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NSW GOVERNMENT

M1 Pacific Motorway extension to Raymond Terrace

Biodiversity Assessment Report

Transport for NSW | July 2021

Executive summary

Background

Transport for New South Wales (Transport) proposes to construct the M1 Pacific Motorway extension to Raymond Terrace (the project). Approval is sought under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* and Part 9, Division 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The project has been determined a controlled action under Section 75 of the EPBC Act for significant impact to threatened species and communities (Section 18 and Section 18A of the EPBC Act). As such, the project requires approval from the NSW Department of Planning, Infrastructure and Environment and the Commonwealth Government.

Performance outcomes

This assessment has been prepared to address the Secretary's Environment Assessment Requirements (SEARs) (SSI 7319), which include the Commonwealth assessment requirements under the EPBC Act (2018/8288). In addition, the desired performance outcomes for the project in relation to biodiversity as outlined in the SEARs are to:

- Consider all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity
- Offsets are equivalent to any remaining impacts from construction and operation of the project
- Assure the delivery of offsets and /or supplementary measures required for the project.

Overview of biodiversity impacts

Biodiversity values identified from targeted field surveys, carried out between 2014 and 2020, have been considered in the development of the concept design for the project and previous to this during the extensive options development phase, for the purpose of avoiding and minimising impacts to biodiversity where reasonable and feasible.

The project would result in the following residual biodiversity impacts:

- Removal of about 174 hectares of native vegetation of which 136 hectares correspond with six threatened ecological communities listed under the *Threatened Species Conservation Act 1995* (TSC) Act
- Removal of about 0.55 hectares of a threatened ecological community listed under the EPBC Act
- Removal of the following threatened plant species:
  - *Diuris arenaria* (TSC Act listed) – about 161 plants
  - *Callistemon linearifolius* (TSC Act listed) – about 157 plants
  - *Eucalyptus parramattensis* subsp. *decadens* (TSC Act and EPBC Act listed) – about 34 plants
  - *Persicaria elatior* (TSC Act and EPBC Act listed) – about three plants.
- Impacts to habitat of five species credit fauna species
- Loss of habitat for 29 ecosystem credit threatened fauna species (nine recorded and 20 assumed present), including loss of hollow-bearing trees, loss of foraging resources and reduction in habitat area
- Removal of 51.12 hectares of vegetation types that contains koala feed tree species
- Minor fragmentation of native vegetation and habitat at three locations; Black Hill, Tomago and Heatherbrae
- Localised disturbance and loss of riparian habitat along the banks of the Hunter River during construction and operation of the new bridge
- Temporary impacts to Key Fish Habitat during construction of the bridge over the Hunter River.

Management measures and offsets

The assessment has identified measures and strategies proposed to avoid and minimise impacts to biodiversity associated with the project including the provision of fauna connectivity structures, fencing to prevent injury to fauna and revegetation in accordance with relevant guidelines.

Any residual impacts will be offset in accordance with the NSW Biodiversity Offsets Policy for Major Projects and the FBA. Offsets for impacts to marine vegetation have been calculated in accordance with the Fisheries NSW policy and guidelines for saline wetlands vegetation formations. A Biodiversity Offset Strategy has been prepared that outlines how Transport intends to offset the residual impacts on the project.

Conclusion

Biodiversity impacts have been avoided and minimised, where possible, by locating the project within or next to existing development and infrastructure corridors or in areas modified by agriculture. The potential impacts to biodiversity by the project are well understood after a multi-year period of field assessments and are able to be controlled by proven management measures employed during design, construction and operation of the project. Residual impacts on biodiversity will be offset in accordance with the NSW Biodiversity Offsets Policy for Major Projects and the FBA.

Overall, the project achieves the desired performance outcomes by minimising and avoiding impacts on terrestrial and aquatic biodiversity, where possible and considering offsets for residual biodiversity impacts from the project.

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1. Introduction

1.1 Background

Transport for New South Wales (Transport) proposes to construct the M1 Pacific Motorway extension to Raymond Terrace (the project). Approval is sought under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and Part 9, Division 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The project is also a controlled action under section 75 of the EPBC Act (reference EPBC 2018/8288) for significant impact to threatened species and communities (Section 18 and Section 18A of the EPBC Act). As such, the project requires approval from the NSW Department of Planning, Infrastructure and Environment (DPIE) and the Commonwealth Government.

The project would connect the existing M1 Pacific Motorway at Black Hill and the Pacific Highway at Raymond Terrace within the City of Newcastle and Port Stephens Council local government areas (LGAs). The project would provide regional benefits and substantial productivity benefits on a national scale. The project location is shown in **Figure 1-1** within its regional context.

1.2 Project description

The project would include the following key features:

- A 15 kilometre motorway comprised of a four lane divided road (two lanes in each direction)
- Motorway access from the existing road network via four new interchanges at:
  - Black Hill: connection to the M1 Pacific Motorway
  - Tarro: connection and upgrade (six lanes) to the New England Highway between John Renshaw Drive and the existing Tarro interchange at Anderson Drive
  - Tomago: connection to the Pacific Highway and Old Punt Road
  - Raymond Terrace: connection to the Pacific Highway.
- A 2.6 kilometre viaduct over the Hunter River floodplain including new bridge crossings over the Hunter River, the Main North Rail Line and the New England Highway
- Bridge structures over local waterways at Tarro and Raymond Terrace, and an overpass for Masonite Road in Heatherbrae
- Connections and modifications to the adjoining local road network
- Traffic management facilities and features
- Roadside furniture including safety barriers, signage, fauna fencing and crossings and street lighting
- Adjustment of waterways, including at Purgatory Creek at Tarro and tributary of Viney Creek
- Environmental management measures including surface water quality control measures
- Adjustment, protection and/or relocation of existing utilities
- Walking and cycling considerations, allowing for existing and proposed cycleway route access
- Permanent and temporary property adjustments and property access refinements
- Construction activities, including establishment and use of temporary ancillary facilities, temporary access tracks, haul roads, batching plants, temporary wharves, soil treatment and environmental controls.

A detailed project description is provided in Chapter 5 of the environmental impact statement (EIS). The locality of the project is shown in **Figure 1-1**, while an overview of the project is shown in **Figure 1-2**.

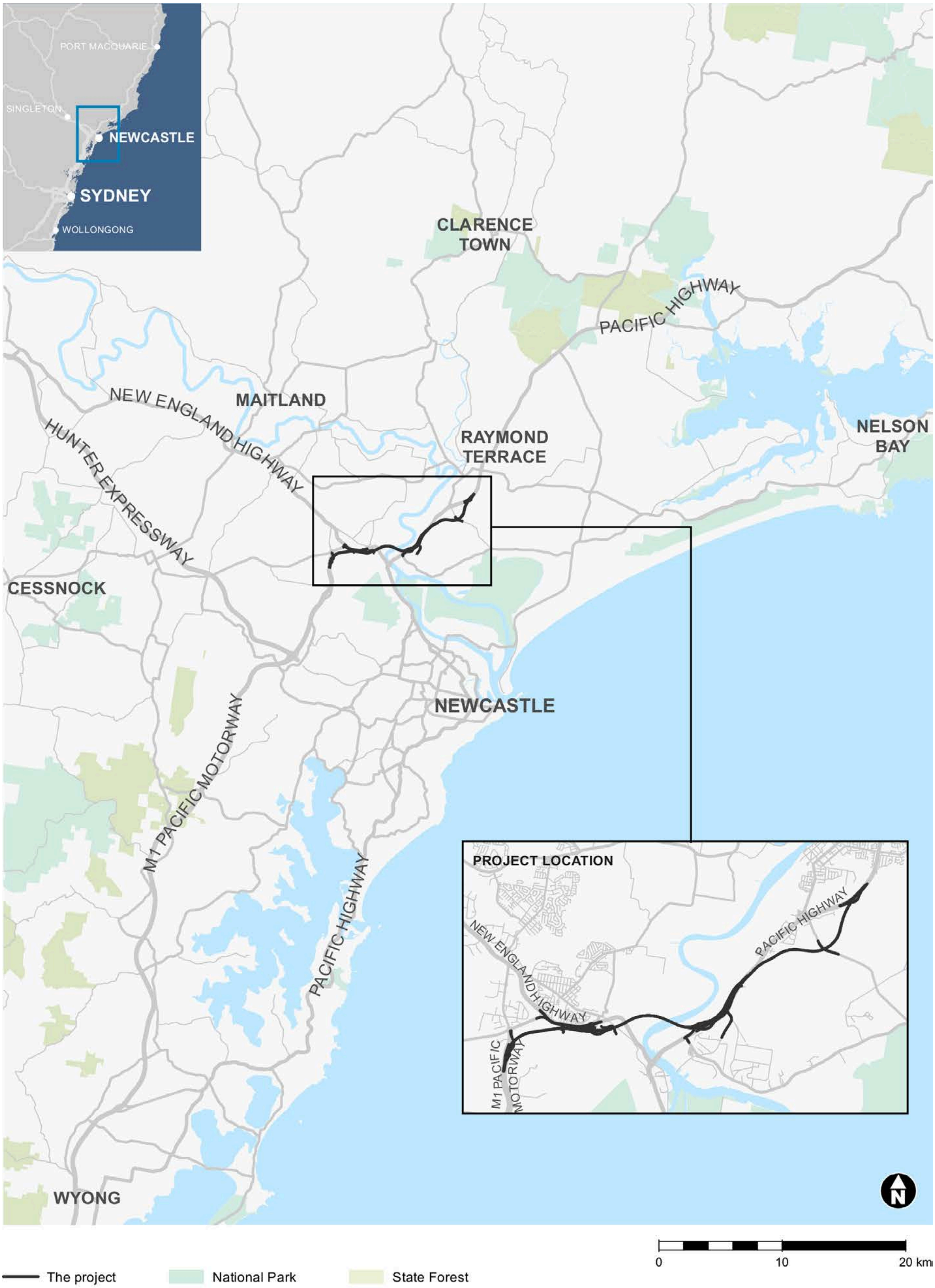


Figure 1-1 Regional context of the project

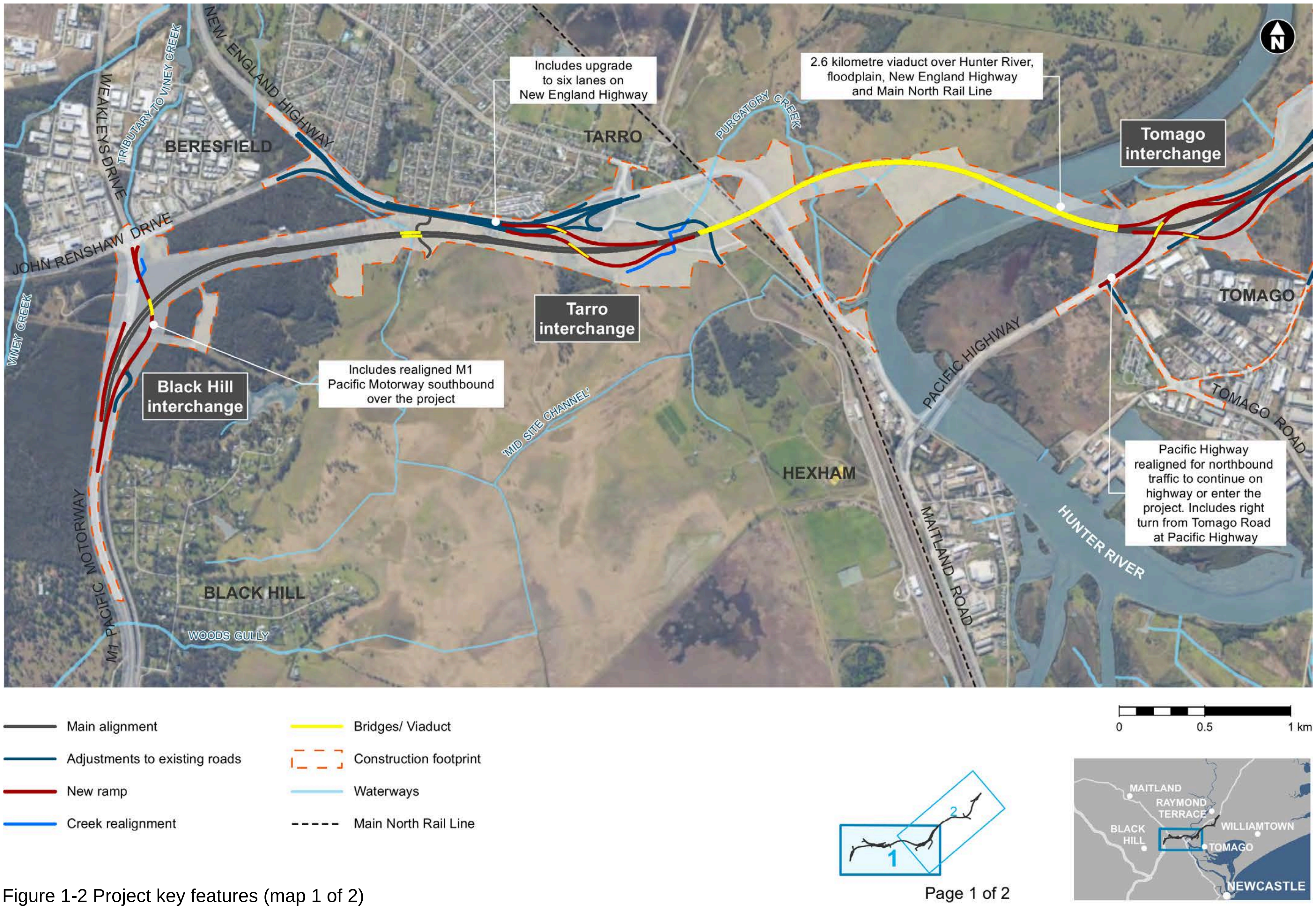


Figure 1-2 Project key features (map 1 of 2)

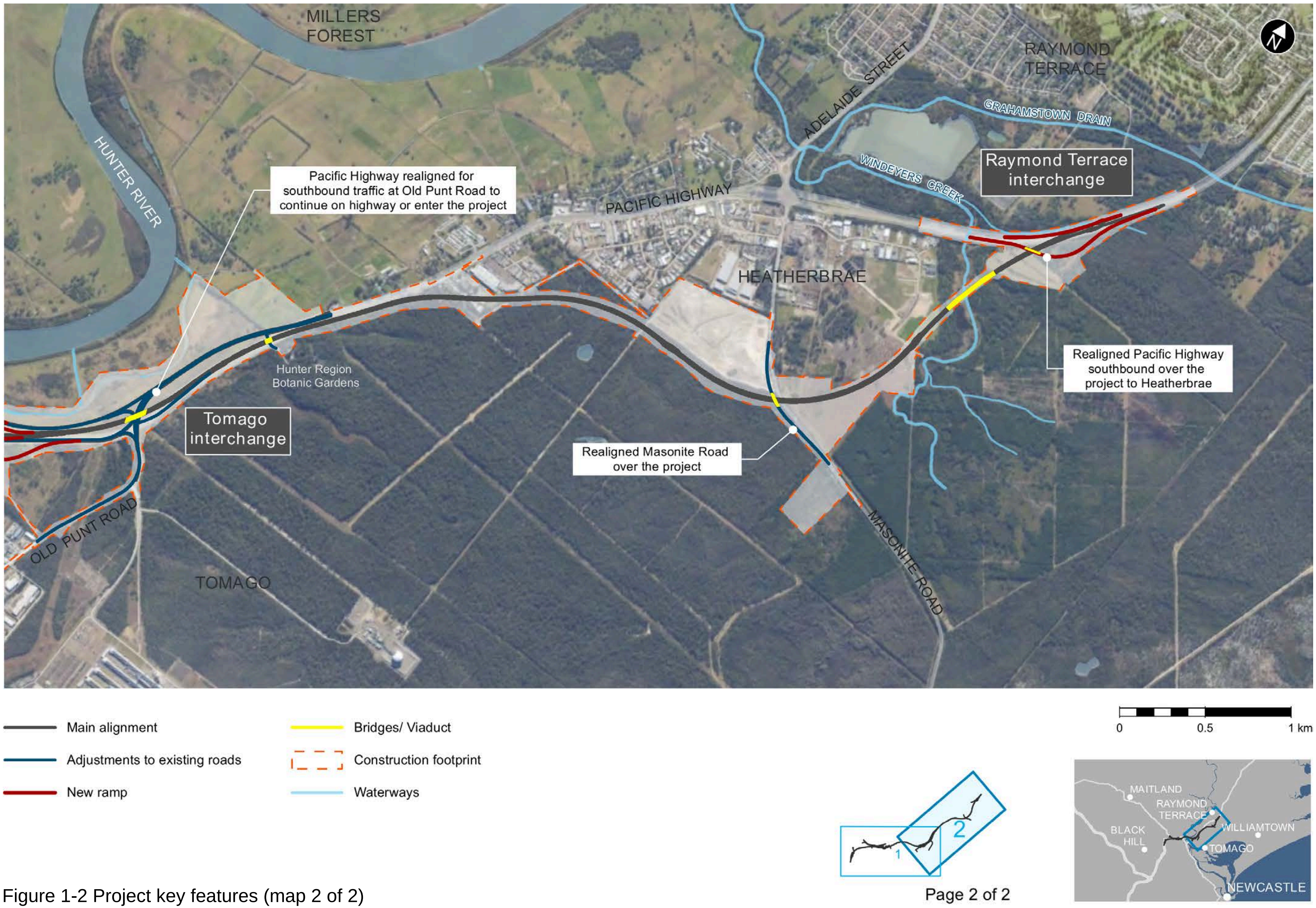


Figure 1-2 Project key features (map 2 of 2)

1.3 Performance outcomes

The desired performance outcomes for the project in relation to biodiversity are to:

- Consider all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity (**Chapter 7** and **Chapter 9**)
- Offsets are equivalent to any remaining impacts from construction and operation of the project (**Chapter 10**)
- Assure the delivery of offsets and /or supplementary measures required for the project (**Appendix I**).

1.4 Secretary's Environmental Assessment Requirements

This assessment forms part of the EIS for the project. The EIS has been prepared under Division 5.2 of the EP&A Act. This assessment specifically addresses the Secretary's Environmental Assessment Requirements (SEARs) (SSI 7319) relating to biodiversity and will assist the Minister for Planning and Public Spaces to make a determination on whether or not to approve the project. It provides an assessment of potential impacts of the project on biodiversity and outlines proposed management measures.

In 2019, revised SEARs were issued for the project, which included biodiversity as a key issue. **Table 1-1** outlines the SEARs relevant to this assessment, including the Commonwealth assessment requirements under the EPBC Act, along with a reference to where these are addressed.

Further information on the policy, planning and Commonwealth legislative requirements as they apply to this assessment are provided in **Section 1.5**.

Table 1-1 SEARs (biodiversity)

Biodiversity Assessment	Required by	Where addressed in this report
1. Environmental Impact Assessment Report		
2. The project will impact matters of national environmental significance (MNES) protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and will be assessed in accordance with the NSW Bilateral Agreement (2015). The Proponent must assess impacts to MNES protected under the EPBC Act. The assessment must be in accordance with the requirements listed in Attachment A.	EPBC Act Bilateral Agreement	MNES of relevance to the project are listed threatened species and communities (section 18 and 18A of the EPBC Act) as discussed in **Chapter 5.** Impacts relevant to MNES are discussed in **Section 8.3.** Commonwealth legislative requirements are provided below under 'Attachment A of the SEARs: General assessment requirements' are discussed in **Section 1.5.**
4. Biodiversity		
1. The Proponent must assess biodiversity impacts in accordance with the Framework for Biodiversity Assessment (FBA) and be carried out by a person accredited in accordance with section 142B(1)(c) of the *Threatened Species Conservation Act, 1995*.	FBA	This BAR has been prepared in accordance with the FBA (refer to **Section 1.5**).

Biodiversity Assessment	Required by	Where addressed in this report
2. The Proponent must assess any impacts on biodiversity values not covered by the FBA, as specified in section 2.3[6], including but not limited to aquatic biodiversity values covered by the *Fisheries Management Act 1994*, relating to aquatic species, riparian and marine vegetation, instream macrophytes and habitat condition.	FBA	**Section 8.4** and **Section 8.5** address impacts not covered by the FBA, including aquatic impacts
3. The Proponent must survey and assess impacts on EECs, threatened species and/or populations[7] and provide the information specified in section 9.2 of the FBA. Species specific surveys shall be undertaken for those species and in accordance with the survey requirements specified by the OEH.	FBA	**Chapter 3** provides the methods used to survey for Endangered Ecological Communities (EECs) **Chapter 4** outlines the survey methodology for threatened species **Chapter 8** outlines impacts on threatened species and EECs **Appendix E** addresses section 9.2 of the FBA
4. The Proponent must identify whether the project as a whole, or any component of the project, would be classified as a Key Threatening Process (KTP) in accordance with the listings in the *Threatened Species Conservation Act 1995* (TSC Act)[8], *Fisheries Management Act 1994* (FM Act) and *Environment Protection and Biodiversity Conservation Act 2000* (EPBC Act).	FBA and EPBC Act Bilateral Agreement	**Chapter 8** describes and assesses impacts associated with Key Threatening Processes The following components of the project would be classified as a KTP: • Loss of habitat – discussed in **Section 8.1** and **Section 8.4.2** • Loss of hollow-bearing trees – discussed in **Section 8.1.3** • Predation by the Plague Minnow (*Gambusia holbrooki*) – discussed in **Section 8.4.2** • The removal of large woody debris or snags – discussed in **Section 8.4.1** and **Section 8.4.2** • Pathogen impacts on biodiversity – discussed in **Section 8.5.7**
12. Socio-economic, land use and property		
5. The Proponent must undertake an assessment of biosecurity risks and management measures relating to the potential for spread of pests, disease or weeds, in accordance with the 'general biosecurity duty' under the *Biosecurity Act 2015*.	SEARs	**Section 3.2** and **Section 3.3** describes the weeds identified in the construction footprint **Section 8.5.5** addresses impacts associated with the invasion and spread of weeds and the 'general biosecurity duty' **Section 8.5.6** addresses impacts associated with the invasion and spread of pests **Section 8.5.7** addresses impacts associated with the invasion and spread of pathogens and disease

Biodiversity Assessment	Required by	Where addressed in this report
17. Safety and Risk		
2. The Proponent must assess the biosecurity risk of the project to minimise the inadvertent spread of disease and pathogens affecting agricultural activities, native vegetation and threatened fauna.	SEARs	**Chapter 3** describes the weeds identified in the construction footprint. **Section 8.5.5** addresses impacts associated with the invasion and spread of weeds **Section 8.5.6** addresses impacts associated with the invasion and spread of pests **Section 8.5.7** addresses impacts associated with the invasion and spread of pathogens and disease **Chapter 9** outlines measures to minimise the inadvertent spread of disease, pathogens and weeds.
Attachment A of the SEARs: Commonwealth (EPBC Act) General assessment requirements		
The EIS must address the matters outlined in Schedule 4 of the EPBC Act Regulations and the matters outlined below in relation to the controlling provisions. For each of the EPBC Act-listed species and ecological communities impacted by the proposed action, the EIS must provide:	EPBC Act Bilateral Agreement	The EIS has addressed the matters outlined in Schedule 4 of the EPBC Act Regulations (see Appendix C of the EIS)
1. Survey results, including details of the scope, timing and methodology for studies or surveys used and how they are consistent with (or justification for divergence from) published Commonwealth guidelines and policy statements. For ecological communities, this includes any condition thresholds provided in the listing advice or approved conservation advice.	EPBC Act Bilateral Agreement	**Chapter 4** describes methods and results of threatened species surveys and how they are consistent with Commonwealth guidelines **Chapter 5** assesses impacts on MNES, including discussion on condition thresholds for threatened ecological communities (TECs) with respect to field survey data
2. A description and quantification of habitat in the study area (including suitable breeding habitat, suitable foraging habitat, important populations and habitat critical for survival), with consideration of, and reference to, any relevant Commonwealth guidelines and policy statements including listing advices, conservation advices and recovery plans, threat abatement plans.	EPBC Act Bilateral Agreement	**Chapter 5** refers to area of habitat impact for MNES Refer also to **Appendix E** for detailed descriptions of habitat and impact to critically endangered species, including the Regent Honeyeater
3. Maps displaying the above information (specific to EPBC matters) overlaid with the proposed action. It is acceptable, where possible, to use the mapping and assessment of Plant Community Types (PCTs) and the species surveys prescribed by the BAM as the basis for identifying EPBC Act-listed species and communities. The EIS must clearly identify which PCTs are considered to align with habitat for the relevant EPBC Act-listed species or community and provide individual maps for each species or community.	EPBC Act Bilateral Agreement	Maps are displayed in **Chapter 3** (see **Figure 3-1** and **Figure 3-2**) in relation to the extent of PCTs, and EECs in the construction footprint; these identify which PCTs are considered to align with the relevant EPBC listed community The area of habitat impacted for EPBC listed species is described in **Chapter 4** and **Chapter 5**

Biodiversity Assessment	Required by	Where addressed in this report
4. Description of the nature, geographic extent, magnitude, timing and duration of any likely direct, indirect and consequential impacts on any relevant EPBC Act-listed species and communities. It must clearly identify the location and quantify the extent of all impact areas to each relevant EPBC Act-listed species or community	EPBC Act Bilateral Agreement	**Chapter 5** refers to area of habitat impact for MNES**, Chapter 8** describes at impacts to species for both construction and operation, and the impact assessment for MNES impact is provided in **Section 8.3**. Refer also to **Appendix E** for detailed descriptions of habitat and impact to critically endangered species, including the Regent Honeyeater
5. Information on proposed avoidance and mitigation measures to deal with the impacts of the action, and a description of the predicted effectiveness and outcomes that the avoidance and mitigation measures will achieve.	EPBC Act Bilateral Agreement	**Chapter 7** addresses avoidance and management measures to minimise biodiversity impacts **Chapter 9** describes management measures to mitigate biodiversity impacts
6. Quantification of the offset liability for each species and community significantly impacted, and information on the proposed offset strategy, including discussion of the conservation benefit for each species and community, how offsets will be secured, and the timing of protection. It is a requirement that offsets directly contribute to the ongoing viability of the specific protected matter impacted by a proposed action i.e. 'like-for-like'. Like-for-like includes protection of native vegetation that is the same ecological community or habitat being impacted (preferably in the same region where the impact occurs), or funding to provide a direct benefit to the matter being impacted e.g. threat abatement, breeding and propagation programs or other relevant conservation measures.	EPBC Act Bilateral Agreement	**Chapter 10** identifies the offset liability for each species and community in line with the FBA and NSW biodiversity offsets policy. The Biodiversity Offset Strategy is provided as **Appendix I** and outlines how Transport intends to offset the impacts for the project

1.5 Planning and policy

This biodiversity assessment is facilitated under Clause 28 of the Biodiversity Conservation (Savings and Transitional) Regulation 2016 which permits the proponent to submit the application in accordance with the former planning provisions. This approach was approved by DPIE (formerly Department of Planning and Environment) on 13 November 2017. As such, the former provisions of the *Threatened Species Conservation Act 1995* (TSC Act) remain in force for this assessment, rather than the Biodiversity Conservation Act 2016 (BC Act).

Accordingly, this project has been assessed under the Framework for Biodiversity Assessment (FBA) (OEH 2014a) and must be conducted by a person accredited in accordance with section 142B(1)(c) of the repealed TSC Act. The BioBanking Credit Calculator (BBCC) proposal ID for the project is 179/2020/5065MP. This report has been prepared by a person accredited in accordance with s142B(1)(c) of the TSC Act (Chris Thomson; accreditation number 179). Further information is provided in **Appendix H**.

The FBA requires proponents to identify and assess the impacts on all nationally listed threatened species and ecological communities. The project has been referred under the EPBC Act (2018/8288) and deemed a controlled action in accordance with section 75 of the EPBC Act and assessed under the Bilateral Agreement. The Bilateral Agreement was made under section 45 of the EPBC Act relating to environmental assessment between the Commonwealth of Australia and the State of New South Wales. Therefore, the project requires approval from the DPIE and the Commonwealth Government. In March 2019, the SEARs were revised to reflect the project being a controlled action. Further details on the controlling provisions is provided in **Chapter 5**.

The NSW Biodiversity Offsets Policy for Major Projects (OEH 2014b) provides a standard method for assessing biodiversity impacts of major projects and established offsetting requirements. For aquatic biodiversity impacts, the FBA refers to the requirements guided by the Fisheries NSW Policy and guidelines for fish habitat conservation and management (Department of Primary Industries 2013). An assessment of aquatic impacts is included in this BAR (see **Section 8.4**).

1.6 Report structure

The report content has been prepared to meet the requirements of the NSW BOPMP (OEH 2014b) and accordingly, the FBA (OEH 2014a). All personnel involved in the development of this document are listed in **Appendix H**.

