Aquatic habitats and riparian zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) and Section 3.35.2 *Standard precautions and mitigation measures* of the *Policy and guidelines for fish habitat conservation and management Update 2013* (DPI (Fisheries NSW) 2013).	During construction	Effective	Minor, localised, modification to already highly disturbed habitat.
Groundwater dependent ecosystems	Interruptions to water flows associated with groundwater dependent ecosystems will be minimised through detailed design where possible.	Detailed design	Effective	No residual impact likely.
Changes to hydrology	Changes to existing surface water flows will be minimised through detailed design where possible.	Detailed design	Effective	Given that local hydrology is already significantly different from natural conditions, the changes associated unlikely to be significant.
Edge effects on adjacent native vegetation and habitat	Exclusion zones will be set up at the limit of clearing in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	No residual impact is anticipated

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
Injury and mortality of fauna	Fauna will be managed in accordance with *Guide 9: Fauna handling* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	There is potential for injury and mortality of fauna due to the required vegetation clearing. The mitigation measures should be effective but injury or death to fauna may still occur
Invasion and spread of weeds	Weed species will be managed in accordance with *Guide 6: Weed management* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	None as the proposed control measures are known to be effective
Invasion and spread of pests	Design of roadside edges should be done in a manner that reduces potential foraging opportunities for deer (ie limit the amount of grassed areas adjacent to the road). Roads and Maritime will work with the South East Local Land Services Northern Illawarra Wild Deer Management program to determine if the study area is suitable for pre-clearing deer control.	Detailed design During construction	Effective	None as the proposed control measures are known to be effective
Invasion and spread of pathogens and disease	Pathogens will be managed in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	None as the proposed control measures are known to be effective
Noise, light and vibration	Shading and artificial light impacts will be minimised through detailed design where possible.	Detailed design	Effective	Localised impacts from noise and light spill will remain.

6 Offset strategy

6.1 Quantification of impacts

Although efforts have been made to avoid, minimise and mitigate potential ecological impacts from the proposal, some residual impacts would occur. This biodiversity assessment identifies that the proposal is not likely to have a significant impact on any threatened biodiversity listed under the TSC Act or EPBC Act (see Section 4.4 and Appendix C).

Roads and Maritime will provide biodiversity offsets or where offsets are not reasonable or feasible, provide supplementary measures (activities such as funding research, funding conservation management activities as part of the OEH Saving our Species program, or funding vegetation restoration activities in partnership with local landcare groups) for impacts that exceed the following thresholds (see Table 6.1).

The works will involve clearing of nationally listed threatened species habitat (ie habitat for *Syzygium paniculatum* and Grey-headed Flying-fox). As more than 1 ha of habitat in moderate to good condition will be cleared, offsets or supplementary measures must be implemented for the proposal. The Roads and Maritime offset thresholds are outlined below in Table 6.1.

Table 6.1: Roads and Maritime offset thresholds

Description of activity or impact	Consider offsets or supplementary measures
Activities in accordance with Roads and Maritime Services Environmental assessment procedure: Routine and Minor Works (RTA 2011)	No
Works on cleared land, plantations, exotic vegetation where there are no threatened species or habitat present	No
Works involving clearing of vegetation planted as part of a road corridor landscaping program (this includes where threatened species or species comprising listed ecological communities have been used for landscaping purposes)	No
Works involving clearing of national or NSW listed critically endangered ecological communities (CEEC)	Where there is any clearing of an CEEC in moderate to good condition
Works involving clearing of nationally listed threatened ecological community (TEC) or nationally listed threatened species habitat	**Where clearing >1 ha of a TEC or habitat in moderate to good condition**
Works involving clearing of NSW endangered or vulnerable ecological community	Where clearing > 5 ha or where the ecological community is subject to an SIS
Works involving clearing of NSW listed threatened species habitat where the species is a species credit species as defined in the OEH Threatened Species Profile Database (TSPD)	**Where clearing > 1ha or where the species is the subject of an SIS**

Description of activity or impact	Consider offsets or supplementary measures
Works involving clearing of NSW listed threatened species habitat and the species is an ecosystem credit species as defined in OEH's Threatened Species Profile Database (TSPD)	**Where clearing > 5ha or where the species is the subject of an SIS**
Type 1 or Type 2 key fish habitats (as defined by NSW Fisheries)	Where there is any net loss of habitat

The proposal is relatively small in the context of other road and intersection upgrade projects and is not a Major Project. The PCTs that would be removed are not listed as threatened ecological communities under the TSC Act or EPBC Act. As such, the most appropriate form of offset is to use a ratio as outlined in Table 6.2.

According to the Roads and Maritime offset ratios, a suitable offset for the proposal would be a 3:1 ratio for loss of threatened fauna species habitat (see Table 6.2 for Roads and Maritime offset ratios) and loss of threatened flora species. The most appropriate offset would be to focus on the loss of natural habitats rather than planted vegetation. The direct impact to habitat for threatened fauna species is likely to be 7.58 hectares. The direct impact to threatened flora species is loss of four individuals of *Syzygium paniculatum*. This would result in an offset requirement of 22.74 hectares of habitat for the threatened fauna species identified as being impacted by the proposal. For *Syzygium paniculatum*, there is an offset requirement of 16 individuals.

Table 6.2: Roads and Maritime offset ratios

Impact type	Ratio
Loss of threatened ecological community	Offset at a ratio of 4:1 where the offset sites are in moderate to good condition Offset at a ratio of 8:1 where the offset sites are in poor condition including rehabilitation sites
Loss of threatened fauna species	**Offset area of habitat lost at a ratio of 3:1**
Loss of threatened flora species	**Offset individuals lost at a ratio of 3:1**

6.2 Biodiversity offset strategy

The final offset requirement for the proposal will be determined during development of the offset package. During the detailed design phase the proposal footprint may change from that assessed here which would result in a different offset requirement for the proposal than what is presented in this report. A biodiversity offset strategy (BOS) will be prepared prior to works commencing and will have a basic goal of offsetting the residual impacts to threatened fauna habitat and threatened flora species at a 3:1 ratio (see Table 6.3).

Table 6.3: Potential offset targets based on the 3:1 offset ratio

Plant community type (PCT)	Predicted impact (ha)	Potential offset required (ha)
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (694)	6.69	20.07
Sydney Blue Gum x Bangalay – Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (1245)	0.89	2.67
Syzygium paniculatum	4 plants	12 plants

7 Conclusion

There is around 10.46 hectares of native vegetation within the study area belonging to two PCTs:

- Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (694)
- Sydney Blue Gum x Bangalay – Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (1245)

These PCTs are in moderate to good condition. The remainder of the study area is composed of built up areas (roadways, footpaths, houses, carparks, university and TAFE buildings) that contain some areas of planted vegetation and disturbed areas dominated by weed growth.

No threatened ecological communities are present in the study area. However, the study area provides habitat for the threatened plant species *Syzygium paniculatum* and four plants were recorded in the study area.

The study area also provides suitable habitat for a range of threatened species listed under the TSC Act and/or EPBC Act including:

- Rainforest Cassia (*Senna acclinis*)
- *Solanum celatum*
- Gang-gang Cockatoo (*Callocephalon fimbriatum*)
- Varied Sittella (*Daphoenositta chrysoptera*)
- Little Lorikeet (*Glossopsitta pusilla*)
- Swift Parrot (*Lathamus discolor*)
- Powerful Owl (*Ninox strenua*)
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) – recorded in the study area
- Little Bentwing-bat (*Miniopterus australis*) – recorded in the study area
- Grey-headed Flying-fox (*Pteropus poliocephalus*) – recorded in the study area
- Greater Glider (*Petauroides volans*).

The key impacts of the proposal include the removal of 7.58 hectares of native vegetation that provides habitat (or potential habitat) for the species listed above. An additional 5.05 hectares of planted trees will also be removed and these trees may be used by threatened fauna species for foraging. The four *Syzygium paniculatum* plants will be removed.

Fauna injury or death has the greatest potential to occur during construction when vegetation clearing will occur and the extent of this impact will be proportionate to the extent of vegetation that is cleared. Indirect / operational impacts include increased habitat isolation and limited new edge effects. Invasion and spread of weeds, invasion and spread of pests, and invasion and spread of pathogens and disease are a risk with a proposal of this type. Noise, light and vibration will be increased during construction and operation.

The streams affected by the proposal are in poor condition due to previous development and agricultural activity within their catchments, which has resulted in changes to hydrological conditions, increased input of nutrients, sedimentation and weed invasion. No threatened species listed under the FM Act are likely to occur in these streams and significant impacts to aquatic ecosystems are unlikely to occur as a result of the proposal.

The study area is situated between two Mitchell Landscapes: the Lake Illawarra Barrier (93% cleared) and the Dapto-Wollongong Coastal Slopes (71% cleared). Both of these landscapes are considered to be over-cleared because of historic activities. In the context of historic vegetation removal, any future vegetation clearing no matter how small will result in incremental cumulative impact that will detrimentally affect biodiversity. The proposal will contribute to cumulative biodiversity impacts and may result in detrimental impacts to biodiversity.

While some of the questions within the seven-part test indicate that a negative impact may occur (see Appendix C), all factors must be considered and an overall conclusion must be drawn from all factors in combination. The overall outcome of the seven-part tests and EPBC Act assessments of significance (see Appendix C) indicate that there is a high level of certainty that the impacts to threatened species are unlikely to be significant.

Some minimisation of biodiversity impacts has occurred at the design stage with the preparation of the Mt Ousley Preferred Option Report. However, mitigation measures will need to be relied upon to lessen the potential ecological impacts of the proposal. Mitigation measures are to be undertaken during the construction and operational phases. The Roads and Maritime *Biodiversity Guidelines: Protecting and managing biodiversity of RTA projects* (NSW Roads and Traffic Authority, 2011) identify a range of mitigation techniques to be applied and these techniques must be implemented during construction. Of particular relevance to this proposal are the following suggested mitigation measures:

- Exclusion zones will be set up at the limit of clearing in accordance with *Guide 2: Exclusion zones of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).
- The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened flora species, not assessed in the biodiversity assessment, are identified in the proposal site. This procedure is important to identify any threatened species that may germinate in disturbed areas during and after construction. *Senna acclinis* and *Solanum celatum* may be present as seed in the soil seed bank and as these species are disturbance specialists, the work areas must be monitored to check whether these species germinate in areas of disturbed soil or topsoil stockpiles.
- The study area is currently habitat for a range of pest species, most notably Rusa Deer (*Cervus timorensis*). The deer may be dispersed out of the study area. The increased road area may also result in deer posing a greater risk to motorists if they are to graze on newly created grassed roadside edges. Design of roadside edges should be done in a manner that reduces potential foraging opportunities for deer (ie limit the amount of grassed areas adjacent to the road). Roads and Maritime will work with the South East Local Land Services Northern Illawarra Wild Deer Management program to determine if the study area is suitable for pre-clearing deer control.
- An option that can be considered during detailed design to reduce the impact to the *Syzygium paniculatum* plants within the study area may be to implement a salvage program. Seed could be harvested from the plants to be removed, grown off site in a nursery, and reused in landscaping required for the proposal. This will retain the genetics of these plants in the habitat and will lead to an overall increase in the size of the local population.

Although efforts have been made to avoid, minimise and mitigate potential ecological impacts from the proposal, some residual impacts would occur. This biodiversity assessment identifies that the proposal is not likely to have a significant impact on any threatened biodiversity listed under the TSC Act or EPBC Act (see Section 4.4 and Appendix C). It is however Roads and Maritime policy that biodiversity offsets (or where offsets are not reasonable or feasible), supplementary measures be provided for impacts that exceed predetermined thresholds. The works would involve clearing of nationally listed threatened species habitat (ie habitat for *Syzygium paniculatum* and Grey-headed Flying-fox). As more than one hectare of habitat in moderate to good condition would be cleared, offsets or supplementary measures must be implemented for the proposal at a 3:1 ratio. The direct impact to habitat for threatened fauna species is likely to be 7.58 hectares. The direct impact to the threatened plant species *Syzygium paniculatum* is four plants. This would result in an offset requirement of 22.74 hectares of habitat for the threatened fauna species identified as being impacted by the proposal and 12 *Syzygium paniculatum* plants. The final offset requirement for the proposal would be determined during development of the offset package. During the detailed design phase the proposal footprint may change from that assessed here which would result in a different offset requirement for the proposal than what is presented in this report. A biodiversity offset strategy (BOS) would be prepared prior to works commencing.

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Appendix A – Species recorded

Recorded flora in PCT 694 - Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion

Family	Scientific name	Common name	Status		Plot 1		Plot 3		Plot 4		Plot 5		Plot 10	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
ACANTHACEAE	*Pseuderanthemum variable*	Pseuderanthemum			1	3	1	5	3	100	2	20	3	100
ADIANTACEAE	*Adiantum formosum*	Giant Maidenhair Fern											2	10
ANTHERICACEAE	*Chlorophytum comosum*	Chlorophytum									1	1		
APIACEAE	*Centella asiatica*	Swamp Pennywort									2	20		
APOCYNACEAE	*Araujia hortorum*	Moth Vine							1	5	1	1		
APOCYNACEAE	*Marsdenia sp.*				1	2								
APOCYNACEAE	*Marsdenia rostrata*	Common Milk Vine											1	1
APOCYNACEAE	*Parsonsia straminea*	Common Silkpod			1	1	2	15						
APOCYNACEAE	*Tylophora barbata*	Bearded Tylophora			2	20	1	5					1	5
ARACEAE	*Gymnostachys anceps*	Caterpillar Flower			1	1			1	2				
ARALIACEAE	*Hedera helix*	English Ivy							1					
ARALIACEAE	*Polyscias sambucifolia*	Elderberry Panax							1	3				
ARECACEAE	*Archontophoenix cunninghamiana*	Bangalow Palm					1	3						
ARECACEAE	*Livistona australis*	Cabbage Tree Palm											3	1
ASPARAGACEAE	*Asparagus aethiopicus*	Asparagus Fern			3	20	4	100	4	50	1	1	2	10
ASPARAGACEAE	*Asparagus plumosus*	Climbing Asparagus Fern									3	20		
ASPARAGACEAE	*Asparagus scandens*	Asparagus Fern					3	100	5	100			5	100
ASTERACEAE	*Bidens pilosa*	Cobblers Peg									1	1		
ASTERACEAE	*Hypochaeris radicata*	Catsear									1	3		
ASTERACEAE	*Ozothamnus diosmifolius*	Tall Paperdaisy					1	1						
BIGNONIACEAE	*Pandorea pandorana*	Wonga Vine			2	10	2	25	2	100			3	50
BLECHNACEAE	*Doodia aspera*	Prickly Rasp Fern			2	20			2	50				
CAPRIFOLIACEAE	*Lonicera japonica*	Honeysuckle					2	5	3	50				
CASUARINACEAE	*Allocasuarina littoralis*	Black She-oak							2	2				
COMMELINACEAE	*Tradescantia fluminensis*	Wandering Jew							3	50				
CONVOLVULACEAE	*Dichondra repens*	Kidney Weed			1	3	2	50	2	50	2		3	100

Family	Scientific name	Common name	Status		Plot 1		Plot 3		Plot 4		Plot 5		Plot 10	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
CONVOLVULACEAE	*Ipomoea indica*	Blue Morning Glory			1	1					1	1		
CRASSULACEAE	*Crassula multicava*	Crassula			1	10								
CYPERACEAE	*Carex longebrachiata*	Pendulous Tassel-sedge							1	5			1	5
DENNSTAEDTIACEAE	*Pteridium esculentum*	Bracken			1	1								
DILLENIACEAE	*Hibbertia dentata*	Twining Guinea-flower			2	20	3	50						
ERICACEAE	*Leucopogon juniperinus*	Juniper Beard-heath					2	10	1	1				
EUPHORBIACEAE	*Croton verreauxii*	Green Native Cascarilla			1	1					2	5	2	10
FABACEAE-CAESALPINIOIDEAE	*Senna pendula*	Cassia					1	1						
FABACEAE-FABOIDEAE	*Desmodium varians*	Slender Tick-trefoil					1	1						
FABACEAE-FABOIDEAE	*Cytisus scoparius subsp. scoparius*	English Broom					1							
FABACEAE-FABOIDEAE	*Glycine tabacina* agg.										1	1		
FABACEAE-FABOIDEAE	*Kennedia rubicunda*	Dusky Coral Pea					2	10						
FABACEAE-MIMOSOIDEAE	*Acacia binervata*	Two-veined Hickory					3	5	3	1				
FABACEAE-MIMOSOIDEAE	*Acacia longissima*	Thin-leaf Wattle					1	1	1	1				
FABACEAE-MIMOSOIDEAE	*Acacia maidenii*												2	1
GERANIACEAE	*Geranium* sp.	Geranium									1	2		
IRIDACEAE	*Freesia laxa*	Scarlet Freesia									1	1		
LOMANDRACEAE	*Lomandra longifolia* subsp. *longifolia*	Spiny Mat-rush			5	50	2	50	2	5			2	5
LUZURIAGACEAE	*Eustrephus latifolius*	Wombat Berry			2	20	1	15			1	1	1	15
LUZURIAGACEAE	*Geitonoplesium cymosum*	Scrambling Lily			2	20	2	50	2	100	1	1	2	25
MALACEAE	*Cotoneaster glaucophyllus*	Cotoneaster			1	1	1	1						
MALVACEAE	*Sida rhombifolia*	Paddys Lucerene									2	20		
MORACEAE	*Maclura cochinchinensis*	Cockspur Thorn											1	1
MUSACEAE	*Musa* sp.	Banana					1	1						
MYRSINACEAE	*Myrsine variabilis*	Variable Muttonwood			2	5	3	50	2	5			2	5
MYRTACEAE	*Acmena smithii*	Lilly Pilly					1	1	1	1			2	2
MYRTACEAE	*Backhousia myrtifolia*	Grey Myrtle					3	5					1	1
MYRTACEAE	*Eucalyptus bosistoana*	Coast Grey Box							2	2				

Family	Scientific name	Common name	Status		Plot 1		Plot 3		Plot 4		Plot 5		Plot 10	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
MYRTACEAE	*Eucalyptus botryoides*	Bangalay											1	2
MYRTACEAE	*Eucalyptus paniculata*	Grey Ironbark			1	1	3	2	2	2				
MYRTACEAE	*Eucalyptus pilularis*	Blackbutt			5	13	4	5	2	2	4	4	5	13
MYRTACEAE	*Melaleuca styphelioides*	Prickly Paperbark											1	1
MYRTACEAE	*Syncarpia glomulifera*	Turpentine			1	2	3	1	4	5	3	3	2	2
OCHNACEAE	*Ochna serrulata*	Ochna			1	3	1	10	2	5				
OLEACEAE	*Ligustrum lucidum*	Large-leaf Privet					1	1						
OLEACEAE	*Ligustrum sinense*	Small-leaf Privet							2	5				
OLEACEAE	*Notelaea longifolia*	Large Mock Olive					1	1	2	2			3	25
OLEACEAE	*Notelaea ovata*	Broad-leaf Mock Olive			1	1								
OLEACEAE	*Notelaea venosa*	Smooth Mock Olive			1	1	2	2	2	10				
ORCHIDACEAE	*Dipodium punctatum*	Hyacinth Orchid			1	1	1	1			1	1		
OXALIDACEAE	*Oxalis exilis*	Yellow Oxalis					1	1						
OXALIDACEAE	*Oxalis latifolia*	Pink Oxalis							1	1				
OXALIDACEAE	*Oxalis* sp.										1	1		
PASSIFLORACEAE	*Passiflora sp.*										1	1		
PASSIFLORACEAE	*Passiflora subpeltata*	White Passion-flower			1	1			1	5				
PHORMIACEAE	*Dianella caerulea* var. *caerulea*	Leafy Blue Flax Lily			2	20	2	10					2	5
PHYLLANTHACEAE	*Breynia oblongifolia*	Breynia			2	10	3	50	1	1			1	1
PHYLLANTHACEAE	*Glochidion ferdinandi var. ferdinandi*	Cheese Tree											2	10
PITTOSPORACEAE	*Billardiera scandens*	Apple-berry					1	1						
PITTOSPORACEAE	*Pittosporum multiflorum*	Orange Thorn			1	1	2	5						
PITTOSPORACEAE	*Pittosporum revolutum*	Yellow Pittosporum			1	1	1	1						
PITTOSPORACEAE	*Pittosporum undulatum*	Sweet Pittosporum			1	2	2	5	1	1	1	2	2	5
PLANTAGINACEAE	*Plantago lanceolata*	Plantain									2	20		
POACEAE	*Axonopus fissifolius*	Narrow-leaved Carpet Grass									2	20		
POACEAE	*Bromus catharticus*	Prarie Grass									2	20		
POACEAE	*Ehrharta erecta*	Panic Veldtgrass					2	50	2	50	4	20		

Family	Scientific name	Common name	Status		Plot 1		Plot 3		Plot 4		Plot 5		Plot 10	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
POACEAE	*Entolasia marginata*	Margined Panic							2	50				
POACEAE	*Entolasia stricta*	Wiry Panic			2	20	1	5						
POACEAE	*Lolium perenne*	Perennial Ryegrass									2	20		
POACEAE	*Microlaena stipoides* var. *stipoides*	Weeping Grass			1	1	3	100	2	25	2	20		
POACEAE	*Oplismenus aemulus*	Broad-leaf Beard-grass									1	1	1	50
POACEAE	*Oplismenus imbecillis*	Narrow-leaf Beard-grass							1	1				
POACEAE	*Poa labillardieri*	Tussock Grass			1	2							1	5
POLYGALACEAE	*Polygala myrtifolia*	Myrtle Polygala			1	2	2	10						
RANUNCULACEAE	*Clematis glycinoides*	Entire-leaf Clematis					2	25	1	1				
RHAMNACEAE	*Alphitonia excelsa*	Red Ash			1	1								
ROSACEAE	*Rubus parviflorus*	Small-leaf Bramble			1	1							1	5
RUTACEAE	*Zanthoxylum fagara*	Lime Prickly-ash							1	1				
RUTACEAE	*Zieria smithii*	Sandfly Zieria			2	10	3	25						
SAPINDACEAE	*Guioa semiglauca*	Guioa											1	1
SCROPHULARIACEAE	*Veronica plebeia*	Trailing Speedwell									1	1		
SMILACACEAE	*Smilax australis*	Lawyer Vine			1	1								
STERCULIACEAE	*Brachychiton acerifolius*	Illawarra Flame Tree			1	1			2	1				
ULMACEAE	*Celtis chinensis*	Chinese Celtis							1	1				
VERBENACEAE	*Clerodendrum tomentosum*	Hairy Clerodendrum			1	2	2	2			1	1		
VERBENACEAE	*Lantana camara*	Lantana			3	20	1	5	6	100	1	2		
VIOLACEAE	*Viola hederacea*	Ivy-leaf Violet							2	25	1	2	3	100

Recorded flora in PCT 1245 - Sydney Blue Gum x Bangalay – Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion

Family	Scientific name	Common name	Status		Plot 6		Plot 7		Plot 9		Plot 11	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
ACANTHACEAE	*Pseuderanthemum variable*	Pseuderanthemum							2	20	2	20
ADIANTACEAE	*Adiantum formosum*	Giant Maidenhair Fern							2	20	2	20
ADIANTACEAE	*Pellaea falcata* var. *falcata*	Sickle Fern									2	20
APIACEAE	*Cyclospermum leptophyllum*	Slender Celery									1	1
APOCYNACEAE	*Araujia hortorum*	Moth Vine									1	1
APOCYNACEAE	*Parsonsia straminea*	Common Silkpod							2	3	1	2
ARACEAE	*Colocasia esculenta*	Taro							1	1		
ARACEAE	*Gymnostachys anceps*	Caterpiller Flower							1	1	1	1
ARECACEAE	*Livistona australis*	Cabbage Tree Palm			1	1			4	4	1	2
ASPARAGACEAE	*Asparagus aethiopicus*	Asparagus Fern							1	1	1	1
ASPARAGACEAE	*Asparagus scandens*	Asparagus Fern			1	1	1	1	2	20	2	20
ASTELIACEAE	*Cordyline stricta*	Narrow-leaf Palm-lily							1	2		
ASTERACEAE	*Bidens pilosa*	Cobblers Peg					1	1				
ASTERACEAE	*Ozothamnus diosmifolius*	Tall Paperdaisy			1	1						
ASTERACEAE	*Sonchus oleraceus*	Common Sow-thistle									1	1
BASELLACEAE	*Anredera cordifolia*	Madeira Vine			1	1			1	1		
BIGNONIACEAE	*Pandorea pandorana*	Wonga Vine									2	20
BIGNONIACEAE	*Tecoma capensis*	Cape Honeysuckle					4	20				
BLECHNACEAE	*Doodia aspera*	Prickly Rasp-fern							2	20	2	20
CELASTRACEAE	*Elaeodendron australe (syn. Cassine australis* var. *australis*	Red-fruited Olive Plum							1	1	1	4
CELASTRACEAE	*Celastrus australis*	Staff Vine							2	20		
COMMELINACEAE	*Tradescantia fluminensis*	Wandering Jew							4	20	2	20
CONVOLVULACEAE	*Dichondra repens*	Kidney Weed									2	20
CONVOLVULACEAE	*Ipomoea indica*	Blue Morning Glory					3	20				
CYPERACEAE	*Carex longebrachiata*	Pendulous Tassel-sedge									1	2
CYPERACEAE	*Cyperus imbecillis*										2	20
EUPHORBIACEAE	*Claoxylon australe*	Brittle wood							4	5		

Family	Scientific name	Common name	Status		Plot 6		Plot 7		Plot 9		Plot 11	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
EUPHORBIACEAE	*Croton verreauxii*	Green Native Cascarilla							1	1	1	2
EUPHORBIACEAE	*Euphorbia peplus*	Petty Spurge							1	1	1	1
EUPOMATIACEAE	*Eupomatia laurina*	Bolwarra			1	1			2	1	1	6
FABACEAE-CAESALPINIOIDEAE	*Senna pendula*	Cassia			1	1					1	1
FABACEAE-FABOIDEAE	*Erythrina* x *sykesii*	Coral Tree							1	1		
FABACEAE-MIMOSOIDEAE	*Acacia decurrens*	Fine-leaf Green Wattle			1	1						
FABACEAE-MIMOSOIDEAE	*Acacia implexa*	Hickory			1	1						
FABACEAE-MIMOSOIDEAE	*Acacia longifolia subsp. longifolia*	Sydney Golden Wattle			1	1						
FABACEAE-MIMOSOIDEAE	*Acacia maidenii*										1	1
FABACEAE-MIMOSOIDEAE	*Acacia parramattensis*	Sydney Green Wattle			3	20						
FABACEAE-MIMOSOIDEAE	*Pararchidendron pruinosum* var. *pruinosum*	Snow-wood			1	1			1	1		
GLEICHENIACEAE	*Sticherus flabellatus*	Shiny Fan Fern									1	3
LAURACEAE	*Cryptocarya microneura*	Murrogun			1	1						
LINDSAEACEAE	*Lindsaea linearis*	Screw Fern									1	3
LOMANDRACEAE	*Lomandra longifolia* subsp. *longifolia*	Spiny Mat-rush			2	5						
LUZURIAGACEAE	*Eustrephus latifolius*	Wombat Berry							1	1	1	1
LUZURIAGACEAE	*Geitonoplesium cymosum*	Scrambling Lily			1	1					2	20
MELIACEAE	*Melia azedarach*	White Cedar									1	1
MELIACEAE	*Toona ciliata*	Red Cedar									1	1
MENISPERMACEAE	*Stephania japonica*	Snake Vine							1	1		
MONIMIACEAE	*Wilkiea huegeliana*	Wilkiea							2	20		
MORACEAE	*Ficus coronata*	Creek Sandpaper Fig							1	1		
MORACEAE	*Ficus macrophylla*	Moreton Bay Fig									2	1
MORACEAE	*Maclura cochinchinensis*	Cockspur Thorn									1	1
MORACEAE	*Streblus brunonianus*	Whalebone Tree			1		1	1	1	2	1	1
MORACEAE	*Trophis scandens subsp. scandens*	Burny Vine							1	1		
MYRSINACEAE	*Myrsine variabilis*	Variable Muttonwood							2	20	1	1
MYRTACEAE	*Acmena smithii*	Lilly Pilly									2	5