The report is structured as follows:

- Chapter 1 – Introduces the project with a summary of the project background, project description, performance outcomes and SEARs
- Chapter 2 – Provides a description of the landscape features that relate to the project
- Chapter 3 – Provides details on the native vegetation survey methods and results
- Chapter 4 – Provides details on the threatened species survey methods and results
- Chapter 5 – Identifies the MNES that are of relevance to the construction footprint
- Chapter 6 – Summarises of biodiversity values that occur within the construction footprint
- Chapter 7 – Describes the alternatives to the project that were considered and how impacts to biodiversity have been avoided and minimised
- Chapter 8 – Describes biodiversity direct and indirect impacts associated with construction and operation of the project
- Chapter 9 – Outlines the mitigation strategy to address potential biodiversity impacts
- Chapter 10 – Identifies the offsetting requirements required for unavoidable and residual impacts. The biodiversity offset strategy is provided in a separate document to this report
- References
- Terms and acronyms.

2. Landscape features

This chapter identifies the landscape features relevant to the construction footprint and 550 metre landscape buffer (linear project), as defined in Section 4 and Appendix 5 of the FBA.

2.1 Study area

The project is located within the Newcastle and Port Stephens Council LGAs, within the suburbs of Black Hill, Beresfield, Tarro, Tomago, Heatherbrae and Raymond Terrace.

According to the FBA, the study area is the area directly affected by the development and any additional areas likely to be affected, either directly or indirectly. For this assessment the study area is referred to as the construction footprint. This construction footprint includes the project design and a buffer allowed for construction activities and thus captures likely direct and indirect impacts. A map of the construction footprint is presented in **Figure 2-1**.

2.2 Identified features

In accordance with Chapter 4 of the FBA, this assessment is required to identify several landscape features such as the Interim Biogeographic Regionalisation of Australia (IBRA) IBRA region, IBRA sub-region, Mitchell landscape, rivers and streams and biodiversity links. As per the FBA, these landscape features are identified within a 550 metre buffer extending from the construction footprint (i.e. a landscape buffer) and are described in the following sections. The landscape buffer is presented in **Figure 2-3**.

2.2.1 IBRA bioregions and subregions

Two IBRA regions are applicable to the landscape buffer; and include the Sydney Basin Bioregion (majority of the construction footprint from Black Hill to Tomago) and the NSW North Coast Bioregion (from Tomago to Heatherbrae). The landscape buffer is primarily located within the Hunter subregion of the Sydney Basin Bioregion as defined by Thackway and Cresswell (1995). The characteristic geology, landforms, soils and vegetation of the Hunter subregion (as it applies to the landscape buffer) and described by Morgan (2001) is as follows:

- The landscape is predominantly rolling hills, wide valleys, with a meandering river system on a wide floodplain (Morgan 2001)
- The geology is dominated by a complex of Permian shales, sandstones, conglomerates, volcanics and coal measures, dominated on the north near the construction footprint by the Hunter Thrust Fault
- A variety of harsh texture contrast soils on slopes and deep sandy loam alluvium on the valley floors are characteristic of this subregion. In dunes on the barrier, saline, organic muds of the Hunter estuary, soils can be deep sands with podsol profiles. Soil salinity is common on some bedrocks in the upper catchment
- Vegetation in the Hunter sub-region is described broadly as being characterised by patches of rainforest brush in the lower valley, however vegetation is dominated by forest and open woodland of *Eucalyptus tereticornis*, *E. crebra*, *E. moluccana*, *E. punctata, Corymbia maculata*, *Angophora costata* and extensive of stands of *Casuarina glauca* in upper reaches and foothills. Coastal dune vegetation consists of *E. pilularis*, *A. costata*, coastal *Banksia* species and *E. robusta*. Mangroves, salt marsh and freshwater reed swamps occur near the estuary.

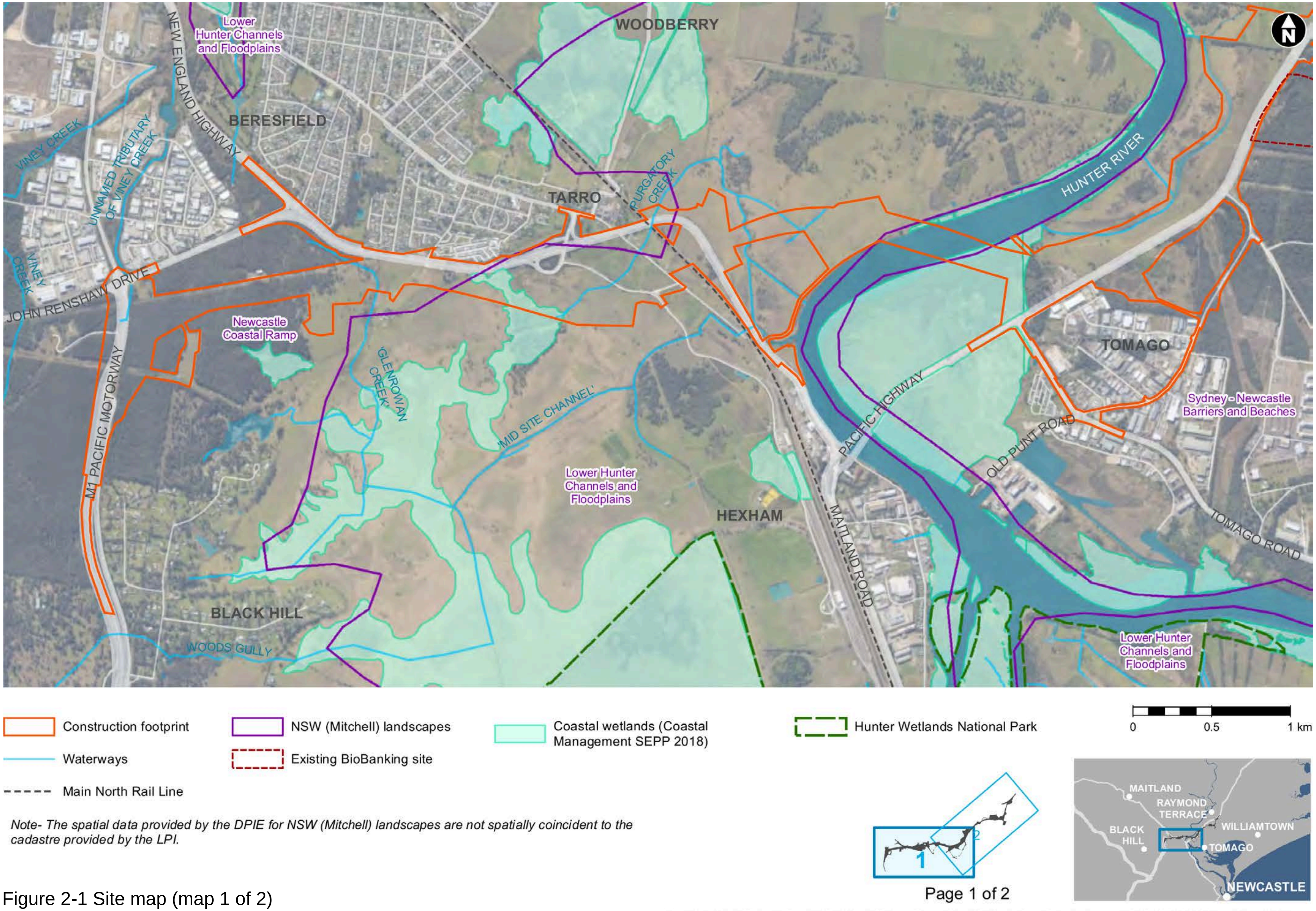
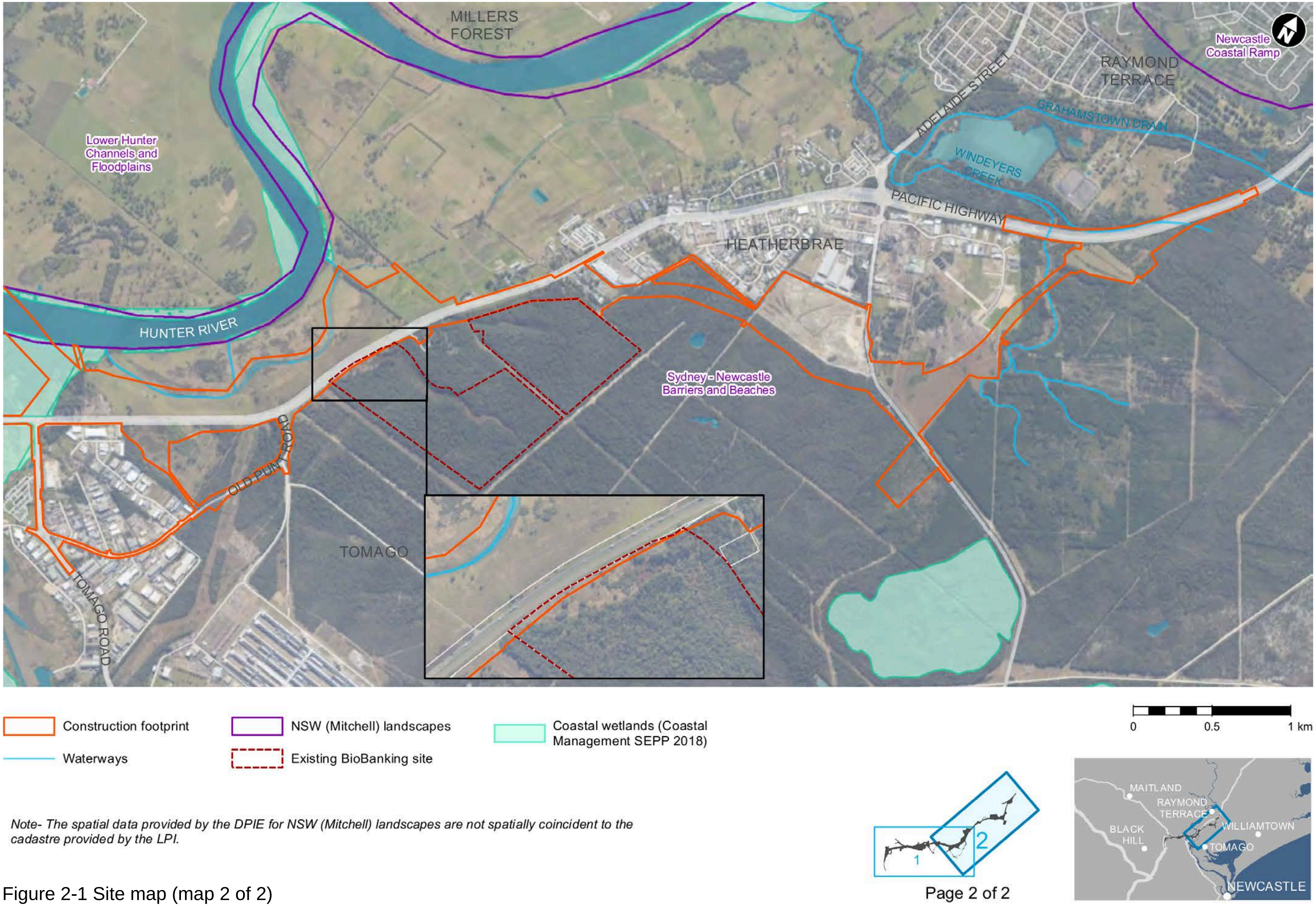


Figure 2-1 Site map (map 1 of 2)



Note- The spatial data provided by the DPIE for NSW (Mitchell) landscapes are not spatially coincident to the cadastre provided by the LPI.

Figure 2-1 Site map (map 2 of 2)

The boundary of the NSW North Coast Bioregion and Karuah Manning subregion crosses the construction footprint around Tomago and Raymond Terrace, resulting in a thin portion of the NSW North Coast Bioregion occupying the eastern end of the construction footprint. There is no detailed description available for the Karuah Manning subregion.

2.2.2 NSW Landscape Regions (Mitchell landscapes)

The landscape buffer is located across three Mitchell (NSW) Landscapes as mapped by the NSW National Parks and Wildlife Service (2002) and described by the NSW Department of Environment and Climate Change (2008) and include:

- Newcastle Coastal Ramp – located at the western extent of the construction footprint around Black Hill, this is the south eastern limit of the Newcastle Coastal Ramp which extends further west and north across parts of the lower Hunter region
- Lower Hunter Channels and Floodplains – occupying the area between Tarro and the Hunter River at the western end of the of the construction footprint
- Sydney – Newcastle Barriers and Beaches – from the Hunter River across the eastern and northern parts of the construction footprint including Raymond Terrace and continuing to the coastal fringe.

The above Mitchell landscapes are shown in **Figure 2-1**. The description provided for the Hunter sub-region of the Sydney Basin Bioregion is also applicable to the above Mitchell Landscapes.

2.2.3 Rivers and streams

The project would traverse the Hunter River and its floodplain within the lower reaches of the river system near Hexham. The Hunter River catchment covers an area of about 22,000 square kilometres and is a major river in NSW. The catchment is predominantly agricultural upstream of Hexham, interspersed by several urban and industrial centres. The lower reaches of the Hunter River are tidal, forming the Hunter River estuary. Three main rivers discharge into the Hunter River estuary, namely the Hunter River, the Paterson River and the Williams River. The confluence of the Williams River and the Hunter River is at Raymond Terrace about one kilometre upstream of the project.

The Hunter River is permanently in flow at the proposed bridge crossing and this section of the river is accessed as fishing grounds for the Estuary Prawn Trawl Fishery. The Estuary Prawn Trawl Fishery targets school prawns and eastern king prawns during the on-season (October to May). The Hunter River also contains oyster leases located near Stockton Bridge about 13 kilometres downstream of the project.

The waterways of the Hunter River catchment have highly variable flow driven by the local climate and anthropogenic factors (OEH 2013). The lower reaches of the Hunter River are tidal; however, the Hunter River is more generally considered saline due to its geology. A small proportion (about 25 per cent) of the salinity of the catchment can be attributed to activities such as mining operations and licenced discharges (OEH 2013). Catchment activities (e.g. industry, agriculture) have also elevated nutrients and suspended solids in the Hunter River.

In addition to the Hunter River, the project would cross several mapped waterways including:

- Tributary of Viney Creek
- "Glenrowan Creek" (Note: this creek is an unnamed tributary and is referred to as Glenrowan Creek in this assessment for ease of interpretation only)
- Purgatory Creek
- Windeyers Creek.

The Hunter River, as well as the minor waterways and tributaries have been extensively modified to allow for establishment of agricultural land and to regulate flooding on the floodplain (refer to discussion on the Hunter Valley Flood Mitigation Scheme in **Section 2.2.4**). Modification of the waterways has included:

- Bank stabilisation (rock armouring) and construction of levee banks
- Excavation, channel straightening and incising of the waterways to produce drainage channels
- Installation of waterway crossings (culverts and drainage pipes)
- Installation of floodgates at the downstream extent of the waterways (at the confluence with Hunter River).

Characteristics of waterways with respect to aquatic habitat are further detailed in **Section 2.2.4** and **Section 4.3**. Other characteristics of waterways, including water quality and hydrological attributes are further discussed in the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS) and the Hydrology and Flooding Working Paper (Appendix J of the EIS), respectively.

2.2.4 Wetlands and aquatic habitat

Waterway Assessment

A summary of the desktop assessment of waterways, in accordance with the (Department of Primary Industries (DPI)) 'Policy and Guidelines for Fish Habitat Conservation and Management' (2013) is provided in **Table 2-1**.

Table 2-1 Desktop assessment of waterways

Assessment requirement	Response
Ecosystem type	The wetlands, floodplains, streams and estuary have been identified and described in this section, **Chapter 3** and **Chapter 4**.
Dimensions of the waterway	The dimensions of waterways have been described in **Table G-3** (**Appendix G**).
Flow characteristics, drainage and hydrological features	Flow characteristics, drainage and hydrological features of waterways (with respect to aquatic biodiversity features) has been summarised in this paper (refer to **Section 4.3**. Characteristics of waterways are further detailed in the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS) and the Hydrology and Flooding Working Paper (Appendix J of the EIS)
Bed substrate	Substrate has been broadly described in this section.
Habitat features	Waterways have been described in this paper (refer **Section 4.3** and **Appendix G**). Waterways are perennial and ephemeral modified streams. The habitat is relatively uniform with no identified riffles.
Existing infrastructure and barriers to fish movement	Refer to **Section 8.4.2** and the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS).
Riparian vegetation	Refer to **Section 3.2** of this report.
Water quality	Water quality impacts has been described in **Section 8.4** and existing water quality is described in the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS).

Hunter Valley Flood Mitigation Scheme

Following a large flood event in 1955, the Hunter Valley Flood Mitigation Scheme was established by the NSW Government, which has subsequently instigated 160 kilometres of levees, 3.8 kilometres of spillways, 40 kilometres of control banks, 245 floodgates on waterways directly connected to the Hunter River and 120 kilometres of drainage canals (BMT WBM, 2012). The scheme provides flood protection to people, property and infrastructure across the Hunter floodplain. The scheme is still in operation, managed by DPIE with support from Hunter Local Land Services, and is subject to periodic maintenance and reviews.

Of relevance to this assessment, a levee bank has been constructed along the Hunter River banks within the construction footprint, and floodgates are currently installed at the downstream extent of the highly modified streams of Purgatory Creek and Windeyers Creek which are situated within the construction footprint. There are also floodgates on other artificial drainage lines in the vicinity of the project including the Hunter River Drain (on the north-eastern side of the Hunter River), several small drainage channels on the western and eastern floodplains of the Hunter River and on Ironbark Creek (downstream of the project on the southern side of Hunter River). The floodgates have significantly altered tidal processes including tidal flushing, movement of salt and freshwater between the Hunter River and its tributaries and has removed the ability for aquatic species migration and movements upstream in the local waterways. This is further discussed in the following sections and in **Section 4.3.** The location of floodgates in the vicinity of the project are shown on **Figure 4-4**.

Wetlands

There are a number of wetlands in the locality (within 10 kilometres) of the project and include wetlands listed under the State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP), as well as the Hunter Estuary Wetland Ramsar site and Hexham Swamp Nature Reserve (refer to **Figure 2-2**).

Hexham Swamp Nature Reserve

Hexham Swamp Nature Reserve forms part of the floodplain environment on the southern side of the Hunter River. The Hexham Swamp Nature Reserve, and the surrounding wetland area, is classified as Coastal Wetland under the Coastal Management SEPP (refer to **Figure 2-2**). The boundary of the Hexham Swamp Nature Reserve is located about two kilometres south of the construction footprint.

The wetland receives water from tributaries and drainage channels situated to the south west of the Hunter River and is maintained by rainfall, although flow is minimal. Surface water from the Hexham Swamp Nature Reserve drains to the south channel of Hunter River via Ironbark Creek, which flows north under Maitland Road. To manage saltwater incursions, there are floodgates on Ironbark Creek at the confluence with the south channel of Hunter River.

Under normal conditions (when the floodplain is not submerged due to a flood event), surface flow from the construction footprint would not reach the Hexham Swamp Nature Reserve because a disused rail embankment separates the northern floodplain from the southern floodplain and forms the northern boundary of the Hexham Swamp Nature Reserve. However, there are connections under the rail embankment which allows some hydrological connectivity between the northern and southern floodplains during flood events. The rail embankment is also over topped in the 2% annual exceedance probability (AEP) flood event and flood modelling shows that the culverts flow back and forth in the 20% AEP flood event (refer to the Hydrology and Flooding Working Paper (Appendix J of the EIS) for further details). Potential impacts to Hexham Swamp Nature Reserve are discussed in **Section 8.2.1**.

Coastal Wetlands (Coastal Management SEPP)

Three Coastal Management SEPP coastal wetlands are located within the construction footprint including:

- South of the existing New England Highway (which flows toward Hexham Swamp Nature Reserve)
- On the western banks of the Hunter River
- On the eastern bank of the Hunter River, north of the Pacific Highway.

Other Coastal Management SEPP Coastal Wetlands within 500 metres of the construction footprint include:

- North of the project in Tarro, separated from the project by Woodberry Road
- In Tomago, located south east of the construction footprint on the southern side of Masonite Road on the Northern floodplain of the Hunter River (which flows toward Hunter Wetlands National Park in the south-east)
- In Tomago, located south east on the northern floodplain of the north channel of the Hunter River
- On the northern bank of the Hunter River and separated from the project by the Hunter River.

Coastal Wetlands within or close to the construction footprint are illustrated on **Figure 2-2**.

Hunter Estuary Wetlands Ramsar site

The Hunter Estuary Wetlands Ramsar site is a 3,000 hectare multi-site complex located downstream from the construction footprint (refer **Figure 2-2**).

- Hunter Wetlands National Park on Kooragang Island (Kooragang Nature Reserve), which were listed under the Ramsar convention in 1984
- The Hunter Wetlands Centre Australia in Shortland, which was added to the listing in 2002.

Kooragang Nature Reserve includes the island between the North and south channel of the Hunter River and Fullerton Cove. Kooragang Nature Reserve receives flow from the north channel of the Hunter River which is tidally influenced. There are also several small inlets and tributaries which flow from the Hunter River through the wetland.

Geographically, Kooragang Nature Reserve is 1.9 kilometres south east of the construction footprint, however, is about 5.1 kilometres downstream from the project where the proposed viaduct crosses the Hunter River. Key habitat types at Kooragang Nature Reserve include mangrove forests dominated by Grey Mangrove, Samphire saltmarsh, Paperbark and Swamp she-oak swamp forests, brackish swamps, mudflats and sandy beaches (OEH, 2012).

The Hunter Wetlands Centre Australia is a 45-hectare property and includes restored wetlands, a visitors' centre and an education centre. The wetland lies to the south of the south channel of the Hunter River, adjacent to the southern portion of the Hexham Swamp Nature Reserve. The Hunter Wetlands Centre Australia receives flow from tributaries and drainage channels situated to the south-west of the Hunter River and is maintained by rainfall, although flow is minimal. Flow from the wetland drains to the south channel of the Hunter River via Ironbark Creek which flows north under Maitland Road. As mentioned above, there are floodgates on Ironbark Creek at the confluence with the south channel of the Hunter River.

The Hunter Wetlands Centre Australia is located about 3.8 kilometres south of the project. There are several barriers which obstruct flow reaching this section of the Ramsar site from the project, including a disused rail embankment on the northern boundary of the Hexham Swamp Nature Reserve (located north of the wetland) and floodgates on Ironbark Creek. Due to the distance from the construction footprint and the very low likelihood of flow reaching the wetland, the Hunter Wetlands Centre Australia is not considered to be subject to potential impacts as a result of the project (refer **Figure 2-2**).

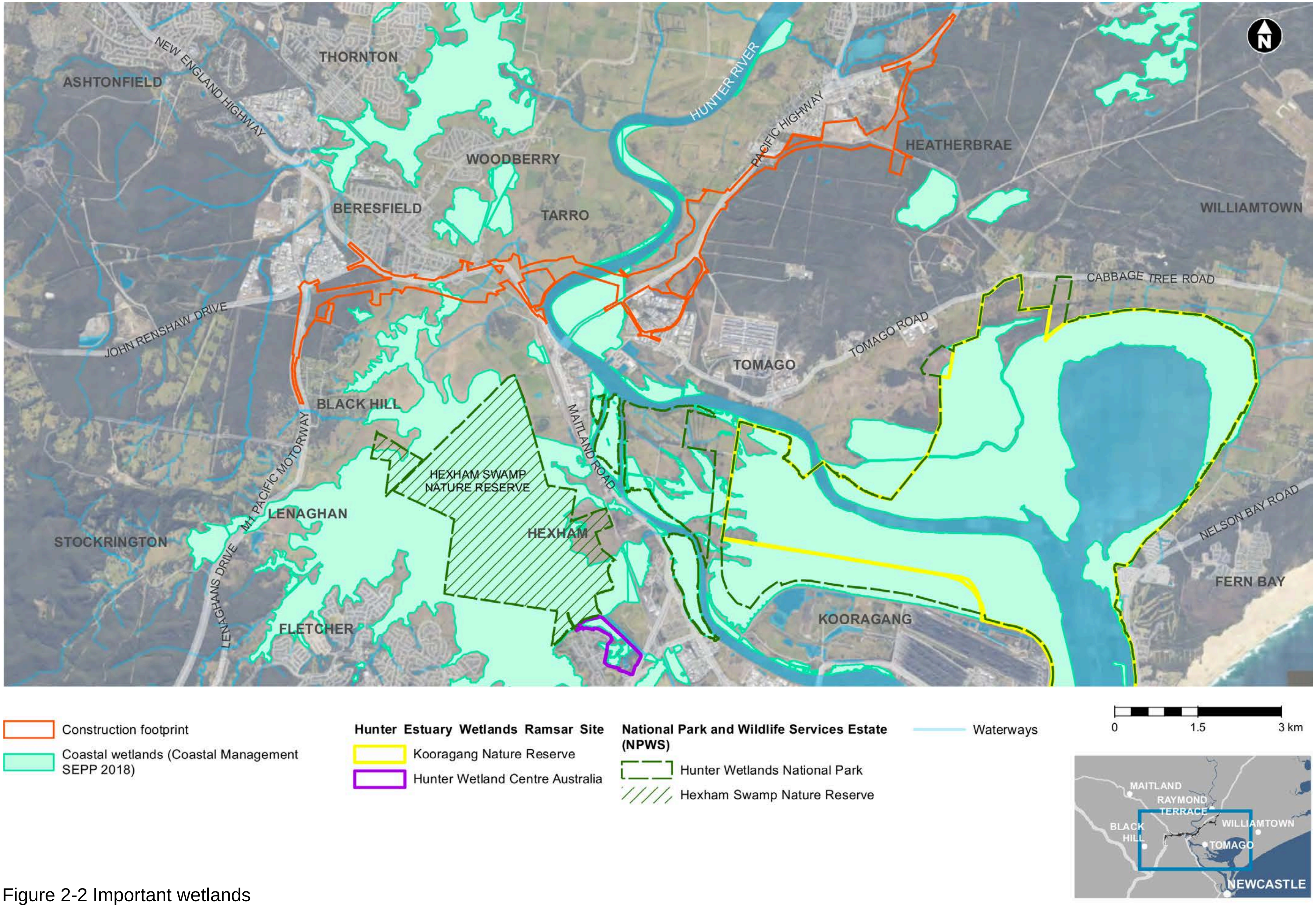


Figure 2-2 Important wetlands

Floodplain wetland

Although not classified under the Coastal Management SEPP or protected wetland, a wetland (referred to as the Hunter River wetland, site M12RT8 – see **Figure 4-4**) is located adjacent to the Hunter Region Botanic Gardens on the north-eastern side of the Hunter River. This wetland is considered likely to be supported by groundwater discharge and a groundwater dependent ecosystem.

Aquatic habitat

Hunter River and tributaries

The Hunter River is a ninth order major river and its lower reaches form an open, wave dominated barrier estuary which extends about 64 kilometres inland to its tidal limits at Oakhampton (OEH 2017). The estuary has two main channel arms (north and south) that diverge about 17 kilometres inland and reconverge before flowing to the mouth. The proposed viaduct (B05) crossing the Hunter River is located about 1.7 kilometres upstream of the existing Hexham Bridge.

The western bank of the Hunter River at the crossing is agricultural land while the eastern bank is densely vegetated by mangrove forests. The area surrounding the lower estuary is heavily urbanised with significant industrial, commercial and residential development and a major harbour port near the mouth of the estuary.

Aquatic habitats within the landscape buffer includes mangroves and saltmarsh, which are associated with the Hunter River estuary, and freshwater wetlands, ephemeral streams and drainage channels that are located on the floodplains and flow toward the Hunter River (refer to **Figure 2-2** and **Figure 3-1**).

As described above, the Hunter River estuary at the construction footprint location and ephemeral waterways on the floodplain have been extensively modified to allow for establishment of agricultural land and to regulate flooding. The banks of the Hunter River in the vicinity of the construction footprint have been stabilised by rock armouring and there is an artificial levee that been built along the length of the river banks.

The waterways on the floodplains have been anthropogenically incised and stabilised to produce artificial drainage channels, and all waterways within the construction footprint (which are connected to the Hunter River) are maintained by floodgates that have been installed as part of the Hunter Valley Flood Mitigation Scheme. The installation of floodgates has significantly altered the availability of aquatic habitat within these waterways as the floodgates have disrupted tidal flows and have created a barrier to upstream migration.

Substrate and vegetation

The substrate of the eastern and western floodplain of the Hunter River and intertidal mangrove area near Tomago Sandbeds contains a layer of estuarine mud (0.5 to 1.0 metres) overlying about 20 metres of sand (Hughes et al. 1998). Estuarine mud is predominately highly organic fine silt sands over medium grained silty sands with clay lenses and layers of shell (Hughes et al. 1998). The substrate in the construction footprint at the edge of the Hunter River is characterised as well bioturbated by crab holes and macroinvertebrate burrowing. The banks of the Hunter River in proximity to the construction footprint are generally lined by mangroves and saltmarsh (DPI, 2000). Instream habitat in the ephemeral freshwater channels is simple, dominated by fine sediments and algae, and a mix of grasses and aquatic macrophytes such as *Typha* sp.

The vegetation of the construction footprint and important wetlands has been addressed in **Chapter 3** in accordance with the FBA requirements.

Key Fish Habitat

Key Fish Habitat (KFH) and associated waterways mapped in and around the construction footprint are listed in **Table 2-2,** the waterways described are classified according to the definitions in DPI (2013). An assessment of all waterways as aquatic habitat is provided in **Section 4.3** and **Appendix G**. The location of KFH following further assessment is shown in **Figure 4-4**.

Table 2-2 Waterways identified as key fish habitat in and around the construction footprint

Waterway name	Key Fish Habitat type (DPI 2013)	Waterway classification (Fairfull and Witheridge 2004)
Purgatory Creek downstream of floodgates at junction with Hunter River	Type 1	Class 2
Hunter River estuary – at proposed Hunter River crossing	Type 1	Class 1
Hunter River estuary – midstream	Type 1	Class 1
Hunter River estuary – downstream	Type 1	Class 1
Unnamed wetland listed under the Coastal Management SEPP	Type 1	Class 1
Viney Creek	Type 2	Class 3

Fish assemblages

Seagrass beds are not known to occur in the lower Hunter River estuary and therefore the fish assemblages are different to those of other nearby NSW estuaries, which are dominated by seagrasses. The most abundant species are Yellowfin Bream (*Acanthopagrus macleayi*), Mulloway (*Argyrosomus japonicus*), Tarwhine (*Rabdosargus sarba*), Sandy Sprat (*Hyperlophus vittatus*) and Silver Biddy (*Gerres subfascistus*). In freshwaters, the most common species are the invasive Plague Minnow and Long-finned Eels.

2.2.5 State, regional and local biodiversity links

No plan detailing regionally significant biodiversity links approved by the NSW Environment, Energy and Science (EES) Group (formerly OEH) Chief Executive exists for the landscape buffer construction footprint.

The regional corridor referred to as Richardson Road (Scotts 2003) has been mapped as a link from the Hexham Swamp Nature Reserve north and east across the Hunter River to Grahamstown Dam. This corridor includes the northern portion of the construction footprint and is mapped on **Figure 2-3**.

There are two coastal climate change corridors present in the locality (i.e. Newcastle and Karuah-Hunter) joining at the Hunter River (DECC 2007), these corridors identify a north-south regional link traversing to the west of Newcastle within the construction footprint (refer to **Figure 2-3**).

The Watagan to Stockton Green Corridor has been identified in the Lower Hunter Regional Strategy (Department of Planning 2005) and the construction footprint is wholly within this large regional green corridor. A layer for this concept green corridor is not contained within the spatial dataset associated with the Hunter Regional Strategy and therefore is unable to be mapped.

There are also two coastal climate change corridors present in the locality (i.e. Newcastle and Karuah-Hunter) joining at the Hunter River (DECC 2007). These corridors identify a north-south regional link traversing to the west of Newcastle within the construction footprint.

2.2.6 Existing BioBanking sites

The construction footprint overlaps with a small portion along the boundary of an existing BioBank Agreement on land owned by Hunter Water Corporation (Lot 1 / DP 748716), located around the Hunter Region Botanic Gardens and east of the existing highway (refer to **Figure 2-1**). The BioBank site is comprised of two areas, one north of the Hunter Region Botanic Gardens (about 44 hectares) and one to the south (about 62 hectares). The entire BioBank site is around 106 hectares in size. The construction footprint impacts on around 0.6 hectares of the western edge of this BioBanking site, next to the existing Pacific Highway.

2.3 Landscape values

As the project is a new motorway, landscape value has been assessed according to Appendix 5 of the FBA (i.e. assessing landscape value for linear shaped developments, or multiple fragmentation impacts). This section includes a discussion on landscape value components applicable to linear shaped developments including:

- Per cent native vegetation cover in the landscape
- Connectivity value
- Patch size
- Area to perimeter ratio.

As the project is a linear development, all landscape value calculations were carried out using ESRI ArcGIS 10.5 to create the 550 metre landscape buffer (as per Appendix 5 of the FBA) either side of the construction footprint. Spatial analysis used aerial imagery across the landscape buffer captured in March 2020. The final landscape value score has been calculated using the BBCC and any assumptions made in the calculation are discussed in the sections below.

2.3.1 Native vegetation extent

The landscape buffer comprises a mix of remnant native vegetation, planted (exotic) vegetation and modified and cleared land used for agriculture. Native vegetation cover (as defined by Section 4.2.2 of the FBA) in the landscape buffer was digitised using a mixture of regional vegetation mapping (LHCCREMS) and aerial imagery (March 2020). The extent of the native vegetation within the landscape buffer is shown on **Figure 2-3**.

Pre-development native vegetation cover in the landscape buffer is estimated at 1,277 hectares (43.79 per cent), whereas the post-construction native vegetation cover (i.e. the cover of native vegetation within the landscape buffer after the completion of vegetation clearing associated with the construction of the project) is estimated at 1,103 hectares (37.48 per cent) (refer to **Table 2-3**). The per cent native vegetation cover in the landscape buffer would therefore be reduced by about 6.31 per cent after the completion of the development. This would take it down one cover category (as defined by the FBA) from between 31 and 45 per cent down to between 36 and 40 per cent.

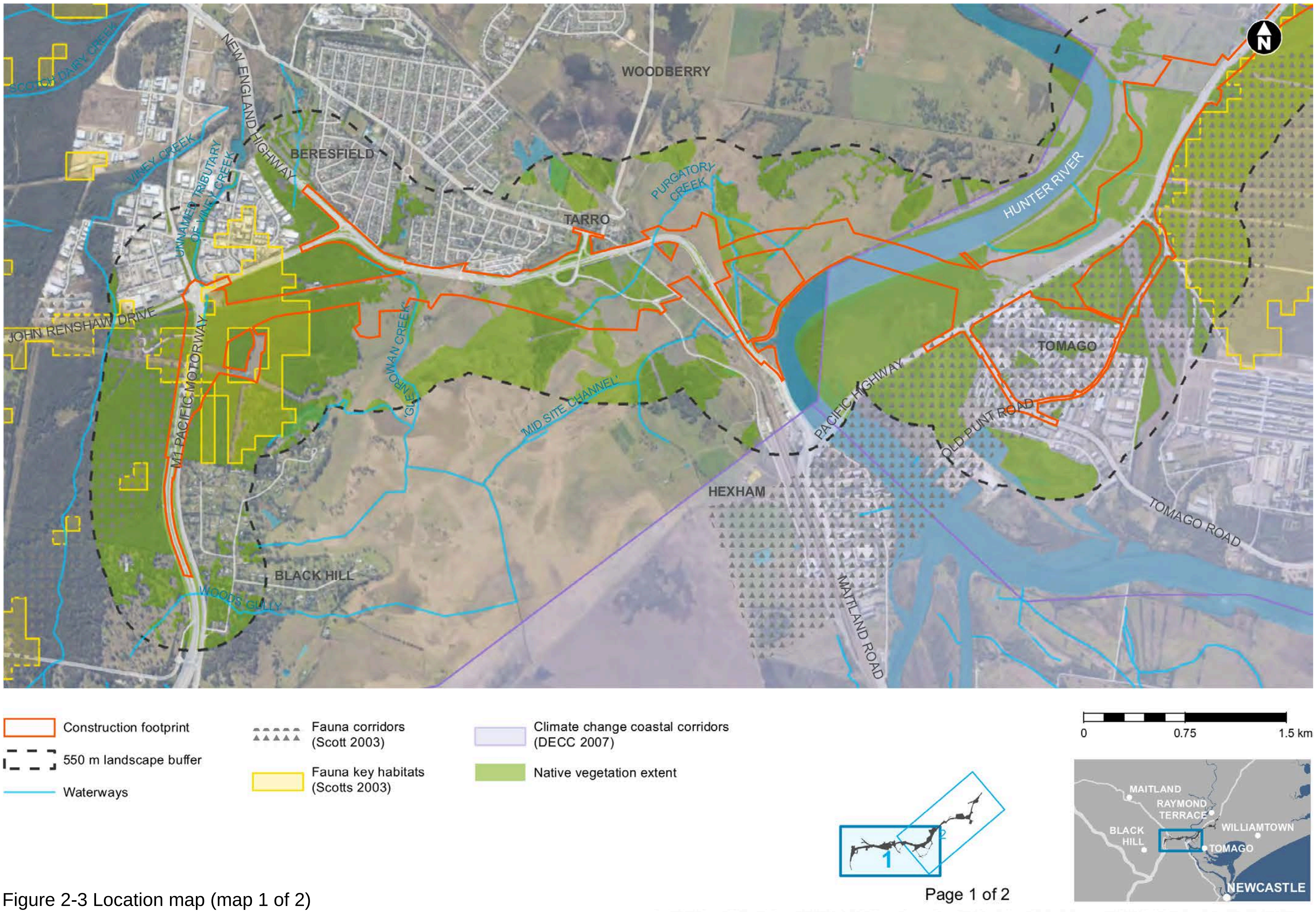
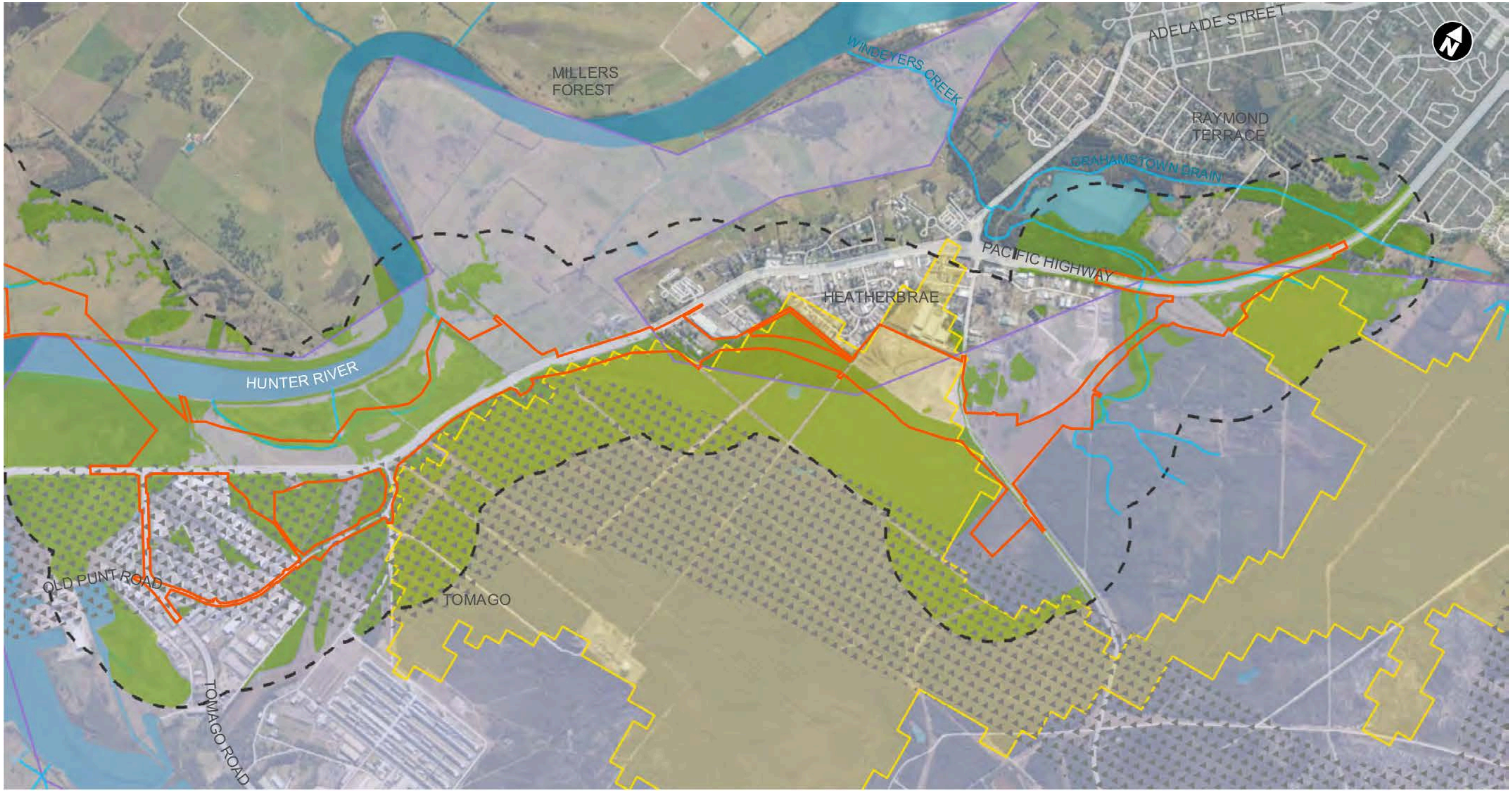
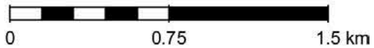


Figure 2-3 Location map (map 1 of 2)



Construction footprint
550 m landscape buffer
Waterways
Fauna corridors (Scott 2003)
Fauna key habitats (Scotts 2003)
Climate change coastal corridors (DECC 2007)
Native vegetation extent



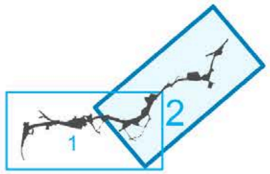


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Figure 2-3 Location map (map 2 of 2)

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Table 2-3 Per cent native vegetation cover in the landscape buffer before and after development

Assessment requirement	Before development		After development		Score (reduction in per cent vegetation cover)
	Current remnant vegetation cover (ha)	Proportion of buffer area (%) pre-development	Future remnant vegetation cover (ha)	Proportion of buffer area (%) post-development	
550 metres from construction footprint (2,916 ha)	1,277 ha	43.79 % (score 9.5)	1,103 ha	37.82 % (score 8.5)	9.5 – 8.5 = 1.0

2.3.2 Connectivity value

According to the FBA, connectivity is the measure of the degree to which an area(s) of native vegetation is linked with other areas of vegetation. For a linear shaped development, a connecting link occurs when native vegetation on the site adjoins native vegetation surrounding the site and the native vegetation:

- Is in moderate to good condition
- Has a patch size greater than one hectare
- Is separated by less than 100 metres (or less than 30 metres for non-woody ecosystems)
- Is not separated by a large water body, dual carriageway, wider highway or similar hostile link.

As described in **Section 2.2.5**, there are no state significant or regionally significant biodiversity links interested by the construction footprint. **Table 2-4** outlines the Hunter River connectivity value score.

Table 2-4 Connectivity value score

Category of connecting link	Construction footprint values	Score
Riparian buffer of a 6th order stream or greater	The Hunter River supports a riparian buffer of a 6th order stream or greater within the construction footprint which scores 12.5 for the connectivity value class. The riparian buffer of the Hunter River in the construction footprint supports Mangrove and Swamp Oak forests as well as Coastal Saltmarsh.	12.5

2.3.3 Patch size

For a development that is linear shaped, the assessor must assess the patch size for each NSW (Mitchell) landscape in which the major project occurs. As discussed previously, three NSW (Mitchell) Landscapes are located within the landscape buffer (refer to **Section 2.2.2**):

- Newcastle Coastal Ramp
- Lower Hunter Channels and Floodplains
- Sydney – Newcastle Barriers and Beaches.

The patch sizes, classes and patch scores associated with each of these NSW (Mitchell) Landscapes are identified in **Table 2-5**. The regional vegetation data associated with the LHCCREMS and overlaid onto aerial imagery (March 2020) was used to assess vegetation patch size. In some cases, there are numerous patch sizes being impacted (e.g. Newcastle Coastal Ramp patches are split by the highway). The FBA does not provide specific guidance on what to do in this scenario, therefore the dominant patch size represented has been chosen, as it provides the truest representation of patch size applicable to the vegetation interested by the construction footprint.

The average patch size score for the vegetation in the construction footprint is 11.7 hectares (the average of the three patch scores).

Table 2-5 Patch size score

NSW (Mitchell) Landscape	Percentage native vegetation cleared	Patch size (ha)	Patch size class	Patch size score (ha)
Newcastle Coastal Ramp	54 %	154	Extra large	10
Lower Hunter Channels and Floodplains	78 %	>1000	Extra large	12.5
Sydney - Newcastle Barriers and Beaches	50 %	>1000	Extra large	12.5
			Average	**11.7**

2.3.4 Area to perimeter ratio (proportional change)

For a major project that is a linear shaped development, the change in area to perimeter ratio of patch size areas that are impacted on must be assessed.

The total area (square metre) and perimeter (metres) of all vegetation patches impacted by the development within the landscape buffer is outlined in **Table 2-6**. The patch area to perimeter ratio increases after the development, equating to a proportional increase in area to perimeter ratio by 1.14. This increase is caused by a reduction in the area of the patches, but an increase in perimeter as a result of fragmentation in some areas.

Table 2-6 Area to perimeter ratio

Before development			After development			Proportional change in area to perimeter ratio	Score
Current vegetation area (m^2)	Current vegetation perimeter (m)	Current area to perimeter ratio	Future vegetation area (m^2)	Future vegetation perimeter (m)	Future area to perimeter ratio		
13,223,823	115,678	114.32	11,371,238	116,038	97.99	14 %	2.0

2.3.5 Landscape value score

A summary of the landscape value assessment is provided in this section, with the total landscape value score of 27.2 based on the following component scores:

- Per cent native vegetation cover = 1.0 (reduction from 9.5 to 8.5)
- Connectivity value class = 12.5
- Average patch size score = 11.7
- Proportional change in area to perimeter ratio (score) = 2.0.

3. Native vegetation

This chapter documents the methods used to identify and map the type and extent of native vegetation within the construction footprint. The results are the classification of Plant Community Types (PCTs) using field data and comparing with the NSW BioNet Vegetation Classification database (Department of Planning Industry and Environment 2020) and includes the stratification and assessment of vegetation condition classes and integrity.

3.1 Methods

3.1.1 Background research

A background review of reports and spatial information was carried out as the initial step to identify the existing environment of the construction footprint and locality. The review focused on database searches, relevant ecological reports and spatial data including:

- NSW BioNet Vegetation Classification database (Department of Planning, Industry and Environment 2020)
- The federal Bureau of Meteorology's Atlas of Groundwater Dependent Ecosystems (GDE) (Bureau of Meteorology 2020)
- NSW Coastal Management State Environmental Planning Policy – interactive map viewer (NSW Department of Planning and Environment 2020)
- Soil Landscapes of the Newcastle 1:100,000 Sheet Map (Matthei 1995)
- Available regional vegetation mapping and previous biodiversity studies including:
  - Lower Hunter Vegetation Mapping (Parsons Brinckerhoff, 2013a)
  - EPBC Act Listed Ecological Communities Mapping in the Lower Hunter (Parsons Brinckerhoff, 2013b)
  - Lower Hunter and Central Coast Regional vegetation survey mapping (VIS_ID 2225) (Department of Planning Industry and Environment, 2010)
  - The Lower Hunter and Central Coast Regional Biodiversity Conservation Strategy Technical Report, Digital Aerial Photograph Interpretation and Updated Extant Vegetation Community Map (Lower Hunter and Central Coast Environmental Management Strategy (LHCCREMS)) (Eco Logical Australia 2003)
  - Vegetation of the Tomago and Tomaree Sandbeds, Port Stephens, New South Wales: Management of Groundwater Dependent Ecosystems (Bell & Driscoll, 2006)
  - Pacific Highway Upgrade: F3 to Raymond Terrace: Results of Targeted Surveys, Summer 2006 (Biosis Research, 2006)
  - Tomago Switching Station Augmentation and Associated Powerlines Species Impact Statement (Biosis Research, 2008)
  - Flora and Fauna Summary Report, F3 to Raymond Terrace: Results of Targeted Surveys, Summer 2006
  - Newcastle Power Station Project Biodiversity Development Assessment Report (Kleinfelder 2019)
  - QR National – Train Support Facility, Hexham. Ecological Investigations (Eco Logical Australia 2012)
  - Proposed Hexham Relief Roads Ecological Assessment (Parsons Brinckerhoff 2012)
  - Ecological Monitoring Report – Long Term Train Support Facility (Eco Logical Australia 2015).

3.1.2 Field survey program

The identification and mapping of vegetation communities in the construction footprint was conducted over several dedicated field surveys between 2014 and 2020. These surveys captured the initial project design, and subsequent alteration and / or additions to the construction footprint as it occurred, as well as ensuring that plant community type mapping was current and consistent with any updates to the NSW BioNet Vegetation Classification Database which occurred during this time.

The final review and completion of the vegetation map occurred in June 2020 using aerial imagery captured in March 2020.

3.1.3 Vegetation surveys

The vegetation surveys were completed using field survey methods in accordance with Chapter 5 of the FBA and the BioBanking Assessment Methodology (BBAM) (OEH 2014c). All work was carried out under the appropriate licences, including scientific licences as required under Clause 22 of the National Parks and Wildlife Regulations 2002, Section 132C of the *National Parks and Wildlife Act 1974* (License Number: SL100044). All personnel involved in vegetation surveys are listed in **Appendix H**.

Plant community identification and mapping

The preliminary extent of vegetation communities within the construction footprint had been mapped previously by the LHCCREMS. This mapping was used in combination with regional soil mapping (Matthei 1995), to develop the field survey strategy, by identifying a list of possible PCTs in the construction footprint and their likely distribution. The preliminary vegetation mapping was then ground-truthed to validate PCTs and identify vegetation zones.

The field survey focused on identifying and mapping preliminary PCT boundaries, at this point all areas of the construction footprint were traversed, taking rapid data points that recorded dominant vegetation and plant species in each stratum. Where possible vegetation was identified at this stage by matching to a PCT described in the NSW BioNet Vegetation Classification database. Some PCTs could not be confidently identified before detailed floristic data and vegetation structure data was collected. In these cases, PCTs were assigned to the most likely PCT upon examination of the field data. PCTs and vegetation zones were further refined as the survey progressed and data from the plot/transect assessments were collated and examined.

The extent of native vegetation within the construction footprint was originally mapped in a GIS using digital aerial photography captured in 2014 and review of the regional vegetation mapping reported previously. This mapping was reviewed in June 2020 using aerial imagery captured in March 2020 and updated to reflect the construction footprint and any areas of clearing, at this point polygons were refined in detail.

The PCTs within the construction footprint are described in **Section 3.2** and their distribution mapped on **Figure 3-1**.

Assessment of vegetation zones

Following finalisation of the PCT classification and mapping, each PCT was then further divided into vegetation zones (an area of native vegetation on the construction footprint that is the same PCT and has a similar broad condition state). This involved ground-truthing the vegetation map to refine PCTs and vegetation zones and included sampling transects/plots in representative examples of each PCT and across the variation in vegetation structure. The condition recorded from plots was used to inform the stratification of PCTs into vegetation zones.

PCTs and vegetation zones were further refined as the survey progressed and data from the plot/transect assessments were examined. PCTs and vegetation zones within the construction footprint were finalised using a GIS.

The vegetation zones were assigned as follows:

- Good condition vegetation referring to intact native vegetation where all tree, shrub, grass and / or forb (an herbaceous flowering plant that is not a graminoid) structural growth form groups expected were present and exotic weed cover low (less than 25 per cent)
- Moderate condition vegetation referring to vegetation that was missing one or more or the expected structural mid or understorey components of the vegetation and weed cover exceeded 25 per cent
- Poor condition vegetation is typically dominated by exotic plant species in the understorey, with few to no native plant species present
- Regenerating condition referring to areas where a portion of the over-storey and mid-storey species characteristic of the PCT were present as young natural regrowth over formerly cleared lands.

Plot-based floristic survey

The plot based full floristic survey focused on sampling each PCT and vegetation zone using a series of 20 by 20 metre quadrats nested inside a 20 by 50 metre transect. Within each plot/transect the following information was recorded:

- 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 per cent and then to the nearest five per cent. If the cover of a species was less than one per cent and the species is considered important, then the estimated cover was 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: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 50, 100, 500 and 1000. Numbers between 20 and 1000 individuals were estimated only as it is not possible to accurately count large numbers of some species in the plot.

Site value assessment

The following site attributes were assessed at each transect/plot to obtain a quantitative measure of vegetation condition to be applied for each vegetation zone within the construction footprint:

- Native species richness (measured in a 20 by 20 metre quadrat)
- Native overstorey cover (measured along a 50-metre line transect)
- Native midstorey cover (measured along a 50-metre line transect)
- Native ground cover (grasses) (measured along a 50-metre line transect)
- Native ground cover (shrubs) (measured along a 50-metre line transect)
- Native ground cover (other) (measured along a 50-metre line transect)
- Exotic plant cover (measured along a 50-metre line transect)
- Number of trees with hollows (estimated by counting the number of trees with hollows visible from the ground in the 50 by 20 metre plot)
- Proportion of over-storey species occurring as regeneration (assessed across the entire vegetation zone)
- Total length of fallen logs (the total length of woody material longer than 10 centimetres in diameter within the 50 by 20 metre plot).

The site attributes listed above were ranked against benchmark data for the relevant PCT and a site value score for each vegetation zone was identified in accordance with subsection 5.3.3 of the FBA. Identification of any priority weeds was carried out within each transect/plot.

The minimum number of transects/plots required per vegetation zone area, according to the FBA and the number that were completed is outlined in **Table 3-1**.

Table 3-1 Comparison of number of transects/plots required and completed per zone area

Plant community type (PCT) (BVT)	Per cent cleared	Area within construction footprint (ha)	Vegetation Zone	Min plots required (FBA)	Plots completed
Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest of the Lower Hunter (1590) (HU804)	48	25.16	1. Good	4	5
		8.35	2. Moderate	3	3
		8.37	3. Regenerating	3	4
Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal (1588) (HU802)	56	6.78	4. Moderate	3	3
		0.82	5. Regenerating	1	1
Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646) (HU860)	45	20.76	6. Good	3	4
		7.83	7. Poor	2	3
Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649) (HU863)	46	1.36	8. Good	1	1
Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598) (HU812)	0	0.45	9. Poor	1	2
Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716) (HU930)	66	1.82	10. Good	1	2
Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717) (HU931)	74	3.85	11. Good	2	2
		6.64	12. Poor	3	3
Broad-leaved Paperbark – Swamp Oak – Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1724) (HU938)	31	1.61	13. Good	1	1
Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727) (HU941)	60	8.76	14. Moderate	3	5
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736) (HU950)	80	33.23	15. Good	4	4
		25.81	16. Moderate	4	4

Plant community type (PCT) (BVT)	Per cent cleared	Area within construction footprint (ha)	Vegetation Zone	Min plots required (FBA)	Plots completed
Jointed Twig-rush sedgeland (1742) (HU956)	70	1.45	17. Good	1	1
Phragmites australis and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (1071) (HU673)	70	7.71	18. Good	3	3
Saltmarsh Estuarine Complex (1746) (HU960)	16	1.26	19. Good	1	2
Grey Mangrove low closed forest (1747) (HU961)	59	2.04	20. Good	2	2
		0.23	21. Moderate	1	1
				Total plots	**56[1]**

Note: [1] 56 plots were carried out within the PCTs displayed in **Figure 3-1**, however additional plots were also completed in areas of non-native vegetation (i.e. pine plantation) and vegetation outside of the construction footprint (up to 66 plots). Only the 56 plots listed in **Table 3-1** and displayed in **Figure 3-1** were used for the vegetation offset assessment.

3.1.4 Limitations

The vegetation field survey was able to provide adequate spatial coverage and survey effort of the construction footprint and survey effort, meeting the requirements of the FBA. The vegetation within the construction footprint has been assigned a PCT as listed in the NSW BioNet Vegetation Classification Database based on the observed species composition, landscape position, and underlying geology and soils. The mapping provided in this report is supported by on ground observations and quantitative data. Plant communities are naturally variable and the boundaries between different PCTs overlap considerably. Often the boundary between PCTs is indistinct and the boundaries between PCTs usually involve ecotones, with a gradual transition from one community to another. However, a choice must be made to map and assign a PCT to an area of the site. As mapping necessitates that a hard boundary is drawn to separate PCTs, boundaries of PCTs and vegetation zones have been mapped as best as possible based on observations made during the field survey and aerial photography. It is likely that the boundaries of PCTs and vegetation zones will change with time. This is particularly the case with the boundaries of the freshwater wetlands which are likely to change periodically based on the amount of rainfall in any given period and the boundaries have been mapped as they were observed during the survey.

The list of species recorded in each PCT during this assessment should not be seen to be fully comprehensive, but rather an indication of the species present at the time of the survey. A period of several seasons or years is needed to identify all the species present in an area, especially as some species are only apparent at certain times of the year (e.g. orchids, annual herbs and grasses).

The conclusions of this report are based upon available data and the field survey findings and are therefore indicative of the environmental condition of the construction footprint at the time of the survey. It should be recognised that conditions, including the presence of threatened species, can change with time. To address this limitation, a precautionary approach has been used which aimed to identify the presence and suitability of the habitat for threatened species.

3.2 Plant Community Types

The ecological communities in the construction footprint were assigned to fourteen PCTs and 21 vegetation zones (refer to **Table 3-2**). Each PCT is identified by name and code consistent with the NSW BioNet Vegetation Classification Database. The corresponding Biometric Vegetation Type code (BVT) is also used for consistency with the BBCC. The PCT and assigned vegetation zones are illustrated in **Figure 3-1**.

Table 3-2 includes the site value score and area of each PCT within the construction footprint and whether the PCT corresponds to a TEC. Further information TECs listed under the TSC Act is provided in **Section 3.4**.