Family	Scientific name	Common name	Status		Plot 6		Plot 7		Plot 9		Plot 11	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
MYRTACEAE	*Backhousia myrtifolia*	Grey Myrtle			1	1						
MYRTACEAE	*Eucalyptus amplifolia*	Cabbage Gum					3	4				
MYRTACEAE	*Eucalyptus botryoides*	Bangalay					2	1			2	2
MYRTACEAE	*Eucalyptus botryoides x saligna*						1	1				
MYRTACEAE	*Eucalyptus pilularis*	Blackbutt									3	1
MYRTACEAE	*Eucalyptus saligna*	Sydney Blue Gum									1	1
MYRTACEAE	*Melaleuca styphelioides*	Prickly Paperbark					1	1	4	6	3	4
MYRTACEAE	*Syncarpia glomulifera*	Turpentine							4	2	1	1
OCHNACEAE	*Ochna serrulata*	Ochna							1	2	1	1
OLEACEAE	*Ligustrum lucidum*	Large-leaf Privet							1	1		
OLEACEAE	*Notelaea longifolia*	Large Mock Olive									2	10
OLEACEAE	*Notelaea venosa*	Smooth Mock Olive			1	2						
OXALIDACEAE	*Oxalis chnoodes*								1	1	2	20
PHORMIACEAE	*Dianella caerulea* var. *caerulea*	Leafy Blue Flax Lily			1	1						
PHYLLANTHACEAE	*Breynia oblongifolia*	Breynia									1	2
PITTOSPORACEAE	*Bursaria spinosa*	Blackthorn			2	10						
PITTOSPORACEAE	*Pittosporum undulatum*	Sweet Pittosporum			1	1					1	2
POACEAE	*Ehrharta erecta*	Panic Veldtgrass			6	100	2	20	2	20	1	1
POACEAE	*Oplismenus aemulus*	Broad-leaf Beard-grass									2	20
POACEAE	*Oplismenus imbecillis*	Narrow-leaf Beard-grass									2	20
POACEAE	*Cenchrus clandestinus (syn. Pennisetum clandestinum*)	Kikuyu					3	20				
RUTACEAE	*Citrus x limonia*	Lemon					1	1				
SAPINDACEAE	*Cardiospermum grandiflorum*	Balloon Vine							2	20		
SAPINDACEAE	*Diploglottis cunninghamii*	Native Tamarind							1	1		
SAPINDACEAE	*Guioa semiglauca*	Guioa			1	3			2	1	2	20
SAPOTACEAE	*Planchonella australis*	Black Apple			1	1					1	2
STERCULIACEAE	*Brachychiton acerifolius*	Illawarra Flame Tree							1	1		

Recorded flora in non PCTs (landscape plantings and weed dominated vegetation)

Family	Scientific name	Common name	Status		Plot 2 – Roadside landscape planting		Plot 8 - – Roadside landscape planting		Plot 12 – Weed dominated vegetation	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance
APOCYNACEAE	*Acokanthera oblongifolia*	Bushman's Poison							1	1
APOCYNACEAE	*Araujia hortorum*	Moth Vine			1	1				
APOCYNACEAE	*Parsonsia straminea*	Common Silkpod			1	1				
ARALIACEAE	*Schefflera actinophylla*	Umbrella Tree			1	1			3	20
ASTERACEAE	*Ageratina adenophora*	Crofton Weed							1	1
ASTERACEAE	*Bidens pilosa*	Cobblers Peg							1	20
ASTERACEAE	*Cosmos* sp.	Cosmoa Daisy							2	20
BIGNONIACEAE	*Jacaranda mimosifolia*	Jacaranda			1	50				
CASUARINACEAE	*Casuarina cunninghamiana*	River Oak					2	2		
CELASTRACEAE	*Celastrus australis*	Staff Vine			1	1				
CONVOLVULACEAE	*Dichondra repens*	Kidney Weed			1	1	1	2		
EUPHORBIACEAE	*Croton verreauxii*	Green Cascarilla							1	20
EUPOMATIACEAE	*Eupomatia laurina*	Bolwarra			2	20			3	20
FABACEAE-FABOIDEAE	*Erythrina cristi-galli*	Cockspur Coral Tree							4	3
FABACEAE-MIMOSOIDEAE	*Acacia implexa*	Hickory			1	1				
FABACEAE-MIMOSOIDEAE	*Acacia linifolia*	Flax-leaf Wattle			1	1				
FABACEAE-MIMOSOIDEAE	*Acacia longifolia subsp. longifolia*	Sydney Golden Wattle			1	1				
FABACEAE-MIMOSOIDEAE	*Acacia longissima*	Thin-leaf Wattle							1	1
FABACEAE-MIMOSOIDEAE	*Pararchidendron pruinosum* var. *pruinosum*	Snow-wood							1	1
LAMIACEAE	*Westringia fruticosa*	Coast Rosemary			1	1				
MELIACEAE	*Melia azedarach*	White Cedar			1	1				
MORACEAE	*Trophis scandens subsp. scandens*	Burny Vine			1	20				
MYRTACEAE	*Corymbia citriodora*	Lemon-scented Gum			1	2				
MYRTACEAE	*Corymbia gummifera*	Red Bloodwood			5	19				
MYRTACEAE	*Corymbia maculata*	Spotted Gum					1	1		
MYRTACEAE	*Eucalyptus amplifolia*	Cabbage Gum					1	1		
MYRTACEAE	*Eucalyptus bosistoana*	Coast Grey Box					1	1		

Family	Scientific name	Common name	Status		Plot 2 – Roadside landscape planting		Plot 8 - – Roadside landscape planting		Plot 12 – Weed dominated vegetation	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance
MYRTACEAE	*Eucalyptus botryoides x saligna*				1	1				
MYRTACEAE	*Eucalyptus crebra*	Narrow-leaf Ironbark			1	1				
MYRTACEAE	*Eucalyptus longifolia*	Woollybutt			3	5				
MYRTACEAE	*Eucalyptus paniculata*	Grey Ironbark			1	1				
MYRTACEAE	*Eucalyptus scoparia*	Wallangarra White Gum			1	1				
MYRTACEAE	*Eucalyptus sideroxylon*	Mugga Ironbark			1	1				
MYRTACEAE	*Leptospermum morrisonii*	Tea-tree			1		2	3		
MYRTACEAE	*Melaleuca styphelioides*	Prickly Paperbark			3	4	1	1		
MYRTACEAE	*Syncarpia glomulifera*	Turpentine			1	1	1	4		
OCHNACEAE	*Ochna serrulata*	Ochna					1	2		
OLEACEAE	*Ligustrum lucidum*	Large-leaf Privet			1	1				
OLEACEAE	*Notelaea longifolia*	Large Mock Olive			1	1				
PASSIFLORACEAE	*Passiflora sp.*				1	1				
PASSIFLORACEAE	*Passiflora subpeltata*	White Passion-flower			1	2				
PHYLLANTHACEAE	*Breynia oblongifolia*	Breynia			1	1				
PITTOSPORACEAE	*Pittosporum multiflorum*	Orange Thorn			1	1				
PITTOSPORACEAE	*Pittosporum revolutum*	Yellow Pittosporum			1	1	1	1		
POLYGALACEAE	*Polygala myrtifolia*	Myrtle Polygala							2	20
PROTEACEAE	*Banksia integrifolia*	Coastal Banksia			1	2				
PROTEACEAE	*Banksia oblongifolia*	Spoon-leaf Banksia			1	1				
PROTEACEAE	*Grevillea robusta*	Silky Oak			1	1				
RHAMNACEAE	*Alphitonia excelsa*	Red Ash							1	1
RUTACEAE	*Zanthoxylum fagara*	Lime Prickly-ash			1	1				
RUTACEAE	*Zieria smithii*	Sandfly Zieria							4	1
SAPINDACEAE	*Alectryon subcinereus*	Native Quince			1	1				
SCROPHULARIACEAE	*Veronica plebia*	Trailing Speedwell							1	2
STERCULIACEAE	*Brachychiton populneus*	Kurrajong							1	1
ULMACEAE	*Celtis chinensis*	Chinese Celtis							1	1

Family	Scientific name	Common name	Status		Plot 2 – Roadside landscape planting		Plot 8 - – Roadside landscape planting		Plot 12 – Weed dominated vegetation	
			TSC Act	EPBC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance
VERBENACEAE	*Clerodendrum tomentosum*	Hairy Clerodendrum			3	20	6	50		
ARECACEAE	*Syagrus romanzoffiana*	Cocos Palm			4	20				
ASPARAGACEAE	*Asparagus aethiopicus*	Asparagus Fern			3	20				
ASPARAGACEAE	*Asparagus plumosus*	Climbing Asparagus Fern							2	20
COMMELINACEAE	*Commelina cyanea*	Scurvy Weed					1	20		
LUZURIAGACEAE	*Eustrephus latifolius*	Wombat Berry			1	1				
MUSACEAE	*Musa* sp.	Banana			1	1				
ORCHIDACEAE	*Dipodium punctatum*	Hyacinth Orchid			2	20				
POACEAE	*Microlaena stipoides* var. *stipoides*	Weeping Grass							1	20
POACEAE	*Oplismenus imbecillis*	Narrow-leaf Beard-grass							4	100

Vegetation condition assessment table

Plant community type (PCT)	Vegetation zone	Condition category	Plot no.	NPS	NOC (%)	NMC (%)	NCG (%)	NCS (%)	NCO (%)	EC (%)	NHT	POR (%)	FL (m)
Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (694)	Zone 1	Moderate / Good	1	34	57	25.5	4	0	34	34	0	1	7
			4	29	50	1	2	0	2	30	2	1	15
			10	31	45	45	16	0	16	20	1	1	25
	Zone 2	Moderate / Good_Medium	3	37	46.5	29.5	4	0	10	52	3	1	1
	Zone 3	Moderate / Good_Other	5	16	59	0.5	14	0	4	18	0	1	0
	Benchmark		BM	23	41-81	15-81	0-15	0-5	2-54	-	2	-	100
Sydney Blue Gum x Bangalay – Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (1245)	Zone 4	Moderate / Good	9	27	39.5	68	0	2	0	14	2	0	30
			11	42	42.5	61	4	0	18	12	2	0	48
	Zone 5	Moderate / Good_Poor	7	5	41.5	4.5	0	0	2	72	1	0	0
	Zone 6	Moderate / Good_Other	6	19	13	8.5	0	0	0	60	0	0	21
	Benchmark		BM	23	41-81	15-81	0-15	0-5	2-54	-	2	-	100

BM = Benchmark
NPS = Native plant species
NOC = Native overstorey cover
NMC = Native midstorey cover
NCG = Native ground cover - grass
NCS = Native ground cover – shrub
NCO = Native ground cover – other
EC = Exotic plant cover
NHT = Number of hollow trees
POR = Proportion of overstorey regeneration
FL = Fallen logs

Recorded fauna

Taxa/Fauna group	Scientific Name	Common name	Status	
			TSC Act	EPBC Act
Amphibians	*Limnodynastes peronii*	Brown-striped Frog		
	Crinia signifera	Common Eastern Froglet		
	Litoria peronii	Peron's Tree Frog		
	Litoria phyllochroa	Leaf-green Tree Frog		
	Litoria tyleri	Tyler's Tree Frog		
Reptiles	*Physignathus lesueurii*	Eastern Water Dragon		
Birds	*Chenonetta jubata*	Australian Wood Duck		
	Falco peregrinus	Peregrine Falcon		
	Vanellus miles	Masked Lapwing		
	Larus novaehollandiae	Silver Gull		
	Cacatua galerita	Sulphur-crested Cockatoo		
	Trichoglossus haematodus	Rainbow Lorikeet		
	Platycercus elegans	Crimson Rosella		
	Platycercus adscitus eximius	Eastern Rosella		
	Cacomantis flabelliformis	Fan-tailed Cuckoo		
	Eudynamys orientalis	Pacific Koel		
	Scythrops novaehollandiae	Channel-billed Cuckoo		
	Podargus strigoides	Tawny Frogmouth		
	Dacelo novaeguineae	Laughing Kookaburra		
	Eurystomus orientalis	Dollarbird		
	Malurus cyaneus	Superb Fairy-wren		
	Pardalotus punctatus	Spotted Pardalote		
	Gerygone olivacea	White-throated Gerygone		
	Acanthiza lineata	Striated Thornbill		
	Acanthiza pusilla	Brown Thornbill		
	Sericornis frontalis	White-browed Scrubwren		
	Meliphaga lewinii	Lewin's Honeyeater		
	Phylidonyris novaehollandiae	New Holland Honeyeater		
	Manorina melanocephala	Noisy Miner		
	Eopsaltria australis	Eastern Yellow Robin		
	Psophodes olivaceus	Eastern Whipbird		
	Rhipidura albiscapa	Grey Fantail		
	Rhipidura leucophrys	Willie Wagtail		
	Grallina cyanoleuca	Magpie-lark		
	Coracina novaehollandiae	Black-faced Cuckoo-shrike		
	Oriolus sagittatus	Olive-backed Oriole		
	Strepera graculina	Pied Currawong		
	Cracticus nigrogularis	Pied Butcherbird		
	Gymnorhina tibicen	Australian Magpie		
	Corvus coronoides	Australian Raven		
	Corvus mellori	Little Raven		
	Ailuroedus crassirostris	Green Catbird		
	Ptilonorhynchus violaceus	Satin Bowerbird		
	Zosterops lateralis	Silvereye		
	Streptopelia chinensis	Spotted Turtle-Dove		
	Pycnonotus jocosus	Red-whiskered Bulbul		
	Turdus merula	Eurasian Blackbird		
	Acridotheres tristis	Indian Myna		
Mammals	*Petaurus breviceps*	Sugar Glider		
	Pseudocheirus peregrinus	Common Ringtail Possum		
	Trichosurus vulpecula	Common Brushtail Possum		
	Pteropus poliocephalus	Grey-headed Flying-fox	V	V

Taxa/Fauna group	Scientific Name	Common name	Status	
			TSC Act	EPBC Act
	Chalinolobus gouldii	Gould's Wattled Bat		
	Miniopterus australis	Little Bentwing-bat	V	
	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	
	Rattus norvegicus	Brown Rat		
	Cervus timorensis	Rusa Deer		
Fish	*Anguilla reinhardtii*	Longfinned Eel		

Appendix B – Habitat assessment table

Likelihood of occurrence criteria

Likelihood	Criteria
Recorded	The species was observed in the study area during the current survey
High	It is highly likely that a species inhabits the study area and is dependent on identified suitable habitat (ie. for breeding or important life cycle periods such as winter flowering resources), has been recorded recently in the locality (10km) and is known or likely to maintain resident populations in the study area. Also includes species known or likely to visit the study area during regular seasonal movements or migration.
Moderate	Potential habitat is present in the study area. Species unlikely to maintain sedentary populations, however may seasonally use resources within the study area opportunistically or during migration. The species is unlikely to be dependent (ie. for breeding or important life cycle periods such as winter flowering resources) on habitat within the study area, or habitat is in a modified or degraded state. Includes cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
Low	It is unlikely that the species inhabits the study area and has not been recorded recently in the locality (10km). It may be an occasional visitor, but habitat similar to the study area is widely distributed in the local area, meaning that the species is not dependent (ie. for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the study area or the species are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
None	Suitable habitat is absent from the study area.

Habitat assessment table - Flora

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
White-flowered Wax Plant (*Cynanchum elegans*)	E	E	Occurs from the Gloucester district to the Wollongong area and inland to Mt Dangar where it grows in rainforest gullies, scrub and scree slopes (Harden, 1992). This species typically occurs at the ecotone between dry subtropical forest/woodland communities.	48 OEH Atlas of NSW Wildlife	Low. Occurs on university land to the west on a rocky slope with rainforest vegetation however, associated habitat is absent from site and the species was not detected during targeted surveys.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Illawarra Irene (*Irenepharsus trypherus*)	E	E	Occurs between Wollongong and the Shoalhaven River where it grows in gullies on the coast and escarpment (Harden, 2000). Specifically it is known to occur within Moist Box-Red foothills forest (NSW National Parks and Wildlife Service, 2003b). It has highly specialised habitat requirements with surveyed sites occupying steep slopes and cliff lines at the ecotone of sclerophyll forest and rainforest.	0 Predicted by BBCC	Low. Broad associated habitat is present in the form of Sydney Blue Gum x Bangalay - Lilly Pilly moist forest, however, the site is more than 15km north of the northern limit of the species' known distribution and at lower elevation than typical habitat for the species. No suitable steep slopes or cliff lines are present in the study area.
Lesser Creeping Fern (*Arthropteris palisotii*)	E	-	Occurs in north-eastern NSW, north from the Comboyne plateau and also in Queensland. This species may be extinct in NSW. It grows in rainforest, mainly on tree trunks (Department of Environment and Conservation, 2005b).	1 OEH Atlas of NSW Wildlife	Low. Associated warm temperate rainforest habitat is absent from the study area and no ferns were observed growing on trees in the study area.
Rainforest Cassia (*Senna acclinis*)	E	-	Occurs in coastal districts and adjacent tablelands of NSW from the Illawarra to Queensland. It grows in or on the edges of subtropical and dry rainforest (Department of Environment and Conservation, 2005b, NSW National Parks and Wildlife Service, 2002c).	2 OEH Atlas of NSW Wildlife	Moderate. In northern NSW, the species occurs in similar vegetation types to those found on the site. The TSPD profile for the species does not specify which vegetation types the species is associated with in the Illawarra. Not recorded during targeted surveys in the study area but could occur on the site as seed in the soil seedbank. Survey timing requirements for the species are; during fruiting (February to March) and where disturbance is less than 15 years previous. Senna acclinis is present on the university land to the west of the study area.
Bearded Bush Pea (*Pultenaea aristata*)	V	V	Occurs from Helensburgh to Mt Keira where it grows in moist dry sclerophyll woodland to heath on sandstone (Harden, 2002). Also grows within upland swamps on the Illawarra Plateau.	99 OEH Atlas of NSW Wildlife	None Species frequently recorded in the locality, however, associated vegetation types are absent from the site.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Bynoe's Wattle (*Acacia bynoeana*)	E	V	Occurs south of Dora Creek-Morisset area to Berrima and the Illawarra region and west to the Blue Mountains. It grows mainly in heath and dry sclerophyll forest on sandy soils (Harden, 2002). Seems to prefer open, sometimes disturbed sites such as trail margins and recently burnt areas. Typically occurs in association with Corymbia gummifera, Eucalyptus haemastoma, E. gummifera, E. parramattensis, E. sclerophylla, Banksia serrata and Angophora bakeri (NSW National Parks and Wildlife Service, 1999a).	1 OEH Atlas of NSW Wildlife PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Allocasuarina glareicola	E	E	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool. Grows in Castlereagh woodland on lateritic soil.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Caladenia tessellata (Thick-lipped Spider-orchid)	E	V	The Thick Lip Spider Orchid is known from the Sydney area (old records), Wyong, Ulladulla and Braidwood in NSW. Populations in Kiama and Queanbeyan are presumed extinct. It was also recorded in the Huskisson area in the 1930s. The species occurs on the coast in Victoria from east of Melbourne to almost the NSW border. Generally found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Leafless Tongue-orchid (*Cryptostylis hunteriana*)		V	The Leafless Tongue Orchid has been recorded from as far north as Gibraltar Range National Park south into Victoria around the coast as far as Orbost. It is known historically from a number of localities on the NSW south coast and has been observed in recent years at many sites between Batemans Bay and Nowra (although it is uncommon at all sites). Also recorded at Munmorah State Conservation Area, Nelson Bay, Wyee, Washpool National Park, Nowendoc State Forest, Ku-Ring-Gai Chase National Park and Ben Boyd National Park. Does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Illawarra Socketwood (*Daphnandra johnsonii*)	E	-	Confined to the Illawarra (below 150 m alt) where it is usually found in subtropical Rainforest mostly on rocky sites along gullies and creeks. Sometimes found in disturbed areas (Harden, 2000) or in moist Eucalypt forest in association with Eucalyptus tereticornis, E. pilularis, E. quadrangulata or Casuarina cunninghamiana (Department of Environment and Conservation, 2004a).	0 Predicted by BBCC	Low. Associated habitat is present (Sydney Blue Gum x Bangalay - Lilly Pilly moist forest), however, the species has not been recorded in the locality and the site is more than 15km north of the northern limit of the species' core area of distribution. It was not recorded during threatened flora surveys.
Yellow Gnat-orchid (*Genoplesium baueri*)	E	E	The species has been recorded from locations between Ulladulla and Port Stephens. About half the records were made before 1960 with most of the older records being from Sydney suburbs including Asquith, Cowan, Gladesville, Longueville and Wahroonga. No collections have been made from those sites in recent years. Currently the species is known from just over 200 plants across 13 sites. The species has been recorded at locations now likely to be within the following conservation reserves: Berowra Valley Regional Park, Royal National Park and Lane Cove National Park. May occur in the Woronora, O'Hares, Metropolitan and Warragamba Catchments. Grows in dry sclerophyll forest and moss gardens over sandstone.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Gossia acmenoides population in the Sydney Basin Bioregion south of the Georges River	EP	-	Known from Shellharbour, Wollongong and Kiama LGAs and encompasses all occurrences south of the Georges River. This population is the southernmost occurrence of the species and is approximately 175 km from the nearest population to the north in the Hunter region of NSW. Found in subtropical and dry rainforest on the ranges and coastal plain of eastern Australia. Estimated less than 100 mature plants, through approximately 30 sites. Occurring often as a single individual or small group.	2 OEH Atlas of NSW Wildlife	Low. Rarely recorded in the locality and associated vegetation types are absent from the site. It was not recorded during threatened flora surveys.
Magenta Lilly Pilly (*Syzygium paniculatum*)	E	V	Occurs between Bulahdelah and St Georges Basin where it grows in subtropical and littoral rainforest on sandy soils or stabilized dunes near the sea (Harden, 2002). On the south coast the Magenta Lilly Pilly occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral (coastal) rainforest. On the central coast Magenta Lilly Pilly occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities.	2 OEH Atlas of NSW Wildlife	Recorded Four *Syzygium paniculatum* plants were found in the study area in three locations.
Hairy Geebung (*Persoonia hirsuta*)	E	E	Occurs in central coast and central tableland districts where it grows in woodland to dry sclerophyll forest on sandstone (Harden, 2002) and rarely shale (NSW Scientific Committee, 1998). Often occurs in areas with clay influence, in the ecotone between shale and sandstone (James, 1997).	1 OEH Atlas of NSW Wildlife	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Illawarra Zieria (*Zieria granulata*)	E	E	Occurs in the Kiama district from Bass Point to Foxground and west to near Albion Park where it grows on dry rocky ridges in sclerophyll forest to rainforest margins (Harden, 2002). Typically it occurs on dry ridge tops and rocky outcrops with shallow volcanic soils. Less frequently found on the moist slopes of the Illawarra escarpment and in low-lying areas on Quaternary sediments. Occurs in a range of communities including Melaleuca armillaris Tall Shrubland, Illawarra Subtropical Rainforest and Illawarra Lowlands Grassy Woodland (Department of Environment and Conservation, 2004d).	2 OEH Atlas of NSW Wildlife	Low. Associated habitat present on site (both PCTs), however, typical dry rocky ridge habitat features are absent from the site.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Solanum celatum	E	-	Restricted to an area from Wollongong to just south of Nowra, and west to Bungonia. Majority of records are prior to 1960 and the majority of populations are likely to have been lost to clearing (Department of Environment and Conservation, 2005b). Grows on hills and slopes in eucalypt woodland; commonly found after fire or disturbance.	0 Predicted by BBCC	Moderate Associated habitat is present on site (both PCTs), however, the species has not been recorded in the locality and the site is more than 7 km north-east of the northern limit of the species' known distribution.Not recorded during targeted surveys but could occur on the site as seed in the soil seedbank and may appear with disturbance.
Wingless Raspwort (*Haloragis exalata subsp. exalata*)	V	V	Square Raspwort occurs in 4 widely scattered localities in eastern NSW. It is disjunctly distributed in the Central Coast, South Coast and North Western Slopes botanical subdivisions of NSW. Square Raspwort appears to require protected and shaded damp situations in riparian habitats. Flowering specimens in NSW are recorded from November to January.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Biconvex Paperbark (*Melaleuca biconvexa*)	V	V	Found only in NSW, with scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north. Generally grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Deane's Paperbark (*Melaleuca deanei*)	V	V	Deane's Paperbark occurs in two distinct areas, in the Ku-ring-gai, Berowra, Holsworthy and Wedderburn areas, and there are also more isolated occurrences at Springwood, Wollemi National Park, Yalwal and the Central Coast areas. The species grows in heath on sandstone.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Omeo Storksbill (*Pelargonium* sp. Striatellum G.W. Carr 10345)	E	E	Known from only 3 locations in NSW, with two on lake-beds on the basalt plains of the Monaro and one at Lake Bathurst. A population at a fourth known site on the Monaro has not been seen in recent years. The only other known population is at Lake Omeo, Victoria. It occurs at altitudes between 680 to 1030 m. It is known to occur in the local government areas of Goulburn-Mulwaree, Cooma-Monaro, and Snowy River, but may occur in other areas with suitable habitat; these may include Bombala, Eurobodalla, Palerang, Tumbarumba, Tumut, Upper Lachlan, and Yass Valley local government areas. It has a narrow habitat that is usually just above the high-water level of irregularly inundated or ephemeral lakes, in the transition zone between surrounding grasslands or pasture and the wetland or aquatic communities. It sometimes colonises exposed lake beds during dry periods.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Needle Geebung (*Persoonia acerosa*)	V	V	The Needle Geebung has been recorded only on the central coast and in the Blue Mountains, from Mt Tomah in the north to as far south as Hill Top where it is now believed to be extinct. Mainly in the Katoomba/ Wentworth Falls/ Springwood area. The Needle Geebung occurs in dry sclerophyll forest, scrubby low-woodland and heath on low fertility soils.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Spiked Rice-flower (*Pimelea spicata*)	E	E	The Spiked Rice-flower occurs in two disjunct areas; the Cumberland Plain (Marayong and Prospect Reservoir south to Narellan and Douglas Park) and the Illawarra (Landsdowne to Shellharbour to northern Kiama). Found on well-structured clay soils.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Illawarra Greenhood (*Pterostylis gibbosa)*	E	E	Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra). It is apparently extinct in western Sydney which is the area where it was first collected (1803). All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage. In the Illawarra region, the species grows in woodland dominated by Forest Red Gum *Eucalyptus tereticornis*, Woollybutt *E. longifolia* and White Feather Honey-myrtle *Melaleuca decora*.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Sydney Plains Greenhood (*Pterostylis saxicola*)	E	E	Restricted to western Sydney between Freemans Reach in the north and Picton in the south. There are very few known populations and they are all very small and isolated. Only one population occurs within a conservation reserve (Georges River National Park). Most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. The vegetation communities above the shelves where Pterostylis saxicola occurs are sclerophyll forest or woodland on shale/sandstone transition soils or shale soils.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Smooth Bush-pea (*Pultenaea glabra*)	V	V	Restricted to the higher Blue Mountains and has been recorded from the Katoomba-Hazelbrook and Mount Victoria areas, with unconfirmed sightings in the Mount Wilson and Mount Irvine areas. All known populations occur within the Blue Mountains Local Government Area. This species is primarily associated with riparian or swamp habitat areas in the mid to upper altitudes of the central Blue Mountains on sandstone derived soils. Grows in swamp margins, hillslopes, gullies and creekbanks and occurs within dry sclerophyll forest and tall damp heath on sandstone.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Kangaloon Sun Orchid (*Thelymitra kangaloonica*)	CE	CE	Thelymitra kangaloonica (Thelymitra sp. Kangaloon) is only known to occur on the southern tablelands of NSW in the Moss Vale / Kangaloon / Fitzroy Falls area. It is found in swamps in sedgelands over grey silty grey loam soils.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.
Austral Toadflax (*Thesium australe*)	V	V	Austral Toad-flax is found in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia. Although originally described from material collected in the SW Sydney area, populations have not been seen in a long time. It may persist in some areas in the broader region. Occurs in grassland on coastal headlands or grassland and grassy woodland away from the coast.	PMST	None. Rarely recorded in the locality and associated vegetation types are absent from the site.