Table 3-2 Summary of identified plant community types and vegetation zones

Plant community type (PCT) (BVT)	Vegetation zone	Area within construction footprint (ha)	Site value score	Threatened ecological community (under TSC Act)?
Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest of the Lower Hunter (1590) (HU804)	1. Good	25.16	77.08	Yes
	2. Moderate	8.35	64.58	
	3. Regenerating	8.37	29.17	
Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal (1588) (HU802)	4. Moderate	6.78	79.69	No
	5. Regenerating	0.82	49.48	
Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646) (HU860)	6. Good	20.76	59.9	No
	7. Poor	7.83	50	
Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649) (HU863)	8. Good	1.36	61.33	Yes
Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598) (HU812)	9. Poor	0.45	71.33	Yes
Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716) (HU930)	10. Good	1.82	66.67	Yes
Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717) (HU931)	11. Good	3.85	62	Yes
	12. Poor	6.64	44	
Broad-leaved Paperbark – Swamp Oak – Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1724) (HU938)	13. Good	1.61	53.33	Yes

Plant community type (PCT) (BVT)	Vegetation zone	Area within construction footprint (ha)	Site value score	Threatened ecological community (under TSC Act)?
Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727) (HU941)	14. Moderate	8.76	55.33	Yes
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736) (HU950)	15. Good	33.23	48.06	Yes
	16. Moderate	25.81	36.43	
Jointed Twig-rush sedgeland (1742) (HU956)	17. Good	1.45	82.17	Yes
Phragmites australis and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (1071) (HU673)	18. Good	7.71	47.29	Yes
Saltmarsh Estuarine Complex (1746) (HU960)	19. Good	1.26	49.07	Yes
Grey Mangrove low closed forest (1747) (HU961)	20. Good	2.04	100	No
	21. Moderate	0.23	42.42	
	Subtotal	**174.3 hectares**		
N/A	Planted native vegetation	13.04	N/A	N/A
N/A	Pine plantation	25.87	N/A	N/A
N/A	Exotic vegetation	1.86	N/A	N/A
	Total	**215.06 hectares**		

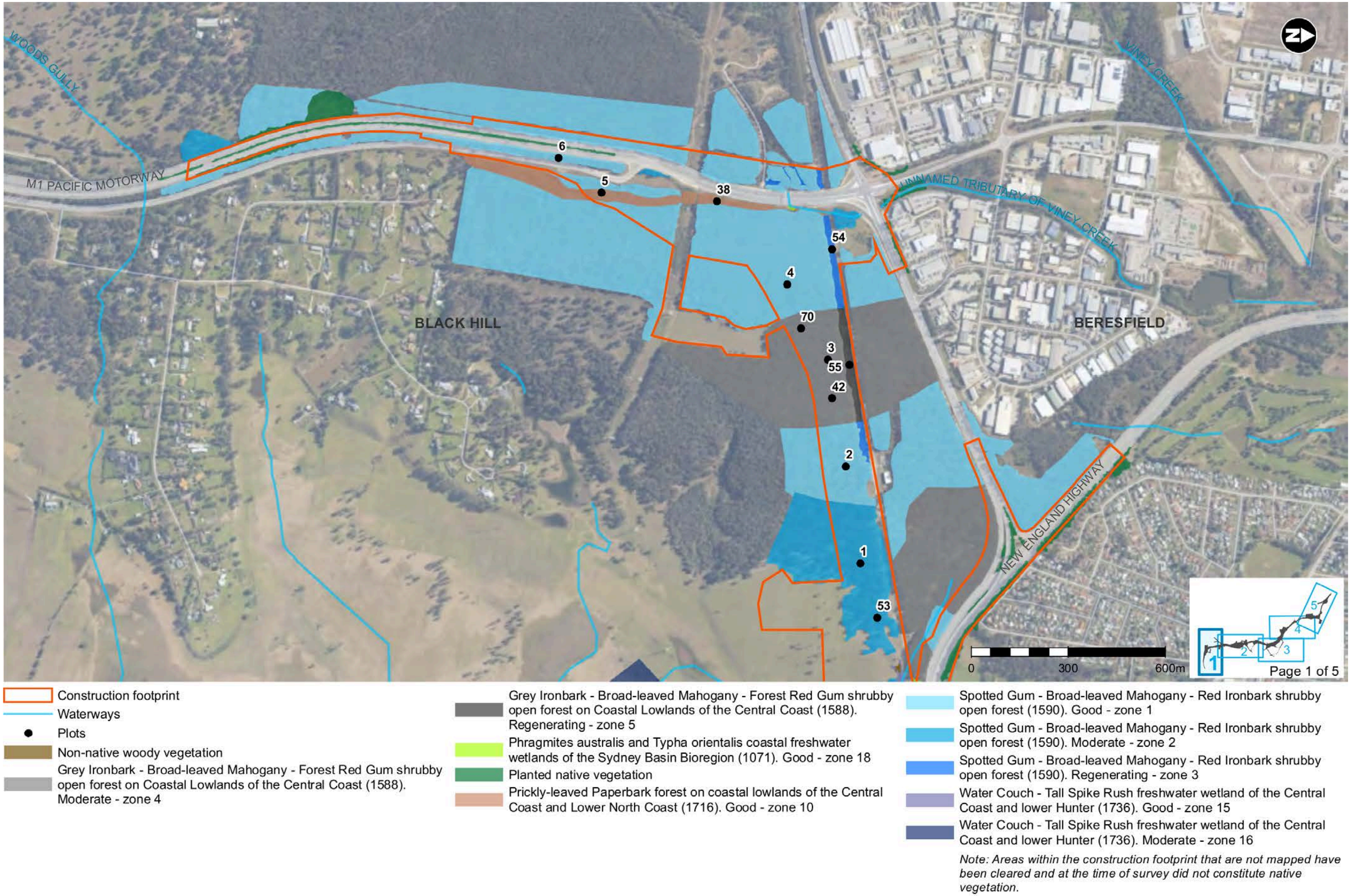

Figure 3-1 Plant Community Types, condition and vegetation survey locations (map 1 of 5)

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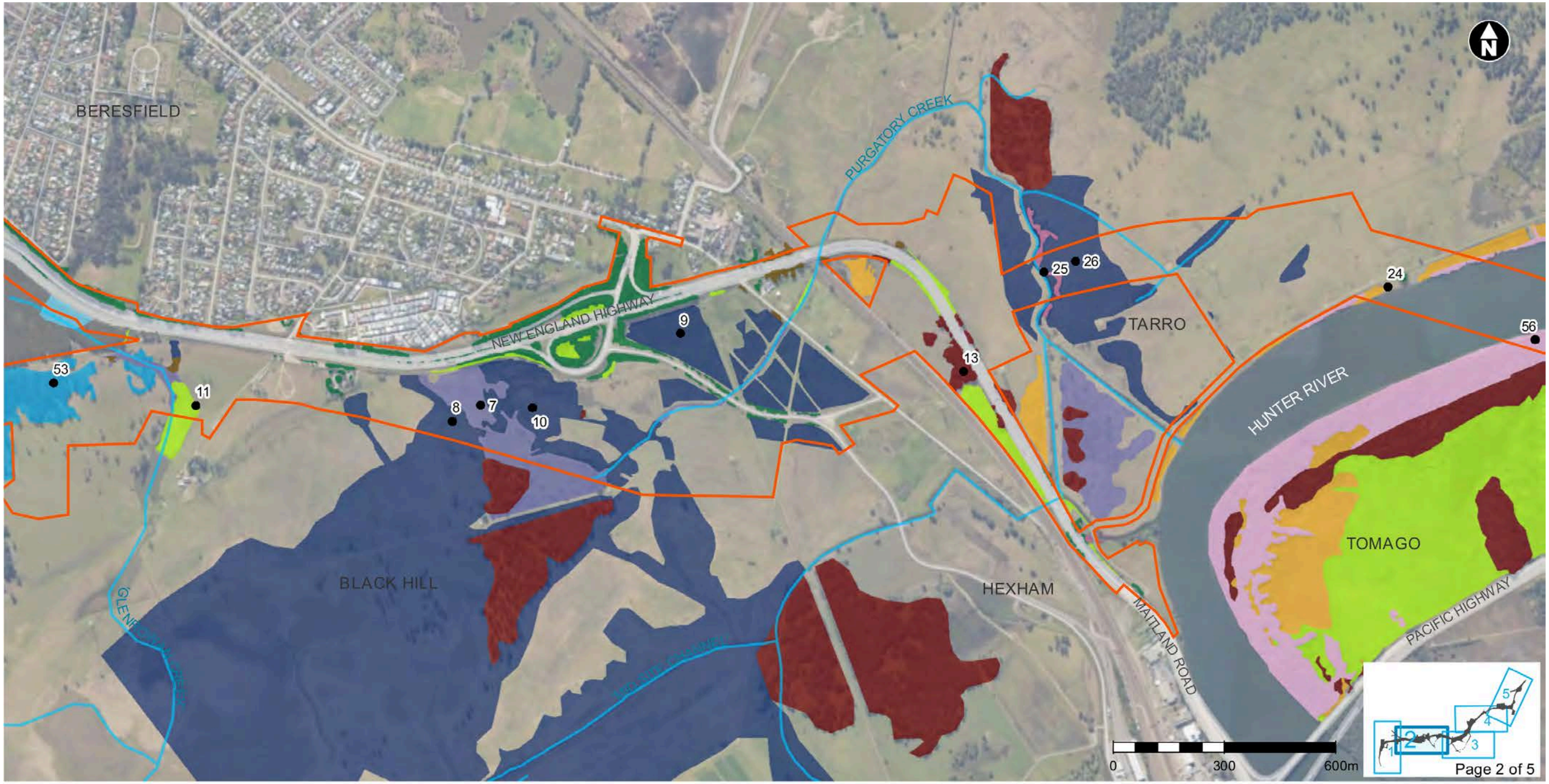

Construction footprint
Waterways
Plots
Non-native woody vegetation
Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (1588). Moderate - zone 4
Grey Mangrove low closed forest (1747). Good - zone 20
Grey Mangrove low closed forest (1747). Moderate - zone 21
Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (1071). Good - zone 18
Planted native vegetation
Saltmarsh Estuarine Complex (1746). Good - zone 19
Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590). Good - zone 1
Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590). Moderate - zone 2
Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727). Moderate - zone 14
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736). Good - zone 15
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736). Moderate - zone 16

Note: Areas within the construction footprint that are not mapped have been cleared and at the time of survey did not constitute native vegetation.

Figure 3-1 Plant Community Types, condition and vegetation survey locations (map 2 of 5)

- Construction footprint
- Waterways
- Plots
- Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717). Good - zone 11
- Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1724). Good - zone 13
- Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598). Good
- Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598). Moderate - zone 9
- Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (1588). Moderate - zone 4
- Grey Mangrove low closed forest (1747). Good - zone 20
- Grey Mangrove low closed forest (1747). Moderate - zone 21
- Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (1071). Good - zone 18
- Planted native vegetation
- Saltmarsh Estuarine Complex (1746). Good - zone 19
- Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646). Good - zone 6
- Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590). Good - zone 1
- Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590). Moderate - zone 2
- Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590). Regenerating - zone 3
- Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727). Moderate - zone 14
- Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736). Good - zone 15
- Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736). Moderate - zone 16

Note: Areas within the construction footprint that are not mapped have been cleared and at the time of survey did not constitute native vegetation

Figure 3-1 Plant Community Types, condition and vegetation survey locations (map 3 of 5)

- Construction footprint
- Existing BioBanking Site
- Waterways
- Plots
- Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717). Good - zone 11
- Non-native woody vegetation
- Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598). Moderate - zone 9
- Jointed Twig-rush sedgeland (1742). Good - zone 17
- Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (1071). Good - zone 18
- Planted native vegetation
- Saltmarsh Estuarine Complex (1746). Good - zone 19
- Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646). Good - zone 6
- Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646). Poor - zone 7
- Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649). Good - zone 8
- Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727). Moderate - zone 14
- Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736). Good - zone 15
- Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736). Moderate - zone 16

Note: Areas within the construction footprint that are not mapped have been cleared and at the time of survey did not constitute native vegetation.

Figure 3-1 Plant Community Types, condition and vegetation survey locations (map 4 of 5)

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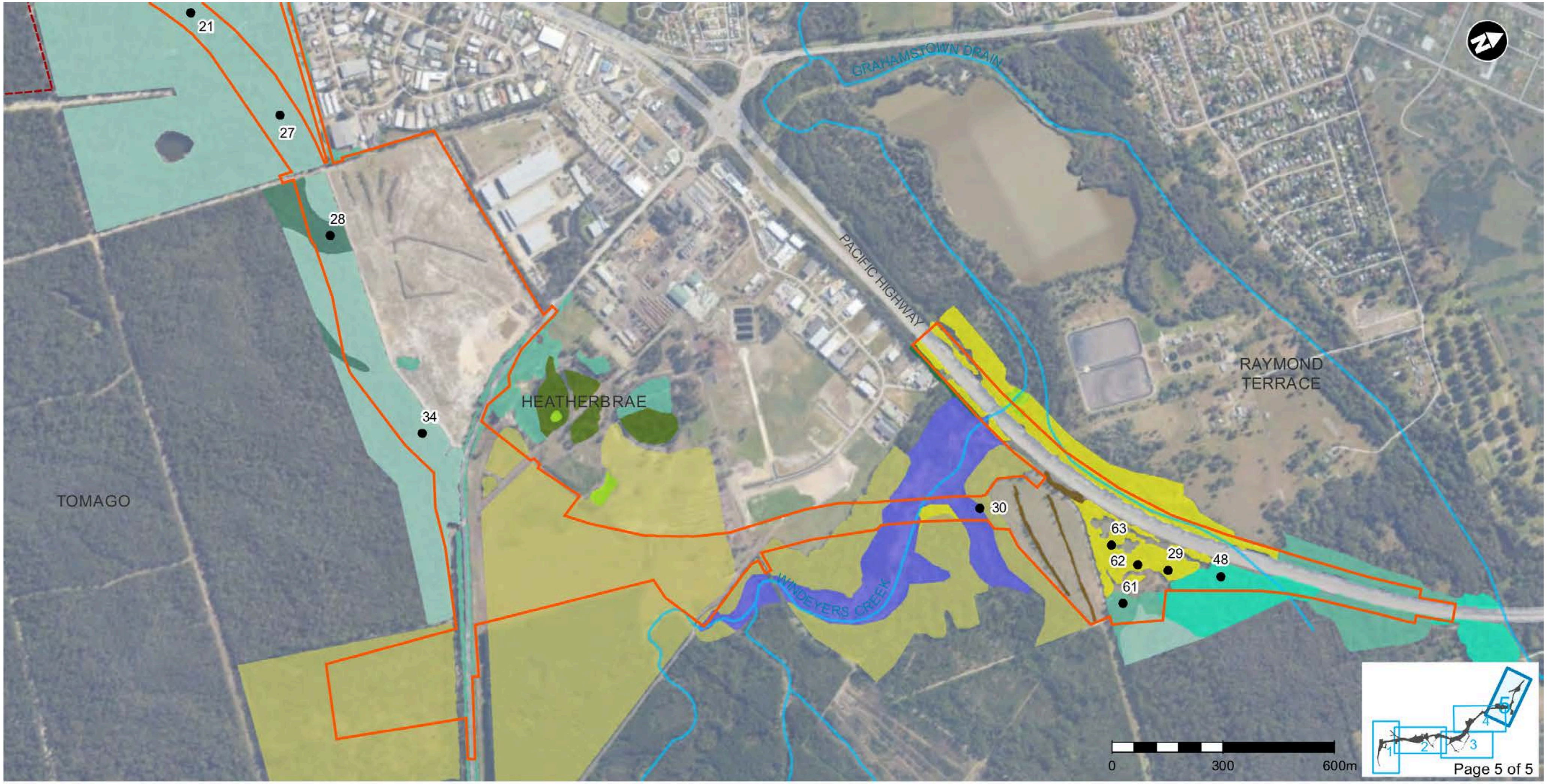

Construction footprint
Existing BioBanking Site
Waterways
Plots
Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717). Good - zone 11
Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717). Poor - zone 12
Non-native woody vegetation
Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598). Disturbed
Jointed Twig-rush sedgeland (1742). Good - zone 17
Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (1071). Good - zone 18
Pine plantation
Planted native vegetation
Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646). Good - zone 6
Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646). Poor - zone 7
Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649). Good - zone 8

Note: Areas within the construction footprint that are not mapped have been cleared and at the time of survey did not constitute native vegetation.

Figure 3-1 Plant Community Types, condition and vegetation survey locations (map 5 of 5)

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

Vegetation zones:

- 1: 1590 – Good (25.16 hectares)
- 2: 1590 – Moderate (8.35 hectares)
- 3: 1590 – Regenerating (8.37 hectares)

BVT code: HU804

PCT code: 1590

Estimate of per cent cleared: 48%

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

Vegetation class: Hunter-Macleay Dry Sclerophyll Forests

Conservation status: Lower Hunter Spotted Gum Ironbark Forest of the Sydney Basin (Endangered, TSC Act)

Vegetation plots:

- Zone 1: Plot 2, Plot 4, Plot 6, Plot 17, Plot 40
- Zone 2: Plot 1, Plot 53, Plot 58
- Zone 3: Plot 54, Plot 64, Plot 65, Plot 66

Photograph 1: Plot 4 showing vegetation zone 1, Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590 - Good)

Description: This community occurs on undulating slopes with Permian soils at Black Hill, Beresfield and Tomago. This community is an open forest dominated by *Corymbia maculata* (Spotted Gum) and *Eucalyptus fibrosa* (Red Ironbark), 18-25 metres tall, with an open to closed midstorey 2-6 metres high dominated by a combination of *Notelaea longifolia*, *Pittosporum undulatum*, *Alphitonia excelsa*, *Melaleuca nodosa* and *Bursaria spinosa* depending on the landscape position, with lower lying areas supporting a higher density of shrubs and paperbark. Vine species such as *Parsonsia straminea* and *Pandorea pandorana* are common in lower lying areas. The ground layer is dominated by a high diversity of grasses and forbs including *Entolasia stricta*, *Microlaena stipoides* and *Dichondra repens*.

Condition: There are three condition classes of this PCT in the construction footprint:

- Vegetation zone 1 – Good condition areas with limited disturbance and low levels of weed invasion, mainly *Lantana camara*. This zone represents the largest area of this PCT within the construction footprint. Roadside remnants adjoining the M1 Pacific Motorway are still in good/moderate condition despite being subject to some modifications. Good condition patches have an average benchmark score of 77.08
- Vegetation zone 2 – Moderate condition examples of this community have been under-scrubbed and subject to pasture improvement and support a mix of native groundcovers, exotic pasture, and regenerating native trees and shrubs. Poor condition areas of this community include remnants adjoining pastoral areas at Beresfield and regenerating trees and shrubs with derived grassland at Tomago with an average benchmark score of 64.58
- Vegetation zone 3 – Regenerating condition areas have been previously entirely cleared and contain a mix of regenerating trees and shrubs. There are two main areas of this vegetation zone, one in Beresfield where vegetation has been cleared in an easement though has been left to regenerate, and the other is across the AGL owned property in Tomago, which is lacking canopy regeneration in many areas, though has been assigned to PCT 1590 as this is the dominant PCT surrounding the site. Regenerating condition patches have an average benchmark score of 29.17.

Landscape features: This community occurs on undulating slopes with Permian derived sediments of the Beresfield Soil Landscape.

Distribution: The community occurs as larger patches on undulating slopes at the south-western end of the project at Black Hill and Beresfield, and a moderate sized patch occurring along a low ridgeline of Permian sediments at Tomago which is bordered by sandy forest to the south and east and floodplain habitats to the north and west. The construction footprint generally represents the eastern distributional limit of the community where it intergrades with coastal Spotted Gum Ironbark Forests (PCT 1588), with the main distribution of the community extending to the north-west and southwest of the construction footprint.

Diagnostic features: This community is distinguished from other Spotted Gum – Ironbark Forests (PCT 1593 and PCT 1588) by the following:

- The dominance of *Corymbia maculata* and *Eucalyptus fibrosa,* and lower abundance of other ironbark species distinguishes it from PCT 1588, which is characterised by a dominance of *E. paniculata* and *E. siderophloia*
- The vegetation is floristically very similar to PCT 1593. However, *Corymbia maculata* is the dominant canopy species across most of the occurrence of this vegetation in the construction footprint, which is the main feature distinguishing PCT 1590 from PCT 1593 as described in the NSW BioNet Vegetation Classification database
- The vegetation contains both *E. umbra* and *E. acmenoides*. *E. umbra* is a diagnostic canopy species of PCT 1590 though not listed for PCT 1593
- The vegetation does contain dense patches of *Melaleuca nodosa* in the midstorey in lower lying areas, which is a diagnostic species of PCT 1593. However, this species is common in other surrounding PCTs and could be expected to occur in suitable waterlogged soils.

Threatened flora species: A population of *Callistemon linearifolius* has been recorded from this community at Beresfield. There are also several planted *Callistemon linearifolius* individuals a small isolated population of *Grevillea parviflora* subsp. *parviflora* in the power easement next to this community at Tomago, which is outside of the construction footprint.

Photograph 2: Plot 1 showing vegetation zone 2, Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590 - Moderate)

Photograph 3: Plot 54 showing vegetation zone 3, Spotted Gum - Broad-leaved Mahogany – Red Ironbark shrubby open forest (1590 - Regenerating)

3.2.2 Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (1588)

Vegetation zones:

- 4: 1588 – Moderate (6.78 hectares)
- 5: 1588 – Regenerating (0.82 hectares)

BVT code: HU802

PCT code: 1588

Estimate of per cent cleared: 56%

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

Vegetation class: Hunter-Macleay Dry Sclerophyll Forests

Conservation status: Not listed

Vegetation plots:

- Zone 4: Plot 3, Plot 42, Plot 70
- Zone 5: Plot 55

Photograph 4: Plot 3 showing vegetation zone 4. Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (1588 - Moderate)

Description: This community occurs on undulating slopes with Permian soils at Black Hill and Beresfield. This community is an open forest dominated by *Eucalyptus siderophloia* (Northern Grey Ironbark), *Eucalyptus paniculata* (Grey Ironbark), *Eucalyptus umbra* (Broad-leaved White Mahogany) and *Corymbia maculata* (Spotted Gum) 18-20 metres tall, with an open midstorey 2-10 metres high including *Bursaria spinosa*, *Notelaea longifolia* and *Acacia ulicifolia*. The ground layer is dominated by a high diversity of grasses and forbs including *Themeda australis*, *Microlaena stipoides*, *Entolasia stricta*, *Eragrostis brownii*, *Aristida vagans*, *Echinopogon caespitosus* and *Lobelia purpurascens*.

Condition: There are two condition classes of this PCT in the construction footprint:

- Vegetation zone 4 – Moderate condition examples of this community are most widespread in the Beresfield area, supporting moderate to high cover of *Lantana camara* and is subject to cattle grazing in some areas. Areas of this PCT are also accessed by the general public as evidenced by motorcycle tracks and dumped rubbish. However, the vegetation contains an intact canopy of mature trees and is still in moderate condition with an average benchmark score of 79.69
- Vegetation zone 5 – Regenerating condition areas have been previously entirely cleared and contain a mix of regenerating trees and shrubs. There are two main areas of this vegetation zone, one in Beresfield where vegetation has been cleared in an easement though has been left to regenerate, and the other is across the AGL owned property in Tomago, which is lacking canopy regeneration in many areas, though has been assigned to PCT 1590 as this is the dominant PCT surrounding the site. Regenerating condition patches have an average benchmark score of 49.48.

Landscape features: This community occurs on undulating slopes with Permian derived sediments of the Beresfield Soil Landscape at Beresfield.

Distribution: The community occurs as larger patches on undulating slopes at the south-western end of the project at Black Hill, and Beresfield. The construction footprint is near the northern and western distributional limit of the community where it intergrades with other Spotted Gum Ironbark Forests (PCT 1590). The main distribution of the community in the region extends south from the construction footprint along the coastal hinterland.

Diagnostic features: This community is distinguished from other Spotted Gum – Ironbark Forests (PCT 1590 and PCT 1593) by the following:

- An absence of *Eucalyptus fibrosa* (characteristic of PCTs 1590 and 1593), the higher abundance of other over-storey species including *E. siderophloia*, *E. paniculata, Eucalyptus globoidea* and *Eucalyptus umbra* (diagnostic species of PCT 1588), and the lower abundance of *Corymbia maculata*, which likely occurs as this PCT integrates with PCT 1590

- Although this vegetation does not perfectly match the description of species for PCT 1588, it does meet the description of Coastal Foothills Spotted Gum - Ironbark Forest (MU15) classified and mapped by the Lower Hunter and Central Coast Environmental Management Strategy (LHCCREMS). A review of vegetation mapping in the Lake Macquarie City Council by Stephen Bell (LMCC 2016) identified PCT 1588 as the most appropriate for conversion from MU15.

Threatened flora species: Several *Callistemon linearifolius* individuals were recorded from this community at Beresfield.

Threatened ecological community: Not Listed. This community has affinities to the TEC Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion, however the occurrence in the construction footprint is around Black Hill which is within the Sydney Basin Bioregion in the Newcastle LGA.

Photograph 5: Plot 55 showing vegetation zone 5. Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (1588 - Moderate)

3.2.3 Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646)

Vegetation zones:

- 6: 1646 – Good (20.76 hectares)
- 7: 1646 – Poor (7.83 hectares)

BVT code: HU860

PCT code: 1646

Estimate of per cent cleared: 45%

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

Vegetation class: Coastal Dune Dry Sclerophyll Forests

Conservation status: Not threatened

Vegetation plots:

- Zone 6: Plot 21, Plot27, Plot 34, Plot 35
- Zone 7: Plot 59, Plot 60, Plot 61

Photograph 6: Plot 27 showing vegetation zone 6, Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646 – Good)

Description: This community occurs on quaternary sands in the Heatherbrae and Tomago area. This community is an open forest dominated by *Eucalyptus pilularis* (Blackbutt), *Angophora costata* (Smooth-barked Apple) and *Corymbia gummifera* (Red Bloodwood) 18-25 metres tall. Much of the community has been burned in the past ten years. The understorey includes an open to closed mid-storey 2-10 metres height dominated by *Banksia serrata* and *Monotoca elliptica* and a diversity of smaller shrub species one to two metres high such as *Lambertia formosa*, *Acacia suaveolens*, *Macrozamia communis* and *Acacia ulicifolia*. The ground layer is dominated by *Pteridium esculentum*, *Actinotus helianthi*, *Patersonia glabrata*, *Lomandra longifolia* and *Pomax umbellata*.

Condition: There are two condition classes of this PCT in the construction footprint:

- Vegetation zone 6 – Good condition areas contain all structural layers intact with limited disturbances and low levels of weeds invasion, mainly comprising *Lantana camara*. This zone has an average benchmark score of 59.9
- Vegetation zone 7 – Poor condition areas of this community include several areas where this community has been cleared or under scrubbed in the past and is missing one or more structural layers. Around Heatherbrae examples of this zone also include invasion by *Pinus radiata*. This zone has an average benchmark score of 50.

Landscape features: This community occurs on quaternary sands in the Heatherbrae and Tomago area.

Distribution: The community occurs as larger patches on undulating quaternary sand dunes at the northern end of the project at Heatherbrae and Tomago. These habitats are contiguous with large areas of wallum vegetation associated with the Tomago Sandbeds. This community extends along the coast from Gosford to Black Head on quaternary sand dunes up to 100 metres elevation.

Diagnostic features: This community is readily distinguished as PCT 1646 by the presence of the dominant canopy species *Eucalyptus pilularis*, *Angophora costata* and *Corymbia gummifera* and diagnostic understorey species on quaternary sands. Other PCTs that are floristically similar (e.g. PCT 1648 and 1579) have geographic limitations and do not occur in the construction footprint.

Threatened flora species: *Diuris arenaria* was recorded at Heatherbrae from cleared tracks and easements, disturbed vegetation and intact woodland just north of Masonite Road to the south-west near the Pacific Highway. This community also provides potential habitat for *Eucalyptus parramattensis* subsp. *decadens* which was recorded in sandy swamp forest vegetation at the northern end of the project.

Photograph 7: Plot 60 showing vegetation zone 7, Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646 – Poor)

3.2.4 Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649)

Vegetation zones:

- 8: 1649 – Good (1.36 hectares)

BVT code: HU863

PCT code: 1649

Estimate of per cent cleared: 46%

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Swamp Forests

Conservation status: Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)

Vegetation plots:

- Zone 8: Plot 28

Photograph 8: Plot 28 showing vegetation zone 8, Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649 – Good)

Description: This community occurs in a swampy sandy depression at Heatherbrae. This community has been burnt in the past ten years. These areas support an open canopy dominated by *Eucalyptus robusta* (Swamp Mahogany) and *Angophora costata* (Smooth-barked Apple) generally up to 15 metres. The understorey is characterised by a dense mid-storey 5-8 metres high dominated by paperbark species (*Melaleuca nodosa, M. sieberi, M. quinquenervia*) and *Leptospermum polygalifolium*. The ground layer is dominated by grasses including *Imperata cylindrica*, *Entolasia stricta*, *Hemarthria uncinata* and some herb species are also common including *Dianella caerulea*.

Condition: There is one condition class for this community in the construction footprint:

- Vegetation zone 8 – This zone is in good condition with all structural layers intact and a low cover of weed species comprising smaller juvenile plants and seedlings including *Conyza* sp. and *Andropogon virginicus*. This zone has an average benchmark score of 61.33.

Landscape features: This community occurs in a swampy sandy depression at Heatherbrae. The community is characteristic of low elevation poorly drained sands below 50 metres elevation.