Habitat assessment table - Fauna

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Giant Burrowing Frog (*Heleioporus australiacus*)	V	V	In the northern population there is a marked preference for sandstone ridgetop habitat and broader upland valleys. In these locations, the frog is associated with small headwater creek lines and along slow flowing to intermittent creek lines. The vegetation is typically woodland, open woodland and heath and may be associated with 'hanging swamp' seepage lines and where small pools form from the collected water. They have also been observed occupying artificial ponded structures such as fire dams, gravel 'borrows', detention basins and box drains that have naturalised over time and are still surrounded by other undisturbed habitat. Do not appear to inhabit areas that have been cleared for agriculture or for urban development. Breed in summer and autumn in burrows in the banks of small creeks (Cogger, 2000, NSW National Parks and Wildlife Service, 2001a).	44 OEH Atlas of NSW Wildlife PMST	Low The local area habitat model for this species created by the National Parks and Wildlife Service (2002) was derived from various Upland Swamp and Sandstone Heath and Woodland communities. These communities are widespread above the escarpment but are not present in the study area. The wet sclerophyll forests in the study area are not considered suitable for this species.
Green and Golden Bell Frog (*Litoria aurea*)	E	V	Various types of habitat has been documented. For breeding utilises a wide range of waterbodies, including both natural and man-made structures, such as marshes, dams and stream sides, and ephemeral locations that are more often dry than wet. Is found in various small pockets of habitat in otherwise developed areas and has the tendency of often turning up in highly disturbed sites. Lotic situations such as fast flowing streams appear to be one of the few water bodies not utilised, at least for breeding purposes (Department of Environment and Conservation, 2004b, Department of Environment and Conservation, 2005a).	533 OEH Atlas of NSW Wildlife PMST	Low The local area habitat model for this species created by the National Parks and Wildlife Service (2002) was derived from wetland communities with known recent records plus a 100 metre buffer around records in non-wetland habitats. Moderate quality habitat was generated from other wetland habitats, some of which were known to be suitable in the past. No wetland habitat suitable for the Green and Golden Bell Frog is not present in the study area.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Littlejohn's Tree Frog (*Litoria littlejohni*)	V	V	Distributed along the eastern slopes of the Great Dividing Range from Watagan State Forest near Wyong, south to Buchan in north-eastern Victoria. It appears to be restricted to sandstone woodland and heath communities at mid to high altitude. It forages both in the tree canopy and on the ground, and it has been observed sheltering under rocks on high exposed ridges during summer. It is not known from coastal habitats (NSW Scientific Committee, 2000).	42 OEH Atlas of NSW Wildlife PMST	Low Littlejohn's Tree Frog is known from only thirteen locations. Several of these are from the Plateau region of the Wollongong LGA. Habitat for this species is restricted to the plateau area and the study area does not contain any suitable sandstone woodland or heath communities.
Stuttering Frog (*Mixophyes balbus*)	E	V	Terrestrial species, found in rainforest, Antarctic beech forest or wet sclerophyll forest. The species depends on freshwater streams and riparian vegetation for breeding and habitation. No records are known from riparian habitat that has been disturbed (NSW Scientific Committee, 2003a, Cogger, 2000).	0 Predicted by the BBCC PMST	Low The rainforests and moist eucalypt forests of the Escarpment are high quality habitat for the Stuttering Frog but this species has declined to the point of near extinction in the region. The National Parks and Wildlife Service (2002) developed a habitat model based on Illawarra Escarpment Subtropical Rainforest and Coachwood Warm Temperate Rainforest for this species. No high quality habitat is present in the study area. In the Wollongong area it was once present in rainforest creeks from Helensburgh to Macquarie Pass but it is now only present in Macquarie Pass NP.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Red-crowned Toadlet (*Pseudophryne australis*)	V	-	Occurs within 160 km of Sydney where it is restricted to Hawkesbury Sandstone. It breeds in deep grass and debris adjacent to ephemeral drainage lines. When not breeding individuals are found scattered on sandstone ridges under rocks and logs (Cogger, 2000).	30 OEH Atlas of NSW Wildlife	Low The predictive habitat model developed for the region by National Parks and Wildlife Service (2002) predicted a relatively small area of high quality habitat to be present for the Red-crowned Toadlet on sandstone soils and the Wollongong LGA represents the southern extent of its distribution. No suitable sandstone ridgetop or gully habitat is present in the study area.
Regent Honeyeater (*Anthochaera phrygia*)	CE	CE	Occurs mostly in box-ironbark forests and woodland and prefers the wet, fertile sites such as along creek flats, broad river valleys and foothills. Riparian forests with *Casuarina cunninghamiana* and *Amyema cambagei* are important for feeding and breeding. Important food trees include *Eucalyptus sideroxylon* (Mugga Ironbark), *E. albens* (White Box), *E. melliodora* (Yellow Box) and *E. leucoxylon* (Yellow Gum) (Garnett and Crowley, 2000) with *Eucalyptus robusta* (Swamp Mahogany) and *Corymbia maculata* (Spotted Gum) used in coastal habitats.	1 OEH Atlas of NSW Wildlife PMST	Low The Regent Honeyeater is a rare visitor to the Illawarra with only one recent record from the Wollongong LGA. It is a sporadic visitor to the area and would focus habitat use on the flowering Swamp Mahoganies in winter. No high or moderate quality habitat for the Regent Honeyeater has been modelled in the study area by the National Parks and Wildlife Service (2002).
Cattle Egret (*Ardea ibis*)	-	M	Subspecies *A. i. coromanda* is found across the Indian subcontinent and Asia as far north as Korea and Japan, and in South-east Asia, Papua New Guinea and Australia (McKilligan, 2005).	4 OEH Atlas of NSW Wildlife	None No suitable wetland habitat or grazing paddocks exist in the study area.
Dusky Woodswallow (*Artamus cyanopterus*)	V	-	The Dusky Woodswallow is often reported in woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including regenerating forests; very occasionally in moist forests or rainforests (Higgins and Peter, 2002).	2 OEH Atlas of NSW Wildlife	Low This species is only likely to occur on rare occasions in wet forest such as that present in the study area. It has not been recorded in the built up areas of Wollongong near to the study area.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Australasian Bittern (*Botaurus poiciloptilus*)	V	E	Occurs in shallow, vegetated freshwater or brackish swamps. Requires permanent wetlands with tall dense vegetation, particularly bulrushes and spike rushes. When breeding, pairs are found in areas with a mixture of tall and short sedges but will also feed in territory that is more open. (Garnett and Crowley, 2000, NSW National Parks and Wildlife Service, 2002b).	2 OEH Atlas of NSW Wildlife PMST	None There is no wetland habitat in the study area suitable for the Australasian Bittern.
Gang-gang Cockatoo (*Callocephalon fimbriatum*)	V	-	Occurs in wetter forests and woodland from sea level to an altitude over 2000 metres, timbered foothills and valleys, coastal scrubs, farmlands and suburban gardens (Pizzey and Knight, 1997).	98 OEH Atlas of NSW Wildlife	High The Gang-gang Cockatoo is considered highly likely to utilise the forests habitats in the study area for foraging when the eucalypts are seeding. It is known to use PCT 694 and PCT 1245 as habitat and there are several records of this species from the coastal plain and plateau. This species is considered unlikely to nest in the study area, as it prefers old growth forest and woodland.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Glossy Black-Cockatoo (*Calyptorhynchus lathami*)	V	-	Occurs in eucalypt woodland and forest with Casuarina/Allocasuarina spp. Characteristically inhabits forests on sites with low soil nutrient status, reflecting the distribution of key Allocasuarina species. The drier forest types with intact and less rugged landscapes are preferred by the species. Nests in tree hollows (Garnett and Crowley, 2000, NSW National Parks and Wildlife Service, 1999b).	8 OEH Atlas of NSW Wildlife	Low The Glossy Black-Cockatoo is known to use PCT 694 and PCT 1245 as habitat but in the greater Illawarra area, it is restricted to Black Sheoak (*Allocasuarina littoralis*) forest, mainly on sandstone slopes (National Parks and Wildlife Service, 2002). It is considered a scarce resident in the Illawarra region, with all records to the south or west of Wollongong City Council particularly above the escarpment on the plateau. PCT 694 and PCT 1245 in the study area are not *Allocasuarina* dominant and are considered unlikely to provide habitat for the Glossy Black-Cockatoo.
Spotted Harrier (*Circus assimilis*)	V	-	The Spotted Harrier occurs throughout the Australian mainland in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe (e.g. chenopods) (Marchant and Higgins, 1993). It is found mostly commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands. The diet of the Spotted Harrier includes terrestrial mammals, birds and reptiles, occasionally large insects and rarely carrion.	1 OEH Atlas of NSW Wildlife	Low The Spotted Harrier is generally known to avoid densely forested or wooded habitats such as those wet sclerophyll forests found in the study area. The PCTs present in the study area are not recognised as habitat for this species.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Barred Cuckoo-shrike (*Coracina lineata*)	V	-	Found in a variety of habitats including rainforest, eucalypt forests and woodlands, clearings, swamp woodlands and timber along watercourses. Forages among foliage for insects and fruit (NSW National Parks and Wildlife Service, 2002b).	1 OEH Atlas of NSW Wildlife	Low The Barred Cuckoo-shrike is a rare vagrant to the area and has been recorded in the Wollongong Botanic Gardens and at Thirroul (National Parks and Wildlife Service 2002). Birds occasionally occur south of the usual range and individuals may occur sporadically and infrequently in the study area.
Varied Sittella (*Daphoenositta chrysoptera*)	V	-	The Varied Sittella inhabits most of mainland Australia except the treeless deserts and open grasslands. It inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. The Varied Sittella feeds on arthropods gleaned from crevices in rough or decorticating bark, dead branches, standing dead trees, and from small branches and twigs in the tree canopy. It 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.	2 OEH Atlas of NSW Wildlife	Moderate Associated wet sclerophyll forest habitat occurs on the site. Infrequently recorded in the locality (National Parks and Wildlife Service 2002).
Black-necked Stork (*Ephippiorhynchus asiaticus*)	E	-	Feed in shallow water up to 0.5 m deep on fish, reptiles and frogs. Build nests in trees close to feeding sites (Garnett and Crowley, 2000).	3 OEH Atlas of NSW Wildlife	None Associated habitat absent from site. Only a rare visitor to the locality (National Parks and Wildlife Service 2002).

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
White-fronted Chat (*Epthianura albifrons*)	V	-	the White-fronted Chat occupies foothills and lowlands below 1000 m above sea level (Higgins et al., 2001, Royal Australian Ornithologists Union, 2003). In New South Wales the White-fronted Chat occurs mostly in the southern half of the state, occurring in damp open habitats along the coast, and near waterways in the western part of the state (Higgins et al., 2001). Along the coastline, White-fronted Chats are found predominantly in saltmarsh vegetation although they are also observed in open grasslands and sometimes in low shrubs bordering wetland areas (Higgins et al., 2001, Royal Australian Ornithologists Union, 2003)	1 OEH Atlas of NSW Wildlife	None Associated habitat absent from site.
Latham's Snipe (*Gallinago hardwickii*)	-	M	Occurs in freshwater or brackish wetlands generally near protective vegetation cover. This species feeds on small invertebrates, seeds and vegetation. It migrates to the northern hemisphere to breed (Garnett and Crowley, 2000).	1 OEH Atlas of NSW Wildlife PMST	None Associated habitat absent from site.
Little Lorikeet (*Glossopsitta pusilla*)	V	-	The distribution of the Little Lorikeet extends from just north of Cairns, around the east coast of Australia, to Adelaide. In New South Wales Little Lorikeets are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri (Royal Australian Ornithologists Union, 2003). Little Lorikeets are generally considered to be nomadic (Higgins, 1999) and forage mainly on flowers, nectar and fruit. The breeding biology of Little Lorikeets is little known however studies indicate that nest hollows are located at heights of between 2 m and 15 m, mostly in living, smooth-barked eucalypts, and hollow openings are approximately 3 cm in diameter (Courtney and Debus, 2006).	1 OEH Atlas of NSW Wildlife	Moderate Associated habitat present on site in Blackbutt - Turpentine - Bangalay moist open forest, including possible foraging and breeding habitat.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Painted Honeyeater (*Grantiella picta*)	V	V	Lives in dry forests and woodlands. Primary food is the mistletoes in the genus Amyema, though it will take some nectar and insects. Its breeding distribution is dictated by presence of mistletoes which are largely restricted to older trees. Less likely to be found in in strips of remnant box-ironbark woodlands, such as occur along roadsides and in windbreaks, than in wider blocks (Garnett and Crowley, 2000).	1 OEH Atlas of NSW Wildlife	Low. Associated habitat absent from site. Possible on the site as a vagrant only and unlikely to breed in the locality.
Little Eagle (*Hieraaetus morphnoides*)	V	-	The Little Eagle is distributed throughout the Australian mainland occupying habitats rich in prey within open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used. For nest sites it requires a tall living tree within a remnant patch, where pairs build a large stick nest in winter and lay in early spring. Prey includes birds, reptiles and mammals, with the occasional large insect and carrion. Most of its former native mammalian prey species in inland NSW are extinct and rabbits now form a major part of the diet (Marchant and Higgins, 1993).	5 OEH Atlas of NSW Wildlife	Low. Associated Blackbutt - Turpentine - Bangalay moist open forest habitat present on site but is considered marginal due to urbanisation and lack of ground dwelling mammalian prey species. No large stick nests typical of eagles were found during the survey.
White-throated Needletail (*Hirundapus caudacutus*)	-	M	Occurs in airspace over forests, woodlands, farmlands, plains, lakes, coasts and towns. Breeds in the northern hemisphere and migrates to Australia in October-April (Pizzey and Knight, 1997).	4 OEH Atlas of NSW Wildlife PMST	Moderate. Associated habitat present on site. A migrant that not breed in the locality. Only likely to forage in the aerial spaces above the site.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Black Bittern (*Ixobrychus flavicollis*)	V	-	Usually found in dense vegetation in and fringing streams, swamps, tidal creeks and mudflats, particularly amongst swamp she-oaks and mangroves. Feeds on aquatic fauna along streams, in estuaries and beside billabongs and pools. Breeding occurs in summer in secluded places in densely vegetated wetlands. It nests in trees that overhang the water (NSW National Parks and Wildlife Service, 2002b, Garnett and Crowley, 2000).	7 OEH Atlas of NSW Wildlife	Low. Associated wetland habitat absent from site.
Swift Parrot (*Lathamus discolor*)	CE	E	Breeding occurs in Tasmania, majority migrates to mainland Australia in autumn, over-wintering, particularly in Victoria and central and eastern NSW, but also south-eastern Queensland as far north as Duaringa. Until recently it was believed that in New South Wales, swift parrots forage mostly in the western slopes region along the inland slopes of the Great Dividing Range but are patchily distributed along the north and south coasts including the Sydney region, but new evidence indicates that the forests on the coastal plains from southern to northern NSW are also extremely important. In mainland Australia is semi-nomadic, foraging in flowering eucalypts in eucalypt associations, particularly box-ironbark forests and woodlands (Garnett and Crowley, 2000),(Swift Parrot Recovery Team, 2001).	20 OEH Atlas of NSW Wildlife PMST	Moderate. Marginal habitat associated with the PCTs present in the study area. The National Parks and Wildlife Service (2002) identifies the Swift Parrot as an irregular migrant to the Illawarra escarpment, coastal plain and plateau. There have been records of the Swift Parrot made from the Wollongong University campus in 2002 suggesting this species occasionally utilises the habitats. As such, the Swift Parrot is considered moderately likely to occur within the study area on an infrequent basis based on the presence of suitable foraging habitat and nearby records.
Square-tailed Kite (*Lophoictinia isura*)	V	-	This species hunts primarily over open forest, woodland and mallee communities as well as over adjacent heaths and other low scrubby habitats in wooded towns. It feeds on small birds, their eggs and nestlings as well as insects. Seems to prefer structurally diverse landscapes (Garnett and Crowley, 2000).	7 OEH Atlas of NSW Wildlife	Low. Associated habitat present on site (both PCTs) but this species is recognised as a rare vagrant to the locality and records of this species from Wollongong are considered likely to be of birds migrating to and from breeding sites on the south coast (National Parks and Wildlife Service 2002).

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Orange-bellied Parrot (*Neophema chrysogaster*)	CE	CE	The Orange-bellied Parrot breeds in the south-west of Tasmania and migrates in autumn to spend the winter on the mainland coast of south-eastern South Australia and southern Victoria. On the mainland, the Orange-bellied Parrot spends winter mostly within 3 km of the coast in sheltered coastal habitats including bays, lagoons, estuaries, coastal dunes and saltmarshes. The species also inhabits small islands and peninsulas and occasionally saltworks and golf courses.	PMST	None Associated habitat absent from site.
Turquoise Parrot (*Neophema pulchella*)	V	-	Occurs in the foothills of the great dividing range in eucalypt woodlands and forests with a grassy or sparsely shrubby understorey. Nests in hollows in trees, stumps or even fence posts. It feeds on seeds of both native and introduced grass and herb species (Garnett and Crowley, 2000).	1 OEH Atlas of NSW Wildlife	Low. Associated habitat absent from site. This species is recognised as a rare vagrant to the locality (National Parks and Wildlife Service 2002). The National Parks and Wildlife Service (2002) modelled a large area of habitat for this species on the plateau but the study area is not considered habitat for this species.
Barking Owl (*Ninox connivens*)	V	-	Occurs in dry sclerophyll woodland. In the south west it is often associated with riparian vegetation while in the south east it generally occurs on forest edges. It nests in large hollows in live eucalypts, often near open country. It feeds on insects in the non-breeding season and on birds and mammals in the breeding season (Garnett and Crowley, 2000).	1 OEH Atlas of NSW Wildlife	Low. Marginal habitat present on site (similar PCTs only), including possible foraging habitat; considered suboptimum due to more closed vegetation structure. No large tree hollows, possibly suitable for breeding, were observed. This species is recognised as a scarce resident in the locality although individuals may occur as vagrants (National Parks and Wildlife Service 2002). This species prefers drier habitats.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Powerful Owl (*Ninox strenua*)	V	-	A sedentary species with a home range of approximately 1000 hectares it occurs within open eucalypt, casuarina or Callitris pine forest and woodland. It often roosts in denser vegetation including rainforest of exotic pine plantations. Generally feeds on medium-sized mammals such as possums and gliders but will also eat birds, flying-foxes, rats and insects. Prey are generally hollow dwelling and require a shrub layer and owls are more often found in areas with more old trees and hollows than average stands (Garnett and Crowley, 2000).	25 OEH Atlas of NSW Wildlife	High Associated habitat present on site (both PCTs), including possible foraging habitat with suitable prey species including Ringtail Possum, Brushtail Possum and Sugar Glider. No large tree hollows suitable for breeding were observed. Birds are known to exist nearby in the urban area of Mangerton. The study area is considered likely to fall within the home range of a pair of Powerful Owls.
Blue-billed Duck (*Oxyura australis*)	V	-	Relatively sparse throughout species range. Regularly found breeding in south-east Queensland, north-east South Australia and throughout New South Wales. Found on temperate, fresh to saline, terrestrial wetlands, and occupies artifical wetlands. Prefers deep permanent open water, within or near dense vegetation. Nest in rushes, sedge, Lignum Muehlenbeckia cunnighamii and paperbark Melaleuca (Garnett and Crowley, 2000).	1 OEH Atlas of NSW Wildlife	None Associated habitat absent from site.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Olive Whistler (*Pachycephala olivacea*)	V	-	Distributed from Queensland to South Australia, and occurs across the altitudinal range from coastal to alpine areas. In NSW, found north of the Hunter River, NSW, extending just into the Lamington Plateau in far south-east Queensland. There are isolated populations in the Macpherson Range, New England NP, Mt. Boss and Barrington Tops areas, and possibly in the Gibraltar Range and Walcha-Nundle areas. Occurs in tall wet sclerophyll forest, rainforest, woodland, alpine heaths (Simpson and Day, 1996). In NE NSW, occurs in cool temperate rainforest and cool, moist sclerophyll forest at elevations of >=800 metres asl. Also recorded in warm temperate and sub tropical rainforests. South of Sydney, the species inhabits rainforest, moist eucalypt forest, coastal, moist thickets and mountain scrubs. Microhabitat is areas with a dense, moist understorey (NSW National Parks and Wildlife Service, 1999f).	2 OEH Atlas of NSW Wildlife	Low. Marginal habitat on the site. Not mapped as high quality potential habitat by the National Parks and Wildlife Service (2002). Only likely to be a rare vagrant in the subject site.
Eastern Osprey (*Pandion cristatus*)	V	M	Generally a coastal species, occurring in estuaries, bays, inlets, islands and surrounding waters, coral atolls, reefs, lagoons, rock cliffs and stacks. Sometimes ascends larger rivers to far inland. Builds nests high in tree, on pylon or on ground on islands. Feeds on fish (Pizzey and Knight, 1997).	2 OEH Atlas of NSW Wildlife	None. Associated habitat absent from site.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Scarlet Robin (*Petroica boodang*)	V	-	In NSW, the Scarlet Robin occupies open forests and woodlands from the coast to the inland slopes. Some dispersing birds may appear in autumn or winter on the eastern fringe of the inland plains. It prefers an open understorey of shrubs and grasses and sometimes in open areas. Abundant logs and coarse woody debris are important structural components of its habitat. In autumn and winter it migrates to more open habitats such as grassy open woodland or paddocks with scattered trees. It forages from low perches, feeding on invertebrates taken from the ground, tree trunks, logs and other coarse woody debris (Higgins and Peter, 2002).	1 OEH Atlas of NSW Wildlife	Low. Associated habitat absent from site. This species is considered to be absent, or nearly so, from Wollongong (National Parks and Wildlife Service 2002).
Flame Robin (*Petroica phoenicea*)	V	-	In NSW the Flame Robin breeds in upland moist eucalypt forests and woodlands, often on ridges and slopes, in areas of open understorey. It migrates in winter to more open lowland habitats (Higgins and Peter, 2002). The Flame Robin forages from low perches, feeding on invertebrates taken from the ground, tree trunks, logs and other woody debris. The robin builds an open cup nest of plant fibres and cobweb, which is often near the ground in a sheltered niche, ledge or shallow cavity in a tree, stump or bank.	2 OEH Atlas of NSW Wildlife	Low. Associated habitat absent from site.
Pink Robin (*Petroica rodinogaster*)	V	-	Found in open forest and woodland including native tea-tree scrubs. Rarely found in open cleared areas. Breeds in dense gullies in temperate rainforests (Pizzey and Knight, 1997).	0 Predicted by the BBCC	Low. In the Illawarra it is a rare vagrant but may be expected to occur in forested areas every few years, particularly during Winter dispersal (National Parks and Wildlife Service 2002). It is only a vagrant to the bioregion and no suitable habitat was predicted by the models created by the National Parks and Wildlife Service (2002).

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Regent Parrot (eastern subspecies) (*Polytelis anthopeplus*)	E	V	The eastern subspecies is restricted to areas around the Murray River in South Australia, Victoria and NSW. In NSW it occurs along the Murray River downstream of Tooleybuc (though there are few records between Mildura and the South Australian border), the Wakool River downstream of Kyalite, and the Murrumbidgee River immediately upstream from the junction with the Murray River and adjoining areas of mallee.	1 OEH Atlas of NSW Wildlife	Low. Associated habitat absent from site. Local records are likely to be of aviary escapees.
Superb Parrot (*Polytelis swainsonii*)	V	V	Mainly found in the Riverina where they nest in loose colonies in riparian woodland on River Red Gum. On the inland slopes, Superb Parrots both forage and feed within box woodland, mostly nesting in dead trees (Garnett and Crowley, 2000).	1 OEH Atlas of NSW Wildlife	Low. Associated habitat absent from site. Local records are likely to be of aviary escapees.
Wompoo Fruit-Dove (*Ptilinopus magnificus*)	V	-	Occurs in rainforests, monsoon forests, adjacent eucalypt forests, fruiting trees on scrubby creeks or in open country (Garnett and Crowley, 2000).	2 OEH Atlas of NSW Wildlife	Low. The species is considered to be locally extinct with the last sighting made in the area in 1920 (National Parks and Wildlife Service 2002).
Rose-crowned Fruit-Dove (*Ptilinopus regina*)	V	-	Occurs in subtropical and dry rainforests and occasionally in moist eucalypt forests and swamp forests where fruit is plentiful. They are thought to move locally as they follow the ripening fruit (NSW National Parks and Wildlife Service, 2002b)	2 OEH Atlas of NSW Wildlife	Low. Associated habitat absent from site. The species is a vagrant in the study area with the two records in the Wollongong LGA both being individuals flying into windows (National Parks and Wildlife Service 2002).
Superb Fruit-Dove (*Ptilinopus superbus*)	V	-	Occurs in rainforests and fringes, scrubs, mangroves and wooded stream-margins, lantana thickets, isolated figs, pittosporums, lilly pillies and blackberries (Pizzey and Knight, 1997).	3 OEH Atlas of NSW Wildlife	Low. Associated habitat absent from site. The species is a vagrant in the study area. In the Illawarra, it is a rare nomad with ten records between 1880 and 2000 (National Parks and Wildlife Service 2002).

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Australian Painted snipe (*Rostratula australis*)	E	E	The Australian Painted Snipe is restricted to Australia. Most records are from the south east, particularly the Murray Darling Basin, with scattered records across northern Australia and historical records from around the Perth region in Western Australia. 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.	PMST	Low. Associated habitat absent from site.
Freckled Duck (*Stictonetta naevosa*)	V	-	In most years this species appear to be nomadic between ephemeral inland wetlands. In dry years they congregate on permanent wetlands while in wet years they breed prolifically and disperse widely, generally towards the coast. In inland eastern Australia, they generally occur in brackish to hyposaline wetlands that are densely vegetated with Lignum (Muehlenbeckia cunninghamii) within which they build their nests (Garnett and Crowley, 2000).	1 OEH Atlas of NSW Wildlife	Low. Associated habitat absent from site.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Masked Owl (*Tyto novaehollandiae*)	V	-	Occurs within a diverse range of wooded habitats including forests, remnants and almost treeless inland plains. This species requires large-hollow bearing trees for roosting and nesting and nearby open areas for foraging. They typically prey on terrestrial mammals including rodents and marsupials but will also take other species opportunistically. Also known to occasionally roost and nest in caves (Garnett and Crowley, 2000).	7 OEH Atlas of NSW Wildlife	Low. The Masked Owl is considered a rare resident in the Illawarra but is known to occur above the escarpment in areas of more open woodland. This species has not been recorded in built up areas of the coastal plain since 1969. While the PCTs in the study area are generally recognised as potential habitat for this species, no large trees with hollows >40 cm wide suitable for breeding are present. Combined with the urbanisation of the area and lack of records on the coastal plain since 1969 this species is considered to have a low likelihood of occurrence in the study area.
Sooty Owl (*Tyto tenebricosa*)	V	-	Occurs in wet eucalypt forest and rainforest on fertile soils with tall emergent trees. Typically found in old growth forest with a dense understorey but also occurs in younger forests if nesting trees are present nearby. It nests in large hollows within eucalypts and occasionally caves. It hunts in open and closed forest for a range of arboreal and terrestrial mammals including introduced species and sometimes birds (Garnett and Crowley, 2000).	23 OEH Atlas of NSW Wildlife	Low. The Illawarra is one of the two important areas for Sooty Owls in the Sydney Basin Bioregion (National Parks and Wildlife Service, 2002). These areas of habitat occur along and just above the escarpment and no habitat for this species is modelled in the study area (National Parks and Wildlife Service, 2002). While the PCTs in the study area are generally recognised as potential habitat for this species, no large trees with hollows suitable for breeding are present. Combined with the urbanisation of the area and total absence of records from the coastal plain this species is considered to have a low likelihood of occurrence in the study area.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Eastern Pygmy-possum (*Cercartetus nanus*)	V	-	Found in a range of habitats from rainforest through sclerophyll forest to tree heath. It feeds largely on the nectar and pollen of banksias, eucalypts and bottlebrushes and sometimes soft fruits. It nests in very small tree holes, between the wood and bark of a tree, abandoned birds nests and shredded bark in the fork of trees (Turner and Ward, 1995).	11 OEH Atlas of NSW Wildlife	Low. The heathy areas of habitat above the escarpment are the highest quality habitats for this species in the locality (National Parks and Wildlife Service, 2002). There is no moderate or high quality habitat for this species modelled in the study area. While associated habitat types present on site (both PCTs) these patches of habitat are small and isolated from larger areas of potential habitat.
Large-eared Pied Bat (*Chalinolobus dwyeri*)	V	V	Found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands. It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes. 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. Found in well-timbered areas containing gullies.	PMST	Low. Not recorded during the survey. No roosting habitat is present in the study area and there are no records nearby. Habitat is likely to be limited to the upper escarpment and plateau (see National Parks and Wildlife Service, 2002).

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Spotted-tailed Quoll (*Dasyurus maculatus*)	V	E	Occurs from the Bundaberg area in south-east Queensland, south through NSW to western Victoria and Tasmania. In NSW, it occurs on both sides of the Great Dividing Range and north-east NSW represents a national stronghold (NSW National Parks and Wildlife Service, 1999f). Occurs in wide range of forest types, although appears to prefer moist sclerophyll and rainforest forest types, and riparian habitat. Most common in large unfragmented patches of forest. It has also been recorded from dry sclerophyll forest, open woodland and coastal heathland, and despite its occurrence in riparian areas, it also ranges over dry ridges. Nests in rock caves and hollow logs or trees. Feeds on a variety of prey including birds, terrestrial and arboreal mammals, small macropods, reptiles and arthropods (NSW National Parks and Wildlife Service, 1999d, NSW National Parks and Wildlife Service, 1999f).	3 OEH Atlas of NSW Wildlife	Low. The Spotted-tailed Quoll has been rarely recorded in the Illawarra and appears to occur in the forested catchment lands above and along the escarpment at extremely low densities (National Parks and Wildlife Service, 2002). Associated habitat types present on site (both PCTs); however, the patches of habitat are small and isolated from larger areas of potential habitat. Only possible as an extremely rare vagrant; e.g. during movements associated with juvenile dispersal.
Eastern Quoll (*Dasyurus viverrinus*)	E	E	Not recorded on mainland Australia for many years and possibly extinct outside of Tasmania. Recorded in a variety of habitats including dry sclerophyll forest, scrub, heathland and cultivated land. Lives in dens which consist of several chambers located in underground burrows, hollow logs and rock piles (Strahan, 1995).	3 OEH Atlas of NSW Wildlife	None. Almost certainly extinct in the locality and likely extinct on throughput mainland Australia. Now restricted to Tasmania.
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	V	-	Usually roosts in tree hollows in higher rainfall forests. Sometimes found in caves (Jenolan area) and abandoned buildings. Forages within the canopy of dry sclerophyll forest. It prefers wet habitats where trees are more than 20 metres high (Churchill, 2008)	5 OEH Atlas of NSW Wildlife	Low. Not recorded during the survey. Habitat is likely to be limited to the upper escarpment and plateau (see National Parks and Wildlife Service, 2002).

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Southern Brown Bandicoot (eastern) (*Isoodon obesulus obesulus*)	E	E	The Southern Brown Bandicoot has a patchy distribution. It is found in south-eastern NSW, east of the Great Dividing Range south from the Hawkesbury River, southern coastal Victoria and the Grampian Ranges, south-eastern South Australia, south-west Western Australia and the northern tip of Queensland. They are generally only found in heath or open forest with a heathy understorey on sandy or friable soils.	PMST	Low. There is no suitable habitat for this species in the study area and no records from the locality.
Golden-tipped Bat (*Kerivoula papuensis*)	V	-	Predominantly distributed throughout Indonesia, New Guinea and the Philippines, the species has been observed on the east coast of NSW and Victoria. Prefers moist dense vegetation in coastal forests, near to where wet and dry forests meet and often in the vicinity of creeks. Possibly prefers ecotonal habitats (such as creek lines) for feeding and passage and an ability to manoeuvre in dense vegetation (Strahan, 1995).	Predicted by the BCC	Low. Not recorded during the survey. No roosting habitat is present in the study area and there are no records nearby. Habitat is likely to be limited to the upper escarpment and plateau.
Little Bent-wing Bat (*Miniopterus australis*)	V	-	Feeds on small insects beneath the canopy of well-timbered habitats including rainforest, Melaleuca swamps and dry sclerophyll forests. Roosts in caves and tunnels and has specific requirements for nursery sites. Distribution becomes coastal towards the southern limit of its range in NSW. Nesting sites are in areas where limestone mining is preferred (Strahan, 1995).	1 OEH Atlas of NSW Wildlife	Recorded. Recorded on Anabat during the survey. Predicted to occur in the locality (TPSD). Associated habitat present on site (both PCTs), includes potential foraging habitat only.
Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)	V	-	Usually found in well-timbered valleys where it forages on small insects above the canopy. Roosts in caves, old mines, stormwater channels and sometimes buildings and often return to a particular nursery cave each year (Churchill, 2008)	19 OEH Atlas of NSW Wildlife	Recorded. Recorded on Anabat during the survey. Associated habitat present on site (both PCTs) includes potential foraging habitat only.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Eastern Free-tail bat (*Mormopterus norfolkensis*)	V	-	The Eastern Freetail-bat is found along the east coast from south Queensland to southern NSW. Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roost mainly in tree hollows but will also roost under bark or in man-made structures (Churchill, 2008).	1 OEH Atlas of NSW Wildlife	Low. Not recorded during the survey. No roosting habitat is present in the study area and there are few records nearby. Habitat is likely to be limited to the upper escarpment and plateau (see National Parks and Wildlife Service, 2002).
Southern Myotis (*Myotis macropus*)	V	-	Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface. In NSW females have one young each year usually in November or December.	3 OEH Atlas of NSW Wildlife	Low. Not recorded during the survey. Associated vegetation types present on site (both PCTs), however, they are distant from water bodies and the creek is not sufficiently open to provide a suitable foraging resource. The study area is not considered to be high quality habitat by the National Parks and Wildlife Service (2002).
Greater Glider (*Petauroides volans*)	-	V	The Greater Glider inhabits eucalyptus forests and woodlands as this species feeds exclusively on Eucalyptus buds and leaves. They occupy tree hollows in the day and tree canopies at night (Department of Environment and Climate Change 2007).	PMST	Moderate. Associated habitat types present on site (both PCTs); however, patches of habitat are small and isolated from larger areas of potential habitat. High quality habitat for the species has been modelled in the study area by the National Parks and Wildlife Service (2002).

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Yellow-bellied Glider (*Petaurus australis*)	V	-	Restricted to tall, mature eucalypt forest in high rainfall areas of temperate to sub-tropical eastern Australia. Feeds on nectar, pollen, the sap of eucalypts and sometimes insects. Preferred habitats are productive, tall open sclerophyll forests where mature trees provide shelter and nesting hollows and year round food resources are available from a mixture of eucalypt species (NSW National Parks and Wildlife Service, 1999g, NSW National Parks and Wildlife Service, 2003c).	5 OEH Atlas of NSW Wildlife	Low. This species may exist in very low densities in the catchment areas on the plateau (National Parks and Wildlife Service, 2002). While there is associated habitat present on site (i.e. Blackbutt - Turpentine - Bangalay moist open forest), the patches of habitat are small and isolated from larger areas of potential habitat and it is not known from the coastal plain.
Squirrel Glider (*Petaurus norfolcensis*)	V	-	Found in dry sclerophyll forest and woodland but not found in dense coastal ranges. Nests in hollows and feeds on gum of acacias, eucalypt sap and invertebrates (NSW National Parks and Wildlife Service, 1999e).	Predicted by the BBCC	Low. This species is often difficult to identify from the common Sugar Glider so it may exist in small numbers above the escarpment (National Parks and Wildlife Service, 2002). Associated habitat present on site (Blackbutt - Turpentine - Bangalay moist open forest); however, patches of habitat are small and isolated from larger areas of potential habitat. This species is not known from the coastal pain.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Brush-tailed Rock-wallaby (*Petrogale penicillata*)	E	V	The range of the Brush-tailed Rock-wallaby extends from south-east Queensland to the Grampians in western Victoria, roughly following the line of the Great Dividing Range. However the distribution of the species across its original range has declined significantly in the west and south and has become more fragmented. In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit. Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges, often facing north.	PMST	Low. No suitable habitat for this species is present in the study area.
Koala (*Phascolarctos cinereus*)	V	V	Found in sclerophyll forest. Throughout New South Wales, Koalas have been observed to feed on the leaves of approximately 70 species of eucalypt and 30 non-eucalypt species. However, in any one area, Koalas will feed almost exclusively on a small number of preferred species. The preferred tree species vary widely on a regional and local basis. Some preferred species in NSW include Forest Red Gum Eucalyptus tereticornis, Grey Gum E. punctata, Monkey Gum E. cypellocarpa and Ribbon Gum E. viminalis. In coastal areas, Tallowwood E. microcorys and Swamp Mahogany E. robusta are important food species, while in inland areas White Box E. albens, Bimble Box E. populnea and River Red Gum E. camaldulensis are favoured (NSW National Parks and Wildlife Service, 1999c, NSW National Parks and Wildlife Service, 2003a).	5 OEH Atlas of NSW Wildlife PMST	Low. Associated habitat types present on site (both PCTs); however patches of habitat are small and isolated from larger areas of potential habitat. None of the PCTs in the study area contain primary or secondary feed tree species and as such would not be considered as primary or secondary habitat for the Koala as identified in the recovery plan (Department of Environment and Climate Change, 2008). A habitat model was generated for the locality that suggests that high quality habitat for the species is not present in the Wollongong LGA (National Parks and Wildlife Service, 2002).

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Long-nosed Potoroo (*Potorous tridactylus tridactylus*)	V	V	The long-nosed potoroo is found on the south-eastern coast of Australia, from Queensland to eastern Victoria and Tasmania, including some of the Bass Strait islands. There are 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 760 mm. Inhabits coastal heaths and dry and wet sclerophyll forests. 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.	PMST	Low. There is no suitable habitat for this species in the study area and no records from the locality.
New Holland Mouse (*Pseudomys novaehollandiae*)	-	V	The New Holland Mouse has a fragmented distribution across Tasmania, Victoria, NSW and Queensland. The species is now largely restricted to the coast of central and northern NSW, with one inland occurrence near Parkes. In NSW, the New Holland Mouse is known from: Royal National Park (NP) and the Kangaroo Valley; Kuringgai Chase NP; and Port Stephens to Evans Head near the Queensland border. Across the species' range, the New Holland Mouse is known to inhabit open heathland, open woodland with heathy understorey, and vegetated sand dunes.	PMST	Low. No suitable habitat for this species is present in the study area.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V	Occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps. Urban gardens and cultivated fruit crops also provide habitat for this species. Feeds on the flowers and nectar of eucalypts and native fruits including lilly pillies. It roosts in the branches of large trees in forests or mangroves (NSW National Parks and Wildlife Service, 2001b, Churchill, 2008)	47 OEH Atlas of NSW Wildlife PMST	Recorded. The Grey-headed Flying-fox was recorded flying over the study area during the field survey and temporarily perched on trees within the study area to rest during the flight to the north as the animals left the camp at Figtree. The rainforests and moist eucalypt forests of the Illawarra Escarpment are recognised as high quality habitat for the Grey-headed Flying-fox (NSW National Parks & Wildlife Service, 2002). The habitats provided by the PCT 694 and PCT 1245 within the study area are considered to provide high quality seasonal foraging resource for the Grey-headed Flying-fox due to the dominance of Blackbutt and the tall rainforest sub canopy / midstorey that is composed of species typical of warm temperate and / or subtropical rainforest.
Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)	V	-	Occurs in eucalypt forest where it feeds above the canopy and in mallee or open country where it feeds closer to the ground. Generally a solitary species but sometimes found in colonies of up to 10. It roosts in tree hollows. Thought to be a migratory species (Churchill, 2008).	Predicted by the BBCC	Low. Not recorded during the survey. There are no records nearby. Habitat is likely to be limited to the upper escarpment and plateau (see National Parks and Wildlife Service, 2002).

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	V	-	The preferred hunting areas of this species include tree-lined creeks and the ecotone of woodlands and cleared paddocks but it may also forage in rainforest. Typically it forages at a height of 3-6 metres but may fly as low as one metre above the surface of a creek. It feeds on beetles, other large, slow-flying insects and small vertebrates. It generally roosts in tree hollows but has also been found in the roof spaces of old buildings (Churchill, 2008)	1 OEH Atlas of NSW Wildlife	Low. Not recorded during the survey. Habitat is likely to be limited to the upper escarpment and plateau (see National Parks and Wildlife Service, 2002).
Broad-headed Snake (*Hoplocephalus bungaroides*)	E	V	A nocturnal species that occurs in association with communities occurring on Triassic sandstone within the Sydney Basin. Typically found among exposed sandstone outcrops with vegetation types ranging from woodland to heath. Within these habitats they generally use rock crevices and exfoliating rock during the cooler months and tree hollows during summer (Webb and Shine, 1994, Webb and Shine, 1998).	16 OEH Atlas of NSW Wildlife PMST	None. Suitable habitat is not absent the site. Not mapped as potential habitat in the Wollongong LGA (National Parks and Wildlife Service, 2002).
Rosenberg's Goanna (*Varanus rosenbergi*)	V	-	Found in coastal heaths, humid woodlands, wet and dry sclerophyll forests. Mostly a terrestrial species it shelters in burrows, hollow logs and rock crevices (Cogger, 2000).	16 OEH Atlas of NSW Wildlife	None. Associated habitat absent from site.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Silver Perch (*Bidyanus bidyanus*)	V	CE	Silver perch are endemic to the Murray-Darling system where they show a preference for faster-flowing water, including rapids and races, and more open sections of river. Hatchery-bred silver perch are also stocked out of their range in a number of impoundments on east coast river systems, where they generally fail to reproduce. However, a self-sustaining population of silver perch occurs in Cataract Dam in the Hawkesbury Nepean System. Silver perch are also bred and grown in aquaculture facilities but these cultured fish are not considered meaningful to survival of silver perch in the wild. Similarly, stocked silver perch appear to make little improvement to the conservation situation of wild silver perch.	PMST	None Records of the species in the locality are of fish stocked in impoundments outside of their natural range and the streams of the site are not suitable as habitat.
Black Rockcod (*Epinephelus daemelii*)	V	V	The black cod is a large groper species that generally inhabits near-shore reefs at depths down to 50 m from southern Queensland through NSW to northern Victoria. Small juvenile black cod are often found in coastal rock pools while slightly older juveniles are often found in estuary systems.	PMST	None This species does not occur in freshwater habitats. The streams of the site are not suitable as habitat.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Trout Cod (*Maccullochella macquariensis*)	E	E	The Trout Cod is a riverine species, inhabiting a variety of flowing waters in the mid to upper reaches of rivers and streams. Trout Cod use river positions where large cover, in the form of woody debris and boulders, is present in high quantity, close to deeper water and high surface velocity, further from the river bank. At present only two potentially sustainable populations are known; a naturally occurring population in the Murray River (NSW) downstream of the Yarrawonga Weir between Yarrawonga and Barmah and the translocated population in Seven Creeks below Polly McQuinns Weir (Vic). There have been no recent records in the Murray River downstream from Echuca (NSW, SA), Macquarie River (NSW), Murrumbidgee River (NSW, ACT), and the Goulburn, Broken, Campaspe, Ovens, King, Buffalo and Mitta Mitta Rivers (Vic). The wild populations formerly occurring in these rivers are now probably extinct. Trout Cod and Murray Cod translocated into Cataract Dam (Nepean River NSW) have hybridised, and the cod population existing there is composed largely of hybrids.	PMST	None Records of the species in the locality are of fish stocked in Cataract Dam. This population is outside of the species' natural range and consists largely of Trout Cod/Murray Cod hybrids and is hence of limited value to the species' conservation. The streams of the site are not suitable as habitat.
Murray Cod (*Maccullochella peelii*)	-	V	The Murray Cod occurs naturally in the waterways of the Murray-Darling Basin (ACT, SA, NSW and Vic) and is known to live in a wide range of warm water habitats that range from clear, rocky streams to slow flowing turbid rivers and billabongs. The upper reaches of the Murray and Murrumbidgee Rivers are considered too cold to contain suitable habitat. Some translocated populations exist outside the species' natural distribution in impoundments and waterways in NSW and Vic which are maintained by the release of hatchery bred fish.	PMST	None Records of the species in the locality are of fish stocked in Cataract Dam. This population is outside of the species' natural range, maintained by the release of hatchery bred fish and contains Trout Cod/Murray Cod hybrids. It is hence of limited value to the species' conservation. The streams of the site are not suitable as habitat.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Macquarie Perch (*Macquaria australasica*)	-	E	The Macquarie Perch is a riverine species that prefers clear water and deep, rocky holes with abundant cover cover such as aquatic vegetation, large boulders, debris and overhanging banks. In Victorian parts of the Murray-Darling, only small natural populations remain in the upper reaches of the Mitta Mitta, Ovens, Broken, Campaspe and Goulburn Rivers; translocated populations occur in the Yarra River and Lake Eildon. In NSW, natural inland populations are isolated to the upper reaches of the Lachlan and Murrumbidgee Rivers. Populations of the eastern form are confined to the Hawkesbury-Nepean and Shoalhaven river systems. Translocated populations in NSW are found in the Mongarlowe River, Queanbeyan River upstream of the Googong Reservoir and in Cataract Dam. In the ACT, it is restricted to the Murrumbidgee, Paddys and Cotter River.	PMST Department of Primary Industries Freshwater threatened species distribution maps	None Records of the species in the locality are likely to represent fish of the inland form stocked in Cataract Dam and possibly natural populations of the eastern form of the species. The streams of the site are not suitable as habitat as they lack areas of clear water with deep, rocky holes and abundant cover.
Australian Grayling (*Prototroctes maraena*)	E	V	The Australian Grayling is diadromous, spending part of its lifecycle in freshwater and at least part of the larval and/or juvenile stages in coastal seas. Adults (including pre spawning and spawning adults) inhabit cool, clear, freshwater streams with gravel substrate and areas alternating between pools and riffle zones. The species has also recorded in a muddy-bottomed, heavily silted habitat in the Tarwin River (Victoria). The species has been found over 100 km upstream from the sea. It has been recorded from many rivers across its range, particularly in Tasmania and Victoria. In NSW it is found from the Shoalhaven River south, with important river systems for the species including the Shoalhaven River, Bega River and Clyde River systems.	PMST Department of Primary Industries Freshwater threatened species distribution maps	Low The streams of the site are not suitable as habitat as they lack areas of cool, clear, freshwater with gravel substrate and areas alternating between pools and riffle zones. The site is north of the species' known distribution.

Common Name *(Scientific Name)*	NSW status (TSC Act or FM Act)	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Adam's Emerald Dragonfly (*Archaeophya adamsi*)	E	-	Adam's Emerald Dragonfly larvae inhabit narrow, shaded riffle zones with moss and abundant riparian vegetation (often closed canopy) in small to moderate sized creeks with gravel or sandy bottoms (Primefact). The species' indicative modelled area of potential distribution stretches from the northern Central Coast region to the Illawarra region, south of Wollongong and to the western parts of the Blue Mountains however it is only known from four localities in NSW; Somersby Falls and Floods Creek in Brisbane Waters NP near Gosford; Berowra Creek, Bedford Creek in the Lower Blue Mountain and Hungry Way Creek in Wollemi NP. The species has not been found elsewhere in the Hawkesbury watershed or in the Sydney region, despite active collecting over the last 35 years.	Department of Primary Industries Aquatic threatened species maps and information	Low The streams of the site are not suitable as habitat as they lack areas of shaded riffle zones with moss and abundant riparian with gravel or sandy bottoms. The site is south of the species' known distribution.
Sydney Hawk Dragonfly	E	-	The Sydney Hawk Dragonfly has specific habitat requirements, and has only ever been collected from deep river pools with cooler water and permanent flow. Until recently, it had only been recorded from three locations in a small area south of Sydney, from Audley to Picton. At two of these sites, the Woronora River and Nepean River sites, the species appears to have disappeared leaving the site near Audley as the only locality where there were regular observations of larvae. Extensive dragonfly sampling failed to discover specimens of this species in other locations, suggesting that it has a highly restricted distribution. However recent surveys recorded it north of Sydney and north of the Hunter Valley, extending its known range almost 200 km north.	Department of Primary Industries Aquatic threatened species maps and information	Low The streams of the site are not suitable as habitat as they lack deep pools with cool water and permanent flow. The site is south of the species' known distribution.

Note: This habitat assessment table does not consider habitat for species such as migratory wading birds, marine birds (such as Albatross, Petrels, Terns, Shearwater, Noddy, Frigatebird etc.), Whales, Dolphins, Sharks, Rays, or Turtles as the proposal will not impact on habitat for these species.

Appendix C – Assessments of significance

Assessments of significance have been conducted for species, populations and communities that were recorded in the study area during field surveys or were identified as having a moderate or higher potential to occur in the study area based on the presence of habitat (see Appendix B).

The proposed works will be assessed under Part 5 of the EP&A Act. Section 5A of the EP&A Act requires that a '7 part test' is undertaken to assess the likelihood of significant impact upon threat-listed species, populations or ecological communities listed under the TSC Act. These assessments have been undertaken in accordance with the *Threatened Species Assessment Guidelines: The Assessment of Significance* (Department of Environment and Climate Change, 2007) which outlines a set of guidelines to help applicants/proponents of a development or activity with interpreting and applying the factors of assessment in the 'seven-part test'. The guidance provided by the Department of Environment and Climate Change (2007) has been used here in preparing these 'seven-part tests' and in determining whether there is likely to be a significant effect to a threatened species, population or ecological community listed under the TSC Act.

For threatened biodiversity listed under the EPBC Act, significance assessments have been completed in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment, 2013). Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment that is affected, and upon the intensity, duration, magnitude and geographic extent of the impacts (Department of Environment, 2013). Importantly, for a 'significant impact' to be 'likely', it is not necessary for a significant impact to have a greater than 50 per cent chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility (Department of Environment, 2013).

The ecological communities and species subject to this assessment are outlined in **Table C.1** along with the predicted impact from the proposal.

Table C.1 Threatened biodiversity subject to this assessment

Species	Status		Predicted impact (habitat in ha)
	TSC Act	EPBC Act	
Rainforest Cassia *(Senna acclinis)*	E	-	No known plants to be removed 7.58 ha of habitat removal from PCTs
Magenta Lilly Pilly (Syzygium paniculatum)	E	V	4 plants to be removed 7.58 ha of habitat removal from PCTs
Solanum celatum	E	-	No known plants to be removed 7.58 ha of habitat removal from PCTs
Gang-gang Cockatoo (Callocephalon fimbriatum)	V	-	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Varied Sittella (*Daphoenositta chrysoptera*)	V	-	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation

Species	Status		Predicted impact (habitat in ha)
Little Lorikeet (*Glossopsitta pusilla*)	V	-	7.58 ha of habitat removal from PCTs including 19 hollow-bearing trees some of which may be suitable for breeding 5.05 ha of habitat removal from planted vegetation
Swift Parrot (*Lathamus discolor*)	E	CE	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Powerful Owl (*Ninox strenua*)	V	-	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Little Bent-wing Bat (*Miniopterus australis*)	V	-	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)	V	-	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation
Greater Glider (*Petauroides volans*)	-	V	7.58 ha of habitat removal from PCTs 5.05 ha of habitat removal from planted vegetation

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Senna acclinis (Rainforest Cassia)

One small natural population of *Senna acclinis* exists along with several planted specimens above the statue along the Ken Ausburn Walking track on university land approximately 700 metres to the south west of the study area (Burgess, 2008). The habitat in this area is regenerating PCT 694 (Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion) which is also the dominant habitat type in the study area. Planted specimens are also known to occur throughout an area of bushland on the university campus off Robson Road that has been heavily revegetated. All plants have suffered heavily from grazing by feral deer (Burgess, 2008). The plants along the Ken Ausburn Walking track were inspected as a reference site for this survey in order to familiarise the observers with the characteristics of this species.

No *Senna acclinis* plants were found in the study area during the survey. However, a population of *Senna acclinis* exists near to the study area in similar habitat to that which is present in the study area. *Senna acclinis* has been planted in the bushland on the university grounds by bush regenerators as part of works according to the university Vegetation Management Plan (Burgess, 2008). The habitat is subject to heavy deer grazing which may mean no *Senna acclinis* plants were present above ground in the study area at the time of survey. Due to the presence of suitable habitat in the study area in the form of PCT 694 and PCT 1245 and a known population nearby, this species is considered moderately likely to occur in the study area and may be present as seed in the soil seedbank.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. **in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

Senna acclinis is restricted to the central and northern coastal forests of New South Wales, and Queensland. In New South Wales it is chiefly recorded from subtropical rainforest remnants but is now rare owing to clearing of habitats (Williams, 1998). *Senna acclinis* is often known to occur as a ‘gap phase’ shrub meaning it occurs in disturbed areas where there has been disturbance such as tree fall or past clearing. It is known to grow on the edges of dense vegetation types such as the margins of subtropical, littoral and dry rainforests where there is sufficient sunlight (Office of Environment and Heritage, 2014a). Disturbance appears to be a key component of the lifecycle of *Senna acclinis* and this species has been recorded as establishing (from the soil seedbank) on previously unoccupied sites after the disturbance caused by weed treatment (Lymburner et al., 2006).

Flowering occurs in spring and summer and the fruit is ripe in summer and autumn (Office of Environment and Heritage, 2014a). Although *Senna acclinis* appears to be self-compatible, it is dependent on a pool of pollinators (generally native bees) capable of removing the generally indehiscent pollen through buzz pollination (Williams, 1998). *Senna acclinis* seed dispersal mutualisms are not known but the dry seeds are thought to be dispersed by ants that are unlikely to disperse seeds over large distances but they will potentially disperse seeds to microsites that are advantageous for germination and seedling recruitment (Williams, 1998).

Senna acclinis was not recorded within the study area during the survey. However, suitable habitat for this species is present and there is a known population within 700 metres of the study area. Pollinators such as native bees are likely to be common in the study area due to the presence of native habitat as are seed dispersal vectors such as ants. Therefore, the study area is likely to possess the required pollination and seed dispersal mechanisms for this species to complete its

lifecycle. It is considered moderately likely that *Senna acclinis* is present in the soil-stored seedbank and that the habitat within the study area is not currently conducive to the presence of above ground plants due to the heavy shade cast by the canopy and dense rainforest midstorey that dominates much of the PCTs in the study area.

The proposal will result in disturbance to the potential habitat of *Senna acclinis* within the study area through road construction and associated activities that will result in vegetation removal, soil removal and soil disturbance. The proposal has the potential to impact on the lifecycle of *Senna acclinis* as follows:

- Habitat for insects responsible for pollination and seed dispersal will be removed but substantial habitat for the pollinators and seed dispersers will remain in the study area suggesting that pollination and seed dispersal could continue during and after the proposal is built.
- If *Senna acclinis* is present in the soil seedbank then it is possible that the disturbance created by the vegetation removal and soil disturbance could create suitable conditions for the germination and establishment of *Senna acclinis* at newly created habitat edges. The disturbance may be beneficial for this species. The suitability of the habitat may increase due to the removal of the tree canopy and midstorey layer, which would result in increased light and soil disturbance triggering seed germination.
- If *Senna acclinis* is present in the soil seedbank then it is possible that it would be removed from site with the soil (if the soil were taken off site) and germination of that seed would be prevented.

Overall, as the presence of *Senna acclinis* within the study area is based on likely presence of seed in the topsoil, the lifecycle of this species is not anticipated to be greatly affected by the proposal. Insect pollinators and seed dispersal vectors will remain in the study area after the proposal is built in sufficient numbers to ensure the reproduction of *Senna acclinis* could occur. Any seed that is possibly present in the soil seedbank may be triggered to germinate by vegetation removal and soil disturbance creating suitable edge habitats. The action proposed is not considered likely to have an adverse effect on the life cycle of *Senna acclinis* such that a viable local population of the species is likely to be placed at risk of extinction.

2. in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

3. in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

4. in relation to the habitat of a Threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Approximately 7.58 ha of habitat that is potentially suitable for *Senna acclinis* will be removed by the proposal. This includes approximately 3.23 ha of PCT 694 and approximately 0.13 ha of PCT 1245. The extent of habitat removal for *Senna acclinis* represents approximately 0.6% of similar habitats within the locality. Approximately 1,058 ha of suitable Blackbutt forest habitat is mapped in the locality by Tozer *et al.* (2006). The habitats within the study area are suitably connected to the remaining habitat in the locality (ie distances of less than 500 m between patches) and pollination can be expected to occur between these patches. As such, the local occurrence of suitable habitat is large.

Habitat fragmentation *per se* relates to the physical dividing up of once continuous habitats into separate smaller 'fragments' (Fahrig, 2002). Due to the nature of the proposal, it may potentially result in an increase to landscape scale fragmentation for habitat for *Senna acclinis* due to the design of the new intersection. The current habitat is likely to be divided up into smaller fragments separated by a barrier posed by the new roadways. The roadways between the fragments may be up to 20 metres wide. In insect-pollinated plants, pollen movement, rather than movement of seeds, is generally the main component of gene flow (Ennos, 1994, Fenster, 1991). The foraging range of native solitary bees is up to a few hundred metres (Goulson, 2003) so therefore pollinators may be able to move between the newly created patches and gene flow would be maintained. Nevertheless, habitat fragmentation will occur.

The habitat within the study area may be considered important for *Senna acclinis* as it is at the southernmost limit of this species' range. The habitat where the naturally occurring population is located above the statue along the Ken Ausburn Walking track on university land approximately 700 metres to the south west of the study area is important for this species in the locality. If *Senna acclinis* is present in the study area, the habitat would be important for the long-term survival of the species in the locality.