Distribution: This PCT is found on the NSW coastal lowlands between Tumbi Umbi on the Central Coast to Crowdy Head on the North Coast. It is present in only one location of the construction footprint at Heatherbrae and is likely to be moderately common throughout the Tomago Sandbeds.

Diagnostic features: This community is readily distinguished by the dominance of *Eucalyptus robusta* and *Angophora costata* with a paperbark dominated mid-storey. It is similar to other swamp forest communities, although the dryer nature and unique flora composition of mesic and dryer species is a readily diagnostic feature of this community.

Threatened flora species: *Diuris arenaria* was recorded at Heatherbrae along a powerline easement and cleared block bordering the extent of this community. This community also provides potential habitat for *Eucalyptus parramattensis* subsp. *decadens* which was recorded in sandy swamp forest vegetation at the northern end of the project.

Photograph 10: Plot 28 showing vegetation zone 8, Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649 – Good). Post-fire regeneration of native groundcovers and shrubs.

3.2.5 Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598)

Vegetation zones: • 9: 1598 – Poor (0.45 hectares) **BVT code:** HU812 **PCT code:** 1598 **Estimate of per cent cleared:** 0% **Vegetation formation:** Forested Wetlands **Vegetation class:** Coastal Swamp Forests **Conservation status:** Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions (Endangered, TSC Act) **Vegetation plots:** • Zone 9: Plot 15, Plot 20	 Photograph 11: Plot 5 showing vegetation zone 9, Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598 – Poor)

Description: This community occurs on the edges of the Hunter River floodplain at Tomago, comprising fragmented patches of modified forest. These areas support an open canopy of *Eucalyptus tereticornis* (Forest Red Gum) 15-18 metres high with an open to dense midstorey up to 5 metres in height dominated by *Melaleuca nodosa* and *Breynia oblongifolia* and the vine species *Parsonsia straminea*. The ground layer is predominantly grassy including *Microlaena stipoides*, *Imperata cylindrica* and *Lomandra longifolia*. This community occurs as a relatively thin strip between the floodplain and sandy blackbutt forest and therefore the midstorey species change with distance from the edge.

Condition: There is one condition class for this community in the construction footprint:

- Vegetation zone 9: This zone is in poor condition and is generally missing one structural layer, varying from the midstorey and groundcover on the edge to canopy species where drainage has been altered. This zone supports moderate cover of weed species including *Lantana camara*, *Rubus fruticosus* agg. and *Andropogon virginicus* and has an average benchmark score of 71.33.

Landscape features: This community occurs on the edges of Hunter River floodplain at Tomago adjoining areas of Spotted Gum - Ironbark forest on Permian sediments and Apple – Blackbutt forest on quaternary sands.

Distribution: This PCT is found in the lower Hunter Valley and the occurrences in the construction footprint generally represent the eastern limit of the community, however similar forests dominated by Forest Red Gum (*Eucalyptus tereticornis*) on floodplain areas are described between Newcastle and the Queensland border which are included under the same TEC Subtropical Coastal Floodplain Forest.

Diagnostic features: This community is readily distinguished by the dominance of *Eucalyptus tereticornis* and *Angophora floribunda* a midstorey dominated by paperbarks (*Melaleuca* sp.) and *Breynia oblongifolia* with a predominantly grassy ground layer including *Microlaena stipoides*, *Imperata cylindrica* and *Lomandra longifolia*. This community shares some floristic similarities in the midstorey to PCT 1646 as it occurs in a floodplain buffer area next to this PCT, however the assemblage of canopy species between these communities is distinctly different and PCT 1646 does not contain *Eucalyptus tereticornis*.

Threatened flora species: No threatened flora species were recorded in this habitat type and considering the modified nature of these habitats it is considered unlikely that any threatened flora populations are present in this community.

Threatened ecological community: Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions. This community also has affinities to another TEC comprising Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion, however diagnostic canopy and shrub species more closely align to the final determination for Hunter Lowland Redgum Forest.

Photograph 12: Vegetation zone 9, Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598 – Poor) where a modified soil bank has trapped water resulting in a dense understorey of *Melaleuca nodosa.*

3.2.6 Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716)

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Vegetation zones:

- 10: 1716 – Good (1.82 hectares)

BVT code: HU930

PCT code: 1716

Estimate of per cent cleared: 66%

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Swamp Forests

Conservation status: Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)

Vegetation plots:

- Zone 10: Plot 5, Plot 38

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Photograph 13: Plot 5 showing vegetation zone 10, Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716 – Good)

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Description: This community occurs along a drainage line which runs parallel to the M1 Pacific Motorway at Black Hill through a patch of PCT 1590. It is an open woodland with a dense midstorey 10-15 metres in height dominated by several paperbark species (*Melaleuca nodosa, M. linariifolia, M. decora*) and the vine species *Parsonsia straminea*. The canopy is up to 20 metres high with an open woodland structure dominated by *Eucalyptus resinifera* and *Syncarpia glomulifera* as well as scattered overstorey species from the surrounding PCT 1590. The ground layer is dominated by a mix of sedges, herbs and grasses including *Carex longebrachiata*, *Dichondra repens*, *Oplismenus* sp., *Entolasia marginata* and *Echinopogon ovatus*.

Condition: There is one condition class for this community in the construction footprint:

- Vegetation zone 10: This zone is in good condition, containing all structural layers and a moderate cover of weed species, including *Lantana camara* and *Ageratina adenophora*. This zone has an average benchmark score of 66.67.

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Landscape features: This community occurs along a drainage line with Permian soils which runs parallel to the M1 Pacific Motorway at Black Hill.

Distribution: This community is found on poorly drained areas on the undulating coastal lowlands from Wamberal north to Yarratt State Forest. In the construction footprint this community occurs as part of a larger patch of PCT 1590.

Diagnostic features: This community is readily distinguished as PCT 1716 by the presence of the dense paperbark midstorey along a swampy drainage line with an open overstorey. The dominant canopy species are unique to this community in this area of the construction footprint and characteristic of PCT 1716. The ground layer is very distinctive from the surrounding communities being dominated by mesic species in some areas including *Carex longebrachiata* and *Oplismenus* sp.

Threatened flora species: No threatened flora species have been recorded in this habitat type.

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Photograph 14: Drainage line through vegetation zone 6, Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716 – Good)

3.2.7 Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717)

Vegetation zones:

- 11: 1717 – Good (3.85 hectares)
- 12: 1717 – Poor (6.64 hectares)

BVT code: HU931

PCT code: 1717

Estimate of per cent cleared: 68%

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Swamp Forests

Conservation status: Swamp sclerophyll forest on coastal floodplains of the NSW North Coast Sydney Basin and South East Corner bioregions (Endangered, TSC Act)

Vegetation plots:

- Zone 11: Plot 36, Plot 48
- Zone 12: Plot 29, Plot 62, Plot 63

Photograph 15: Plot 36 showing vegetation zone 11, Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717 – Good)

Description: This community occurs on low elevation, poorly drained floodplain areas. These areas support a canopy dominated by *Eucalyptus robusta* (Swamp Mahogany) and paperbark species (*Melaleuca quinquenervia*, *M. linariifolia*) around 12-18 metres high. The groundlayer is dominated by a mix of herbs, grasses, sedges and ferns including *Goodenia paniculata*, *Centella asiatica*, *Cynodon dactylon*, *Gahnia clarkei*, *Baloskion tetraphyllus* and *Blechnum indicum*. The vine species *Parsonsia straminea* is also common throughout much of this community.

Condition: There are two condition classes of this PCT in the construction footprint:

- Vegetation zone 11: This zone is in good condition with all structural layers intact and low levels of weeds. This zone has an average benchmark score of 62
- Vegetation zone 12: Poor condition areas of this community support a mid-storey dominated by *Casuarina glauca* and paperbark species as well as other shrub species in disturbed areas including wattles (*Acacia longifolia*, *A. irrorata*) and *Breynia oblongifolia*, with a grassy ground layer. *Lantana camera* and *Pinus radiata* are in low to moderate abundance. This zone has an average benchmark score of 44.

Landscape features: This community occurs on poorly drained floodplains and depressions below 50 metres elevation. It typical occurs on poorly drained unconsolidated sediments of the coastal lowlands.

Distribution: This community occurs as several isolated patches in the construction footprint at Tomago and one large patch at Heatherbrae. This PCT is found on coastal lowlands between the NSW Central Coast and Karuah.

Diagnostic features: This community is floristically similar to Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast (PCT 1718) and Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (PCT 1724), however this community is considered to be PCT 1717 for the following reasons:

- The dominance of *Eucalyptus robusta* and *Melaleuca quinquenervia,* with a midstorey of *M. linariifolia* and a sedge/fern dominated understorey. PCT 1718 does not list *Melaleuca quinquenervia* as a diagnostic species, *Eucalyptus robusta* does not appear to be a dominant canopy species in PCT 1724
- PCT 1724 is described as being an open forest around standing water. This vegetation typically occurred in slightly higher areas.

Threatened flora species: Several threatened species are associated with habitats within this community, particularly in ecotone areas. Drier edges at the northern end of the project at Heatherbrae support *Eucalyptus parramattensis* subsp. *decadens* occurring in ecotone areas between moister poorly drained habitats and dryer sandy slopes. A small patch of *Callistemon linearifolius* also occurs in a similar location within this PCT. The threatened aquatic flora species *Maundia triglochinoides* was also recorded in Windeyers Creek which supports sandy wetlands and swamp forest elements; however, these are outside of the construction footprint.

Photograph 16: Plot 29 showing vegetation zone 12, Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717 – Poor).

3.2.8 Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1724)

Vegetation zones:

- 13: 1724 – Good (1.61 hectares)

BVT code: HU938

PCT code: 1724

Estimate of per cent cleared: 31%

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Swamp Forests

Conservation status: Swamp sclerophyll forest on coastal floodplains of the NSW North Coast Sydney Basin and South East Corner bioregions (Endangered, TSC Act)

Vegetation plots:

- Zone 13: Plot 49

Photograph 17: Plot 49 showing vegetation zone 13, Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1724 – Good)

Description: This community occurs on low elevated poorly drained floodplain areas with standing water. Only one patch of this PCT was identified in the construction footprint near the intersection of the Pacific Highway and Old Punt Road, which includes section of standing water along the drainage line. This patch supports a diverse canopy dominated by *Casuarina glauca* (Swamp Oak) and paperbark species (*Melaleuca quinquenervia*, *M. linariifolia*), with occurrences of *Eucalyptus robusta* (Swamp Mahogany), around 12-18 metres high in the centre of the patch. *Livistona australis* are also scattered throughout. This patch also has an assemblage of mesic species through the canopy, including large *Alphitonia excelsa* and *Glochidion ferdinandii*, and very large mature *Eucalyptus grandis* around the outer eastern/northern edges on both sides of Old Punt Road. The ground layer is dominated by sedges and ferns including *Gahnia sieberiana*, *Calochlaena dubia* and *Hypolepis muelleri*.

Condition: There is one condition class of this PCT in the construction footprint:

- Vegetation zone 13: This zone is in good condition with all structural layers intact and a mature (possibly old growth) canopy, however an infestation of *Lantana camara* is present in drier areas. This zone has an average benchmark score of 53.33.

Landscape features: This community occurs on in areas of standing water on alluvial sands and muds on floodplains and barrier sands from one to 350 metres elevation.

Distribution: This community occurs as one patch in the construction footprint along a drainage depression in Tomago. This PCT is found on floodplains and barrier sands of the lower North Coast and Central Coast.

Diagnostic features: This community is floristically similar to several swamp forests PCTs, particularly Swamp Mahogany - Broad-leaved Paperbark - Swamp Water Fern - Plume Rush swamp forest on coastal lowlands of the Central Coast and Lower North Coast (PCT 1725) and Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (PCT 1717), though it is considered to be PCT 1724 for the following reasons:

- The community is dominated by a mixture of species including *Melaleuca quinquenervia* and *Eucalyptus robusta* (which are characteristic of PCT1717, PCT 1724 and PCT 1725), as well as *Casuarina glauca*, *Glochidion ferdinandi* and *Livistona australis* (which are not described as diagnostic species for PCT 1725). The vegetation only has a low abundance of *Eucalyptus robusta*, which appears to be a distinguishing feature between PCT 1724 and PCT 1717

- PCT 1724 is described as being an open forest around standing water, which is present both as PCT 1071 towards the Pacific Highway and a long open water drainage line dominated by *Enydra fluctuans* and *Carex appressa* that almost connects to the culvert underneath Old Punt Road
- PCT 1725 is not known from the Hunter sub-region
- The occurrence of *Eucalyptus grandis* suggests that there may have been an adjoining mesic community in the past prior to any clearing. *Eucalyptus grandis* in the construction footprint is at the very southern limit of its range and does not fit into any PCTs that are known to occur in the Hunter sub-region.

Threatened flora species: No threatened species were identified from this vegetation community during surveys, however it does provide suitable habitat for wetland species such as *Maundia triglochinoides* and *Persicaria elatior*, which was identified form the floodplain on the other side of the Pacific Highway.

3.2.9 Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727)

Vegetation zones:

- 14: 1727 – Moderate (8.76 hectares)

BVT code: HU941

PCT code: 1727

Estimate of per cent cleared: 60%

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Floodplain Wetlands

Conservation status: Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act); Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community (Endangered, EPBC Act) – in part

Vegetation plots:

- Zone 14: Plot 13, Plot 22, Plot 43, Plot 45, Plot 46

Photograph 18: Plot 13 showing vegetation zone 14, Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727 - Moderate)

Description: This community occurs on low elevated poorly drained floodplain areas with saline sub-soils. These areas support a canopy dominated by *Casuarina glauca* (Swamp Oak) 15 to 18 metres high and the vine species *Parsonsia straminea* is also a common component of the midstorey and canopy. The understorey includes a mix of grasses, herbs and sedges including *Carex appressa*, *Phragmites australis*, *Commelina cyanea*, *Tetragonia tetragonioides* and *Sporobolus virginicus*. Much of this community has been subject to some disturbance from previous clearing and agricultural practices resulting in weed invasion and a modified vegetation structure. Common weed species include *Lantana camara*, *Alternanthera philoxeroides* and *Ehrharta erecta*.

Condition: There is one condition class for this community in the construction footprint:

- Vegetation zone 14 – This zone is in moderate condition, generally exhibiting an intact canopy though some areas remain only as isolated patches. This community supports a moderate cover of weed species with an average benchmark score of 55.33.

Landscape features: This community occurs on low elevation, poorly drained floodplain areas with saline sub-soils. The community is typically found on the margins of brackish water bodies on floodplains below 20 metres elevation. Substrates typical comprise poorly drained unconsolidated sediments of the coastal lowlands.

Distribution: This community occurs in several locations of the construction footprint including adjoining the New England Highway at Beresfield, floodplain areas on the eastern side of the Hunter River at Tomago. This PCT is found on coastal lowlands between the NSW Central Coast and Failford.

Diagnostic features: There are six PCTs dominated by Casuarina glauca that are recognised from the Hunter subregion (BioNet). The vegetation in the construction footprint is considered most likely to be PCT 1727 for the following reasons:

- The community is located in a coastal floodplain area, on the margin of the Hunter River often with some saline influence resulting in a dominance of salt-tolerant species is characteristic of PCT 1727 and PCT 1729. PCTs 1717, 1724 and 1728 do not occur in brackish environments. PCT 1731 is associated with brackish water in the central and upper Hunter Valley
- Both PCT 1727 and PCT 1729 are dominated by *Casuarina glauca*. Occasional occurrences of *Melaleuca styphelioides* is consistent with the description of PCT 1727. Of the ground stratum species listed in BioNet, the vegetation is the construction footprint contains four out of six listed for 1727 and two out of four listed for 1729

- PCT 1727 is associated with unconsolidated sediments, which is present in the construction footprint. PCT 1729 is associated with alluvial sand.

Threatened flora species: No threatened flora species were recorded in this community and considering the relatively disturbed nature of the community is unlikely to support threatened flora species.

Photograph 19: Plot 22 showing vegetation zone 13, Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727 - Moderate)

3.2.10 Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736)

Vegetation zones:

- 15: 1736 – Good (33.23 hectares)
- 16: 1736 – Moderate (25.81 hectares)

BVT code: HU950

PCT code: 1736

Estimate of per cent cleared: 80%

Vegetation formation: Freshwater Wetlands

Vegetation class: Coastal Freshwater Lagoons

Conservation status: Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)

Vegetation plots:

- Zone 15: Plot 0, Plot 7, Plot 22, Plot 23
- Zone 16: Plot 8, Plot 9, Plot 10, Plot 26

Photograph 20: Plot 7 showing vegetation zone 15, Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736 – Good)

Description: This community occurs on low elevated poorly drained floodplain areas. These areas are dominated by a mix of sedges and grasses with limited or no canopy and/or mid-storey present. Dominant species include *Cynodon dactylon*, *Juncus* sp., *Persicaria* sp., *Carex appressa*, *Paspalum distichum*, *Bolboschoenus caldwellii*, *Lobelia concolor*, *Ranunculus inundatus*, *Ludwigia peploides* and *Eleocharis* species. Some locations support an open mid-storey of *Casuarina glauca* or *Melaleuca styphelioides* up to 10 metres high. Much of this community has been subject to some disturbance from previous clearing, modified hydrology and agricultural practices with these areas being currently open to cattle grazing resulting in weed invasion and a modified vegetation structure. Common weed species include *Alternanthera philoxeroides*, *Pennisetum clandestinum* and *Paspalum dilatatum*.

Condition: There are two condition classes of this PCT in the construction footprint:

- Vegetation zone 15: Good condition areas of this community are currently open to cattle grazing and support moderate weed levels, with an average benchmark score of 48.06
- Vegetation zone 16: Poor condition areas of this community include pastoral areas that are periodically inundated and support varying cover of exotic pasture species, however there are still low-moderate levels of native flora diversity. The native flora diversity and cover in low condition areas is likely to vary with increases during times of flood and decreases during dry periods. This zone has an average benchmark score of 36.43.

Landscape features: This community occurs on low elevation, poorly drained floodplain areas which are regularly inundated. It occurs on unconsolidated sediments from one to 120 metres elevation.

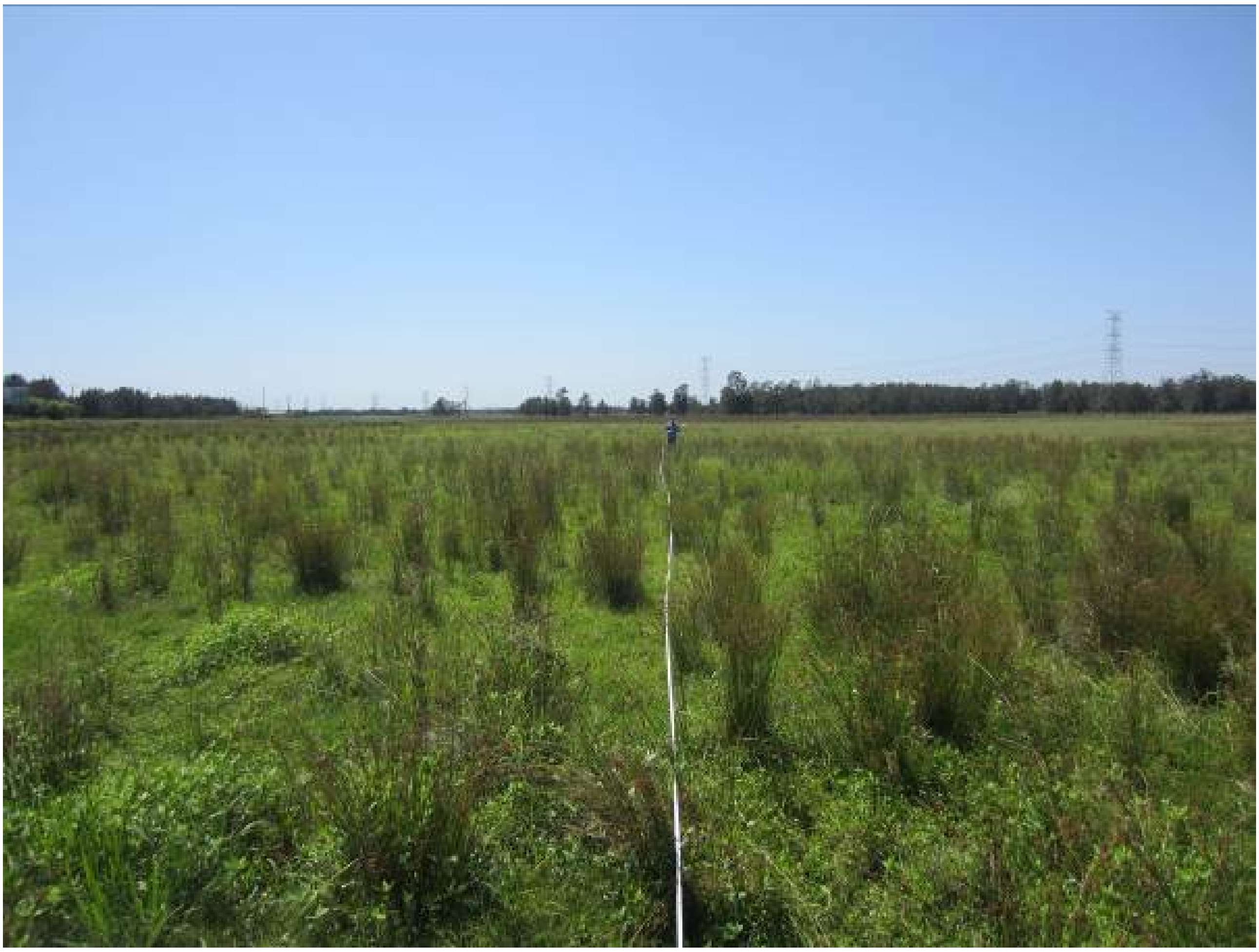
Distribution: This community occurs on the floodplain areas of Hexham swamp at Beresfield and Hexham next to the New England Highway and on eastern side of the Hunter River on the floodplain at Tomago and Heatherbrae. This PCT is found on coastal lowlands from Paxton to just north of Raymond Terrace.

Diagnostic features: This community is distinguished from other freshwater wetland sedge dominated communities (PCT 1740, 1741 and 1742) by the following:

- Higher condition areas of this community contain a dominance of aquatic or semi-aquatic flora species, in particular *Carex appressa*, *Paspalum distichum* and *Bolboschoenus caldwellii*. *Paspalum distichum* is a diagnostic species of PCT 1736, whereas PCT 1740 is dominated by *Eleocharis* sp., PCT 1741 is dominated by *Lepironia articulata* or; at some sites; by the grass *Pseudoraphis paradoxa*, and PCT 1742 is dominated by *Baumea* sp

- Low condition areas were identified based on the slightly lower elevation in comparison to surrounding areas of exotic pasture and the co-dominance of *Cynodon dactylon* with exotic pasture grasses along with the presence (in low abundance) of other diagnostic native flora species.

Threatened flora species: *Persicaria elatior* was identified in one location on the eastern side of the Hunter River.



Photograph 21: Plot 9 showing vegetation zone 16, Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736 – Moderate)

3.2.11 Jointed Twig-rush sedgeland (1742)

Vegetation zones:

- 17: 1742 – Good (1.45 hectares)

BVT code: HU956

PCT code: 1742

Estimate of per cent cleared: 70%

Vegetation formation: Freshwater Wetlands

Vegetation class: Coastal Freshwater Lagoons

Conservation status: Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)

Vegetation plots:

- Zone 17: Plot 30

Photograph 22: Plot 30 showing vegetation zone 17, Jointed Twig-rush sedgeland (1742 – Good)

Description: This community occurs on low elevated poorly drained sandy soils along drainage lines including Windeyers Creek and un-named creeks next to the Hunter Region Botanic Gardens. These areas are dominated by various sedges, grasses, herbs and ferns with limited canopy and/or mid-storey cover. Dominant species include *Persicaria* sp., *Baumea articulata*, *Eleocharis equisetina*, *Pseudoraphis paradoxa*, *Blechnum indicum* and *Isachne globosa*. A sparse to moderate canopy/mid-storey cover is present in some locations including *Casuarina glauca*, *Melaleuca quinquenervia* and *Eucalyptus robusta*. There are limited disturbances within this community apart from low-moderate weed levels, however the riparian zone of Windeyers Creek has been substantially modified through the establishment of pine plantations.

Condition: There is one condition class for this community in the construction footprint:

- Vegetation zone 17: This zone is in good condition and supports a low-moderate cover of weed species mainly comprising *Isolepis prolifera*. This zone has an average benchmark score of 82.17.

Landscape features: This community occurs on poorly drained to inundated coastal sands and muds below elevations of 20 metres.

Distribution: This community occurs along two drainage lines within the construction footprint at Heatherbrae including Windeyers Creek and un-named creeks next to the Hunter Region Botanic Gardens. This PCT is found on coastal lowlands from Wyong to Failford.

Diagnostic features: This community is distinguished from other freshwater wetland sedge dominated communities (PCT 1736, 1740 and 1741) by the following:

- The co-dominance of *Baumea articulata,* which is a diagnostic species of PCT 1742
- The occurrence of this vegetation on sandy alluvial soils
- These features are also diagnostic of PCT 1741, however this PCT is described as only occurring on the coastal strip from south of Nelson Bay to Tuncurry.

Threatened flora species: No threatened flora species were recorded in this community and considering the relatively disturbed nature of the community is unlikely to support threatened flora species.

Photograph 23: Vegetation zone 17 showing Jointed Twig-rush sedgeland (1742 – Good) in drainage line next to the Hunter Region Botanic Gardens.

3.2.12 *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (1071)

Vegetation zones:

- 18: 1071 – Good (7.71 hectares)

BVT code: HU673

PCT code: 1071

Estimate of per cent cleared: 75%

Vegetation formation: Freshwater Wetlands

Vegetation class: Coastal Freshwater Lagoons

Conservation status: Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)

Vegetation plots:

- Zone 18: Plot 11, Plot 12, Plot 44

Photograph 24: Plot 11 showing vegetation zone 18, *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (1071 – Good)

Description: This community occurs on low elevation, poorly drained floodplain areas often with standing water. These areas are dominated almost exclusively by *Typha orientalis* or *Phragmites australis*, depending on the level of waterlogging, and generally a low abundance of other native flora species. Other native species include *Hypolepis muelleri*, *Ranunculus inundatus*, *Paspalum distichum* and *Cycnogeton microtuberosum*.

Condition: There is one condition class for this community in the construction footprint:

- Vegetation zone 18: This zone is in good condition and supports a low-moderate cover of weed species mainly comprising *Isolepis prolifera*. This zone has an average benchmark score of 47.29.

Landscape features: Man-made water bodies, drainage lines and depressions across a wide variety of environments. Includes modified former wetlands such as Hexham Swamp. Occurs also in original form in wide variety of situations associated with coastal plains, valleys, lagoons and other sites of poor drainage.

Distribution: This community is widespread across the construction footprint. The largest occurrence is in a floodplain depression on the inside bend of the Hunter River, located between estuarine habitats and the existing highway. This community also occurs in small patches along drainage lines where standing water is held. This community occurs in the Cumberland, Hunter, Illawarra, Pittwater, Sydney Cataract, and Wyong sub-regions.

Diagnostic features: This community is readily distinguished from other wetland communities by the dominance of *Typha orientalis* or *Phragmites australis*. There are two PCTs known to occur in the Hunter region that contains these species, PCT 1071 and PCT 1737, however the vegetation in the construction footprint is most likely PCT 1071 for the following reasons:

- *Phragmites australis* is not a diagnostic species in PCT 1737, however it is listed alongside *Typha orientalis* as diagnostic species of PCT 1071
- It is noted that PCT 1737 does have a high confidence level, compared to a very low confidence level for PCT 1737. However, PCT 1071 is described as including modified former wetlands, such as Hexham Swamp Nature Reserve. PCT 1737 is described as occurring on the margins of freshwater, with Hexham being the northern limit. Considering the proximity of Hexham Swamp Nature Reserve to the vegetation in the construction footprint, the brackish influence of the Hunter River and the history of modification from agricultural activities, vegetation in the construction footprint appears to best match PCT 1071.

Threatened flora species: No threatened flora species were recorded in this community.

Photograph 25: Vegetation zone 18 showing *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (1071 – Good) dominated by Phragmites australis

3.2.13 Saltmarsh Estuarine Complex (1746)

Vegetation zones:

- 19: 1746 – Good (1.26 hectares)

BVT code: HU960

PCT code: 1746

Estimate of per cent cleared: 16%

Vegetation formation: Saline Wetlands

Vegetation class: Saltmarshes

Conservation status: Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act); Subtropical and Temperate Coastal Saltmarsh (Vulnerable, EPBC Act).

Vegetation plots:

- Zone 19: Plot 24, Plot 57

Photograph 26: Plot 24 showing vegetation zone 19, Saltmarsh Estuarine Complex (1746 – Good) on the western bank of the Hunter River.