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable, as no critical habitat has been listed for *Senna acclinis*.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Senna acclinis does not have a recovery plan. However, a targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. *Senna acclinis* has been assigned to the Site-managed species management stream under the OEH Saving our Species program. The OEH has established six management sites where conservation activities need to take place to ensure the conservation of this species which include:

- Toonumbar National Park (Kyogle)
- Afterlee (Kyogle)
- Bundagen Headland (Coffs Harbour)
- Brinerville (Bellingen)
- Stockyard Creek (Nambucca)
- Hallidays Point (Greater Taree).

These sites are not near the study area and will not be affected by the proposal.

7. whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

A KTP is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present, there are currently 38 listed KTPs. Of

the 38 listed KTPs under the TSC Act, the only KTP relevant to *Senna acclinis* that would be increased by the proposal is clearing of native vegetation.

Conclusion

No *Senna acclinis* plants were found in the study area during the survey. However, one small natural population of *Senna acclinis* exists along with several planted specimens above the statue along the Ken Ausburn Walking track on university land approximately 700 metres to the south west of the study area. The habitat in this area is regenerating PCT 694, which is also the dominant habitat type in the study area. The habitat in the study area is subject to heavy deer grazing which may mean no *Senna acclinis* plants were present above ground in the study area at the time of survey. Due to the presence of suitable habitat in the study area in the form of PCT 694 and PCT 1245 and a known population nearby, this species is considered moderately likely to occur in the study area and may be present as seed in the soil seedbank

The impacts of the proposal to *Senna acclinis* would be limited to loss of some potentially suitable habitat. Seed from this species may be stored in the soil seedbank and this could be lost due to the proposal. The main points of consideration are as follows:

- Habitat for insects responsible for pollination and seed dispersal will be removed but substantial habitat for the pollinators and seed dispersers will remain in the study area suggesting that pollination and seed dispersal could continue during and after the proposal is built. If *Senna acclinis* is present in the soil seedbank then it is possible that the disturbance created by the vegetation removal and soil disturbance could create suitable conditions for the germination and establishment of *Senna acclinis* at newly created habitat edges. The disturbance created by the proposal may create positive conditions for germination of *Senna acclinis*.
- The extent of habitat removal for *Senna acclinis* represents approximately 0.6% of similar habitats within the locality.
- The proposal may potentially result in an increase to landscape scale fragmentation for habitat for *Senna acclinis* due to the design of the new intersection but gene exchange may still occur between newly created patches.
- The habitat within the study area may be considered important for *Senna acclinis* in the locality as it is at the southernmost limit of this species' range.
- No critical habitat will be affected.
- The proposal would not interfere with the management sites identified for the recovery of *Senna acclinis*.
- The only KTP relevant to *Senna acclinis* that would be increased by the proposal is clearing of native vegetation but the proposal will not contribute to any of the other key threats to this species.

After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant effect to *Senna acclinis*.

Syzygium paniculatum (Magenta Lilly Pilly)

Four *Syzygium paniculatum* plants were found in the study area in three locations. Three of the plants are located within bushland and one plant is located in a revegetated area near the arrester bed, off Dumfries Avenue. It is unlikely that these plants were planted in the study area. If this species were a part of the revegetation program near the arrester bed, there would likely be more than one plant in this area. The location of the other three plants within natural bushland, and the low numbers of this species, suggests that these plants have established naturally and were not planted as part of a landscaping plan or bush regeneration program. It is plausible that the *Syzygium paniculatum* plants within the study area have established naturally without human intervention through seed dispersal by native animals.

It is uncertain but plausible that these plants are part of a naturally occurring population. Planted individuals of threatened species, located within their natural range and habitat, may have also have conservation value. The value of such planted individuals to the conservation of a naturally-

occurring population of a species would be influenced by a variety of factors, particularly the origin of the material used to propagate them and the life cycle characteristics of the species.

So, with application of the precautionary principle, the *Syzygium paniculatum* plants within the study area are considered to be part of a local population of the species for the purposes of this assessment and to warrant actions to avoid or reduce harm from the project.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The local population

The known total Australian population of wild *Syzygium paniculatum* is estimated to be approximately 1,200 plants (with an estimated population size for mature individuals in the range of 760-1,900). These plants are distributed along a 400 kilometre stretch of coastal NSW between Upper Lansdowne in the north to Conjola National Park in the south (NSW Office of Environment and Heritage, 2012). Within the Australian population, occurrences of *Syzygium paniculatum* are disjunct and five metapopulations (in this case geographically separated components of the population) have been identified. The five metapopulations have been identified based on the assumption of an approximately 30 kilometre foraging range for the species' larger potential dispersal agents (eg Grey-headed Flying-fox and White-headed Pigeon) (NSW Office of Environment and Heritage, 2012). The five metapopulations include Jervis Bay; Coalcliff; Botany Bay; Central Coast; and Karuah-Manning. These include 43 known subpopulations, in addition to six unconfirmed records in the Sydney Basin Bioregion. The Coalcliff metapopulation consists of ten plants and is the closest to the study area, located approximately 20 kilometres to the north (the study area is within the range of species responsible for seed dispersal). It is plausible that the *Syzygium paniculatum* plants within the study area may have been dispersed from Coalcliff and that the plants in the study area may form part of the Coalcliff metapopulation.

Syzygium paniculatum is also a popular horticultural plant and is often used as an ornamental landscape planting in urban areas. Planted *Syzygium paniculatum* trees are present throughout the greater Wollongong region. The Wollongong Botanic Gardens contains some very large mature *Syzygium paniculatum* trees (over 30 metres tall) and *Syzygium paniculatum* has been extensively planted in the garden beds in and around the University of Wollongong grounds (author's personal observation). Therefore, the study area is adjacent to a potential source of seed from mature *Syzygium paniculatum* plants. Birds and the Grey-headed Flying-fox are likely to feed on the fruit produced by the planted trees and may disperse the seed into adjacent bushland. Therefore, the occurrence of the four *Syzygium paniculatum* plants within the study area may have resulted from seed dispersal from these planted specimens. Although the seed may have originated from planted trees, the seed dispersal and consequent establishment of the plants in the study area would have occurred without human intervention and may be considered natural.

The presence of *Syzygium paniculatum* within the study area is most likely a result of natural seed dispersal and establishment without human intervention. The seed may have originated from the Coalcliff site (20 kilometres to the north of the study area) or may have originated from planted trees from the Wollongong Botanic Garden or University of Wollongong grounds. The planted *Syzygium paniculatum* trees in the region and the Coalcliff plants are likely to interact due to their proximity. Birds and flying-foxes are likely to forage on the trees indiscriminately and are capable of dispersing seed whether the plants are naturally occurring or planted. For the purposes of this assessment, the plants in the study area are assumed to have become established from seed dispersal and are considered to be naturally occurring irrespective of the origin of the seed.

It is likely that the Coalcliff metapopulation is larger than is currently known and may consist of many smaller separated occurrences spread along the Illawarra escarpment in addition to the plants at Coalcliff. There are likely to be some small outlying subpopulations of *Syzygium*

paniculatum dispersed along the Illawarra escarpment that have originated from the Coalcliff plants or from planted trees. There may also be interaction between planted *Syzygium paniculatum* trees and the Coalcliff metapopulation. Large areas of potentially suitable habitats in the form of rainforest (subtropical, warm-temperate, and littoral; coastal sand forest; and wet sclerophyll forest with extensive rainforest midstorey along creek lines with alluvial soils, are present within 30 kilometres of the Coalcliff metapopulation along the lower Illawarra escarpment. In addition to the four plants within the study area, there are valid records of *Syzygium paniculatum* from Farmborough Heights, Mount Kembla, Mount Keira, Austinmer, Wombarra, and the Royal National Park (Lady Carrington Bower) (see Figure 1). These records are all within a 30-kilometre distance of the Coalcliff site. It is likely that small occurrences of *Syzygium paniculatum* occur throughout the habitats on the lower Illawarra escarpment in an interconnected 'local population'.

The 'local population' of *Syzygium paniculatum* for the purposes of this assessment is considered to be all plants known and likely to occur along the lower Illawarra escarpment within 30 kilometres of the study area. As it is unknown whether the plants in the study area have originated from the Coalcliff site or from nearby planted trees, all occurrences of this species are considered to be part of the 'local population' as there is likely to be some interaction between planted trees and the trees at the Coalcliff site. The 'local population' includes the four plants within the study area, the ten known plants at Coalcliff, and all plants at Farmborough Heights, Mount Kembla, Mount Keira, Austinmer, Wombarra, and the Royal National Park (Lady Carrington Bower). The 'local population' would include a minimum of 20 individuals but when planted trees are taken into account, including the plants in the Wollongong Botanic Garden and University of Wollongong grounds the 'local population' is likely to be greater than 100 plants.

Life cycle

Syzygium paniculatum has a generalised pollination strategy, exhibiting the ability to self-pollinate and to outcross. However, this species has a strong inclination to self-pollinate resulting in very low genetic diversity within and between metapopulations (Thurlby, 2010). A large number of individuals have identical genotypes (genetic make-ups) (Thurlby et al., 2012). From a study of 79 adult plants from 11 different subpopulations there were only nine genotypes found (Thurlby et al., 2012). Of the nine known genotypes, 72% of individuals across six of the subpopulations possessed an identical genotype (Thurlby et al., 2012). The plants within the study area are likely to possess an identical genotype.

Pollination would most likely be aided by visits to flowers by nectar and pollen-feeding vertebrates and invertebrates (eg flying-foxes, possums, honeyeaters, lorikeets, introduced and native bees, beetles, moths and butterflies) (NSW Office of Environment and Heritage, 2012). The seed is contained within a succulent berry, which quickly breaks down after the fruit has ripened. The life expectancy of seed is thought to be less than three months so it is therefore unlikely that *Syzygium paniculatum* populations support lasting soil seed banks (NSW Office of Environment and Heritage, 2012). Dispersal of seeds is likely to be achieved through several agents including water (particularly in riparian habitats subject to periodic flooding), gravity, and animals which feed on the fruits of the species (eg White-headed Pigeon, Pied Currawong, and Grey-headed Flying Fox) (NSW Office of Environment and Heritage, 2012). It is likely that other fruit-eating birds and small native mammals also consume the fruit. Pollinators are abundant in the locality due to the presence of suitable habitat as are seed dispersal vectors. A camp of Grey-headed Flying-fox is present nearby and the animals regularly frequent the habitat in the study area.

During the survey, the *Syzygium paniculatum* plants in the study area were producing flowers. Seed dispersal by birds and/or the Grey-headed Flying-fox is likely to be the reason for the occurrence of this species in the study area. The local population of *Syzygium paniculatum* is able to flower, be pollinated, set seed, disperse seed, and establish in new areas of habitat. Therefore, the species appears to be able to complete its lifecycle in the habitat.

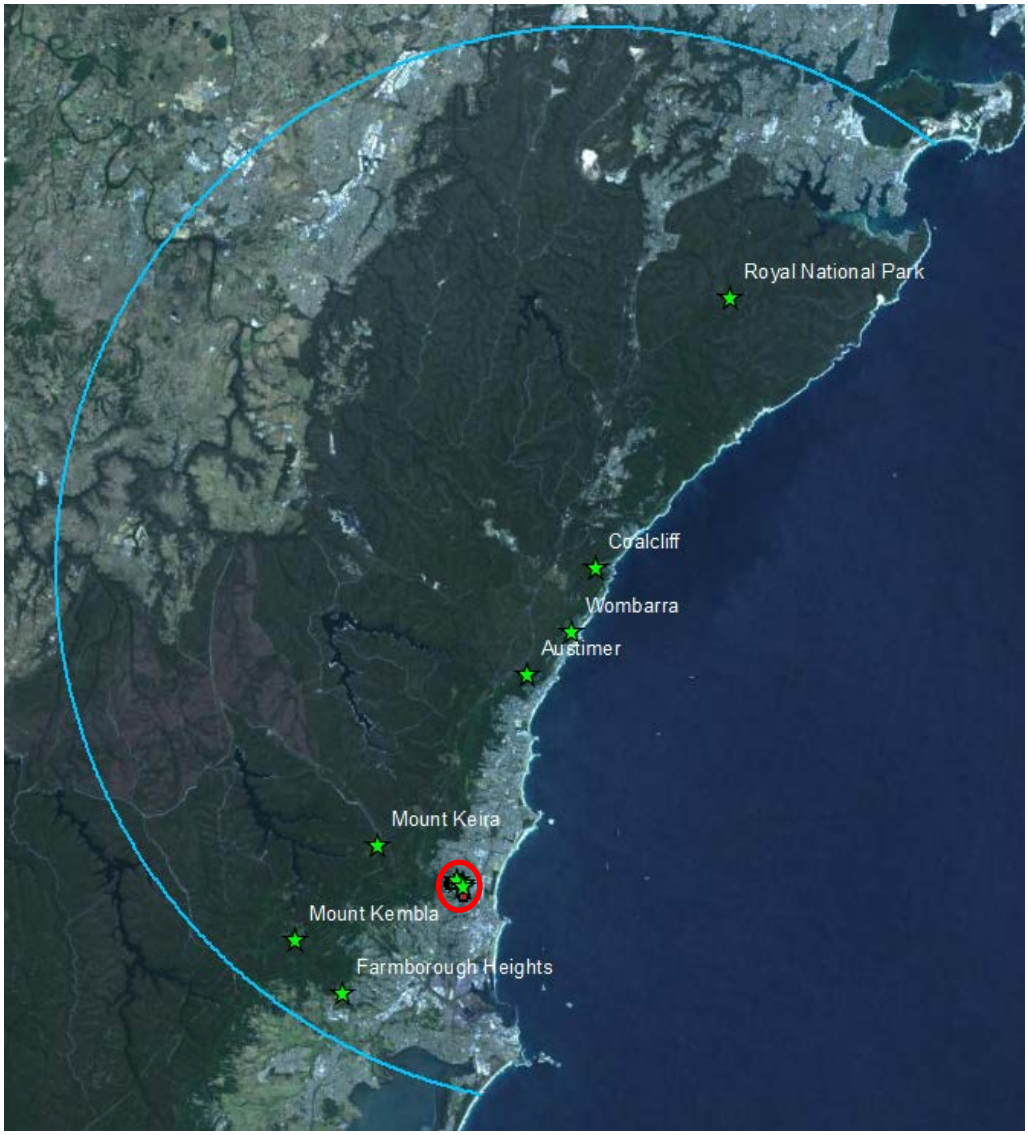

Figure 1: Location of the 'local population' of *Syzygium paniculatum* (Green stars indicate known occurrences of *Syzygium paniculatum*. Blue line indicates an average 30km foraging distance from Coalcliff site. Red circle indicates the plants within the study area).

Viability of the local population

Viability is defined as the capacity of a species to successfully complete each stage of its life cycle under normal conditions. Studies have shown that despite low population numbers, low overall genetic diversity and limited genetic variation between individuals, *Syzygium paniculatum* is persisting in occupied habitats as well as producing viable, dispersible seed (self-pollinated and to outcrossed) that can colonise new habitat (Thurlby et al., 2012, Thurlby, 2010).

The local *Syzygium paniculatum* population is able to complete each stage of its life cycle as indicated by the presence of the plants that have established in the study area from seed dispersal. The local population of *Syzygium paniculatum* is able to flower, be pollinated, set seed, disperse seed, and establish in new areas of habitat. As such, the local population is considered viable.

Summary

The 'local population' of *Syzygium paniculatum* for the purposes of this assessment is all plants known and likely to occur along the Illawarra escarpment within dispersal range of the Coalcliff site (an area defined as 30 kilometres based on the foraging range of seed dispersers, see Figure 1). The 'local population' includes trees from Coalcliff, planted trees, and any plants that have

established naturally in habitats from seed dispersal. The 'local population' of *Syzygium paniculatum* is assumed viable.

The action proposed is unlikely to have an adverse effect on the life cycle of *Syzygium paniculatum* such that a viable local population of the species is likely to be placed at risk of extinction. The lifecycle of the 'local population' will continue if the four plants within the study area are removed. Flowering, pollination, seed set (fruiting), seed dispersal, and colonisation of new areas of habitat will continue in the 'local population'. There would be some localised impacts to pollinators and seed dispersers from the habitat to be removed from the study area. However, the availability of habitat for pollinators and seed dispersers in the locality is extensive. Pollinators and seed dispersers will remain in the locality and pollination and seed dispersal within the 'local population' of *Syzygium paniculatum* will continue.

2. in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

3. in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

4. in relation to the habitat of a Threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Approximately 7.58 ha of habitat that is potentially suitable for *Syzygium paniculatum* will be removed by the proposal. This includes approximately 6.69 ha of Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (PCT 694) and approximately 0.89 ha of Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (PCT 1245). This extent of habitat removal for *Syzygium paniculatum* represents approximately 0.1% of these habitat types as mapped in the locality by Tozer et al. (2006) (approximately 7,076 ha of PCT 694 and PCT 1245 are mapped in the locality). This mapping provides an overestimate of the habitat available to *Syzygium paniculatum* but an estimate of the extent of gallery rainforest on alluvium and adjacent areas within these broad habitat types cannot be made at this scale.

Habitat fragmentation *per se* relates to the physical dividing up of once continuous habitats into separate smaller 'fragments' (Fahrig, 2002). Isolation relates to the distance between habitat patches. There will be some habitat loss but the proposal will not lead to an increase in landscape scale fragmentation. A minor increase in habitat isolation will occur, as the remaining habitats within the study area will become separated by a greater distance (approximately 150 metres between habitat patches). However, pollination and seed dispersal, the two primary components of gene flow in this species will be maintained. The foraging range of birds and flying-foxes is very

large so therefore, pollinators and seed dispersers will be able to move between the newly created patches and gene flow would be maintained.

The habitat within the study area may not be considered important for *Syzygium paniculatum*. Approximately 7,076 ha of moderate to good quality PCT 694 and PCT 1245 are mapped in the locality (although this is an overestimate) by Tozer et al. (2006). There are approximately 8.85 ha of moderate to good quality PCT 694 and PCT 1245 within the study area. The habitat within the study area represents approximately 0.13% of the habitat available in the locality for *Syzygium paniculatum*. The habitat to be affected is suitable for *Syzygium paniculatum* but is located in a fragmented landscape. The habitat forms part of a larger mosaic of habitat patches on the Illawarra Coastal Plain that would be used by pollinators and seed dispersers. However, the habitat to be affected is of high quality and does not provide a key role in habitat connectivity in the locality. The ecological integrity of the habitat to be affected is poor compared to the extensive higher quality habitats present on the lower Illawarra escarpment that are located away from urbanisation and human disturbance. The habitats in the broader locality are more secure than the habitat in the study area (the study area is road reserve and university land).

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable, as no critical habitat has been listed for *Syzygium paniculatum*.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The *National Recovery Plan Magenta Lilly Pilly Syzygium paniculatum* (NSW Office of Environment and Heritage, 2012) outlines the following objectives for the recovery of this species:

- Objective 1: To ensure a coordinated and efficient approach to the implementation of recovery efforts
- Objective 2: To establish the full extent of the distribution of Magenta Lilly Pilly
- Objective 3: To increase the understanding of Magenta Lilly Pilly biology and ecology
- Objective 4: To minimise the decline of Magenta Lilly Pilly through in situ habitat protection and management
- Objective 5: To reduce impacts of Myrtle Rust on Magenta Lilly Pilly and its habitat
- Objective 6: To maintain a representative ex situ collection of Magenta Lilly Pilly
- Objective 7: To raise awareness of the conservation significance of Magenta Lilly Pilly and involve the broader community in the recovery program.

These recovery objectives will not be interfered with by the proposal. Objective 4 is focused on OEH land and is therefore not applicable to the proposal.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. *Syzygium paniculatum* has been assigned to the Site-managed species management stream under the OEH Saving our Species program. The OEH has established three management sites where conservation activities need to take place to ensure the conservation of this species which include:

- Great Lakes (Great Lakes)
- Wyrrabalong (Wyong)
- Wamberal Lagoon (Gosford).

These sites are not near the study area and will not be affected by the proposal.

7. whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Key threatening processes are listed under the TSC Act and at the present, there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to *Syzygium paniculatum* that would be increased by the proposal is clearing of native vegetation.

Conclusion

The main points of consideration are as follows:

- The action proposed is unlikely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
- The extent of habitat removal for *Syzygium paniculatum* represents approximately 0.1% of the same habitat types mapped in the locality.
- No habitat fragmentation will occur and any further habitat isolation that may occur due to the proposal will have a negligible effect on this species.
- The habitat within the study area may not be considered important for *Syzygium paniculatum* due to reduced ecological integrity and small size.
- No critical habitat will be affected.
- The identified recovery objectives and actions for *Syzygium paniculatum* will not be interfered with by the proposal.
- The proposal will directly involve a Key Threatening Process known to affect this species: clearing of native vegetation.

After consideration of the factors above, it is unlikely that the proposal will result in a significant effect on the local occurrence of *Syzygium paniculatum*. However, impacts to this threatened species will occur and mitigation measures should be considered to reduce the impact to the greatest extent possible.

Potential mitigation options

Syzygium paniculatum can be grown from seed (see Thurlby et al., 2012) and is a common species used in horticulture. Propagation of *Syzygium paniculatum* via seed may be a viable method of cultivating genetically identical plants as multiple embryos in each seed are easily germinated and a high proportion of individuals survive beyond the seedling and sapling stages (Thurlby, 2010).

An option to reduce the impact to the individuals within the study area may be to implement a salvage program. Seed could be harvested from the plants to be removed, grown off site in a nursery, and reused in landscaping required for the proposal. This will retain the genetics of these plants in the habitat and will lead to an overall increase in the size of the local population.

Solanum celatum

Solanum celatum is restricted to an area from Wollongong to just south of Nowra, and west to Bungonia. The majority of records of this species were made prior to 1960. However, it is likely that this species is overlooked during surveys and may not be present above ground unless conditions are optimal. *Solanum celatum* is known to grow in rainforest clearings, edges of rainforest and wet sclerophyll forest and disturbed margins. *Solanum celatum* is a gap phase shrub and only likely to be present above ground after a disturbance event.

No *Solanum celatum* plants were found in the study area during the survey. However, suitable habitat is present in the form of PCT 694 and PCT 1245. This species is considered moderately likely to occur in the study area and may be present as seed in the soil seedbank.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. **in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

Solanum celatum is known to grow in rainforest clearings, edges of rainforest and wet sclerophyll forest and disturbed margins. *Solanum celatum* is a gap phase shrub and only likely to be present above ground after a disturbance event. Flowering occurs from August to October and fruit is produced from December to January. *Solanum celatum* is a fire sensitive obligate seeder, with adults plants killed by fire and recruitment occurring from a soil stored seed bank (NSW Scientific Committee, 2003b). Like other species of Solanum, *Solanum celatum* can be assumed to be pollinated by native bees or introduced honeybees. The fruit and seed is likely to be bird dispersed.

Solanum celatum was not recorded within the study area during the survey. However, suitable habitat for this species is present. Pollinators such as native and introduced bees are likely to be common in the study area due to the presence of native habitat as are seed dispersal vectors such as fruit eating birds. Therefore, the study area is likely to possess the required pollination and seed dispersal mechanisms for this species to complete its lifecycle. Taking a precautionary approach, it is moderately likely that *Solanum celatum* is present in the soil-stored seedbank and that the habitat within the study area is not currently conducive to the presence of above ground plants due to the heavy shade cast by the canopy and dense rainforest midstorey that dominates much of the PCTs in the study area. This gap phase shrub needs an open canopy and may require fire to germinate (fire has not occurred in the study area lately).

The proposal will result in disturbance to the potential habitat of *Solanum celatum* through road construction and associated activities that will result in vegetation removal, soil removal and soil disturbance. The proposal has the potential to impact on the lifecycle of *Solanum celatum* as follows:

- Habitat for insects responsible for pollination and birds responsible for seed dispersal will be removed but substantial habitat for the pollinators and seed dispersers will remain in the study area suggesting that pollination and seed dispersal could continue during and after the proposal is built.
- If *Solanum celatum* is present in the soil seedbank then it is possible that the disturbance created by the vegetation removal and soil disturbance could create suitable conditions for the germination and establishment of *Solanum celatum* at newly created habitat edges. The disturbance may be beneficial for this species. The suitability of the habitat may increase due to the removal of the tree canopy and midstorey layer, which would result in increased light and soil disturbance triggering seed germination.
- If *Solanum celatum* is present in the soil seedbank then it is possible that it would be removed from site with the soil (if the soil were taken off site) and germination of that seed would be prevented.

Overall, as the presence of *Solanum celatum* within the study area is based on likely presence of seed in the topsoil, the lifecycle of this species is not anticipated to be greatly affected by the proposal. Pollinators and seed dispersal vectors will remain in the study area after the proposal is built in sufficient numbers to ensure the reproduction of *Solanum celatum* could occur. Any seed that is possibly present in the soil seedbank may be triggered to germinate by vegetation removal and soil disturbance creating suitable edge habitats. The action proposed is not considered likely to have an adverse effect on the life cycle of *Solanum celatum* such that a viable local population of the species is likely to be placed at risk of extinction.

2. in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

3. in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

4. in relation to the habitat of a Threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Approximately 7.58 ha of habitat that is potentially suitable for *Solanum celatum* will be removed by the proposal. This includes approximately 3.23 ha of PCT 694 and approximately 0.13 ha of PCT 1245. The extent of habitat removal for *Solanum celatum* represents approximately 0.6% of similar habitats within the locality. Approximately 1,058 ha of suitable Blackbutt forest habitat is mapped in the locality by Tozer *et al.* (2006). The habitats within the study area are suitably connected to the remaining habitat in the locality (ie distances of less than 500 m between patches) and pollination and seed dispersal can be expected to occur between these patches. As such, the local occurrence of suitable habitat is large.

Habitat fragmentation *per se* relates to the physical dividing up of once continuous habitats into separate smaller 'fragments' (Fahrig, 2002). Due to the nature of the proposal, it may potentially result in an increase to landscape scale fragmentation for habitat for *Solanum celatum* due to the design of the new intersection. The current habitat is likely to be divided up into smaller fragments separated by a barrier posed by the new roadways. The roadways between the fragments may be up to 20 metres wide. In insect-pollinated plants, pollen movement, rather than movement of seeds, is generally the main component of gene flow (Ennos, 1994, Fenster, 1991). The foraging range of native solitary bees is up to a few hundred metres (Goulson, 2003) so therefore pollinators may be able to move between the newly created patches and gene flow would be maintained. Nevertheless, habitat fragmentation will occur.

The habitat within the study area may be considered important for *Solanum celatum* as this species is not known from other regions. If *Solanum celatum* is present in the study area, the habitat would be important for the long-term survival of the species in the locality.

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable, as no critical habitat has been listed for *Solanum celatum*.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is no recovery plan for *Solanum celatum.* However, this species has been assigned to the Site-managed species management stream under the OEH Saving our Species program. The OEH has established five management sites where conservation activities need to take place to ensure the conservation of this species. These sites include:

- Mount Brown area (Wollongong)
- Macquarie Pass National Park (Shellharbour)

- Stockyard Mountain area (Kiama)
- Bungonia National Park (Goulburn Mulwaree)
- Translocation site (unknown).

The proposal will not affect any of the five management sites.

7. whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

A KTP is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present, there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to *Solanum celatum* that would be increased by the proposal is clearing of native vegetation.

Conclusion

No *Solanum celatum* plants were found in the study area during the survey. Due to the presence of suitable habitat in the study area in the form of PCT 694 and PCT 1245, this species is considered moderately likely to occur and may be present as seed in the soil seedbank.

The impacts of the proposal to *Solanum celatum* would be limited to loss of some potentially suitable habitat. Seed from this species may be stored in the soil seedbank and this could be lost due to the proposal. The main points of consideration are as follows:

- Habitat for insects responsible for pollination and birds responsible for seed dispersal will be removed but substantial habitat for the pollinators and seed dispersers will remain in the study area suggesting that pollination and seed dispersal could continue during and after the proposal is built.
- If *Solanum celatum* is present in the soil seedbank then it is possible that the disturbance created by the vegetation removal and soil disturbance could create suitable conditions for the germination and establishment of *Solanum celatum* at newly created habitat edges. The disturbance created by the proposal may create positive conditions for germination of *Solanum celatum*.
- The extent of habitat removal for *Solanum celatum* represents approximately 0.6% of similar habitats within the locality.
- The proposal may potentially result in an increase to landscape scale fragmentation for habitat for *Solanum celatum* due to the design of the new intersection but gene exchange may still occur between newly created patches.
- The habitat within the study area may be considered important for *Solanum celatum* in the locality but this cannot be determined as plants were not found on site.
- No critical habitat will be affected.
- The proposal would not interfere with the management sites identified for the recovery of *Solanum celatum*.
- The only KTP relevant to *Senna acclinis* that would be increased by the proposal is clearing of native vegetation but the proposal will not contribute to any of the other key threats to this species.

After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant effect to *Solanum celatum*.

Gang-gang Cockatoo (*Callocephalon fimbriatum*)

The Gang-gang Cockatoo is considered highly likely to utilise the forests habitats in the study area for foraging when the eucalypts are seeding. It is known to use PCT 694 and PCT 1245 as habitat and there are several records of this species from the Illawarra coastal plain and plateau. This species is considered unlikely to nest in the study area, as it prefers old growth forest and woodland with hollows of a sufficient size (>10 cm in size) for nesting.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. **in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The ecology of the Gang-gang Cockatoo is poorly understood as there are no detailed studies on this species. The Gang-gang Cockatoo inhabits eucalypt open forests and woodlands with an acacia understorey. In summer it lives in moist highland forest types, and in winter it moves to more open types at lower elevations. This species requires tree hollows for nesting and sometimes for roosting. Eucalypt trees and acacia shrubs are used for foraging. The Gang-Gang Cockatoo nests in hollows in the trunks, limbs or dead spouts of tall living trees, especially eucalypts, often near water. A clutch of usually two eggs is laid in spring to summer. The incubation period is about four weeks, the nestling period seven to eight weeks, and the post-fledging dependence period lasts at least four to six weeks. The Gang-gang Cockatoo feeds on seeds obtained in trees and shrubs, mostly from eucalypts and wattles, though it eats some seeds of introduced trees and shrubs around human settlements in winter, and also insect larvae (galls, sawflies). The Gang-gang Cockatoo apparently breeds semi-colonially where densities are high. It is thought to show high fidelity to a selected nest hollow (NSW Scientific Committee, 2008).

The proposal would not affect breeding habitat for this species, as no suitable hollows are present in the study area and this species breeds in higher altitude forests away from the coast. Suitable winter foraging habitat is present in the PCTs and this species is likely to forage on the seeds of eucalypts and acacias throughout the study area. Similar foraging habitat is extensive along the escarpment so the habitat within the study area is not considered a limiting foraging resource. As such, the lifecycle of this species is unlikely to be greatly affected by the proposal. The proposal is not considered likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

2. **in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

3. **in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

   i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

   ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

4. **in relation to the habitat of a Threatened species, population or ecological community:**

   i. **the extent to which habitat is likely to be removed or modified as a result of the action proposed**

   ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

   iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

Habitat removal is limited to potential foraging habitat and the extent to which habitat is likely to be removed or modified as a result of the proposal is as follows:

- 7.58 ha of habitat removal from PCTs
- 5.05 ha of habitat removal from planted vegetation

This impact represents approximately 0.6% of similar habitats within the locality. Approximately 1,058 ha of suitable Blackbutt forest habitat is mapped in the locality by Tozer *et al.* (2006).

Due to its nature, the proposal will result in the breaking apart of some habitat blocks into smaller portions. The new roadways and roundabouts will create a hard barrier to movement for some species but the Gang-gang Cockatoo is likely to be less affected. The Gang-gang Cockatoo is highly mobile (a partial or altitudinal migrant). The habitat of the Gang-gang Cockatoo in eastern NSW has been fragmented but the Gang-gang Cockatoo is highly mobile and can disperse or migrate tens of kilometres, so population fragmentation is unlikely except where populations are isolated by extensive suburbia (as in northern Sydney) (NSW Scientific Committee, 2008). The level of fragmentation caused by the proposal will not have an impact on the ability of the Gang-gang Cockatoo to move through the landscape.

There is over 1,000 hectares of high quality foraging habitat for the Gang-gang Cockatoo mapped in the locality. The remaining escarpment and plateau provides even greater areas of habitat. The study area forms a small portion of the available local foraging resource and would not be considered a limiting resource for this species. As such, the habitats in the study area are not considered important to the long-term survival of the Gang-gang Cockatoo in the locality.

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable, as no critical habitat has been listed for the Gang-gang Cockatoo.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is no recovery plan for the Gang-gang Cockatoo. However, a targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. The Gang-gang Cockatoo has been assigned to the Landscape species management stream under the OEH Saving our Species program and the following actions for recovery have been identified for this species:

- Protect known and potential remnant gang-gang cockatoo habitat, particularly tall wet forest and dry sclerophyll forest vegetation communities with large trees supporting hollows that are 10cm in diameter or larger and manage these areas to allow ongoing regeneration of local native trees, shrubs and ground layer plants. Where possible, negotiate management agreements with landholders that are funded in perpetuity that allows ongoing recruitment of native local trees, shrubs and grasses.
- Restore gang-gang cockatoo habitat in strategic locations close to known habitat and movement corridors, using appropriate local tree, shrub and ground cover species. Care must be taken to ensure that the removal of exotic berry-bearing shrubs and trees such as cotoneaster, hawthorn and pyracantha, that provide foraging habitat, is compensated for by planting of appropriate native foraging plant species such as acacias and eucalypts.
- Report illegal shooting or trapping of gang-gang cockatoos to Environment Line (131 555).
- Liaise with land managers and landholders managing fire to raise awareness about the importance of live and standing dead hollow-bearing trees, and to minimise losses of these trees when carrying out prescribed burns.

The recovery actions identified in the Saving Our Species program, that have been identified by the OEH to help recover the Gang-gang Cockatoo are largely not applicable to the proposal. The proposal would not interfere with the recovery actions identified for the Gang-gang Cockatoo.

7. **whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A KTP is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Gang-gang Cockatoo that would be increased by the proposal is clearing of native vegetation.

Conclusion

The proposal would not affect breeding habitat for the Gang-gang Cockatoo. Additionally, the study area does not contain any limiting winter foraging grounds. As such, the impacts of the proposal to the Gang-gang Cockatoo would be limited to loss of some potential foraging habitat caused by direct clearing or damage to vegetation during the construction phase. The main points of consideration are as follows:

- No impacts to the life cycle of the Gang-gang Cockatoo are anticipated as a result of the proposal.
- The Gang-gang Cockatoo would suffer a small reduction in extent of PCTs suitable as foraging habitat from the proposal of around 7.58 ha. This is a small proportional impact. The impact to plantings and urban trees that may provide suitable foraging habitat for the Gang-gang Cockatoo is around 5.05 hectares
- Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat for the Gang-gang Cockatoo.
- High quality habitat for the Gang-gang Cockatoo is not mapped in the study area. As such, the habitats in the study area are not considered important to the long-term survival of the Gang-gang Cockatoo in the locality.
- No critical habitat will be affected.
- The proposal would not interfere with the recovery actions that have been identified for the recovery of the Gang-gang Cockatoo.
- The only KTP relevant to the Gang-gang Cockatoo that would be increased by the proposal is clearing of native vegetation but the proposal will not contribute to any of the other key threats to this species.

After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant effect to the Gang-gang Cockatoo.

Varied Sittella (*Daphoenositta chrysoptera*)

The Varied Sittella is considered likely to utilise the forests habitats in the study area for foraging. It is known to use PCT 694 and PCT 1245 as habitat.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. **in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Varied Sittella inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. 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.

Suitable habitat for the Varied Sittella is present in the study area within PCT 694 and PCT 1245. The Varied Sittella is considered moderately likely to forage in the study area and may breed in the

habitat. The habitat in the study area is considered likely to be suitable for this species to complete its lifecycle with suitable foraging, roosting and breeding habitat present. The removal of habitat will affect the lifecycle of this species if it is present. However, due to the abundance of aggressive birds such as Noisy Miners, and adjacent urbanisation, the quality of the habitat is not considered high. Any birds that may use the habitat in the study area would also likely use adjacent habitats along the escarpment that are of higher quality. After the proposal has been built there will be sufficient habitat left in the study area for this species to complete its lifecycle and the habitat quality of remaining patches is considered likely to remain in a similar state to pre-construction conditions. The proposal is not considered likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

2. in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

3. in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

4. in relation to the habitat of a Threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The extent to which habitat is likely to be removed or modified because of the proposal is as follows:

- 7.58 ha of habitat removal from PCTs
- 5.05 ha of habitat removal from planted vegetation

This impact represents approximately 0.6% of similar habitats within the locality. Approximately 1,058 ha of suitable Blackbutt forest habitat is mapped in the locality by Tozer *et al.* (2006).

The apparent decline in the populations of the Varied Sittella has been attributed to declining habitat cover and quality and the sedentary nature of the Varied Sittella makes cleared land a potential barrier to movement (NSW Scientific Committee, 2010). Survival and population viability are sensitive to habitat isolation, reduced patch size and habitat simplification, including reductions in tree species diversity, tree canopy cover, shrub cover, ground cover, logs, fallen branches and litter (NSW Scientific Committee, 2010). The proposal will result in local fragmentation of the habitats within the study area. However, the distances between the fragments will be around 20 metres and this is not likely to be a great enough distance to prevent the Varied Sittella from dispersing between habitat patches. Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat.

High quality habitat for the Varied Sittella is not mapped in the study area and the study area only forms a very small proportion of the habitat available to this species in the local area. High quality habitats exist in the adjoining escarpment and plateau area and these are likely to be important for this species. The habitats in the study area are not considered to be a limiting resource for the Varied Sittella and are not considered important to the long-term survival of the Varied Sittella in the locality.

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable, as no critical habitat has been listed for the Varied Sittella.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is no recovery plan for the Varied Sittella. However, a targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. The Varied Sittella has been assigned to the Landscape species management stream under the OEH Saving our Species program and the following actions for recovery have been identified for this species:

- Raise public awareness of the importance of large old trees (particularly isolated paddock trees and hollow-bearing trees, live and dead) and undertaking restoration and revegetation to replace cohorts of trees where they have been removed from the landscape, particularly in areas adjacent to and connecting woodland remnants.
- Encourage landholders to protect ground layer and midstorey vegetation by implementing sensitive grazing practices and avoiding slashing or underscrubbing, and to promote the retention of a floristically and structurally diverse and spatially variable understorey in patches of woodland. Target in-perpetuity covenants or stewardship agreements to landholders with high quality remnant woodland habitat.
- Target removal of weeds significantly compromising habitat values (e.g. invasive perennial grasses) and restore native vegetation. Care should be taken to avoid widespread removal of beneficial exotic woody vegetation without replacement and avoid non-target impacts of herbicides.
- Measure the abundance and impact of noisy miners on species populations and habitat, and implement appropriate management actions with demonstrated effectiveness (e.g. direct control, habitat restoration) to reduce the impacts of noisy miners, if/where required.
- Conduct targeted research into identifying different practical methods for restoring the structure and function of the ground layer in degraded habitat, including soil biota and its functionality.
- Undertake revegetation, using a diverse mix of locally appropriate native species, focussing on expanding areas of existing habitat, connecting isolated habitat patches (either through corridor or stepping stone plantings) or establishing additional habitat patches in landscapes with already existing, although insufficient, patches of suitable habitat. Areas with access to water, especially riparian areas, are particularly important, although care should be taken to ensure that riparian revegetation programs are sufficiently wide (minimum 50m wide).

The recovery actions identified in the Saving Our Species program that have been identified by the OEH to help recover the Varied Sittella are largely not applicable to the proposal. The proposal would not interfere with the recovery actions identified for the Varied Sittella.

7. whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

A KTP is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of

the 38 listed KTPs under the TSC Act, the only KTP relevant to the Varied Sittella that would be increased by the proposal is clearing of native vegetation and loss of hollow bearing trees.

Conclusion

The impacts of the proposal to the Varied Sittella would be limited to loss of some potential foraging, roosting and breeding habitat caused by direct clearing or damage to vegetation during the construction phase. The main points of consideration are as follows:

- Minor impacts to the life cycle of the Varied Sittella are anticipated as a result of the proposal. This habitat contains the requisite features for this species to complete its lifecycle and some habitat will be removed. However, the habitat is not limiting and the impact is considered likely to be low.
- The Varied Sittella would suffer a small reduction in extent of PCTs suitable as foraging habitat from the proposal of around 7.58 ha. This is a small proportional impact. The impact to plantings and urban trees that may provide suitable foraging habitat for the Varied Sittella is around 5.05 hectares.
- Some localised habitat fragmentation will occur due to the proposal but this species is still expected to be able to move between habitat patches. Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat for the Varied Sittella.
- High quality habitat for the Varied Sittella is not mapped in the study area. As such, the habitats in the study area are not considered important to the long-term survival of the Varied Sittella in the locality. The extensive areas of habitat along the escarpment are considered more important for this species' persistence in the locality.
- No critical habitat will be affected.
- The proposal would not interfere with the recovery actions that have been identified for the recovery of the Varied Sittella.
- The KTPs relevant to the Varied Sittella that would be increased by the proposal is clearing of native vegetation and loss of hollow-bearing trees but the proposal will not contribute to any of the other key threats to this species.

After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant effect to the Varied Sittella.

Little Lorikeet (*Glossopsitta pusilla*)

The Little Lorikeet is considered likely to utilise the forests habitats in the study area for foraging and potentially breeding. It is known to use PCT 694 and PCT 1245 as habitat so is considered moderately likely to occur in the study area.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. **in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The distribution of the Little Lorikeet extends from just north of Cairns, around the east coast of Australia, to Adelaide. In New South Wales Little Lorikeets are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri (Royal Australian Ornithologists Union, 2003). Little Lorikeets are generally considered to be nomadic (Higgins, 1999) and forage mainly on flowers, nectar and fruit. The breeding biology of Little Lorikeets is little known however studies indicate that nest hollows are located at heights of between 2 m and 15 m, mostly in living, smooth-barked eucalypts, and hollow openings are approximately 3 cm in diameter (Courtney and Debus, 2006).

The habitats within the study area contain suitable foraging and breeding habitat for the Little Lorikeet. As such, the study area contains the requisite features for this species to complete its

lifecycle with suitable foraging, roosting and breeding habitat present. However, this species is a large scale nomad and is unlikely to remain in the study area in a sedentary manner for any length of time. The most likely occurrence of this species in the study area would be when the eucalypts are flowering and a significant blossom resource is present. The presence of potential breeding habitat is assumed based on the presence of hollow-bearing trees and it is not known whether this species breeds in the area. Due to the general lack of records from the locality, it is unlikely that this species is a breeding resident.

The removal of habitat will affect the lifecycle of this species if it is present. However, due to the abundance of aggressive birds such as Noisy Miners, and adjacent urbanisation, the quality of the habitat is not considered high. Any birds that may use the habitat in the study area would also likely use adjacent habitats along the escarpment that are of higher quality. After the proposal has been built there will be sufficient habitat left in the study area for this species to complete its lifecycle and the habitat quality of remaining patches is considered likely to remain in a similar state to pre-construction conditions. The proposal is not considered likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

2. in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

3. in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

4. in relation to the habitat of a Threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

As a specialist nectarivore dependent on flowering eucalypts, Little Lorikeets are vulnerable to the loss of quantity and quality of key forage tree species. As a large-scale nomad, it has the ability to cover vast areas of its range, seeking suitable flowering eucalypt habitat. The species is a very rare occasional visitor to the region and may utilise trees in the study area for foraging intermittently when no other suitable resources are available. The Little Lorikeet would suffer a small reduction in extent of PCTs suitable as foraging habitat from the proposal of around 7.58 ha. This is a small proportional impact of approximately 0.6% of similar habitats within the locality. Approximately 1,058 ha of suitable Blackbutt forest habitat is mapped in the locality by Tozer *et al.* (2006). The impact to plantings and urban trees that may provide suitable foraging habitat for the Little Lorikeet is around 5.05 hectares. Up to 19 hollow-bearing trees will also be removed but they are considered unlikely to be used for breeding.

Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat for the Little Lorikeet. Due to its nature, the proposal will result in the breaking apart of some habitat blocks into smaller portions. The new roadways and roundabouts will create a hard barrier to movement for some species but the Little Lorikeet is considered to be less affected. The Little Lorikeet is a highly mobile nomad and will freely fly long distances over open areas to move between foraging grounds. The level of fragmentation caused by the proposal will not have an impact on the ability of the Little Lorikeet to move through the landscape.

The National Parks and Wildlife Service (2002a) has mapped 48 hectares of high quality habitat for the Swift Parrot in the region of the Illawarra escarpment, coastal plan and plateau. This habitat mapping can be considered likely to also represent the available foraging habitat for the Little Lorikeet, as both of these species are large-scale nomads that follow blossom resources. High quality habitat is not mapped in the study area. As such, the habitats in the study area are not considered important to the long-term survival of the Little Lorikeet in the locality.

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable, as no critical habitat has been listed for the Little Lorikeet.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is no recovery plan for the Little Lorikeet. However, a targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. The Little Lorikeet has been assigned to the Landscape species management stream under the OEH Saving our Species program and the following actions for recovery have been identified for this species:

- Raise public awareness of the importance of large old trees (particularly isolated paddock trees and hollow-bearing trees, live and dead) and undertaking restoration and revegetation to replace cohorts of trees where they have been removed from the landscape, particularly in areas adjacent to and connecting woodland remnants.
- Encourage landholders to protect ground layer and midstorey vegetation by implementing sensitive grazing practices and avoiding slashing or underscrubbing, and to promote the retention of a floristically and structurally diverse and spatially variable understorey in patches of woodland. Target in-perpetuity covenants or stewardship agreements to landholders with high quality remnant woodland habitat.
- Target removal of weeds significantly compromising habitat values (e.g. invasive perennial grasses) and restore native vegetation. Care should be taken to avoid widespread removal of beneficial exotic woody vegetation without replacement and avoid non-target impacts of herbicides.
- Measure the abundance and impact of noisy miners on species populations and habitat, and implement appropriate management actions with demonstrated effectiveness (e.g. direct control, habitat restoration) to reduce the impacts of noisy miners, if/where required.
- Conduct targeted research into identifying different practical methods for restoring the structure and function of the ground layer in degraded habitat, including soil biota and its functionality.
- Identify sites where tree hollows are limiting and develop and implement a nest box strategy that has clear objectives and includes monitoring, maintenance, and evaluation of success.
- Undertake revegetation, using a diverse mix of locally appropriate native species, focussing on expanding areas of existing habitat, connecting isolated habitat patches (either through corridor or stepping stone plantings) or establishing additional habitat patches in landscapes with already existing, although insufficient, patches of suitable habitat. Areas with access to water, especially riparian areas, are particularly important, although care should be taken to ensure that riparian revegetation programs are sufficiently wide (minimum 50m wide).

The recovery actions identified in the Saving Our Species program that have been identified by the OEH to help recover the Little Lorikeet are largely not applicable to the proposal. The proposal would not interfere with the recovery actions identified for the Little Lorikeet.

7. **whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A KTP is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTPs relevant to the Little Lorikeet that would be increased by the proposal is clearing of native vegetation and loss of hollow-bearing trees.

Conclusion

The study are contains potential foraging and breeding habitat for the Little Lorikeet. However, due to the general absence of records for this species in the locality it is only considered moderately likely to occur. However, suitable habitat is present within the PCTs and potential impacts to this species must be considered. The impacts of the proposal to the Little Lorikeet would be limited to loss of some lower quality foraging habitat caused by direct clearing or damage to vegetation during the construction phase. Up to 19 hollow-bearing trees will also be removed but they are considered unlikely to be used for breeding. The main points of consideration are as follows:

- No impacts to the life cycle of the Little Lorikeet are anticipated as a result of the proposal.
- The Little Lorikeet would suffer a small reduction in extent of PCTs suitable as foraging habitat from the proposal of around 7.58 ha. This is a small proportional impact. The impact to plantings and urban trees that may provide suitable foraging habitat for the Swift Parrot is around 5.05 hectares
- Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat for the Little Lorikeet.
- High quality habitat for the Little Lorikeet is not mapped in the study area. As such, the habitats in the study area are not considered important to the long-term survival of the Little Lorikeet in the locality.
- No critical habitat will be affected.
- The proposal would not interfere with the recovery actions that have been identified for the recovery of the Little Lorikeet.
- The only KTPs relevant to the Little Lorikeet that would be increased by the proposal is clearing of native vegetation and loss of hollow-bearing trees but the proposal will not contribute to any of the other key threats to this species.

After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant effect to the Little Lorikeet.

Swift Parrot (*Lathamus discolor*)

The Swift Parrot is endemic to south-eastern Australia and breeds only in Tasmania. It migrates to mainland Australia in autumn. The National Parks and Wildlife Service (2002) identifies the Swift Parrot as an irregular migrant to the Illawarra escarpment, coastal plain and plateau. There have been records of the Swift Parrot made from the Wollongong University campus in 2002 suggesting this species occasionally utilises the habitats. As such, the Swift Parrot is considered moderately likely to occur within the study area on an infrequent basis based on the presence of suitable foraging habitat and nearby records.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. **in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Swift Parrot is endemic to south-eastern Australia and breeds only in Tasmania. It migrates to mainland Australia in autumn. As such, the proposal would not affect breeding habitat for this species. Additionally, the study area does not contain any important winter foraging grounds as modelled by the National Parks and Wildlife Service (2002) so none would be impacted. No impacts to the life cycle of the Swift Parrot species are anticipated as a result of the proposal and the proposal is not considered likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

2. in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

3. in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

4. in relation to the habitat of a Threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

As a specialist nectarivore dependent on flowering eucalypts and lerp, Swift Parrots are vulnerable to the loss of quantity and quality of key forage tree species. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat. The species is a very rare occasional visitor to the region and may utilise trees in the study area for foraging intermittently when no other suitable resources are available. The Swift Parrot would suffer a small reduction in extent of PCTs suitable as foraging habitat from the proposal of around 7.58 ha. This is a small proportional impact considering the National Parks and Wildlife Service (2002a) has mapped 48 hectares of high quality habitat for the Swift Parrot in the region of the Illawarra escarpment, coastal plan and plateau. The impact to plantings and urban trees that may provide suitable foraging habitat for the Swift Parrot is around 5.05 hectares.

Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat for the Swift Parrot. Due to its nature, the proposal will result in the breaking apart of some habitat blocks into smaller portions. The new roadways and roundabouts will create a hard barrier to movement for some species but the Swift Parrot is considered to be less affected. The Swift Parrot is a highly mobile nomad and will freely fly long distances over open areas to move between foraging grounds. The level of fragmentation caused by the proposal will not have an impact on the ability of the Swift Parrot to move through the landscape.

The National Parks and Wildlife Service (2002a) has mapped 48 hectares of high quality habitat for the Swift Parrot in the region of the Illawarra escarpment, coastal plan and plateau. The habitat model was developed for this species with high quality habitat derived from vegetation communities dominated by Swamp Mahogany, and with communities with high presence of Coast

Banksia (*Banksia integrifolia* subsp. *integrifolia*) included as moderate quality habitat (NSW National Parks and Wildlife Service, 2002a). High quality habitat for the Swift Parrot is not mapped in the study area. As such, the habitats in the study area are not considered important to the long-term survival of the Swift Parrot in the locality.

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable, as no critical habitat has been listed for the Swift Parrot.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros, 2011) aims to prevent further population decline of the Swift Parrot and to achieve a demonstrable sustained improvement in the quality and quantity of Swift Parrot habitat to increase carrying capacity. These objectives will be achieved by implementing recovery actions for each of the following specific recovery objectives:

- Objective 1: To identify and prioritise habitats and sites used by the species across its range, on all land tenures.
- Objective 2: To implement management strategies to protect and improve habitats and sites on all land tenures
- Objective 3: To monitor and manage the incidence of collisions, competition and Beak and Feather Disease (BFD).
- Objective 4: To monitor population trends and distribution throughout the range.

These objectives, and the associated recovery actions outlined in the *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros, 2011) are not applicable to the study area or proposal. The identified recovery actions mostly relate to identifying the extent and quality of habitat, monitoring, raising community awareness, and coordinating and reviewing the recovery process. There is an action relating to manage and protect Swift Parrot habitat at the landscape scale. However, this action applies to fencing off habitat on private land to encourage regeneration of habitat, revising forestry practices, developing a strategic management plan for Swift Parrot breeding habitat in Tasmania, and providing Swift Parrot conservation information for consideration during the New South Wales Local Government Local Environmental Planning review process. The recovery actions identified in the *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros, 2011) will not be interfered with by the proposal.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. The Swift Parrot has been assigned to the Landscape species management stream under the OEH Saving our Species program and the following actions for recovery have been identified for this species:

- Raise public awareness of the importance of large old trees of species that provide important food resources. Protect large old trees, including from the effects of fire. Ensure the recruitment of large old trees by retaining medium-sized trees, facilitating regeneration, and undertaking replanting.
- Within a region, increase the extent and quality of habitat to increase food supply and improve foraging efficiency. Focus on sites that may better function as drought refuges. Include locally occurring species that provide important food resources in revegetation programs where appropriate. Ensure that fuel reduction burns do not result in canopy scorch, which can reduce flowering in subsequent years. Manage aggressive honeyeater impacts through habitat modification (e.g. reduce the amount of edge and establish a structurally complex understorey.
- Engage the community in the identification and enhanced management of priority sites. Priority sites are those that (1) have been used by a large proportion of the population, or (2) have

been used in multiple seasons, or (3) have been used for an extended period of time within a season. Engage stakeholders in the identification and development of site-based management projects for priority areas, being areas containing a high proportion of priority sites, or areas that contribute to the overall diversity and distribution of resources available to swift parrots under a range of environmental conditions.
- With the assistance of the community, monitor swift parrot distribution, abundance, and habitat use. Investigate knowledge gaps to improve the effectiveness of management actions, including understanding the phenology of key food species, determining movement strategies, patterns and pathways between regions, and modelling the impacts of climate change projections on the distribution and abundance of foraging habitat and resources.
- Raise public awareness on collision risks and how these can be minimised. At priority sites and movement pathways assessed as having a high risk of collision, develop and implement mitigation strategies.
- Establish the Beak and Feather Disease Virus (BFDV) status of rehabilitated parrots proposed to be released using appropriate tests and quarantine procedures. Parrots carrying BFDV should not be released into the wild.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Swift Parrot are largely not applicable to the proposal. The proposal would not interfere with the recovery actions identified for the Swift Parrot.

7. whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

A KTP is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Swift Parrot that would be increased by the proposal is clearing of native vegetation.

Conclusion

The Swift Parrot is endemic to south-eastern Australia and breeds only in Tasmania. It migrates to mainland Australia in autumn. As such, the proposal would not affect breeding habitat for this species. Additionally, the study area does not contain any important winter foraging grounds. This species has been rarely recorded on the university grounds so it does occur in the habitats infrequently. As such, the impacts of the proposal to the Swift Parrot would be limited to loss of some lower quality foraging habitat caused by direct clearing or damage to vegetation during the construction phase. The main points of consideration are as follows:

- No impacts to the life cycle of the Swift Parrot are anticipated as a result of the proposal.
- The Swift Parrot would suffer a small reduction in extent of PCTs suitable as foraging habitat from the proposal of around 7.58 ha. This is a small proportional impact. The impact to plantings and urban trees that may provide suitable foraging habitat for the Swift Parrot is around 5.05 hectares
- Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat for the Swift Parrot.
- High quality habitat for the Swift Parrot is not mapped in the study area. As such, the habitats in the study area are not considered important to the long-term survival of the Swift Parrot in the locality.
- No critical habitat will be affected.
- The proposal would not interfere with the recovery actions that have been identified for the recovery of the Swift Parrot.
- The only KTP relevant to the Swift Parrot that would be increased by the proposal is clearing of native vegetation but the proposal will not contribute to any of the other key threats to this species.

After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant effect to the Swift Parrot.

Powerful Owl (*Ninox strenua*)

The Powerful Owl is recognised as an uncommon resident of the Illawarra escarpment, coastal plan and plateau and is present in many forested environments including urban bushland, such as Mangerton Park (NSW National Parks and Wildlife Service, 2002a). On the Illawarra escarpment, coastal plan and plateau the distribution of prey is a determining factor driving the presence of the Powerful Owl with tall escarpment forests with some mesic influence being important as they provide sufficient habitat for prey species particularly Common Ringtail Possum and Sugar

Glider (NSW National Parks and Wildlife Service, 2002a). Most of the optimal habitat for the Powerful Owl on the Illawarra escarpment, coastal plan and plateau occurs along and just above the escarpment with 5,996 hectares of high quality habitat for this species being modelled (NSW National Parks and Wildlife Service, 2002a). This modelled high quality habitat also includes the areas of PCT 694 and PCT 1245 within the study area that are tall wet forests with a mesic (rainforest) influence that contain suitable prey species including Brushtail Possum, Ringtail Possum, Sugar Glider and Grey-headed Flying-fox. While the habitat in the study area provides suitable foraging habitat for the Powerful Owl, no suitable breeding habitat is present. The Powerful Owl is dependent on suitably large tree-hollows (at least 0.5 m deep), generally found in the trunks of tall, living, mature trees of diameter at breast height of 80-240 cm that are at least 150 years old (Department of Environment and Conservation, 2006).