Description: Rarely tidally inundated salt tolerant herbaceous community which may be dominated by chenopods or grasses depending on local conditions. This community is dominated by *Triglochin striatum*, *Sarcocornia quinqueflora*, *Juncus kraussii*, *Sporobolus virginicus*, *Paspalum distichum* and *Thyridia repens*. In the construction footprint, this community has been substantially disturbed and modified. It is restricted to a few locations within the construction footprint most prominent in proximity to the Hunter River (refer to **Photograph 28**) while other parts of the floodplain include disturbed grassy examples that are disconnected from tidal influences such as Tomago (refer to **Photograph 29**) and around the existing highway near Tarro. Narrow strips also occur along the western bank of the Hunter River. These communities support a low to moderate abundance of exotic flora including common weed species including *Polypogon monspeliensis*, *Juncus acutus*, *Pennisetum clandestinum*, *Spergularia marina*, *Stenotaphrum secundum*, *Atriplex prostrata* and *Cotula coronopifolia*.

Condition: There is one condition class for this community in the construction footprint:

- Vegetation zone 19: This zone is in good condition and supports a low-moderate cover of weed species. This zone has an average benchmark score of 49.07.

Landscape features: This community occurs on open saline mudflats and semi-tidal saline muds, usually occurs on the landward side of mangroves.

Distribution: This community is restricted to several locations within the construction footprint including disturbed grassy examples disconnected from tidal influences and narrow strips along the western bank of the Hunter River. This PCT is distributed along the entire length of the NSW coast.

Diagnostic features: This community is readily distinguished from other saline and wetland communities by following:

- The dominance of salt-tolerant flora species including *Triglochin striatum*, *Sarcocornia quinqueflora* and *Juncus kraussii* and general absence of mangrove species
- PCT 1126 contains a similar assemblage of species, however this PCT occurs on tidally inundated land. Even the most tidally influenced occurrences of saltmarsh vegetation on the western bank of the Hunter River in the construction footprint are located on an elevated rise and would be rarely inundated.

Threatened flora species: No threatened flora species were recorded in this community and considering the relatively modified nature of the community, it is unlikely to support threatened flora species.

Photograph 27: Plot 57 showing vegetation zone 19, Saltmarsh Estuarine Complex (1746 – Good) as a disturbed grassy example dominated by *Sporobolus virginicus*

3.2.14 Grey Mangrove low closed forest (1747)

Vegetation zones: • 20: 1747 – Good (2.04 hectares) • 21: 1747 – Moderate (0.23 hectares) **BVT code:** HU961 **PCT code:** 1747 **Estimate of per cent cleared:** 59% **Vegetation formation:** Saline Wetlands **Vegetation class:** Mangrove Swamps **Conservation status:** Not threatened **Vegetation plots:** • Zone 20: Plot 14, Plot 56 • Zone 21: Plot 25	 Photograph 28: Plot 14 showing vegetation zone 20, Grey Mangrove low closed forest (1747 – Good)

Description: This community occurs on saline muds within the tidal zone of estuaries, including the Hunter River and Purgatory Creek in the construction footprint. This community is dominated by *Avicennia marina* (Grey Mangrove) with an open midstorey of *Aegiceras corniculatum* and a sparse muddy ground layer dominated by pneumatophores of the Grey Mangrove. Common understorey species includes a sparse cover of salt tolerant species such as *Tetragonia tetragonioides* and *Sporobolus virginicus*, *Suaeda australis*, *Crinum pedunculatum* and *Triglochin striatum*.

Condition: There are two condition classes for this community in the construction footprint:

- Vegetation zone 20: Good condition areas are present on the banks of the Hunter River with an intact mid-upper stratum and low level of weed cover. This zone has a benchmark score of 100
- Vegetation zone 21: Moderate condition areas occur along Purgatory Creek and artificial drainage lines which are currently isolated from tidal flows due to the floodgates being installed at the confluence with the Hunter River, and these areas are dominated by exotic pasture with a low-moderate cover of Grey Mangrove. This zone has a benchmark score of 42.42.

Landscape features: This community occurs on saline muds within the tidal zone of estuaries.

Distribution: This community is restricted to two locations within the construction footprint including the banks of the Hunter River (**Photograph 28**) and Purgatory Creek (**Photograph 29**). This PCT is distributed along the entire length of the NSW coast.

Diagnostic features: This community is distinguished from other saline wetland communities (e.g. PCT 916 and 918) by the following:

- The dominance of *Avicennia marina* as an open forest formation. *Avicennia marina* is also described from PCT 916, however this PCT is known from intertidal flats and can contain up to four mangrove species. PCT 918 is known to contain *Aegiceras corniculatum*, however it is described as the dominant species
- PCT 916 and PCT 918 have a classification confidence level of very low, whereas PCT 1747 is high.

Threatened flora species: No threatened flora species were recorded in this community.

Photograph 29: Plot 25 showing vegetation zone 21, Grey Mangrove low closed forest (1747 – Moderate) on Purgatory Creek

3.3 Non-remnant vegetation

3.3.1 Planted native vegetation

Around 13 hectares of planted native vegetation occurs across the construction footprint, with most occurrence the result of roadside landscape plantings carried out as part of road construction. Planted native species composition vary from locally indigenous species such as *Eucalyptus tereticornis*, to non-indigenous natives such as *Eucalyptus microcorys*. Similarly, embankments along the M1 Pacific Motorway have a variety of native shrubs and grasses (**Photograph 32**), though other areas have been planted with ornamental species such as *Doryanthes excelsior*.

Along the New England Highway garden escapees are common, though native regeneration of species from adjacent remnant patches is also evident (**Photograph 30** and **Photograph 31**). Around the Anderson Drive exit off the New England Highway at Tarro, thick plantings of *Casuarina glauca* and *Callistemon* sp. line the edges of the road (**Photograph 33**). Often it was not possible to assign this vegetation to a PCT and as it has been planted for the purposes of slope stabilisation and visual aesthetics, this vegetation has been grouped together as a singular zone. These areas provide foraging and connectivity habitat for a range of mobile fauna species.

Photograph 30: Planted native vegetation at the New England Highway and John Renshaw Drive fly-over intersection at Beresfield.

Photograph 31: Planted native vegetation along the New England Highway at Beresfield

Photograph 32: Planted native vegetation along the M1 Pacific Motorway embankment at Black Hill.

Photograph 33: Planted native vegetation around the Anderson Drive exit off the New England Highway at Tarro.

3.3.2 Pine plantation

Pine plantations dominate a relatively large area of private land at Heatherbrae, and around 26 hectares intersect the construction footprint. These planted areas have a high density and dense canopy of *Pinus radiata* with thick leaf litter and support limited or no native midstorey and groundcover species (**Photograph 34**). Some areas of pine plantation support a low density of native plant regrowth in the understorey. Some areas of pine planation occur in areas of low elevation which are often inundated for extended periods (**Photograph 35**). Other common species recorded in pine plantations include *Lantana camara*, *Acacia leiocalyx* and *Pteridium esculentum*.

Some areas of pine forest contain a low diversity of native midstorey regrowth in edge areas. These species are most aligned with those that occur in PCT 1646. However, pine plantations were not assigned to a PCT or veg zone as they are areas planted for the purpose of harvesting.

Photograph 34: Pine plantation intact

Photograph 35: Pine plantation north of Masonite Road showing a flooded trail through pine plantation

3.3.3 Cleared land and exotic vegetation

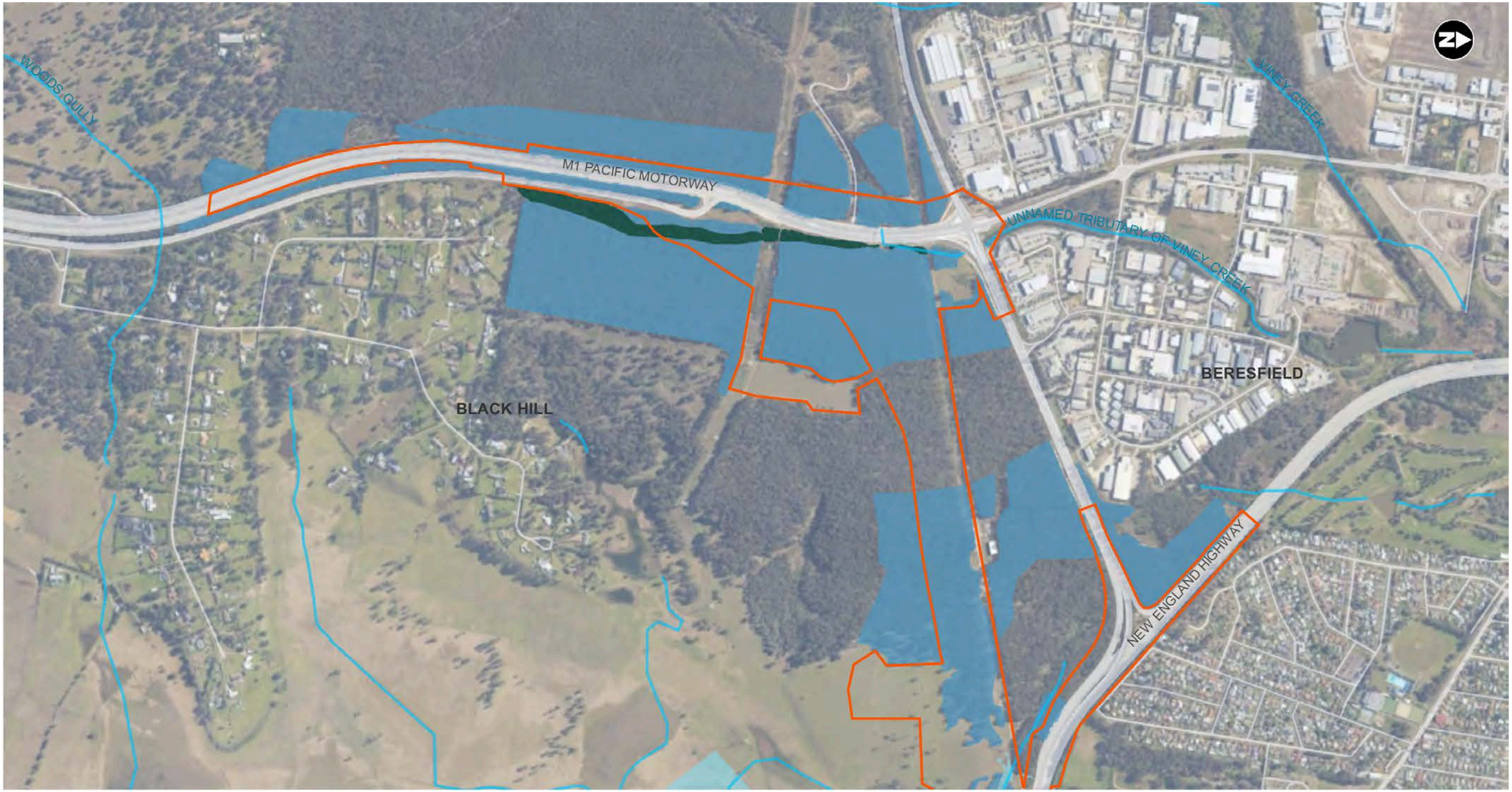
The construction footprint has a long history of change associated with farming and the gradual expansion of urban and industrial development. This has resulted in a mosaic of cleared land, weeds and exotic planted vegetation, with patches of remaining remnant vegetation. Cleared land accounts for about 56 per cent of land within the landscape buffer. Exotic vegetation is made up of planted species in gardens and along roadsides and spreading shrubby and scrambling weeds such as *Rubus fruticosus* agg. and *Lantana camara*. The presence of weeds within the construction footprint is discussed further in **Section 8.5.5**.

3.4 Threatened ecological communities

Eleven of the 14 PCTs identified during the field survey correspond with six TECs listed under the TSC Act. **Table 3-3** summarises the corresponding PCTs for each TEC and the area within the construction footprint**.** A description of each TEC is provided in the following sections. The location and distribution of TECs is shown in **Figure 3-2**.

Table 3-3 Threatened Ecological Communities (TSC Act) present within the construction footprint

Threatened ecological community	TSC Act Status	Corresponding PCT	Area within construction footprint (ha)
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregion	Endangered	1746	1.26
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	1742, 1071, 1736	68.18
Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions	Endangered	1598	0.45
Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions	Endangered	1590	41.88
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	1727	8.76
Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	1649, 1716, 1717, 1724	15.28
		Total	**136**



Construction footprint

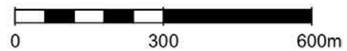
Waterways

TSC Act

Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions

Lower Hunter Spotted Gum - Ironbark Forest in the Sydney Basin Bioregion

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



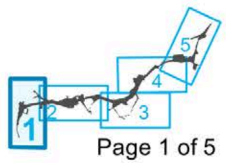
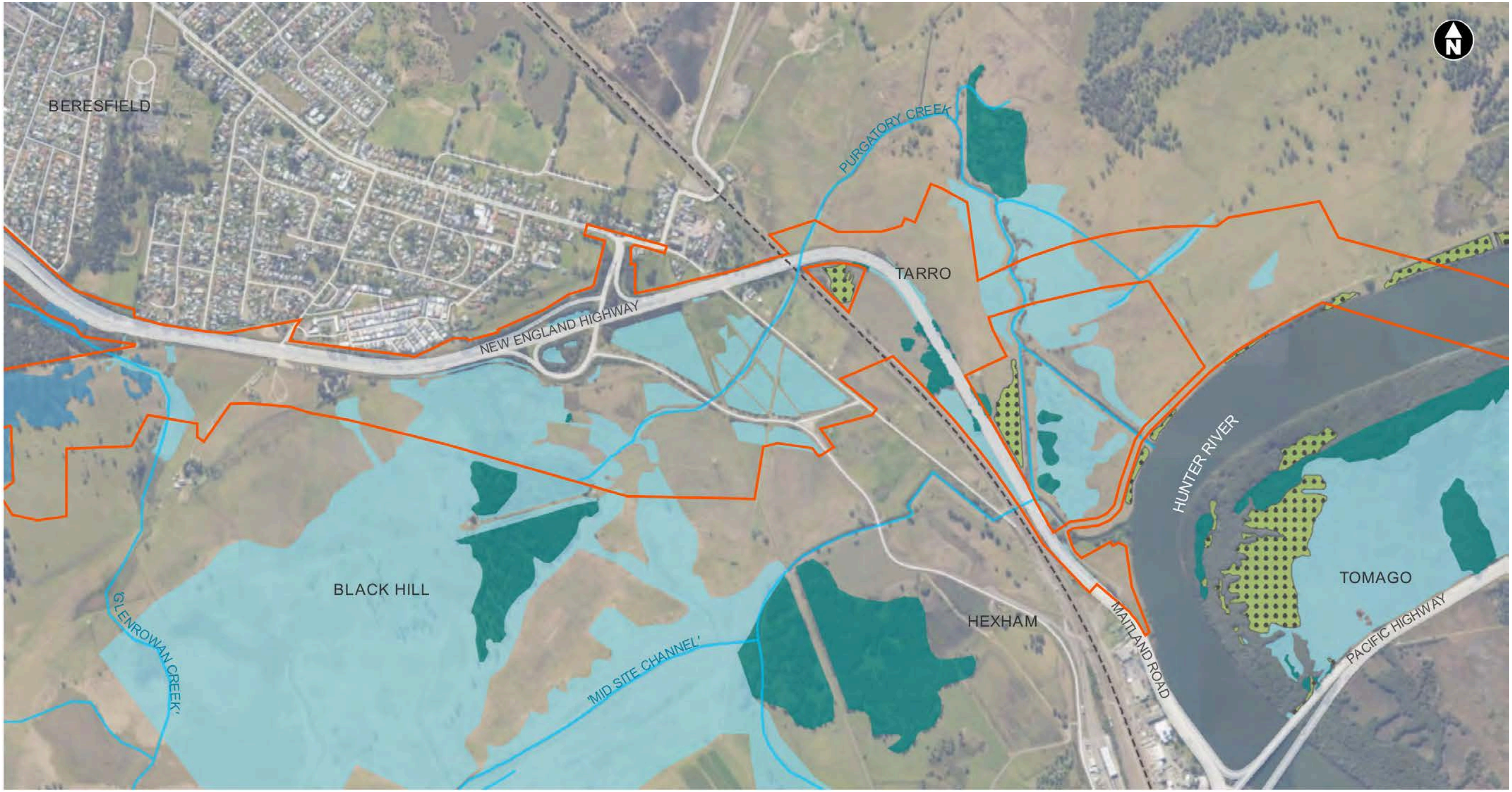


Figure 3-2 Threatened ecological communities (map 1 of 5)

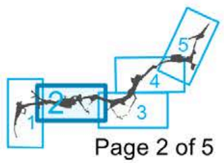


Construction footprint
Waterways
Main North Rail Line
EPBC Act
Subtropical and Temperate Coastal Saltmarsh

TSC Act
Coastal saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions
Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions
Lower Hunter Spotted Gum - Ironbark Forest in the Sydney Basin Bioregion

Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

0 300 600m



Page 2 of 5

Figure 3-2 Threatened ecological communities (map 2 of 5)

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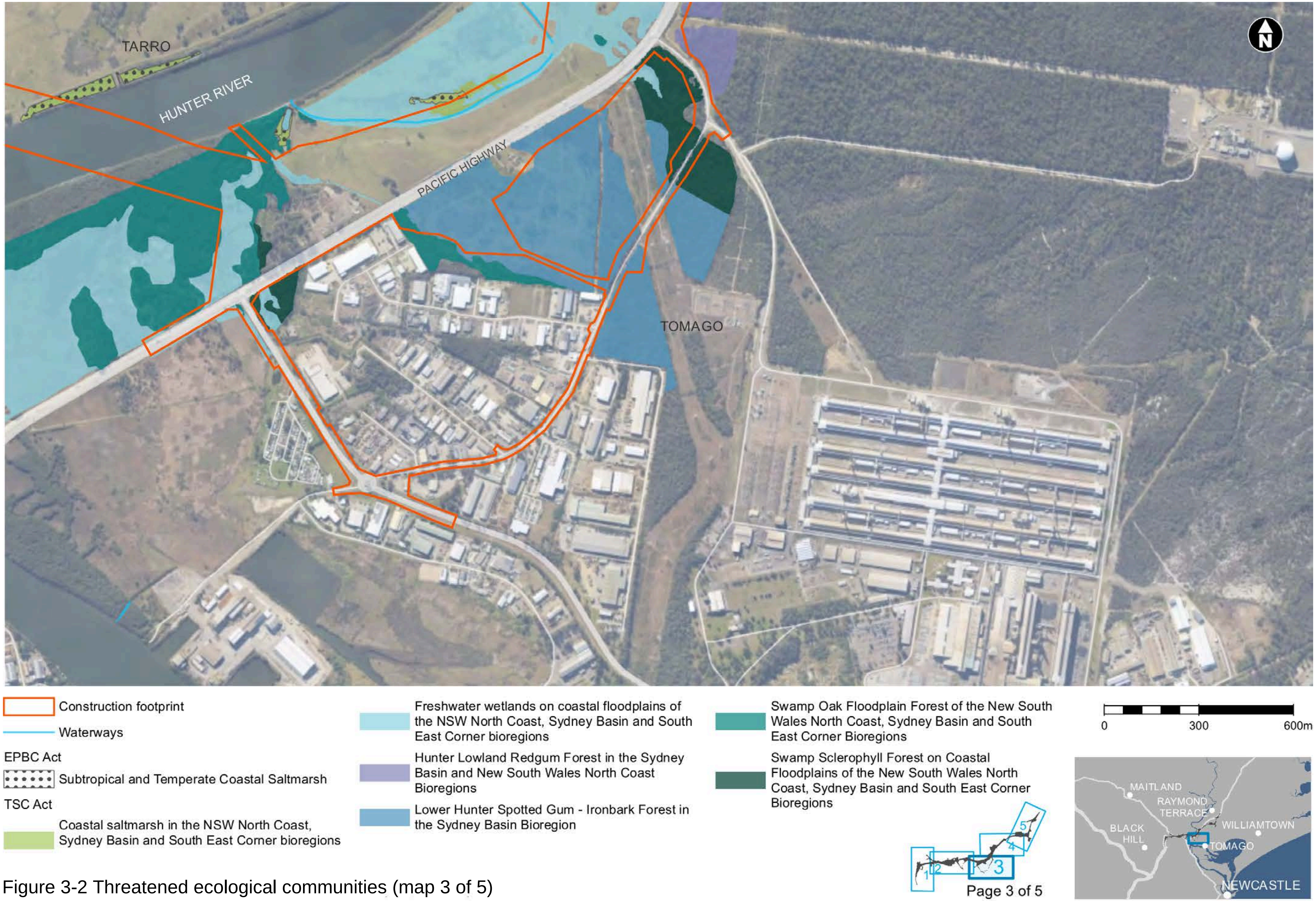

Figure 3-2 Threatened ecological communities (map 3 of 5)

Figure 3-2 Threatened ecological communities (map 4 of 5)

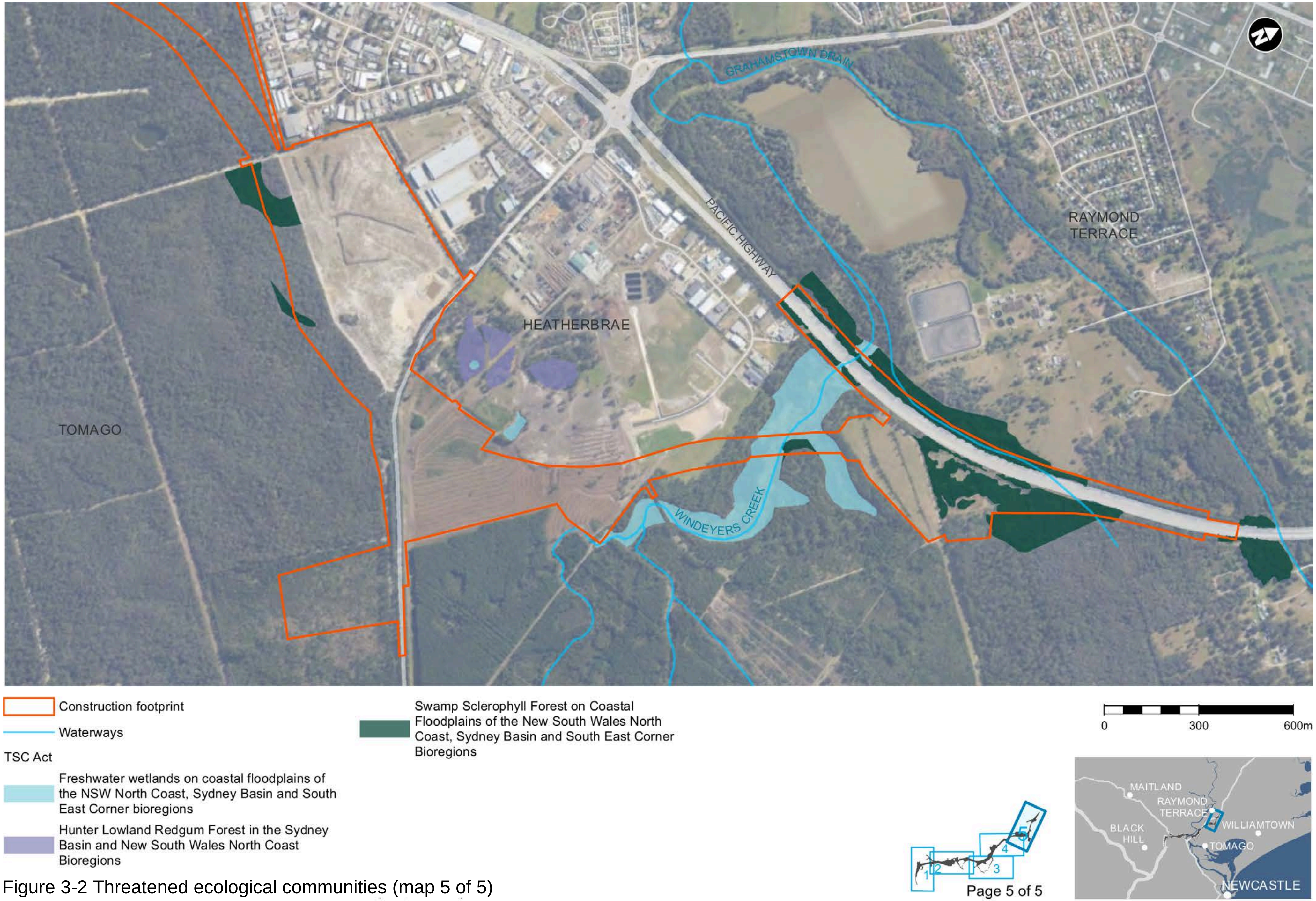

Figure 3-2 Threatened ecological communities (map 5 of 5)

3.4.1 Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregion

Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions is the name given to the ecological community occurring in the intertidal zone on the shores of estuaries and lagoons including when they are intermittently closed along the NSW coast. Coastal saltmarsh has been recorded from sites along the NSW coast (NSW North Coast, Sydney Basin and South East Corner Bioregions).

A detailed description of the Coastal Saltmarsh ecological community is provided by the NSW Scientific Committee (2004). Briefly, the community is characterised by grasslands, sedgelands and herbfields sometimes with isolated Mangrove trees. The vegetation structure and composition varying with elevation and the degree of tidal inundation (NSW Scientific Committee 2004). Common species recorded in the construction footprint comprise *Juncus kraussii, Triglochin striata* and *Sarcocornia quinqueflora.* PCT 1746 within the construction footprint fits this description well.

Patches of this community in the construction footprint are in a moderate to poor condition being subject to cattle grazing and modified hydrology. Importantly, the NSW Scientific Committee (2004) does not exclude patches of vegetation from the listing based on condition or structure thresholds. The community listing under the TSC Act includes poorer condition patches.

3.4.2 Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions is the name given to the ecological community associated with periodic or semi-permanent inundation by freshwater, although there may be minor saline influence in some wetlands. They typically occur on silts, muds or humic loams in depressions, flats, drainage lines, backswamps, lagoons and lakes associated with coastal floodplains (NSW Scientific Committee 2005a). A detailed description of the Freshwater Wetlands ecological community is provided by the NSW Scientific Committee (2005a). Briefly, the community is characterised by grasslands, sedgelands and herbfields sometimes with isolated trees. The vegetation structure and composition varies with elevation and the level of flooding and frequency of inundation.

Vegetation composition varies throughout the construction footprint with the ecological community occurring across three different PCTs including:

- 1071 *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion occurring in deeper sections of water being dominated by *Typha orientalis* and *Phragmites australis* including deeper drainage channels and the slightly saline habitats across most of the construction footprint
- 1736 Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter generally occurring on the outer fringes of wetland areas including Hexham Swamp Nature Reserve and on the Hunter River floodplain at Tomago
- 1742 Jointed Twig-rush sedgeland occurs on low elevated swampy drainage lines on sandy soils at Heatherbrae and is dominated by a range of wetland flora including *Baumea articulata*.

A detailed description of the Freshwater Wetlands ecological community is provided by the NSW Scientific Committee (2010). It states:

> *The composition and structure of the vegetation is also influenced by grazing history, changes to hydrology and soil salinity, catchment runoff and disturbance, and may have a substantial component of exotic grasses and forbs. Artificial wetlands created on previously*

dry land specifically for purposes such as sewerage treatment, stormwater management and farm production, are not regarded as part of this community, although they may provide habitat for threatened species.

Moderate condition examples of the ecological community occur in the construction footprint and much of these areas are open to cattle grazing, particularly PCT 1736, where there is varying cover of exotic pasture species and native wetland flora. Considering the location of these areas on the floodplain and the presence of wetland species, they meet the definition for Freshwater Wetland provided in the scientific determination.

Only one patch of PCT 1071 was excluded from listing as Freshwater Wetland as it occurred in a stormwater drain along the edge of the M1 Pacific Motorway that would likely have previously been woodland. Therefore, of the 7.71 hectares of PCT 1071 identified within the construction footprint, about 7.67 hectares meets the definition of the listing Freshwater Wetland TEC listing.

3.4.3 Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions

Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast Bioregions is the name given to the ecological community found on gentle slopes arising from depressions and drainage flats on Permian sediments of the Hunter Valley floor in the Sydney Basin and NSW North Coast Bioregions (NSW Scientific Committee 2011). A detailed description of the Hunter Lowland Redgum Forest ecological community is provided by the NSW Scientific Committee (2011). Briefly, the community is characterised by forests dominated by *Eucalyptus tereticornis* with a range of other associated canopy species including *Angophora floribunda*. The species composition of a site will be influenced by the size of the site, recent rainfall or drought condition and by its disturbance (including fire) history (NSW Scientific Committee 2011).

Much of this community in the construction footprint is in a moderate to poor condition and therefore the species composition has been largely modified and much of the original floristic composition is absent. This ecological community is associated with PCT 1598, which includes species composition consistent with the observations in the construction footprint including dominant canopy and mid-storey species such as *Eucalyptus tereticornis*, *Angophora floribunda* and *Breynia oblongifolia*.

3.4.4 Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions

Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin Bioregion and NSW North Coast Bioregions is the name given to the ecological community that occurs principally on Permian geology in the central to lower Hunter Valley (NSW Scientific Committee 2019). A detailed description of the Lower Hunter Spotted Gum – Ironbark Forest ecological community is provided by the NSW Scientific Committee (2019). Briefly, the community is characterised by forests dominated by *Corymbia maculata* and *Eucalyptus fibrosa* with a range of other associated canopy species.