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. **in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Powerful Owl breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation. Their nesting requirements are more specialised being totally dependent on suitably large tree-hollows generally found in the trunks of tall, living, mature trees. Powerful Owls nest in large tree hollows (at least 0.5 m deep), in large eucalypts (diameter at breast height of 80-240 cm) that are at least 150 years old. The main prey items are medium-sized arboreal marsupials, particularly the Greater Glider, Common Ringtail Possum and Sugar Glider. Flying foxes are important prey in some areas and birds comprise about 10-50% of the diet depending on the availability of preferred mammals. As most prey species require hollows and a shrub layer, these are important habitat components (Office of Environment and Heritage, 2017).

In terms of the life cycle of the Powerful Owl, the vegetation within the study area provides suitable foraging habitat for this species but no suitable breeding habitat is present. The areas of PCT 694 and PCT 1245 within the study area are tall wet forests with a mesic (rainforest) influence that contain suitable prey species for the Powerful Owl including Brushtail Possum, Ringtail Possum, Sugar Glider and Grey-headed Flying-fox. Any birds that have a home range that includes the lower escarpment (i.e. any birds around Mt Kembla) may utilise the habitat in the study area on occasion for foraging. No suitable breeding habitat is present as the trees in the study area are not suitably large (or old) enough to contain tree-hollows in the trunk of a size suitable for this species to nest in. As such, foraging habitat will be removed but no breeding habitat will be affected. There is limited potential for direct mortality of owls from the proposal.

Potential habitats for the Powerful Owl in the locality are extensive with 5,996 hectares of high quality habitat for this species being modelled on the Illawarra escarpment, coastal plan and plateau (NSW National Parks and Wildlife Service, 2002a). The loss of potential foraging habitat associated with the proposal is not expected to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

This is because no breeding habitat will be affected and the foraging habitat to be affected represents a small proportion of the available habitat in the locality. The proposal is considered unlikely to result in a reduction in population size or reproductive success of the Powerful Owl.

2. in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

3. in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

4. in relation to the habitat of a Threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The proposal will result in the removal of approximately 7.58 ha of native vegetation which is considered to provide suitable foraging habitat for the Powerful Owl. This extent of habitat removal represents 0.05% of the 5,996 hectares of high quality habitat for this species being modelled on the Illawarra escarpment, coastal plan and plateau

Importantly, the proposal will not result in fragmentation of habitat for the Powerful Owl. No large blocks of high quality habitat for this species will be broken apart by the works. The Powerful Owl is a highly mobile species that occupies a large home range and they are able to persist in areas where large-scale disturbances occur (i.e. urban areas of Sydney, Melbourne and Brisbane and areas near the proposal such as Mangerton Park). The proposal will not affect any core breeding habitat for the Powerful Owl and the movement of owls between habitat patches will not be affected.

While the habitat in the study area is modelled as being high quality (NSW National Parks and Wildlife Service, 2002a) no important breeding for the Powerful Owl will be removed. Tree hollows potentially suitable as nesting habitat for the Powerful Owl were not noted in areas to be cleared and are not present in the immediate surrounding habitats. The habitat to be cleared forms part of a larger matrix of foraging habitat for the Powerful Owl and while the areas of habitat to be cleared contribute to the habitat for prey populations, the extent of habitat removal is small and considered unlikely to greatly affect foraging opportunities for the Powerful Owl in the locality. The habitat to be removed by the proposal is not considered to be limiting for the Powerful Owl and as such is not considered of critical importance to this species.

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for the Powerful Owl.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The *NSW Recovery Plan for the Large Forest Owls* (Department of Environment and Conservation, 2006) identifies the following objectives for recovery of the Powerful Owl:

- Model and map owl habitat and validate with surveys.
- Monitor owl population parameters.
- Audit forestry prescriptions.
- Manage and protect habitat off reserves and state forests.
- Undertake research.
- Increase community awareness and involvement in owl conservation.
- Provide organisational support and integration.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. These owls have been assigned to the Landscape species management stream and the following actions for recovery of the Powerful Owl have been identified:

- Consolidate all available information, knowledge and assessment protocols to create a consensus of best practice guidelines, providing a single point source to advise land managers about powerful owl conservation. Update regularly. Seek novel educational frameworks that increase public interest in applying these guidelines.
- Document and protect known nests. Ensure that no habitat degradation occurs within 100m (e.g. hazard reduction burns or tree felling). Facilitate the location of new nest sites through observer training and encouragement.
- Negotiate with relevant landholders to enter into agreements, particularly in-perpetuity covenants or stewardship agreements, that promote the retention of large old trees, riparian habitat, owl roost sites and other high value habitat (as developed in the best practice guidelines).
- In regions where high priority powerful owl populations can be increased and stabilised, improve habitat quality and reconstruct connectivity. Focus initially on restoration of arboreal habitat that will foster populations of habitat-specific mammalian prey. Create wide corridors, especially in riparian habitat where prey are potentially more abundant due to better resources and soil fertility.
- At sites where tree hollows are few or declining within high priority powerful owl populations, trial the installation of nest boxes to increase mammalian prey densities. Expand the program if demonstrated to be effective for owls and use as a tool to educate the public about the impact of hollow loss.
- Encourage development of citizen science programs in urban areas where an increase in community engagement is likely to create broader conservation awareness of powerful owls.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover these owl species are largely not applicable to the works as they are actions for the OEH to complete. The proposal is not anticipated to interfere with the recovery of these species.

7. whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

A KTP is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the threatened owls that will be increased by the works is clearing of native vegetation. This will be minimised where possible by retention of larger

native trees. The clearing of native vegetation is to be minimised to the extent necessary to achieve the works.

Conclusion

The Powerful Owl is recognised as an uncommon resident of the Illawarra escarpment, coastal plan and plateau and is present in many forested environments including urban bushland. Most of the optimal habitat for the Powerful Owl on the Illawarra escarpment, coastal plan and plateau occurs along and just above the escarpment. Modelled high quality habitat for the Powerful Owl occurs in the study area. While the habitat in the study area provides suitable foraging habitat for the Powerful Owl, no suitable breeding habitat is present.

As such, the impacts of the proposal to the Powerful Owl would be limited to loss of foraging habitat caused by direct clearing or damage to vegetation during the construction phase. The main points of consideration are as follows:

- No impacts to the life cycle of the Powerful Owl are anticipated as a result of the proposal. Foraging habitat will be removed but no breeding habitat will be affected. There is limited potential for direct mortality of owls from the proposal.
- The Powerful Owl would suffer a small reduction in extent of PCTs suitable as foraging habitat from the proposal of around 7.58 ha. This is a small proportional impact.
- Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat for the Powerful Owl.
- While the habitat in the study area is modelled as being high quality (NSW National Parks & Wildlife Service, 2002) no important breeding for the Powerful Owl will be removed. The habitat to be cleared forms part of a larger matrix of foraging habitat for the Powerful Owl and while the areas of habitat to be cleared contribute to the habitat for prey populations, the extent of habitat removal is small and considered unlikely to greatly affect foraging opportunities for the Powerful Owl in the locality. The habitat to be removed by the proposal is not considered to be limiting for the Powerful Owl and as such is not considered of critical importance to this species.
- No critical habitat will be affected.
- The proposal would not interfere with the recovery actions that have been identified for the recovery of the Powerful Owl.
- The only KTP relevant to the Powerful Owl that would be increased by the proposal is clearing of native vegetation but the proposal will not contribute to any of the other key threats to this species.

After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant effect to the Powerful Owl.

Grey-headed Flying-fox (*Pteropus poliocephalus*)

The Grey-headed Flying-fox was recorded flying over the study area during the field survey and temporarily perched on trees within the study area to rest during the flight to the north as the animals left the camp at Figtree. The Wollongong Figtree camp is located in the suburb of West Wollongong approximately 3 kilometres southeast of the study area. The rainforests and moist eucalypt forests of the Illawarra Escarpment are recognised as high quality habitat for the Grey-headed Flying-fox (NSW National Parks and Wildlife Service, 2002a). The Grey-headed Flying-fox feeds on Blackbutt (*Eucalyptus pilularis*) during flowering events and they will also use fruiting rainforest trees as a food source (NSW National Parks and Wildlife Service, 2002a, Eby and Law, 2008). As such, the habitats provided by the PCT 694 and PCT 1245 within the study area are considered to provide high quality seasonal foraging resource for the Grey-headed Flying-fox due to the dominance of Blackbutt and the tall rainforest sub canopy / midstorey that is composed of species typical of warm temperate and / or subtropical rainforest.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. **in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Grey-headed Flying-fox occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Annual mating commences in January and conception occurs in April or May; a single young is born in October or November.

There are no roost camps located in the study area and at the time of this assessment the proposal would not directly impact on any known breeding / maternity site. The Wollongong Figtree camp is located in the suburb of West Wollongong approximately 3 kilometres southeast of the study area and will not be impacted by the proposal. However, the study area does provide a high quality seasonal foraging resource for the Grey-headed Flying-fox due to the dominance of Blackbutt and the tall rainforest sub canopy / midstorey that is composed of species typical of warm temperate and / or subtropical rainforest. As such, the impacts of the proposal to the Grey-headed Flying-fox would be limited to loss of foraging habitat caused by direct clearing or damage to vegetation during the construction phase.

The proposal would remove around 7.58 hectares of high quality foraging habitat for the Grey-headed Flying-fox in the form of eucalypt trees and rainforest midstorey in PCT 694 and PCT 1245. However, the removal of vegetation would be avoided where possible and minimised during detailed design. Planted trees including Spotted Gum (*Corymbia maculata*), other planted eucalypts, and fig trees may also provide a foraging resource during flowering and/or fruiting periods. The impact to plantings and urban trees that may provide suitable foraging habitat for the Grey-headed Flying-fox is around 5.05 hectares.

The affected area of foraging habitat would represent a small percentage of the total extent of important foraging habitats for the Grey-headed Flying-fox present within the locality and within the broader foraging range of individuals from the Wollongong Figtree camp. Given the relative widespread nature of similar vegetation along the Illawarra Escarpment, the proposal is not expected to significantly affect the life cycle of the Grey-headed Flying-fox. While some high quality seasonal foraging habitat will be removed, the impact is not considered likely to have an adverse effect on the life cycle of the species such that a viable local population of the species (taken here to be the Wollongong Figtree sub-population) is likely to be placed at risk of extinction. Extensive areas of high quality foraging habitat will remain within the foraging range of the Grey-headed Flying-fox individuals that use the Wollongong Figtree camp and sufficient foraging resources will remain in the study area, and locality, after the proposal has been built for this species to complete its life cycle.

2. **in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

3. **in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

   i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

   ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

4. in relation to the habitat of a Threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The extent of native foraging habitat for the Grey-headed Flying-fox would be reduced by around 7.58 ha by the proposal. This is the high quality foraging habitat in the form of eucalypt trees and rainforest midstorey in PCT 694 and PCT 1245. This represents less than 0.5% of the suitable foraging habitat for this species in the locality which is a small proportion. Additionally, The impact to plantings and urban trees that may provide suitable foraging habitat for the Grey-headed Flying-fox is around 5.05 hectares.

Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat for the Grey-headed Flying-fox. Due to its nature, the proposal will result in the breaking apart of some habitat blocks into smaller portions. The new roadways and roundabouts will create a hard barrier to movement for some species but the Grey-headed Flying-fox is considered to be less affected. The Grey-headed Flying-fox is highly mobile and will freely fly long distances (up to 50 km) over open areas including urbanised city centres to move between roost camps and foraging sites. The Grey-headed Flying-fox currently flies over the study area and uses the habitat patches and the level of fragmentation caused by the proposal is considered unlikely to alter this behaviour. Importantly, the proposal would not affect the movement of the Grey-headed Flying-fox between habitat patches.

The proposal will result in the removal of some high quality foraging habitat for the Grey-headed Flying-fox in the form of eucalypt trees and rainforest midstorey in PCT 694 and PCT 1245. This habitat would be of seasonal importance while the Blackbutt trees are flowering and rainforest species are bearing fruit. The National Parks and Wildlife Service (2002a) modelled the habitats for the Grey-headed Flying-fox on the Illawarra Escarpment, Coastal Plain and Plateau and found that there were 3,500 hectares of high quality habitats on the escarpment for the Grey-headed Flying-fox. The National Parks and Wildlife Service (2002a) modelling does not include the study area in the area of high quality habitat. Nonetheless, the PCTs within the study area do provide some high quality foraging resources and are likely to be seasonally important for a small number of individuals, but on a lesser scale than the large areas of wet forest and rainforest higher on the escarpment that provide larger areas of high quality habitat. Importantly, the proposal would not affect the Wollongong Figtree roosting camp, which is a very important site for the species in the locality.

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for the Grey-headed Flying-fox.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The *Draft National Recovery Plan for the Grey-headed Flying-fox* (Department of Environment Climate Change and Water, 2009) outlines the following actions:

- Identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes across their range
- Enhance winter and spring foraging habitat for Grey-headed Flying-foxes

- Identify, protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes
- Significantly reduce levels of deliberate Grey-headed Flying-fox destruction associated with commercial horticulture
- Provide information and advice to managers, community groups and members of the public that are involved with controversial flying-fox camps
- Produce and circulate educational resources to improve public attitudes toward Grey-headed Flying-foxes, promote the recovery program to the wider community and encourage participation in recovery actions
- Monitor population trends for the Grey-headed Flying-fox
- Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts
- Oversee a program of research to improve knowledge of the demographics and population structure of the Grey-headed Flying-fox
- Maintain a National Recovery Team to oversee the implementation of the Grey-headed Flying-fox National Recovery Plan

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. The Grey-headed Flying-fox has been assigned to the Landscape species management stream under the OEH Saving our Species program and the following actions for recovery have been identified for this species:

- Increase the extent and viability of foraging habitat for the Grey-headed Flying-fox that is productive during winter and spring through dedicated habitat creation and restoration using guides published by OEH (in preparation).
- Negotiate agreements with landholders, particularly in-perpetuity covenants or stewardship agreements that promote the protection and retention of high quality foraging habitat and roost sites for Grey-headed Flying-foxes.
- Rehabilitate degraded flying-fox roost sites through weed management, planting new roost trees, managing understorey vegetation to maintain suitable microclimate conditions, establishing buffers between roost camps and nearby human settlements to minimise conflict.
- Conduct dedicated engagement programs in communities affected by flying-fox roost sites, building the capacity of all stakeholders to engage in the process of decision-making and developing camp management plans. Provide information about mitigating the impacts of flying-foxes on nearby residences and businesses such as strategic vegetation management, and structural modifications like double-glazing, air conditioning and shade cloths.
- Distribute public education materials to land managers and local community groups working with contentious flying-fox roost sites highlighting species status, reasons for being in urban areas, reasons for decline etc.
- Develop site-based heat stress response protocols for camps likely to be affected by heat stress events. Protocols should be based on best practice guidelines, and should be implemented by licensed fauna rehabilitators. Data should be recorded to inform future management of heat stress events.
- Increase the extent and viability of foraging habitat for the Grey-headed Flying-fox that is productive during winter and spring through dedicated habitat creation and restoration using guides published by OEH (in preparation).
- Negotiate agreements with landholders, particularly in-perpetuity covenants or stewardship agreements that promote the protection and retention of high quality foraging habitat and roost sites for Grey-headed Flying-foxes.
- Rehabilitate degraded flying-fox roost sites through weed management, planting new roost trees, managing understorey vegetation to maintain suitable microclimate conditions, establishing buffers between roost camps and nearby human settlements to minimise conflict.
- Conduct dedicated engagement programs in communities affected by flying-fox roost sites, building the capacity of all stakeholders to engage in the process of decision-making and developing camp management plans. Provide information about mitigating the impacts of

flying-foxes on nearby residences and businesses such as strategic vegetation management, and structural modifications like double-glazing, air conditioning and shade cloths.
- Distribute public education materials to land managers and local community groups working with contentious flying-fox roost sites highlighting species status, reasons for being in urban areas, reasons for decline etc.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Grey-headed Flying-fox are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal would not interfere with the recovery actions that have been identified for the recovery of the Grey-headed Flying-fox.

7. whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

A KTP is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Grey-headed Flying-fox that would be increased by the proposal is clearing of native vegetation.

The main threats to the Grey-headed Flying-fox include:

- Loss and disturbance of roosting sites.
- Unregulated shooting.
- Electrocution on powerlines, entanglement in netting and on barbed-wire.
- Competition with Black Flying-foxes.
- Negative public attitudes and conflict with humans.
- Impacts from climate change.
- Disease.

The proposal would not increase any of the above threats.

Conclusion

There are no roost camps located in the study area and at the time of this assessment the proposal would not directly impact on any known breeding / maternity site. As such, the impacts of the proposal to the Grey-headed Flying-fox would be limited to loss of foraging habitat caused by direct clearing or damage to vegetation during the construction phase. The main points of consideration are as follows:

- The proposal would remove around 7.58 hectares of high quality foraging habitat for the Grey-headed Flying-fox in the form of eucalypt trees and rainforest midstorey in PCT 694 and PCT 1245. The impact to plantings and urban trees that may provide suitable foraging habitat for the Grey-headed Flying-fox is around 5.05 hectares. This is a small proportional impact when compared to the 3,500 hectares of high quality habitat modelled by the National Parks and Wildlife Service (2002a).
- Importantly, the proposal would not result in any further substantial landscape scale fragmentation of habitat for the Grey-headed Flying-fox.
- The PCTs within the study area do provide some high quality foraging resources and are likely to be seasonally important for a small number of individuals, but on a lesser scale than the large areas of wet forest and rainforest higher on the escarpment that provide larger areas of high quality habitat. Importantly, the proposal would not affect the Wollongong Figtree roosting camp, which is a very important site for the species in the locality.
- No critical habitat will be affected.
- The proposal would not interfere with the recovery actions that have been identified for the recovery of the Grey-headed Flying-fox.

- The only KTP relevant to the Grey-headed Flying-fox that would be increased by the proposal is clearing of native vegetation but the proposal will not contribute to any of the other key threats to this species.

After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant effect to the Grey-headed Flying-fox.

Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and Little Bentwing-bat (*Miniopterus australis*)

This assessment concerns the Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and Little Bentwing-bat (*Miniopterus australis*) which were identified on site from Anabat analysis. These species of bat are known to roost in caves, derelict mines, storm-water tunnels, culverts, bridges, buildings and other man-made structures. Suitable foraging habitat is present within the PCTs in the study area. No suitable roosting habitat for this species is present in the study area.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

1. **in the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Eastern Bentwing-bat primarily roosts in caves, but will also use derelict mines, storm-water tunnels, buildings and other man-made structures. The Eastern Bentwing-bat forms populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young. At other times of the year, populations disperse within about 300 km range of maternity caves. The Eastern Bentwing-bat hunts in forested areas (Office of Environment and Heritage, 2017).

The Little Bentwing-bat inhabits moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub. It is generally found in well-timbered areas. Little Bentwing-bats roost in caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings during the day, and at night forage for small insects beneath the canopy of densely vegetated habitats. They often share roosting sites with the Eastern Bentwing-bat and, in winter, the two species may form mixed clusters. In NSW the largest maternity colony is in close association with a large maternity colony of Eastern Bentwing-bats and appears to depend on the large colony to provide the high temperatures needed to rear its young. Maternity colonies form in spring and birthing occurs in early summer. Males and juveniles disperse in summer. Only five nursery sites /maternity colonies are known in Australia (Office of Environment and Heritage, 2017).

These species do not breed in the study area but may be present during autumn and winter. The population of the Eastern Bentwing-bat and Little Bentwing-bat that may utilise the habitats in the study area are considered viable.

All vegetation within the study area is likely to provide foraging habitat for these species and the riparian zone is likely to be a focal point for foraging. These bats do not breed in the study area but may spend time in the locality during autumn and/or winter where during which time they may forage in the habitats. The impacts of the proposal are not expected to have an adverse effect on the life cycle of these species such that a viable local population is likely to be placed at risk of extinction. Considerable foraging habitat will remain in the locality and these species can be expected to continue to overwinter in the locality after the proposal has been built.

2. **in the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

3. in the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

4. in relation to the habitat of a Threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The proposal would remove around 7.58 ha of potential foraging habitat for the Eastern Bentwing-bat and Little Bentwing-bat. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered. The habitat within the study area is not limiting for these two species. No roosting or breeding habitat will be affected.

Importantly, the proposal would not result in fragmentation of habitat for these species. These species are highly mobile and will freely fly long distances over open areas to move between habitats. The proposal would not affect the movement of the Eastern Bentwing-bat or Little Bentwing-bat between habitat patches.

The vegetation in the study area would form a small component of a larger foraging range for these two species. Riparian vegetation is likely to be a focal point of foraging activity, as are the edges of vegetation patches. The loss of native vegetation from the study area would reduce the amount of foraging habitat available for these species by a small amount. However, when compared to the larger and higher quality vegetation remnants in the locality (ie the vegetation along the escarpment), the vegetation within the study area is not considered as important for the long-term survival of the Eastern Bentwing-bat or Little Bentwing-bat in the locality.

5. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable, as no critical habitat has been listed for These two bat species.

6. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan does not exist for the Eastern Bentwing-bat or Little Bentwing-bat. However, the following actions have been identified by the OEH for recovery of these two species under the Saving Our Species program.

Eastern Bentwing-bat:

- Prevent human access to roost and maternity caves and the areas immediately around cave entrances during winter and the breeding season, through the erection of signage, or the removal of access tracks and paths.

- Remove vegetation encroaching on cave entrances, with a minimum of disturbance.
- Initiate a caver education program promoting awareness of the threat of pathogens to microbats, and providing information on appropriate hygiene, and where appropriate decontamination, protocols. Program should particularly target people likely to come into contact with pathogens overseas and who may introduce them to Australia.
- Protect and maintain high quality foraging habitat in the vicinity of maternity caves. Target high productivity habitats, primarily riparian areas, wetlands, and other areas of native vegetation associated with high moisture status and fertility. Where possible negotiate conservation agreements with landholders; agreements should preferably be funded and in perpetuity.
- Undertake revegetation, using a diverse mix of locally appropriate native species. Revegetation should focus on areas of good moisture and fertility, particularly riparian areas and wetlands. Priority should be given to expanding existing small habitat patches.
- Restrict physical cave entrance closures to situations where there is a real hazard to public health and safety, and where the risk cannot be dealt with by other means (for example removing access tracks). Where closures are required, closures should be undertaken in a manner that continues to allow safe access for bats, and that does not influence the cave's microclimate.

Little Bentwing-bat:

- Liaise with relevant authorities or land managers to ensure that the location and sensitivity of key foraging areas are known prior to any hazard reduction burns. Also ensure that areas immediately surrounding maternity/nursery caves are identified as an important biodiversity asset in any relevant fire planning and have a 100m buffer zone applied. Planned fires near maternity or roosting site should not be undertaken during the breeding season (August to early April), during winter when bats are in residence, or when the wind direction is likely to blow heavy smoke or flames into the cave. Undertake research into the effects of fire on the species.
- Encourage land managers to enter into land management agreements that protect and restore key areas particularly swamps and habitat adjacent to caves and other roost sites.
- Undertake restoration and augmentation planting and/or direct seeding, including species from the ground layer and understorey in areas of degraded and/or potentially suitable habitat where weeds can be effectively managed. Revegetation should focus on expanding existing smaller areas of suitable habitat and connecting areas of suitable habitat to create corridors for movement. A diversity of local native species should be planted.
- Check that cave entrances are not blocked in a way that prevents easy continual access by bats. Monitor the density of vegetation (native or exotic) at the entrance to any active or potential maternity or hibernation roost cave and manually remove (do not use chemicals) as necessary to ensure bats have ready access year round.
- Identify important maternity or hibernation roost sites (e.g. caves, tunnels, bridges, drains, culverts) and negotiate with relevant landholders or land managers to enter into an agreement that protects these sites from disturbance or degradation. This should include provision to check and seek expert advice if the bats are present prior to undertaking maintenance works.
- Discourage recreational users from roosting areas such as caves, culverts, and stormwater drains by erecting signs or blocking preventing human access whilst still allowing access to bats. In caves where public access is permitted, restrict access during breeding season (November-March) and winter to approved scientific research only and provide information in the form of brochures and signage about appropriate care and behaviour whilst at the site. Provide this information to caving, climbing, abseiling and bushwalking groups.
- Raise awareness amongst landholders in close proximity (approximately 15km radius) to maternity or hibernation roost caves, of the potential impacts of using harmful pesticides and other chemicals and discourage their use in or adjacent to habitat areas.
- Monitor the species at a number of sites, including the single known breeding colony in NSW, to keep watch on the potential introduction of pathogens such as white-nosed fungus. Restrict use of known important maternity or hibernation roost caves during the breeding and overwintering period to those undertaking approved management or scientific research. Disseminate brochures and liaise with recreational caving, bushwalking, abseiling and climbing

groups to highlight the risks of disease spread and also describe appropriate hygiene protocols for use on site.

- Liaise with relevant authorities and/or land managers to discourage the destruction of caves. If mine sites are to be closed or previously abandoned mines reopened, they should first be checked for the presence of bats (during summer) and access should still be provided for the bats to safely enter and leave. Closure technique should be discussed with relevant microbat experts to ensure that possible habitat for bats is maintained. If gates are used, they should be bat friendly with horizontal bars at last 15cm apart and preferably with a larger gap across the top. Bats should be excluded prior to closure (and this should not occur during the breeding season from August to early April or winter). The impact of closure on bat usage should be monitored for several seasons.
- Undertake research to understand the effects of fragmentation on the species.
- Liaise with relevant authorities and/or land managers to ensure that the location and sensitivity of roosting and key foraging areas are known and encourage that existing lighting impacting on these areas be modified and that any future lighting avoid spilling onto these areas where possible.
- Investigate wintering roosts including whether the species use banana trees and tree hollows in order to understand species habitat.

The recovery actions listed above identified in the Saving Our Species program that have been identified by the OEH to help recover these bat species are largely not applicable to the proposal. The proposal is not considered likely to interfere with the recovery of these species.

7. whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

A KTP is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present, there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTPs relevant to the Eastern Bentwing-bat or Little Bentwing-bat that would be increased by the proposal is clearing of native vegetation and removal of dead wood and dead trees.

Conclusion

The Eastern Bentwing-bat and Little Bentwing-bat would suffer a small reduction in extent of foraging habitat from the proposal. No roosting habitat will be affected. The proposal is unlikely to reduce the population size of the Eastern Bentwing-bat or Little Bentwing-bat or decrease the reproductive success of these species. The proposal would not interfere with the recovery of the Eastern Bentwing-bat or Little Bentwing-bat and would not contribute to the key threats to these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant effect to the Eastern Bentwing-bat or Little Bentwing-bat.

Environment Protection and Biodiversity Conservation act 1999 assessment

Syzygium paniculatum (Magenta Lily Pilly)

Four *Syzygium paniculatum* plants were found in the study area in three locations. Three of the plants are located within bushland and one plant is located in a revegetated area near the arrester bed, off Dumfries Avenue. It is unlikely that these plants were planted in the study area. If this species were a part of the revegetation program near the arrester bed, there would likely be more than one plant in this area. The location of the other three plants within natural bushland, and the low numbers of this species, suggests that these plants have established naturally and were not planted as part of a landscaping plan or bush regeneration program. It is plausible that the

Syzygium paniculatum plants within the study area have established naturally without human intervention through seed dispersal by native animals.

It is unlikely that the *Syzygium paniculatum* plants within the study area are part of an 'important population' as defined by the *Matters of National Environmental Significance, Significant Impact Guidelines 1.1* (Department of the Environment, 2013). The *Syzygium paniculatum* plants within the study area are not part of a key source populations either for breeding or dispersal, are not likely to be necessary for maintaining genetic diversity, and are not at or near the limit of the species range.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of an important population of a species

The known total Australian population of wild *Syzygium paniculatum* is estimated to be approximately 1,200 plants (with an estimated population size for mature individuals in the range of 760-1,900). These plants are distributed along a 400 kilometre stretch of coastal NSW between Upper Lansdowne in the north to Conjola National Park in the south (NSW Office of Environment and Heritage, 2012). Within the Australian population, occurrences of *Syzygium paniculatum* are disjunct and five metapopulations (in this case geographically separated components of the population) have been identified. The five metapopulations have been identified based on the assumption of an approximately 30 kilometre foraging range for the species' larger potential dispersal agents (eg Grey-headed Flying-fox and White-headed Pigeon) (NSW Office of Environment and Heritage, 2012). The five metapopulations include Jervis Bay; Coalcliff; Botany Bay; Central Coast; and Karuah-Manning. These include 43 known subpopulations, in addition to six unconfirmed records in the Sydney Basin Bioregion. The Coalcliff metapopulation consists of ten plants and is the closest to the study area, located approximately 20 kilometres to the north (the study area is within the range of species responsible for seed dispersal). It is plausible that the *Syzygium paniculatum* plants within the study area may have been dispersed from Coalcliff and that the plants in the study area may form part of the Coalcliff metapopulation.

Syzygium paniculatum is also a popular horticultural plant and is often used as an ornamental landscape planting in urban areas. Planted *Syzygium paniculatum* trees are present throughout the greater Wollongong region. The Wollongong Botanic Gardens contains some very large mature *Syzygium paniculatum* trees (over 30 metres tall) and *Syzygium paniculatum* has been extensively planted in the garden beds in and around the University of Wollongong grounds (author's personal observation). Therefore, the study area is adjacent to a potential source of seed from mature *Syzygium paniculatum* plants. Birds and the Grey-headed Flying-fox are likely to feed on the fruit produced by the planted trees and may disperse the seed into adjacent bushland. Therefore, the occurrence of the four *Syzygium paniculatum* plants within the study area may have resulted from seed dispersal from these planted specimens. Although the seed may have originated from planted trees, the seed dispersal and consequent establishment of the plants in the study area would have occurred without human intervention and may be considered natural.

Removal of four *Syzygium paniculatum* plants will not lead to a long-term decrease in the size of the local population. The plants in the study area are outliers and the core population will not be affected.

2. reduce the area of occupancy of an important population

Approximately 7.58 ha of habitat that is potentially suitable for *Syzygium paniculatum* will be removed by the proposal. This includes approximately 6.69 ha of Blackbutt - Turpentine - Bangalay moist open forest on sheltered slopes and gullies, southern Sydney Basin Bioregion (PCT 694) and approximately 0.7 ha of Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion (PCT 1245). This extent of habitat removal for *Syzygium paniculatum* represents approximately 0.1% of these habitat types as mapped in the locality by Tozer et al. (2006) (approximately 7,076 ha of PCT 694 and PCT 1245 are mapped in

the locality). This mapping provides an overestimate of the habitat available to *Syzygium paniculatum* but an estimate of the extent of gallery rainforest on alluvium and adjacent areas within these broad habitat types cannot be made at this scale.

The proposal will not reduce the area of occupancy for *Syzygium paniculatum.*

3. fragment an existing important population into two or more populations

Habitat fragmentation *per se* relates to the physical dividing up of once continuous habitats into separate smaller 'fragments' (Fahrig, 2002). No landscape scale fragmentation will occur from the proposal. Pollen and seed movement, the two primary components of gene flow in this species will be maintained. The foraging range of birds and flying-foxes is very large so therefore pollinators and seed dispersers will be able to move between the habitats and gene flow would be maintained.

4. adversely affect habitat critical to the survival of a species

There is extremely low genetic diversity within 11 subpopulations sampled across the species range, with a distinct north-south genetic divide centred on the Central Coast. Given this, all confirmed naturally occurring populations of *Syzygium paniculatum* are considered to be important and, therefore, all habitat in which these populations occur is considered to be critical to the survival of the species (NSW Office of Environment and Heritage, 2012). The five known metapopulations include Jervis Bay; Coalcliff; Botany Bay; Central Coast; and Karuah-Manning. The Coalcliff metapopulation is represented by a single subpopulation of about ten plants and is the closest to the study area. It is reasonable to conclude that the small sub population of plants within the study area would form part of the same Coalcliff metapopulation and it is possible that the plants have established in the study area from seed dispersal from the Coalcliff population. The habitat in the study area can therefore be considered supplementary to the Coalcliff habitat and not critical.

A targeted strategy for managing threatened species is being developed under the OEH Saving Our Species program. *Syzygium paniculatum* has been assigned to the Site-managed species management stream under the OEH Saving our Species program. The OEH has established three management sites where conservation activities need to take place to ensure the conservation of this species which include:

- Great Lakes (Great Lakes)
- Wyrrabalong (Wyong)
- Wamberal Lagoon (Gosford).

These sites are considered critical for the conservation of this species and will not be affected by the proposal.

5. disrupt the breeding cycle of an important population

Syzygium paniculatum has a generalised pollination strategy, exhibiting the ability to self-pollinate and to outcross. Pollination would most likely be aided by visits to flowers by nectar and pollen-feeding vertebrates and invertebrates (eg flying-foxes, possums, honeyeaters, lorikeets, introduced and native bees, beetles, moths and butterflies) (NSW Office of Environment and Heritage, 2012). The seed is contained within a succulent berry, which quickly breaks down after the fruit has ripened. The life expectancy of seed is thought to be less than three months so it is therefore unlikely that *Syzygium paniculatum* populations support lasting soil seed banks (NSW Office of Environment and Heritage, 2012). Dispersal of seeds is likely to be achieved through several agents including water (particularly in riparian habitats subject to periodic flooding), gravity, and animals which feed on the fruits of the species (eg White-headed Pigeon, Pied Currawong, and Grey-headed Flying Fox) (NSW Office of Environment and Heritage, 2012). It is likely that other fruit-eating birds and small native mammals also consume the fruit.

Syzygium paniculatum prefers canopy cover for *in situ* seed germination due to the greater availability of moisture under closed canopy conditions but seedlings emerging under adult trees

are thought to be short lived (NSW Office of Environment and Heritage, 2012). Like many rainforest species, seedling progression may require a disturbance event, such as a tree fall or storm, which opens up the canopy (NSW Office of Environment and Heritage, 2012).

A small sub population of *Syzygium paniculatum* consisting of four plants is known to be present in the study area. Suitable habitat for this species is present throughout PCT 64 and PCT 1245. Pollinators are abundant in the study area due to the presence of native habitat as are seed dispersal vectors. A camp of Grey-headed Flying-fox is present nearby and the animals are likely to regularly frequent the habitat. Seed dispersal by the Grey-headed Flying-fox may be the reason for the occurrence of this small sub population in the study area. Therefore, the study area possesses the required pollination and seed dispersal mechanisms for this species to complete its lifecycle.

The proposal will result in disturbance to the known *Syzygium paniculatum* habitat within the study area through road construction and associated activities that will result in vegetation removal, soil removal and soil disturbance. The proposal has the potential to impact on the lifecycle of *Syzygium paniculatum* as follows:

- Habitat for animals responsible for pollination and seed dispersal will be removed but substantial habitat for the pollinators and seed dispersers will remain in the study area suggesting that pollination and seed dispersal could continue during and after the proposal is built.
- It is possible that the disturbance created by the vegetation removal and soil disturbance could create suitable conditions for the germination and establishment of *Syzygium paniculatum* at newly created habitat edges. The disturbance may be beneficial for this species. The suitability of the habitat may increase due to the removal of the tree canopy and midstorey layer, which would result in increased light and soil disturbance allowing seedlings to reach maturity.

Overall, the breeding cycle of this species is not anticipated to be greatly affected. Pollinators and seed dispersal vectors will remain in the study area after the proposal is built in sufficient numbers to ensure the sexual reproduction of *Syzygium paniculatum* could occur. The action proposed is not considered likely to disrupt the breeding cycle of *Syzygium paniculatum*.

6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Approximately 7.58 ha of habitat that is potentially suitable for *Syzygium paniculatum* will be removed by the proposal. This includes approximately 3.23 ha of PCT 694 and approximately 0.13 ha of PCT 1245. The extent of habitat removal for *Syzygium paniculatum* represents approximately 0.6% of similar habitats within the locality. Approximately 1,058 ha of suitable Blackbutt forest habitat is mapped in the locality by Tozer *et al*. (2006). The habitats within the study area are suitably connected to the remaining habitat in the locality (ie distances of less than 500 m between patches) and pollination can be expected to occur between these patches. As such, the local occurrence of suitable habitat is large. The magnitude of this impact is not considered likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat

The action is unlikely to result in an invasive species harmful to *Syzygium paniculatum* becoming established in the habitat. The potential for weed invasion was considered possible with a proposal of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the road using best practice methods.

8. introduce disease that may cause the species to decline, or

Myrtle Rust is known to affect *Syzygium paniculatum*. No evidence of Myrtle Rust was observed on the study area during the survey but there is the possibility that this pathogen could be introduced during construction. Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. Machinery associated with vegetation clearance and subsequent construction has the potential to transmit pathogens to remaining native vegetation remnants. This is a potential indirect impact to *Syzygium paniculatum* through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as part of the CEMP to prevent the introduction or spread of pathogens.

The proposals mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

9. interfere substantially with the recovery of the species.

The *National Recovery Plan Magenta Lilly Pilly Syzygium paniculatum* (NSW Office of Environment and Heritage, 2012) outlines the following objectives for the recovery of this species:

- Objective 1: To ensure a coordinated and efficient approach to the implementation of recovery efforts
- Objective 2: To establish the full extent of the distribution of Magenta Lilly Pilly
- Objective 3: To increase the understanding of Magenta Lilly Pilly biology and ecology
- Objective 4: To minimise the decline of Magenta Lilly Pilly through in situ habitat protection and management
- Objective 5: To reduce impacts of Myrtle Rust on Magenta Lilly Pilly and its habitat
- Objective 6: To maintain a representative ex situ collection of Magenta Lilly Pilly
- Objective 7: To raise awareness of the conservation significance of Magenta Lilly Pilly and involve the broader community in the recovery program.

These recovery objectives will not be interfered with by the proposal. Objective 4 is focused on OEH land and is therefore not applicable to the proposal.

Conclusion

Syzygium paniculatum will suffer a small reduction in extent of suitable habitat from the action and four plants will be removed. No critical habitat will be impacted. The action is unlikely to reduce the population size of *Syzygium paniculatum* or decrease the reproductive success of this species. The action will not interfere with the recovery of *Syzygium paniculatum* and will not contribute to the key threats to this species. After consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to *Syzygium paniculatum*.

Grey-headed Flying-fox *(Pteropus poliocephalus)*

The Grey-headed Flying-fox was recorded flying over the study area during the field survey and temporarily perched on trees within the study area to rest during the flight to the north as the animals left the camp at Figtree. The Wollongong Figtree camp is located in the suburb of West Wollongong approximately 3 kilometres southeast of the study area. The rainforests and moist eucalypt forests of the Illawarra Escarpment are recognised as high quality habitat for the Grey-headed Flying-fox (NSW National Parks and Wildlife Service, 2002a). The Grey-headed Flying-fox feeds on Blackbutt (*Eucalyptus pilularis*) during flowering events and they will also use fruiting rainforest trees as a food source (NSW National Parks and Wildlife Service, 2002a, Eby and Law, 2008). As such, the habitats provided by the PCT 694 and PCT 1245 within the study area are considered to provide high quality seasonal foraging resource for the Grey-headed Flying-fox due to the dominance of Blackbutt and the tall rainforest sub canopy / midstorey that is composed of species typical of warm temperate and / or subtropical rainforest.

It is unlikely that the Grey-headed Flying-foxes that use the study area are part of an 'important population' as defined by the *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* (Department of the Environment, 2013). The Grey-headed Flying-foxes that use the study area are not part of a key source population either for breeding or dispersal, are not likely to be necessary for maintaining genetic diversity, and are not at or near the limit of the species range.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of an important population of a species

There are no roost camps in the study area and the action will not affect any known permanent roosting, breeding / maternity site. Therefore, it is likely that the impacts of construction and operation of the action would be confined to loss of feeding habitat caused by direct clearing or damage to native vegetation during the construction phase. There is also a low risk of vehicle strike during operation.

The proposal would remove around 7.58 hectares of high quality foraging habitat for the Grey-headed Flying-fox in the form of eucalypt trees and rainforest midstorey in PCT 694 and PCT 1245. However, the removal of vegetation would be avoided where possible and minimised during detailed design. Planted trees including Spotted Gum (*Corymbia maculata*), other planted eucalypts, and fig trees may also provide a foraging resource during flowering and/or fruiting periods. The impact to plantings and urban trees that may provide suitable foraging habitat for the Grey-headed Flying-fox is around 5.05 hectares. Given the relative widespread nature of similar native vegetation and planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the proposal is not expected to lead to a long-term decrease in the size of an important population.

2. reduce the area of occupancy of an important population

The area of occupancy of the Grey-headed Flying-fox is not known but the species exists as one interconnected population along the eastern Australian coastal belt from Rockhampton in central Queensland to Melbourne in Victoria. The area occupied by this species will remain the same after the action. No decrease in the area of occupancy for this species expected as a result of the proposal.

3. fragment an existing important population into two or more populations

Highly mobile species such as bats are expected to be less impacted by fragmentation. The Grey-headed Flying-fox is particularly well adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal fruits and blossom in differing parts of the landscape. The proposal would not fragment an important population of the Grey-headed Flying-fox. Individuals will still be able to disperse between roosts along the east Australian coast. Genetic exchange within the population and dispersal will not be disrupted by the proposal.

4. adversely affect habitat critical to the survival of a species

This species typically exhibits very large home range and Grey-headed Flying-fox is known to travel distances of at least 50 kilometres from roost sites to access seasonal foraging resources. There are no known roost camps within the study area and the site does not provide critical roosting habitat.

However there are a number of known roost camps with a 50km radius of the proposal, the closest being the Fig Tree camp. The draft recovery plan for the Grey-headed Flying-fox identifies critical foraging habitat for this species as:

- Productive during winter and spring, when food bottlenecks have been identified
- Known to support populations of >30,000 individuals, within an area of 50 kilometre radius of a camp site

- Productive during the final weeks of gestation, and during the weeks of birth, lactation and conception (Sept-May)
- Productive during the final stages of fruit development and ripening in commercial crops affected by Grey-headed Flying-foxes
- Known to be continuously occupied as a camp site.

Native vegetation within the study area may constitute critical foraging habitat. Blackbutt trees flower from September to March when the Grey-headed Flying-fox is giving birth and rearing young. The affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the Fig Tree camp site. Given the extensive nature of high quality foraging habitats along the escarpment, the proposal is not expected to adversely affect foraging habitat critical to the survival of this species in this region.

5. disrupt the breeding cycle of an important population

As stated above there would be a minor impact on foraging habitat identified as important during the breeding cycle of the species. The upgrade would not directly impact on a known roost camp / breeding or maternity site. Extensive foraging resources are available on the escarpment that will provide suitable resources during the maternity season. The habitats in the study area are not limiting for this species.

6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

No evidence of a roost camp has been identified from the study area. Further, there would be a relatively minor impact on foraging habitat. This impact is not expected to lead to a decline in the species in this region considering the magnitude of this impact and the expanse of high quality foraging habitat available to local animals along the escarpment.

7. result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat

The action is unlikely to result in an invasive species harmful to the Grey-headed Flying-fox becoming established in the habitat. The potential for weed invasion was considered possible with a proposal of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the road using best practice methods.

8. introduce disease that may cause the species to decline, or

There are no known disease issues affecting this species in relation to the action. The action would be unlikely to increase the potential for significant disease vectors to affect local populations.

9. interfere substantially with the recovery of the species.

The *Draft National Recovery Plan for the Grey-headed Flying-fox* (*Pteropus poliocephalus*) (Department of Environment Climate Change and Water, 2009) outlines the following actions:

- Identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes across their range
- Enhance winter and spring foraging habitat for Grey-headed Flying-foxes
- Identify, protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes
- Significantly reduce levels of deliberate Grey-headed Flying-fox destruction associated with commercial horticulture

- Provide information and advice to managers, community groups and members of the public that are involved with controversial flying-fox camps
- Produce and circulate educational resources to improve public attitudes toward Grey-headed Flying-foxes, promote the recovery program to the wider community and encourage participation in recovery actions
- Monitor population trends for the Grey-headed Flying-fox
- Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts
- Oversee a program of research to improve knowledge of the demographics and population structure of the Grey-headed Flying-fox
- Maintain a National Recovery Team to oversee the implementation of the Grey-headed Flying-fox National Recovery Plan

The recovery actions listed above are largely not applicable to the action and the action is not expected to interfere substantially with the recovery of the species.

Conclusion

The Grey-headed Flying-fox will suffer a small reduction in extent of suitable foraging habitat from the action. No breeding camps or other important habitat will be impacted. The action is unlikely to reduce the population size of the Grey-headed Flying-fox or decrease the reproductive success of this species. The action will not interfere with the recovery of the Grey-headed Flying-fox and will not contribute to the key threats to this species. After consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to the Grey-headed Flying-fox.

Greater Glider *(Petaurus volans)*

Suitable habitat types for the Greater Glider are present on site in both PCTs. Furthermore, high quality habitat for the species has been modelled in the study area by the National Parks and Wildlife Service (2002). As such, this species is considered moderately likely to occur in the study area due to the presence of suitable habitats. The tree hollows within the study area are not considered large enough to support this species so no breeding habitat is expected to be present.

It is unlikely that the Greater Gliders that may use the study area are part of an 'important population' as defined by the *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* (Department of the Environment, 2013). The Greater Gliders that may use the study area are not part of a key source population for breeding or dispersal, are not likely to be necessary for maintaining genetic diversity, and are not at or near the limit of the species range.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of an important population of a species

The greater glider is restricted to eastern Australia, occurring from the Windsor Tableland in north Queensland through to central Victoria (Wombat State Forest), with an elevational range from sea level to 1200 m above sea level (Threatened Species Scientific Commitee, 2016). An isolated inland subpopulation occurs in the Gregory Range west of Townsville and another in the Einasleigh Uplands (Threatened Species Scientific Commitee, 2016). The inland sub-populations of this species would be considered important. There is no evidence to suggest that any animals that may use the study area as habitat would not constitute an important population.

There are no robust estimates of population size or population trends of the greater glider across its total distribution (Threatened Species Scientific Commitee, 2016). The Threatened Species Scientific Committee (2016) considers that the total number of mature individuals is not extremely low, very low or low and the population size is estimated at >100,000 mature individuals. Across its broader distribution density ranges from 0.01 to 5 individuals per hectare (Threatened Species Scientific Commitee, 2016). With approximately 9.95 hectares of potential foraging habitat in PCTs

within the study area the carrying capacity of the habitat may range from 0.09 to 49.75 individuals, which is a broad range. Given the quality of the habitat observed combined with the absence of records during the nocturnal survey it is likely that only one or two animals would utilise the habitat of they were present. An impact to one or two individuals from moderate quality habitat is unlikely to lead to a long-term decrease in the size of the Greater Glider population when the population is estimated at >100,000 mature individuals.

2. reduce the area of occupancy of an important population

The extent of occurrence for the Greater Glider is estimated at 1,586,870 km^2 and the area of occupancy estimated at 16,164 km^2 (Threatened Species Scientific Commitee, 2016). The proposal will decrease the amount of available habitat by approximately 7.58 hectares. This impact represents 2% of the current area of occupancy. However, the habitat is only moderately suitable and may not be occupied. Overall, the predicted impact is unlikely to reduce the area of occupancy for this species and the study area is unlikely to have been included in the area of occupancy calculations undertaken for this species.

3. fragment an existing important population into two or more populations

Due to low dispersal ability the Greater Glider is thought to be sensitive to fragmentation and have relatively low persistence in small forest fragments (Threatened Species Scientific Commitee, 2016). Modelling suggests that they require native forest patches of at least 160 km^2 to maintain viable populations (Threatened Species Scientific Commitee, 2016). While the habitat in the study area is much smaller than this, this species has still been assessed as a precautionary measure due to the presence of suitable PCTs and habitat modelling by the National Parks and Wildlife Service (2002).

Due to the nature of the proposal, it may potentially result in an increase in habitat fragmentation due to the design of the new intersection. The current habitat is likely to be divided up into smaller fragments separated by a barrier posed by the new roadways. The roadways between the fragments may be up to 20 metres wide. Given sufficient height of vegetation adjacent to the road, the Greater Glider could glide this distance and move between newly created habitat patches. While some fragmentation will occur, the level of fragmentation is not considered likely to fragment an existing important population into two or more populations.

4. adversely affect habitat critical to the survival of a species

Critical habitat for the Greater Glider is not present in the study area. Critical habitat for this species includes tall wet old growth forest in patches of greater than 160 km^2 with abundant live hollow-bearing trees and a diversity of eucalypts for foraging. The habitat in the study area is of a suitable broad type but the size of patches is small and tree hollows of a suitable size are limited.

5. disrupt the breeding cycle of an important population

No impacts on breeding are anticipated, as no suitable breeding habitat is present in the study area.

6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The habitat in the study area is of a suitable broad type but the size of patches is small and tree hollows of a suitable size are limited. The area of occupancy for the Greater Glider is estimated at 16,164 km^2 (Threatened Species Scientific Commitee, 2016) and the impacts from the proposal on some moderate quality habitat are considered unlikely to lead to a decline in the species in this region.

7. result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat

The action is unlikely to result in an invasive species harmful to the Greater Glider becoming established in the habitat. The potential for weed invasion was considered possible with a proposal of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods.

8. introduce disease that may cause the species to decline, or

There are no known disease issues affecting the Greater Glider in relation to the action. The action would be unlikely to increase the potential for significant disease vectors to affect local populations.

9. interfere substantially with the recovery of the species.

There is no recovery plan for the Greater Glider. However, broad conservation actions have been developed and include the following:

- Reduce the frequency and intensity of prescribed burns.
- Identify appropriate levels of patch retention, habitat tree retention, and logging rotation in hardwood production.
- Protect and retain hollow-bearing trees, suitable habitat and habitat connectivity.

The recovery of this species is best served by forestry prescriptions to protect and conserve habitat for this species. The proposal is not considered likely to interfere with the recovery of this species.

Conclusion

The Greater Glider will suffer a small reduction in extent of moderately suitable foraging habitat from the action. No breeding habitat will be affected. The action is unlikely to reduce the population size of the Greater Glider or decrease the reproductive success of this species. The action will not interfere with the recovery of the Greater Glider and will not contribute to the key threats to this species. After consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to the Greater Glider.

Swift Parrot *(Lathamus discolor)*

The Swift Parrot is endemic to south-eastern Australia and breeds only in Tasmania. It migrates to mainland Australia in autumn. The National Parks and Wildlife Service (2002) identifies the Swift Parrot as an irregular migrant to the Illawarra escarpment, coastal plain and plateau. There have been records of the Swift Parrot made from the Wollongong University campus in 2002 suggesting this species occasionally utilises the habitats. As such, the Swift Parrot is considered moderately likely to occur within the study area on an infrequent basis based on the presence of some marginally suitable foraging habitat and nearby records. No critical or high quality foraging habitats are present.

An action is likely to have a significant impact on a Critically Endangered or Endangered species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of a population

The study area contains some potential foraging habitat for the Swift Parrot. While the habitat in the study area is not optimal, the loss of potential feed trees would directly affect the species opportunity to feed in the area. However, the study area is not considered a critical area for the Swift Parrot. The Swift Parrot may utilise trees in the study area for foraging intermittently when no other suitable inland (i.e. box ironbark woodlands) or coastal resources (i.e. Spotted Gum and Swamp Mahogany forests) are available. The action would remove Potential foraging habitat for this species will be reduced by about 7.58 hectares. This is a small proportional impact considering the National Parks and Wildlife Service (2002a) has mapped 48 hectares of high quality habitat for the Swift Parrot in the region of the Illawarra escarpment, coastal plan and plateau. The impact to plantings and urban trees that may provide suitable foraging habitat for the Swift Parrot is around 5.05 hectares.

The Swift Parrot does not breed in the study area and the extent of habitat remaining in the study area would provide sufficient resources to sustain future visitation, such that the action is unlikely to lead to a long-term decrease in the size of the Australian population.

2. reduce the area of occupancy of the species

As a specialist nectarivore dependent on flowering eucalypts, Swift Parrots are vulnerable to the loss of quantity and quality of key forage tree species. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat. The species is an occasional visitor to the region and may utilise trees in the study area for foraging intermittently when no other suitable resources are available.

The proposal would contribute to the loss of potential foraging habitat that would reduce the area of habitat available. However, the action will not reduce the area of occupancy of this species, which is estimated at 4,000 km².

3. fragment an existing population into two or more populations

Importantly, the action will not result in fragmentation of habitat for the Swift Parrot. The level of fragmentation likely to be caused will not affect large-scale migrants such as the Swift Parrot. This species is highly mobile and as a regular behaviour flies long distances over open areas to move between suitable foraging habitats. The action will not affect the movement of the Swift Parrot between habitat patches or fragment the population.

4. adversely affect habitat critical to the survival of a species

Key habitats for this species on the coast and coastal plains of New South Wales include large stands of Spotted Gum (*Corymbia maculata*), Swamp Mahogany (*E. robusta*), Red Bloodwood (*Corymbia gummifera*) and Forest Red Gum (*E. tereticornis*) forests. The study area does not have forests of these species. The habitat within the study area is considered to be secondary or supplementary habitat for the Swift Parrot as this species is not regularly recorded from the area and the area is not known as critical habitat.

5. disrupt the breeding cycle of a population

The Swift Parrot is endemic to south-eastern Australia and breeds only in Tasmania, and migrates to mainland Australia in autumn. As such, the action will not impact on breeding habitat for this species. Important winter foraging grounds will not be impacted.

6. modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Foraging habitat for this species will be reduced by about 7.58 hectares of PCTs and 5.05 ha of planted vegetation. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat. The species is an occasional visitor to the region and may utilise trees in the study area for foraging intermittently when no other suitable resources are available. The action is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat

The main invasive species harmful to the habitat for the Swift Parrot are weeds that modify habitat and also other birds that are aggressive competitors. Noisy Miners are abundant in the habitat which may make the habitat less suitable for the Swift Parrot due to competitive exclusion. The action may result in weed invasion and the removal of habitat may concentrate local miner populations increasing competition. The management of invasive species would be managed under the construction environmental management plan and during operation.

8. introduce disease that may cause the species to decline, or

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction has the potential to transmit the fungus to remaining native vegetation remnants. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as part of the CEMP to prevent the introduction or spread of pathogens.

The proposals mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

9. interfere with the recovery of the species.

The *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros, 2011) aims to prevent further population decline of the Swift Parrot and to achieve a demonstrable sustained improvement in the quality and quantity of Swift Parrot habitat to increase carrying capacity. These objectives will be achieved by implementing recovery actions for each of the following specific recovery objectives:

- Objective 1: To identify and prioritise habitats and sites used by the species across its range, on all land tenures.
- Objective 2: To implement management strategies to protect and improve habitats and sites on all land tenures
- Objective 3: To monitor and manage the incidence of collisions, competition and Beak and Feather Disease (BFD).
- Objective 4: To monitor population trends and distribution throughout the range.

These objectives, and the associated recovery actions outlined in the *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros, 2011) are not applicable to the study area or proposal. The identified recovery actions mostly relate to identifying the extent and quality of habitat, monitoring, raising community awareness, and coordinating and reviewing the recovery process. There is an action relating to manage and protect Swift Parrot habitat at the landscape scale. However, this action applies to fencing off habitat on private land to encourage regeneration of habitat, revising forestry practices, developing a strategic management plan for Swift Parrot breeding habitat in Tasmania, and providing Swift Parrot conservation information for consideration during the New South Wales Local Government Local Environmental Planning review process. The recovery actions identified in the *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros, 2011) will not be interfered with by the proposal.

Conclusion

The Swift Parrot will suffer a small reduction in extent of foraging habitat from the action. The action is unlikely to reduce the population size of the Swift Parrot or decrease the reproductive success of this species. The action will not interfere with the recovery of the Swift Parrot. For the Swift Parrot, impacts are most likely to be significant where a proposal or activity may result in loss of habitat in, or adjacent to priority foraging, nesting and roosting sites (Saunders and Tzaros, 2011). The proposal will not impact on any priority foraging habitat. As such, after consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to the Swift Parrot.

Migratory species

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

1. substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a Migratory species
2. result in an invasive species that is harmful to the Migratory species becoming established in an area of important habitat for the Migratory species, or
3. seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a Migratory species.

An area of 'important habitat' for a migratory species is defined as:

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

While migratory species of bird do use the study area and locality, the study area would not be classed as an 'important habitat' as defined under the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment, 2013), in that the study area does not contain:

- a region that supports an ecologically significant proportion of a population of migratory species
- habitat utilised by a migratory species which is at the limit of the species range
- habitat within an area where the species is declining.

As such, it is unlikely that the action would significantly affect migratory species.

There is no evidence to suggest that an ecologically significant proportion of the population of any identified migratory species exists within the study area.

The potential for weed invasion has been considered highly likely with an action of this nature and appropriate controls will be provided during the construction and operation of the road to reduce this threat in accordance with standard Roads and Maritime procedures. The management of invasive species would be managed under the construction environmental management plan.

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