Species presence and relative abundance (dominance) will vary from site to site as a function of environmental factors such as soil properties (chemical composition, texture, depth, drainage), topography, climate and through time as a function of disturbance (e.g. fire, logging, grazing) and weather (e.g. flooding, drought, extreme heat or cold) (NSW Scientific Committee 2019).

Good condition and poor condition remnants were recorded in the construction footprint as part of PCT 1590. This community also has close affinities particularly in the near-coastal environments of the construction footprint to another spotted gum ironbark community (PCT 1588) present in the construction footprint. These communities were delineated based on the floristic composition and landscape position with areas co-dominated by *Eucalyptus fibrosa* and a generally drier understorey on crests and upper slopes identified as being part of Lower Hunter Spotted Gum – Ironbark Forest (1590), and areas co-dominated by other ironbark species including *Eucalyptus siderophloia* and *Eucalyptus paniculata* as well as *Eucalyptus umbra* in gullies and lower slopes with a moister understorey often supporting moderate levels of *Lantana camara* identified as PCT 1588 and not being part of the ecological community.

3.4.5 Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions is the name given to the ecological community associated with grey-black clay-loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains (NSW Scientific Committee 2011). A detailed description of the Swamp Oak Floodplain Forest ecological community is provided by the NSW Scientific Committee (2011). Briefly, the community is characterised by forests dominated by *Casuarina glauca* occurring on saline sub-soils on coastal floodplains (NSW Scientific Committee 2011). This is consistent with PCT 1727 identified in the construction footprint.

Much of the habitat has been disturbed in the construction footprint and some areas represent regrowth following clearing and grazing, with younger trees, moderate levels of weed invasion and reduced floristic diversity. Areas of Swamp Oak regrowth/plantings (e.g. around the Anderson Drive / New England Highway intersection) on elevated and modified areas (i.e. not on floodplains) have been excluded from the mapping of Swamp Oak Floodplain Forest.

3.4.6 Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions is the name given to the ecological community associated with humic clay loams and sandy loams, on waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal floodplains (NSW Scientific Committee 2005b). A detailed description of the Swamp Oak Floodplain Forest ecological community is provided by the NSW Scientific Committee (2011). Briefly, the community is characterised by forests dominated by *Melaleuca quinquenervia*, *Eucalyptus robusta* and *Melaleuca linariifolia* occurring on coastal floodplains.

The species composition of a site will be influenced by the size of the site, recent rainfall or drought conditions and by its disturbance (including fire, grazing, flooding and land clearing) history (NSW Scientific Committee 2005b).

PCTs identified in the construction footprint that are consistent with this TEC, include PCT 1649, PCT 1716, PCT 1717, and PCT 1724. This community in the construction footprint includes good condition and moderate/poor condition examples. Good condition areas support a diversity of sedges and ferns in the understorey including *Gahnia clarkei*, *Baloskion tetraphyllum* and *Blechnum indicum* with an intact canopy and midstorey layer dominated by the diagnostic species listed above. Poor condition areas include a range of exotic flora in the understorey with a lower cover of diagnostic native species and a partially cleared canopy including some of the diagnostic species listed above as well as exotic species such as *Radiata Pine*.

3.5 Groundwater dependent ecosystems

This assessment uses the definition of a groundwater dependent ecosystem (GDE) as outlined by Serov et al. (2012), which is an “ecosystem which has its species composition and natural ecological processes wholly or partially determined by groundwater”.

The project overlaps with three groundwater systems divided by the Hunter River as designated by the Department of Planning, Industry and Environment (Water). Groundwater levels have been measured in these systems as part of the Hydrology and Flooding Woking Paper (Appendix J of the EIS):

- Hunter Alluvium system, comprising coastal alluvial floodplain along the Hunter River. Groundwater levels are typically shallow in these locations (between about 2.4 metres below ground level (mbgl) to - 0.2 mbgl)
- The Tomago Coal Measures, comprising porous rock to the north of the floodplain (between about 6.3 mbgl to 16.8 mgbl, and to -0.3 mbgl where it is confined beneath the Hunter Alluvium system)
- Tomago Sandbeds coastal sands to the east of the Hunter River (between about to 1.6 mbgl to 2.7 mgbl).

The level of groundwater dependence of vegetation communities in the construction footprint has been identified using the Atlas of Groundwater Dependent Ecosystems (GDE Atlas) (Bureau of Meteorology, 2020) and the Risk Assessment Guidelines for Groundwater Dependent Ecosystems released by the former NSW Department of Primary Industries (Kuginis et al., 2012). The mapping of GDEs provided by the GDE Atlas provides an indication whether a GDE may be present but the mapping is based on a coarse regional vegetation mapping dataset and does not accurately reflect on-ground conditions. Based on the PCTs identified in the construction footprint during field surveys and a review of Bell and Driscoll (2006), Kuginis et al. (2012) and the GDE Atlas, it is likely that some of the PCTs present in the construction footprint would have a degree of groundwater dependence (refer to **Table 3-4**), and include:

- Known aquatic GDEs:
  - Floodplain wetlands (Hexham Swamp Nature Reserve and surrounding wetlands, Hunter Wetlands National Park)
  - Hunter River.
- Potential terrestrial GDEs:
  - Coastal Floodplain Wetlands on the floodplain of the Hunter River (Tarro, Hexham and Tomago)
  - Mangrove Swamps on margins of the Hunter River
  - Coastal Dune Dry Sclerophyll Forests on the Tomago Sandbeds (Tomago and Heatherbrae)
  - Freshwater wetlands adjacent to the floodplain such as sedgeland plant communities.

The GDE Atlas identifies a number of aquatic GDEs, within the landscape buffer of the construction footprint, including the Hunter River, communities downstream of the construction footprint associated with the Hunter Wetlands National Park, Tarro Swamp and Woodberry Swamp to the north and a series of sand swamp communities associated with the Tomago Sandbeds (Deep Swamp and Sandhole Swamp).

The location of GDEs within the Hunter Central Rivers catchment management area is also mapped by Kuginis et al. (2012). These authors map high probability GDEs within or near the construction footprint, and these appear to be widespread associated with the Hunter River floodplain at Beresfield and Tarro and the western extent of the Tomago Sandbeds at Heatherbrae and Tomago.

The northern portion of the construction footprint, north of Tomago Road is within the western extent of the Tomago Sandbeds, a large groundwater aquifer on coastal sand and is protected as a drinking water supply under the *Hunter Water Act 1991*. The Tomago Sandbeds consist of an unconfined aquifer about 100 square kilometres in area and 18 metres deep on average (Hunter Water 2006). The water table is shallow and recharged mostly by rainfall with some infiltration through the base of Grahamstown Dam. A vegetation survey of the Tomago Sandbeds was carried out by Bell and Driscoll (2006) principally to identify GDEs. These authors indicate that all of the vegetation across the Tomago Sandbeds has some degree of groundwater dependence with 80 per cent of the area having a depth to water of three metres or less.

Based on the PCTs identified in the construction footprint during field surveys and a review of Bell and Driscoll (2006), Kuginis et al. (2012) and the GDE Atlas, the likely terrestrial GDEs present in the construction footprint are identified in **Table 3-4** and displayed by PCT in **Figure 3-1**. Based on the distribution of each PCT, a possible corresponding groundwater system has also been assigned.

Table 3-4 Potential terrestrial groundwater dependent ecosystems present within the construction footprint and possible corresponding groundwater system

PCT ID	Plant community type	Possible corresponding groundwater system	Area within construction footprint (ha)
1071	*Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion	Hunter Alluvium system	7.71
1590	Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest	Tomago Sandbeds (excluding Black Hill occurrence)	41.88
1598	Forest Red Gum grassy open forest on floodplains of the lower Hunter	Tomago Sandbeds	0.45
1646	Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast	Tomago Sandbeds	28.59
1649	Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands	Tomago Sandbeds	1.36
1716	Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast	Hunter Alluvium system (partly)	1.82
1717	Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast	Tomago Sandbeds	10.49
1724	Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast	Tomago Sandbeds	1.61
1727	Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast	Hunter Alluvium system (in part)	8.76
1736	Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter	Hunter Alluvium system (in part)	59.04
1742	Jointed Twig-rush sedgeland	Tomago Sandbeds	1.45
1746	Saltmarsh Estuarine Complex	Hunter Alluvium system	1.26
1747	Grey Mangrove low closed forest	Hunter Alluvium system	2.27
		Total	**166.70**

The PCTs identified in **Table 3-4** are not obligate GDEs (i.e. they are not entirely dependent on groundwater) and are likely to be opportunistic facultative GDEs that may depend on the subsurface presence of groundwater (often accessed via the capillary fringe – subsurface water just above the water table) in some locations but not in others. This capillary water may be accessed by the plants where an alternative source of water (i.e. rainfall) cannot be accessed during excessive dry periods to maintain ecological function.

As the plants within these PCTs may at times rely on capillary water in the soil that rises from the water table, any lowering of the water table may result in a reduction in groundwater availability and if this occurs during a period of low rainfall, may contribute to declining vegetation health over the short-term. However, if the groundwater table is shallow where the potential GDE occurs (such as within the Tomago Sandbeds where groundwater levels are as shallow as 0.2 mbgl), and there is no perched aquifer above the water table (separated from the water table by a layer of impermeable rock or sediment), then impacts on vegetation health may also occur over the short-term during construction.

Groundwater depth varies greatly across the construction footprint, however based on the depths detailed in the Hydrology and Flooding Working Paper (Appendix J and the EIS) and listed above, it is possible to identify the PCTs (as shown above in **Table 3-4**) that are likely to have the most dependence on groundwater, which are those located in low-lying areas in the Hunter River floodplain and Tomago Sandbeds. This is discussed further in **Section 8.5.1**.

4. Threatened species

This chapter documents the methods and results of an assessment of threatened species and habitats within the construction footprint.

4.1 Candidate species

The following section addresses the potential presence of threatened flora and fauna species as candidate species to be considered in the assessment of targeted surveys, impacts and offset calculations.

Candidate species are listed species that are identified by the FBA as ecosystem credit species, which are predicted to occur based on their known presence in the IBRA subregion, the presence of associated PCTs, and the size and condition of the vegetation patches on the site. The remaining candidate species and species credit species are those that cannot be reliably predicted from the habitat surrogates and their presence is to be assessed through habitat assessment and targeted surveys.

4.1.1 Background research

A default list of candidate species was first identified using the assessment filtering tool in the BBCC. Then using the following databases and literature sources, a review was conducted to identify possible additional candidate species:

- BioNet Atlas of NSW Wildlife
- BioNet Threatened Biodiversity Data Collection
- NSW Department of Primary Industries (DPI) Fisheries Spatial Data Portal
- The federal Department of Environment's Protected Matters Search Tool (PMST)
- Area of Outstanding Biodiversity Value register (Department of Planning, Industry and Environment)
- Port Stephens Council Comprehensive Koala Plan of Management (CKPoM) (Port Stephens Council and Australian Koala Foundation, 2002)
- Pacific Highway Upgrade: F3 to Raymond Terrace: Results of Targeted Surveys, Summer 2006 (Biosis Research, 2006)
- Tomago Transmission Line Species Impact Statement (Biosis Research, unknown date)
- Flora and Fauna Summary Report, F3 to Raymond Terrace: Results of Targeted Surveys, Summer 2006
- Newcastle Power Station Project Biodiversity Development Assessment Report (Kleinfelder 2019)
- Hunter Wetlands National Park: Plan of Management (NSW National Parks and Wildlife Service 2020)
- QR National – Train Support Facility, Hexham. Ecological Investigations (Eco Logical Australia 2012)
- Proposed Hexham Relief Roads Ecological Assessment (Parsons Brinckerhoff 2012)
- Ecological Monitoring Report – Long Term Train Support Facility (Eco Logical Australia 2015).

Additionally, the following spatial databases (using a 10 kilometre radius around the construction footprint) were also consulted:

- Lower Hunter Koala Study (Eco Logical Australia 2013) mapping of key habitat areas for the Koala in the lower Hunter
- Grey-headed Flying-fox management strategy for the Lower Hunter (GeoLink, 2013)
- Swift Parrots and Regent Honeyeaters in the Lower Hunter Region of New South Wales: An assessment of status identification of high priority habitats and recommendations for conservation (Birdlife Australia 2013).

4.1.2 Ecosystem credit species

The BBCC assessment tool identified 38 ecosystem credit species for consideration within the construction footprint. In assessing the likely presence of these species, the FBA allows an assessor to identify whether any of the habitat components for the predicted threatened species are present or not within the construction footprint.

The likelihood of occurrence for each species is discussed in **Table 4-1** and is based on the presence of habitat components and species included or excluded (grey shaded cells) accordingly. The assessment identified 25 of the 38 ecosystem credit species initially identified by the BBCC with a likelihood to occur within the construction footprint. The included species are subsequently assessed in conjunction with biodiversity values reported in **Chapter 6** and potential impacts in **Chapter 8**.

The criteria used to determine likelihood of occurrence was based on the following:

- **High**: highly likely that a species inhabits the construction footprint 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 (within 10 kilometres) and is known or likely to maintain resident populations in the construction footprint. Also includes species known or likely to visit the construction footprint during regular seasonal movements or migration
- **Moderate:** potential habitat is present in the construction footprint. Species unlikely to maintain sedentary populations, however, may seasonally use resources within the construction footprint 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 construction footprint, 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
- **Unlikely:** unlikely that the species inhabits the construction footprint and has not been recorded recently in the locality (within 10 kilometres) or within the last 20 years. It may be an occasional visitor, but habitat similar to the construction footprint is widely distributed in the local area, meaning that the species is not dependent (i.e. for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the construction footprint or the species are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.

Table 4-1 Ecosystem credit species based on IBRA subregion, PCT, patch size and condition (source BBCC)

Species	Habitat requirements	Likelihood of occurrence
Australian Painted Snipe *(Rostratula australis)*	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. Habitat within the construction footprint is too degraded for this species.	Moderate / included
Barking Owl (*Ninox connivens*)	Found throughout continental Australia except for the central arid regions. Inhabits woodland and open forest, including fragmented remnants and partly cleared farmland. It is flexible in its habitat use, and hunting can extend in to closed forest and more open areas. No records within proximity to the construction footprint.	Unlikely / excluded

Species	Habitat requirements	Likelihood of occurrence
Black-chinned Honeyeater (eastern subspecies) (*Melithreptus gularis* subsp. *gularis)*	Occupies mostly upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts, especially *Eucalyptus sideroxylon*, *E. albens*, *E. microcarpa*, *E. melliodora*, *E. blakelyi* and *E. tereticornis*. Also inhabits open forests of smooth-barked gums, stringybarks, ironbarks, river sheoaks (nesting habitat) and tea-trees.	Moderate / included
Black-tailed Godwit (*Limosa limosa)*	In NSW, it is most frequently found at Kooragang Island (Hunter River estuary). Occurs in sheltered bays, estuaries and lagoons with large intertidal mudflats and sand flats. Also found at inland mudflats, swamps. Habitats within the construction footprint not suitable	Unlikely / excluded
Blue-billed Duck (*Oxyura australis*)	Prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation. The species is completely aquatic, swimming low in the water along the edge of dense cover. Usually nest solitarily in Cumbungi over deep water between September and February. They will also nest in trampled vegetation in Lignum, sedges or Spike-rushes, where a bowl-shaped nest is constructed. Habitat within the construction footprint not suitable	Unlikely / excluded
Brown Treecreeper (eastern subspecies) (*Climacteris picumnus* subsp. *Victoriae)*	Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and *Eucalyptus camaldulensis* forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains.	Moderate / included
Bush Stone-curlew (*Burhinus grallarius*)	Open forests and woodlands with a sparse grassy ground layer and fallen timber. Largely nocturnal, being especially active on moonlit nights. Feed on insects and small vertebrates, such as frogs, lizards and snakes. Nest on the ground in a scrape or small bare patch. No records within 20 years in proximity to the construction footprint and too degraded.	Unlikely / excluded
Corben's Long-eared Bat (*Nyctophilus corbeni)*	Inhabits a variety of vegetation types, including mallee, *Allocasuarina luehmannii* and box eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. Roosts in tree hollows, crevices, and under loose bark.	Moderate / included
Diamond Firetail (*Stagonopleura guttata*)	Found in grassy eucalypt woodlands, including Box-Gum Woodlands and *Eucalyptus pauciflora* woodlands. Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities. Often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland.	Moderate / included
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*	Prefers moist habitats, with trees taller than 20m. Generally, roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings.	Moderate / included
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roosts mainly in tree hollows but will also roost under bark or in human-made structures.	Moderate / included

Species	Habitat requirements	Likelihood of occurrence
Eastern Grass Owl (*Tyto longimembris)*	Eastern Grass Owls have been recorded occasionally in all mainland states of Australia but are most common in northern and north-eastern Australia. In NSW they are more likely to be resident in the north-east. Eastern Grass Owls are found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains. Habitat not suitable within the construction footprint	Unlikely / excluded
Freckled Duck (*Stictonetta naevosa*)	Prefer permanent freshwater swamps and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds. Habitat too degraded within the construction footprint	Unlikely / excluded
Gang-gang Cockatoo (*Callocephalon fimbriatum*)	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. Also occur in subalpine *Eucalyptus pauciflora* woodland and occasionally in temperate or regenerating forest. In winter, occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box ironbark assemblages, or in dry forest in coastal areas. It requires tree hollows in which to breed. No records in proximity to the construction footprint, habitat not suitable	Unlikely / excluded
Glossy Black-Cockatoo (*Calyptorhynchus lathami*)	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. Also occur in subalpine *Eucalyptus pauciflora* woodland and occasionally in temperate or regenerating forest. In winter, occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box ironbark assemblages, or in dry forest in coastal areas. It requires tree hollows in which to breed.	Moderate / included
Great Knot (*Calidris tenuirostris*)	Occurs within sheltered, coastal habitats containing large, intertidal mudflats or sand flats, including inlets, bays, harbours, estuaries and lagoons. Often recorded on sandy beaches with mudflats nearby, sandy spits and islets and sometimes on exposed reefs or rock platforms. Habitat not suitable within the construction footprint	Unlikely / excluded
Greater Broad-nosed Bat (*Scoteanax rueppellii)*	Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Although this species usually roosts in tree hollows, it has also been found in buildings.	Moderate / included
Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis* subsp. *temporalis)*	In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Balranald. It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW. Inhabits open Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands on alluvial plains.	High / included
Hooded Robin (south-eastern form) (*Melanodryas cucullata* subsp. *cucullata)*	The Hooded Robin is widespread, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania. However, it is common in few places, and rarely found on the coast. Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses.	Moderate / included
Little Eagle (*Hieraaetus morphnoides*)	The Little Eagle is found throughout the Australian mainland excepting the most densely forested parts of the Dividing Range escarpment. It occurs as a single population throughout NSW. Occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used.	Moderate / included

Species	Habitat requirements	Likelihood of occurrence
Little Lorikeet (*Glossopsitta pusilla*)	Forages primarily in the canopy of open *Eucalyptus* forest and woodland, yet also finds food in *Angophora* sp., *Melaleuca* sp. and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity. Isolated flowering trees in open country (e.g. paddocks, roadside remnants) and urban trees also help sustain viable populations of the species.	High / included
Magpie Goose (*Anseranas semipalmata*)	Mainly found in shallow wetlands (less than 1 metre deep) with dense growth of rushes or sedges. Equally at home in aquatic or terrestrial habitats; often seen walking and grazing on land; feeds on grasses, bulbs and rhizomes. Activities are centred on wetlands, mainly those on floodplains of rivers and large shallow wetlands formed by run-off; breeding can occur in both summer and winter dominated rainfall areas and is strongly influenced by water level; most breeding now occurs in monsoonal areas; nests are formed in trees over deep water; breeding is unlikely in south-eastern NSW. No records within proximity to the construction footprint, and habitat to degraded	Unlikely / excluded
Masked Owl (*Tyto novaehollandiae*)	Extends from the coast where it is most abundant to the western plains. Overall records for this species fall within about 90% of NSW, excluding the most arid north-western corner. There is no seasonal variation in its distribution. Dry eucalypt forests and woodland typically prefers open forest with low shrub density. Requires old trees for roosting and nesting. Recent records from the construction footprint and land to the west of the M1 Pacific Motorway	High / included
Painted Honeyeater (*Grantiella picta)*	Inhabits Boree/*Acacia pendula*, *A. harpophylla* and Box-Gum Woodlands and Box-Ironbark Forests. A specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Prefers mistletoes of the genus Amyema. No records within 20 years from the construction footprint and habitat not suitable	Unlikely / excluded
Powerful Owl (*Ninox strenua)*	In NSW, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered records on the western slopes and plains suggesting occupancy prior to land clearing. The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as *Syncarpia glomulifera*, *Allocasuarina littoralis*, *Acacia melanoxylon*, *Angophora floribunda*, *Exocarpus cupressiformis* and a number of eucalypt species. Recent records to the west of the M1 Pacific Motorway at Black Hill	Moderate / included
Scarlet Robin (*Petroica boodang*)	The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs. This species lives in both mature and re-growth vegetation. It occasionally occurs in mallee or wet forest communities, or in wetlands and tea-tree swamps.	Moderate / included
Sooty Owl (*Tyto tenebricosa*)	Occupies the easternmost one-eighth of NSW, occurring on the coast, coastal escarpment and eastern tablelands. Territories are occupied permanently. Occurs in rainforest, including dry rainforest, subtropical and warm temperate rainforest, as well as moist eucalypt forests. Habitat not suitable.	Unlikely / excluded

Species	Habitat requirements	Likelihood of occurrence
Speckled Warbler (*Chthonicola sagittata*)	The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt re-growth and an open canopy. Large, relatively undisturbed remnants are required for the species to persist in an area.	Moderate/ included
Spotted Harrier (*Circus assimilis)*	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Occurs in grassy open woodland including Acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands.	Moderate / included
Spotted-tailed Quoll (*Dasyurus maculatus)*	Wet and dry sclerophyll forests and rainforests, and adjacent open agricultural areas. Generally associated with large expansive areas of habitat to sustain territory size. Requires hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites. Reported from the Tomago Sandbeds	High / included
Square-tailed Kite (*Lophoictinia isura)*	Typically inhabits coastal forested and wooded lands of tropical and temperate Australia. In NSW it is often associated with ridge and gully forests dominated by *Eucalyptus longifolia*, *Corymbia maculata*, *E. elata*, or *E. smithii*. Individuals appear to occupy large hunting ranges of more than 100km^2. They require large living trees for breeding, particularly near water with surrounding woodland /forest close by for foraging habitat. Nest sites are generally located along or near watercourses, in a tree fork or on large horizontal limbs.	Moderate / included
Squirrel Glider (*Petaurus norfolcensis*)	Inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas. Prefers mixed species stands with a shrub or Acacia midstorey.	High / included
Swift Parrot (*Lathamus discolour*)	On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as Swamp Mahogany, Spotted Gum, Red Bloodwood, Red Ironbark, and White Box.	Moderate / included
Turquoise Parrot (*Neophema pulchella*)	Range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland. Habitat not suitable within the construction footprint	Unlikely / excluded
Varied Sittella (*Daphoenositta chrysoptera*)	The Varied Sittella is sedentary and inhabits most of mainland Australia except the treeless deserts and open grasslands. 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.	High / included
White-fronted Chat (*Epthianura albifrons*)	In NSW, it occurs mostly in the southern half of the state, in damp open habitats along the coast, and near waterways in the western part of the state. Along the coastline, it is found predominantly in saltmarsh vegetation but also in open grasslands and sometimes in low shrubs bordering wetland areas. Gregarious species usually found foraging on bare or grassy ground in wetland areas, singly or in pairs. Nests in the Sydney region have also been seen in low isolated mangroves.	Moderate / included

Species	Habitat requirements	Likelihood of occurrence
Yellow-bellied Glider (*Petaurus australis)*	Occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary with latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Feed primarily on plant and insect exudates, including nectar, sap, honeydew and manna with pollen and insects providing protein. Extract sap by incising (or biting into) the trunks and branches of favoured food trees, often leaving a distinctive 'V'-shaped scar. Habitat not suitable within the construction footprint	Unlikely / excluded
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris)*	Wide-ranging species found across northern and eastern Australia. Roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows.	Moderate / included

4.1.3 Species credit species

The list of species credit species targeted for detailed assessment has been identified in the BBCC. In assessing the potential presence of candidate species, the BBCC identifies important geographic / habitat features for some species. If these features are absent from the construction footprint, the species may be excluded from assessment. **Table 4-2** provides an assessment of habitat in the construction footprint for species listed in the BBCC that have geographic or habitat constraints. Species credit species that were identified as not requiring further consideration on the basis that important habitat features are absent from the construction footprint are identified by grey shaded cells.

Table 4-2 Assessment of potential candidate species credit species with geographic and habitat constraints

Species	Scientific name	Question: Do any of the following features occur on the area to be assessed?	Assessment
Flora			
Red Helmet Orchid	*Corybas dowlingii*	Sheltered areas such as gullies and southerly slopes in tall open forest on well drained gravelly soil at elevations of 10m - 200m	Yes
Eucalyptus parramattensis subsp. *decadens*	*Eucalyptus parramattensis subsp. decadens*	Land within northern section of sub-region, associated with poorly drained sand deposits within 10km radius	Yes
Maundia triglochinoides	*Maundia triglochinoides*	Swamps or shallow fresh water on clay	Yes
Biconvex Paperbark	*Melaleuca biconvexa*	Swamps, swamp margins or creek edges	Yes
Heath Wrinklewort	*Rutidosis heterogama*	Heath on sandy soils, or moist areas in open forest	Yes
Zannichellia palustris	*Zannichellia palustris*	Land containing freshwater bodies	Yes
Birds			
Australasian Bittern	*Botaurus poiciloptilus*	land east of Cessnock in Hunter CMA subregion	Yes
Greater Sandplover	*Charadrius leschenaultii*	Intertidal mudflats or sandflats within inlet, bays, harbours, estuaries, lagoons or ocean beaches or sandy spits	No

Species	Scientific name	Question: Do any of the following features occur on the area to be assessed?	Assessment
Lesser Sand-plover	*Charadrius mongolus*	Intertidal mudflats or sandflats within inlets, bays, harbours, estuaries, lagoons or ocean beaches or sandy spits	No
Black-necked Stork	*Ephippiorhynchus asiaticus*	Land within 40m of freshwater or saline wetlands (e.g. saltmarsh, mangroves, mudflats, swamps, billabongs, floodplains, watercourse pools, wet heathland and/or farm dams)	Yes
Pied Oystercatcher	*Haematopus longirostris*	Land within 40m of high-water mark on beaches, sandbars, margins of estuaries	No
Comb-crested Jacana	*Irediparra gallinacea*	Land within 40m of permanent wetlands with a good surface cover of floating vegetation	Yes
Black Bittern	*Ixobrychus flavicollis*	Land within 40m of freshwater and estuarine wetlands, in areas of permanent water and dense vegetation or emergent aquatic vegetation	Yes
Broad-billed Sandpiper	*Limicola falcinellus*	Intertidal mudflats or sandflats within inlets, bays, harbours, estuaries, lagoons, ocean beaches and/or sandy spits	No
Eastern Osprey	*Pandion cristatus*	Land within 40m of fresh/brackish/saline waters of larger rivers or creeks; estuaries, coastal lagoons, lakes and/or inshore marine waters	Yes
Little Tern	*Sternula albifrons*	Land within 40m of inshore coastal waters or shallow waters of estuaries, coastal lagoons and/or lakes	No
Terek Sandpiper	*Xenus cinereus*	Mangroves and intertidal mudflats or sandflats within inlets, bays, harbours, estuaries, lagoons, ocean beaches and/or sandy spits	Yes
Mammals			
Large-eared Pied Bat	*Chalinolobus dwyeri*	Land containing escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels	No
Brush-tailed Rock Wallaby	*Petrogale penicillata*	Land within 1km of rock outcrops or cliff lines	No
Common Planigale	*Planigale maculata*	Rainforest, eucalypt forest, heathland, marshland, grassland or rocky areas	Yes
Amphibians			
Wallum Froglet	*Crinia tinnula*	Land within 40m of swamps, wet or dry heaths or sedge grasslands	Yes
Green and Golden Bell Frog	*Litoria aurea*	Land within 100m of emergent aquatic or riparian vegetation.	Yes
Green-thighed Frog	*Litoria brevipalmata*	Land within 100m of semi-permanent or ephemeral ponds or depressions containing leaf litter	Yes
Reptiles			
Pale-headed Snake	*Hoplocephalus bitorquatus*	Land within 40m of watercourses, containing hollow-bearing trees, loose bark and/or fallen timber	Yes

Based on the absence of geographic / habitat features (outlined in **Table 4-2**), seven threatened fauna species were filtered out of the assessment. The remaining six threatened flora and 11 threatened fauna species were identified for further assessment as target species (these are listed in **Table 4-3** along with additional species that have no habitat / geographic constraint). The FBA allows the assessor to review and refine the list of candidate species via a second filtering step whereby a candidate species is considered absent from the development site where it can be demonstrated that:

- The habitat is substantially degraded for that species
- An expert report states that the species is unlikely to be present
- The species is a vagrant and is unlikely to use habitat on the development site
- Records of the species are at least 20 years old or have doubtful authenticity.

The candidate species listed above as matching geographic and habitat features were assessed further with the addition of all subject species identified in the BBCC survey list considering these criteria (refer **Table 4-3** for results). This assessment resulted in further filtering out of eight threatened flora species and two threatened fauna species on the basis of poor habitat and records greater than 20 years old for the construction footprint (refer **Table 4-3** and grey shading).

Table 4-3 List of candidate species credit species and second filtering step

Species	Scientific name	Habitat requirements	Likelihood of occurrence
Flora			
Trailing Woodruff	*Asperula asthenes*	This small herb occurs only in NSW. It is found in scattered locations from Bulahdelah north to near Kempsey, with several records from the Port Stephens/Wallis Lakes area. Occurs in damp sites, often along river banks.	Moderate / included
Nettled Bottle Brush	*Callistemon linearifolius*	Recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. Grows in dry sclerophyll forest on the coast and adjacent ranges.	High / included
Red Helmet Orchid	*Corybas dowlingii*	*Corybas dowlingii* is restricted to the central coast and Hunter regions of New South Wales where it is currently known from the Port Stephens, Bulahdelah, Lake Macquarie and Freemans Waterhole areas. Sheltered areas such as gullies and southerly slopes in tall open forest on well-drained gravelly soil at elevations of 10-200 metres.	Moderate / included
Leafless Tongue Orchid	*Cryptostylis hunteriana*	*Cryptostylis hunteriana* has been reported to occur in a wide variety of habitats including heathlands, heathy woodlands, sedgelands, *Xanthorrhoea* sp. plains, dry sclerophyll forests (shrub/grass sub-formation and shrubby sub-formation), forested wetlands, freshwater wetlands, grasslands, grassy woodlands, rainforests and wet sclerophyll forests (grassy sub-formation).	Moderate / included
White-flowered Wax Plant	*Cynanchum elegans*	The White-flowered Wax Plant usually occurs on the edge of dry rainforest vegetation. Other associated vegetation types include littoral rainforest; Coastal Tea-tree – Coastal Banksia coastal scrub; Forest Red Gum aligned open forest and woodland; Spotted Gum aligned open forest and woodland; and Bracelet Honeymyrtle scrub to open scrub.	Moderate / included
Small snake orchid	*Diuris pedunculata*	Confined to north east NSW. The Small Snake Orchid grows on grassy slopes or flats. Often on peaty soils in moist areas. Also, on shale and trap soils, on fine granite, and among boulders.	Moderate / included

Species	Scientific name	Habitat requirements	Likelihood of occurrence
Rough Doubletail	*Diuris praecox*	Known from between Bateau Bay and Smiths Lake. Grows on hills and slopes of near-coastal districts in open forests which have a grassy to fairly dense understorey. Exists as subterranean tubers most of the year. It produces leaves and flowering stems in winter.	Moderate / included
Camfield's Stringybark	*Eucalyptus camfieldii*	Restricted distribution in a narrow band with the most northerly records in the Raymond Terrace area south to Waterfall. Poor coastal country in shallow sandy soils overlying Hawkesbury sandstone. Coastal heath mostly on exposed sandy ridges. Occurs mostly in small scattered stands near the boundary of tall coastal heaths and low open woodland of the slightly more fertile inland areas. Associated species frequently include stunted specimens of *E. oblonga* (Narrow-leaved Stringybark), *E. capitellata* (Brown Stringybark) and *E. haemastoma* (Scribbly Gum).	Moderate / included
Slaty Red Gum	*Eucalyptus glaucina*	Found only on the north coast of NSW and in separate districts: near Casino where it can be locally common and farther south, from Taree to Broke, west of Maitland. Grows in grassy woodland and dry eucalypt forest. Grows on deep, moderately fertile and well-watered soils.	Unlikely / excluded
Eucalyptus parramattensis subsp. *decadens*	*Eucalyptus parramattensis* subsp. *decadens*	The Tomago Sandbeds meta-population is bounded by Salt Ash and Tanilba Bay in the north and Williamtown and Tomago in the south. Generally, occupies deep, low-nutrient sands, often those subject to periodic inundation or where water tables are relatively high. It occurs in dry sclerophyll woodland with dry heath understorey. It also occurs as an emergent in dry or wet heathland. Often where this species occurs, it is a community dominant. In the Tomago Sandbeds area, the species is usually associated with the 'Tomago Swamp Woodland' as defined by NSW NPWS (2000).	High / included
Small-flower Grevillea	*Grevillea parviflora* subsp. *parviflora*	*Grevillea parviflora* subsp. *parviflora* occurs sporadically throughout the Sydney Basin. It occurs on ridge crests, upper slopes or flat plains in both low-lying areas between 30–65 metres above sea level and on higher topography between 200–300 metres above sea level south of Sydney. It occurs in sandy or light clay soils, usually over thin shales often with lateritic ironstone gravels which are often infertile and poorly drained.	High / included
Maundia triglochinoides	*Maundia triglochinoides*	Grows in swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients. Flowering occurs during warmer months. Associated with wetland species e.g. *Cycnogeton procerum*.	High / included
Biconvex Paperbark	*Melaleuca biconvexa*	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.	Unlikely / excluded
Groves Paperbark	*Melaleuca groveana*	Grove's Paperbark grows in heath and shrubland, often in exposed sites, in low coastal hills, escarpment ranges and tablelands on outcropping granite, rhyolite and sandstone on rocky outcrops and cliffs. It also occurs in dry shrubby open forest and woodlands.	Unlikely / excluded

Species	Scientific name	Habitat requirements	Likelihood of occurrence
Ozothamnus tesselatus	*Ozothamnus tesselatus*	Restricted to a few locations in an east-west zone south of Bunnan and between west Bylong and east Ravensworth. Grows in eucalypt woodland.	Unlikely / excluded
Tall Knotweed	*Persicaria elatior*	In northern NSW Tall Knotweed is known from Raymond Terrace (near Newcastle) and the Grafton area (Cherry Tree and Gibberagee State Forests). This species normally grows in damp places, especially beside streams and lakes. Occasionally in swamp forest or associated with disturbance.	Moderate / included
North Rothbury Persoonia	*Persoonia pauciflora*	Extremely restricted distribution; all but one of the plants which make up the only known population occur within a 2.5 kilometres radius of the original specimen at North Rothbury in the Cessnock local government area. It is found in dry open forest or woodland dominated by Spotted Gum, Broad-leaved Ironbark and/or Narrow-leaved Ironbark and supporting a moderate to sparse shrub layer and grassy groundcover. The majority of the population is known to occur on silty sandstone soils derived from the Farley Formation.	Unlikely / excluded
Singleton Mint Bush	*Prostanthera cineolifera*	Restricted to only a few localities near Walcha, Scone, Cessnock and St Albans. Grows in open woodlands on exposed sandstone ridges. Usually found in association with shallow or skeletal sands.	Unlikely / excluded
Heath Wrinklewort	*Rutidosis heterogama*	On the Central Coast it is located north from Wyong to Newcastle. Grows in heath on sandy soils and moist areas in open forest, and has been recorded along disturbed roadsides	Moderate / included
Black-eyed Susan	*Tetratheca juncea*	It is usually found in low open forest/woodland with a mixed shrub understorey and grassy groundcover. However, it has also been recorded in heathland and moist forest. The majority of populations occur on low nutrient soils associated with the Awaba Soil Landscape. While the species has a preference for cooler southerly aspects, it has been found on slopes with a variety of aspects. It generally prefers well-drained sites and occurs on ridges, although it has also been found on upper slopes, mid-slopes and occasionally in gullies.	Unlikely / excluded
Zannichellia palustris	*Zannichellia palustris*	A submerged aquatic plant. In NSW, known from the lower Hunter and in Sydney Olympic Park. Grows in fresh or slightly saline stationary or slowly flowing water. Flowers during warmer months. NSW populations behave as annuals, dying back completely every summer.	Unlikely / excluded
Fauna			
Regent Honeyeater	*Anthochaera phrygia*	Temperate woodlands and open forests of the inland slopes of south-east Australia. The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters usually nest in horizontal branches or forks in tall mature eucalypts and Sheoaks.	Moderate / included
Australasian Bittern	*Botaurus poiciloptilus*	Australasian Bitterns are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly *Typha* sp. and *Eleocharis* sp.	Moderate / included

Species	Scientific name	Habitat requirements	Likelihood of occurrence
Eastern Pygmy Possum	*Cercartetus nanus*	Found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest.	Moderate / included
Wallum Froglet	*Crinia tinnula*	Wallum Froglets are found in a wide range of habitats, usually associated with acidic swamps on coastal sand plains. They typically occur in sedgelands and wet heathlands. They can also be found along drainage lines within other vegetation communities and disturbed areas, and occasionally in swamp sclerophyll forests.	High / included
Emu population, NSW North Coast Bioregion and Port Stephens Council LGA	*Dromaius novaehollandiae*	Generally absent from densely settled regions and largely absent from south-eastern coastal and subcoastal regions. The species was formerly widespread in north-eastern NSW but is now restricted to coastal and near-coastal areas between Evans Head and Red Rock and a potential small isolated population further west in the Bungawalbin area. There are no recent (confirmed records) of an extant population in the construction footprint.	Unlikely / excluded
Black-necked Stork	*Ephippiorhynchus asiaticus*	In NSW, the species becomes increasingly uncommon south of the Clarence Valley, and rarely occurs south of Sydney. Since 1995, breeding has been recorded as far south as Bulahdelah. Floodplain wetlands (swamps, billabongs, watercourses and dams) of the major coastal rivers are the key habitat in NSW for the Black-necked Stork. Secondary habitat includes minor floodplains, coastal sandplain wetlands and estuaries.	Moderate / included
Pale-headed Snake	*Hoplocephalus bitorquatus*	A patchy distribution from north-east Queensland to the north-eastern quarter of NSW. In NSW it has historically been recorded from as far west as Mungindi and Quambone on the Darling Riverine Plains, across the north west slopes, and from the north coast from Queensland to Sydney. The Pale-headed Snake is a highly cryptic species that can spend weeks at a time hidden in tree hollows. Found mainly in dry eucalypt forests and woodlands, cypress forest and occasionally in rainforest or moist eucalypt forest.	Moderate / included
Black Bittern	*Ixobrychus flavicollis*	In NSW, records of the species are scattered along the east coast, with individuals rarely being recorded south of Sydney or inland. Inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, the species may occur in flooded grassland, forest, woodland, rainforest and mangroves.	Moderate / included
Green and Golden Bell Frog	*Litoria aurea*	Since 1990 there have been about 50 recorded locations in NSW, most of which are small, coastal, or near coastal populations. These locations occur over the species' former range; however, they are widely separated and isolated. A large important population of this species is located on Kooragang Island. Ephemeral and permanent freshwater wetlands, ponds, dams with an open aspect and fringed by Typha and other aquatics, free from predatory fish.	Moderate / included

Species	Scientific name	Habitat requirements	Likelihood of occurrence
Green-thighed Frog	*Litoria brevipalmata*	Isolated localities along the coast and ranges from just north of Wollongong to south-east Queensland. Green-thighed Frogs occur in a range of habitats from rainforest and moist eucalypt forest to dry eucalypt forest and heath, typically in areas where surface water gathers after rain. It prefers wetter forests in the south of its range but extends into drier forests in northern NSW and southern Queensland.	Moderate / included
Eastern Osprey	*Pandion cristatus*	The Osprey has a global distribution with four subspecies previously recognised throughout its range. Favour coastal areas, especially the mouths of large rivers, lagoons and lakes. Feed on fish over clear, open water.	Moderate / included
Brush-tailed Phascogale	*Phascogale tapoatafa*	Patchy distribution around the coast of Australia. Prefer dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter. Also inhabit heath, swamps, rainforest and wet sclerophyll forest.	Moderate / included
Koala	*Phascolarctos cinereus*	In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. Inhabit eucalypt woodlands and forests. Feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species. Populations are known from Port Stephens Council LGA included the construction footprint.	Moderate / included
Common Planigale	*Planigale maculata*	Coastal north-eastern NSW, coastal east Queensland and Arnhem Land. The species reaches its confirmed southern distribution limit on the NSW lower north coast however there are reports of its occurrence as far south as the central NSW coast west of Sydney. Common Planigales inhabit rainforest, eucalypt forest, heathland, marshland, grassland and rocky areas where there is surface cover, and usually close to water.	Moderate / included
Terek Sandpiper	*Xenus cinereus*	The two main sites for the species in NSW are the Richmond River estuary and the Hunter River estuary. The latter has been identified as nationally and internationally important for the species. In Australia, has been recorded on coastal mudflats, lagoons, creeks and estuaries. Favours mud banks and sandbanks located near mangroves but may also be observed on rocky pools and reefs, and occasionally up to 10 kilometres inland around brackish pools.	Unlikely / excluded

The assessment above identifies the list of potential candidate species credits from the BBCC. Before finalising this list, additional species not listed in the BBCC that are considered to potentially occur are identified in **Section 4.1.4**.

4.1.4 Additional candidate species

A number of additional species credit species were not identified in the BBCC, although were identified from the background review of regional records and / or were identified in the SEARs (in correspondence with government agencies, specifically from EES Group). This included a review of the PMST and BioNet Atlas of NSW. Several species known from the area that have since been listed under the BC Act have also been included in this table. These species were assessed for their likelihood of occurrence. Those species identified as having a moderate to high likelihood of occurring in the construction footprint have been listed in **Table 4-4** along with the source of the records or information. These species are also considered candidate species and were targeted in field surveys.

Table 4-4 Additional candidate species credit species with a moderate to high likelihood of occurring in the construction footprint

Scientific name	Common name	TSC Act	EPBC Act	Distribution and habitat features	No. records Source
Flora					
Acacia bynoeana	Bynoe's Wattle	E	V	Found in central eastern NSW, from the Hunter District south to the Southern Highlands and west to the Blue Mountains. It has recently been found in the Colymea and Parma Creek areas west of Nowra. Occurs in heath or dry sclerophyll forest on sandy soils. Seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches. Associated overstorey species include Red Bloodwood, Scribbly Gum, Drooping Red Gum, Old Man Banksia and Small-leaved Apple.	PMST
Commersonia prostrata	Dwarf Kerrawang	-	E	Dwarf Kerrawang is found on the North Coast (less than 100 plants at the Tomago Sandbeds north of Newcastle). Occurs on sandy, sometimes peaty soils in a wide variety of habitats: Snow Gum Woodland and Ephemeral Wetland floor at Rowes Lagoon; Blue leaved Stringybark Open Forest at Tallong; and in Brittle Gum Low Open Woodland at Penrose; Scribbly Gum / Swamp Mahogany Ecotonal Forest at Tomago. Appears to respond positively to some forms of disturbance (e.g. some Victorian records are from gravel road surfaces and the Tomago population is on an area previously subject to sandmining), however, there are conflicting reports about the response of the species to fire.	12 – Atlas
Diuris arenaria	Sand Doubletail	V		Sand Doubletail is known from the Tomaree Peninsula near Newcastle. This species occurs in coastal heath and dry grassy eucalypt forest on sandy flats. Grows in gently undulating country in eucalypt forest with a grassy understorey on clay soil.	1 – Atlas SEARS
Pterostylis chaetophora		V	-	Recorded in Queensland and NSW. In NSW it is currently known from 18 scattered locations in a relatively small area between Taree and Kurri Kurri, extending to the south-east towards Tea Gardens and west into the Upper Hunter, with additional records near Denman and Wingen. There are also isolated records from the 1940s and 1980s from the Sydney region but identification of two of these Sydney records has not been verified from voucher specimens and it is unclear if any of these possible populations still exist. The preferred habitat is seasonally moist, dry sclerophyll forest with a grass and shrub understorey. Plants are deciduous and die back to underground tubers after seeding. New rosettes are produced following soaking autumn and winter rains and flowering occurs from September to November. Fails to flower in dry seasons.	482 – Atlas SEARS

Scientific name	Common name	TSC Act	EPBC Act	Distribution and habitat features	No. records Source
Rhizanthella slateri	Eastern Australian Underground Orchid	V	E	Occurs from south-east Queensland to south-east NSW. In NSW, currently known from fewer than 10 locations, including near Bulahdelah, the Watagan Mountains, the Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra. Habitat requirements are poorly understood, and no particular vegetation type has been associated with the species, although it is known to occur in sclerophyll forest.	PMST
Rhodamnia rubescens	Scrub Turpentine	CE	-	Occurs in coastal districts north from Batemans Bay in New South Wales, about 280 kilometres south of Sydney, to areas inland of Bundaberg in Queensland. Populations of *R. rubescens* typically occur in coastal regions and occasionally extend inland onto escarpments up to 600 metres above sea level. in areas with rainfall of 1000-1600 mm. Found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils. This species is characterised as highly to extremely susceptible to infection by Myrtle Rust.	SEARs
Rhodomyrtus psidioides	Native Guava	CE	-	Occurs from Broken Bay, about 90 kilometres north of Sydney, New South Wales, to Maryborough in Queensland. Populations are typically restricted to coastal and sub-coastal areas of low elevation however the species does occur up to c. 120 kilometres inland in the Hunter and Clarence River catchments and along the Border Ranges in NSW. Pioneer species found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest often near creeks and drainage lines. This species is characterised being extremely susceptible to infection by Myrtle Rust. Myrtle Rust affects all plant parts.	SEARs
Fauna					
Haliaeetus leucogaster	White-bellied Sea-Eagle	V (BC Act)	M	Distributed along the coastline (including offshore islands) of mainland Australia and Tasmania. Found in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands. Habitats occupied by the sea-eagle are characterised by the presence of large areas of open water (larger rivers, swamps, lakes, and the sea). It feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion. It generally forages over large expanses of open water; this is particularly true of birds that occur in coastal environments close to the sea-shore. However, the it will also forage over open terrestrial habitats (such as grasslands). Nests may be built in a variety of sites including tall trees (especially *Eucalyptus* species), bushes, mangroves, cliffs, rocky outcrops, caves, crevices, on the ground or even on artificial structures.	267 – Atlas PMST

Scientific name	Common name	TSC Act	EPBC Act	Distribution and habitat features	No. records Source
Miniopterus australis	Little Bent-winged Bat (species / breeding)	V	-	East coast and ranges of Australia from Cape York in Queensland to Wollongong in NSW. Little Bent-winged 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.	334 – Atlas
Miniopterus orianae oceanensis	Large Bent-winged Bat (species / breeding)	V	-	Occurs on east and north west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other manmade structures.	146 – Atlas
Myotis macropus	Southern Myotis	V	-	Generally, roost in groups close to water in caves, mine shafts, hollow-bearing trees, and storm water channels, buildings, under bridges and in dense foliage. Forages over streams and pools catching insects and small fish.	112 – Atlas
Pteropus poliocephalus	Grey-headed Flying-fox (species / breeding)	V	V	Generally found within 200 kilometres of the eastern coast of Australia, from Rockhampton in Queensland to Adelaide in South Australia. In times of natural resource shortages, they may be found in unusual locations. Occur 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 kilometres of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Individual camps may have tens of thousands of animals and are used for mating, and for giving birth and rearing young.	402 – Atlas PMST
Uperoleia mahonyi	Mahony's Toadlet	E (BC Act)	-	Endemic to the mid-north coast of New South Wales (NSW) and to date has been found between Kangy Angy and Seal Rocks. Inhabits ephemeral and semi-permanent swamps and swales on the coastal fringe of its range. Known records occur in heath or wallum habitats almost exclusively associated with leached (highly nutrient impoverished) white sand. Also is known to occur in wallum heath, swamp mahogany-paperbark swamp forest, heath shrubland and Sydney red gum woodland. Known records are associated with shallow ephemeral/semi-permanent water bodies with limited flow of water. Aquatic vegetation at breeding sites includes sedges (*Schoenoplectus* sp., *Baumea* sp. and *Lepironia articulata*) and Broadleaf Cumbungi (*Typha orientalis*). Females have been recorded up to 400m from water-bodies indicating moderate dispersal distances and use of multiple habitat types.	15 – Atlas SEARS

V = Vulnerable, E = Endangered, CE = Critically Endangered

4.2 Targeted surveys

All surveys were carried out under the appropriate licences, including scientific licences as required under Clause 22 of the National Parks and Wildlife Regulations 2002, Section 132C of the *National Parks and Wildlife Act 1974* (License Number: SL100044) and Animal Care and Ethics approval and animal research authority 15/681 from DPI. All personnel involved in targeted surveys are listed in **Appendix H**. A change to scientific licence as a result of superseded legislation is granted under Part 2 of the BC Act.

4.2.1 Threatened plants

Targeted flora surveys were carried out between December 2014 and November 2018 (inclusive) during all seasons. The lengthy duration of the project provided an opportunity to plan and implement surveys across multiple seasons and conditions resulting in a comprehensive survey program that targeted all species during the optimum survey month for each candidate species. The survey approach and methods are described below and have been divided into non-cryptic and cryptic species.

The targeted flora surveys followed the methods described in the Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft 2004 (Department of Environment and Conservation 2004) and the NSW Guide to Surveying Threatened Plants (OEH 2016). Orchid surveys were also guided by the Survey Guidelines for Australia's Threatened Orchids (Department of Environment, 2013). A systematic approach was adopted by identifying the potential habitat for each species and then completing searches along a series of parallel field transects ensuring coverage of all areas of the construction footprint subject to direct impacts.

The location of targeted threatened flora surveys including non-cryptic and cryptic plant species is shown in **Figure 4-1**.

Non-cryptic plant species

The list of candidate species described in **Section 4.1** were considered in terms of the likely associated PCT, topographic, soil and geological preferences, microhabitats (e.g. damp areas), and disturbance regime of the habitat in the construction footprint. This was done so that survey effort was targeted in the most suitable habitat for the species targeted surveys were then completed for all identified candidate flora species with suitable habitat. The survey effort expended for non-cryptic flora species is outlined in **Table 4-5**.

Cryptic plant species

Consideration of the optimum survey approach for cryptic orchid species was done in consultation with Dr Mark Clements, an orchid expert from the National Herbarium and CSIRO. The target species included *Diuris arenaria*, *Diuris praecox*, *Corybas dowlingii*, *Cryptostylis hunteriana, Pterostylis chaetophora* and *Rhizanthella slateri*. The broad habitats identified by Mark Clements and associated PCTs listed in the BioNet Threatened Biodiversity Data Collection were targeted during the surveys.

The presence of flowers is critical for locating cryptic orchid species and as such the surveys were carried out during the flowering period for each target species. As some plants will flower before others, several visits were carried out throughout the flowering periods in an attempt to locate all flowering plants over the species' flowering period. A survey at the beginning of the flowering period and at the end of the flowering period was carried out for each species.

The surveys were carried out when the nearest known population of the target species (reference site) was flowering to maximise the likelihood of detecting orchids present in the construction footprint. Glenrock SCA was checked for *Diuris praecox* (August 2018), Grahamstown Dam was checked for *Pterostylis chaetophora* (September 2018). Advice was sought from EES Group (formerly OEH) accountable threatened species officers regarding flowering time for each species and suitable reference population locations.

The survey for all orchid species involved the use of paired parallel transects with two observers walking about five to 10 metres apart (where possible depending on vegetation density) to survey each broad habitat type in an attempt to locate orchid colonies. Where an orchid species was found it was identified (where reproductive material was present) and the location marked on a GPS receiver. The immediate area around the orchid colony was then searched in detail to locate the extent of the colony. The specific areas, broad habitats and microhabitats that were targeted are outlined in **Table 4-6**. The survey effort was based around minimising the chance of false absences and maximising the efficiency of the survey.

Table 4-5 Targeted species for non-cryptic threatened plant species

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Length of transects
Acacia bynoeana (Bynoe's Wattle)	V	V	*Acacia bynoeana* is a medium shrub. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). As a medium shrub the maximum distance between transects in open vegetation is 20 metres, in dense vegetation is 10 metres. In open vegetation, field traverse length is 0.5 kilometres per hectare of potential habitat in open vegetation (OEH 2016). In open vegetation, the recommended field traverse length is 0.5km per hectare of potential habitat. Recommended survey time is estimated at 0.13 hours. With about 50 hectares of potential habitat in the construction footprint, survey time is 6.25 hours in open vegetation.	Dry sclerophyll forest across the construction footprint.	-	Heath or dry sclerophyll forest on sandy soils	Parallel transects about 10-20 metres apart	Between December 2014 and April 2016 Between September and November 2018	30km of transects 32 person hours
Asperula asthenes (Trailing Woodruff)	V	V	*Asperula asthenes* is a low, trailing perennial herb that is best detected during its flowering period from October to December, though is detectable year-round. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). Maximum distance between transects 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat (OEH 2016). With as much as 8 hectares of potential aquatic habitat in the construction footprint (however much of this habitat is dry and unsuitable), survey time is around 25 to 67 hours.	All wetland habitat in the construction footprint, specifically around the Hunter River floodplain, Tomago and Heatherbrae.	PCT 1742	Fringes of the wetlands and shallow depressions	Parallel transects about 5-10 metres apart	Between December 2014 and April 2016 April 2018	0.1 – 0.5km

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Length of transects
Callistemon linearifolius (Netted Bottle Brush)	V	-	*Callistemon linearifolius* is a medium shrub. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). As a medium shrub the maximum distance between transects in open vegetation is 20 metres, in dense vegetation is 10 metres. In open vegetation, field traverse length is 0.5 kilometres per hectare of potential habitat in open vegetation (OEH 2016). With about 50 hectares of potential habitat in the construction footprint, survey time is 6.25 hours in open vegetation.	Dry sclerophyll forest across the construction footprint.	PCT 1590 PCT 1588	Dry sclerophyll forest on the coast and adjacent ranges	Parallel transects about 10-20 metres apart	Between December 2014 and April 2016 Between September and November 2018	30km of transects 32 person hours
Commersonia prostrata (Dwarf Kerrawang)	E	E	*Commersonia prostrata* is a prostrate shrub that can be readily detected year-round within suitable habitats. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). The maximum distance between transects in open vegetation is 20 metres, in dense vegetation is 10 metres. In open vegetation, field traverse length is 0.5 kilometres per hectare of potential habitat in open vegetation (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 6.5 and 33 hours in open to closed vegetation.	Sandy soil habitats at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road.	PCT 1646	Sandy, sometimes peaty soils.	Parallel transects about 10-20 metres apart	October 2015 September 2016 September 2018	80km of transects 80 person hours

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Length of transects
Cynanchum elegans (White-flowered Wax Plant)	E	E	*Cynanchum elegans* is a climber or twiner that can be readily detected year-round within suitable habitats. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). As a herb/forb, maximum distance between transects is 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat in open to closed vegetation (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 6.5 and 33 hours in open to closed vegetation.	Occurrence of Spotted Gum forest within the construction footprint	PCT 1590 PCT 1588	Edge of dry rainforest vegetation	Parallel transects about 10-20 metres apart	Between December 2014 and April 2016. Between September and November 2018	30km of transects 32 person hours
Eucalyptus camfieldii (Camfield's Stringybark)	V	V	*Eucalyptus camfieldii* is a medium sized tree that can be readily detected year-round within suitable habitats. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). The maximum distance between transects in open vegetation is 40 metres, in dense vegetation is 20 metres. In open vegetation, field traverse length is 0.5 kilometres per hectare of potential habitat in open vegetation (OEH 2016). With about 70 hectares of associated habitat (PCTs) survey time is about 3 to 6 hours in open vegetation.	Sandy soil habitats at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road.	PCT 1646	Poor coastal country in shallow sandy soils overlying Hawkesbury sandstone. Coastal heath mostly on exposed sandy ridges.	Parallel transects about 10-20 metres apart	October 2015 September 2016 September 2018	80km of transects 80 person hours

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Length of transects
Eucalyptus parramattensis subsp. *decadens* (Drooping Red Gum)	V	V	*Eucalyptus parramattensis* subsp. *decadens* is a small-medium sized tree that can be readily detected year-round within suitable habitats. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). The maximum distance between transects in open vegetation is 40 metres, in dense vegetation is 20 metres. In open vegetation, field traverse length is 0.5 kilometres per hectare of potential habitat in open vegetation (OEH 2016). With about 70 hectares of associated habitat (PCTs) survey time is about 3 to 6 hours in open vegetation.	Sandy soil habitats at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road.	PCT 1646 PCT 1716 PCT 1717	Deep, low-nutrient sands, often those subject to periodic inundation or where water tables are relatively high.	Parallel transects about 20-40 metres apart	Between December 2014 and September 2018.	80km of transects 80 person hours
Grevillea parviflora subsp. *parviflora* (Small-flower Grevillea)	V	V	A small shrub that can be readily detected year-round within suitable habitats. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). The maximum distance between transects in open vegetation is 20 metres, in dense vegetation is 10 metres. In open vegetation, field traverse length is 0.5 kilometres per hectare of potential habitat in open vegetation (OEH 2016). With about 26 hectares of potential habitat, survey time is about 3 to 6.25 hours in open vegetation.	Occurrence of Spotted Gum forest within the construction footprint	PCT 1590	Sandy or light clay soils usually over thin shales, often with lateritic ironstone gravels and nodules.	Parallel transects about 10-20 metres apart	Between December 2014 and April 2016. Between September and November 2018	30km of transects 32 person hours

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Length of transects
Maundia triglochinoides	V	-	*Maundia triglochinoides* is a sedge that can be readily detected year-round within suitable habitats. The recommended approach is parallel field transects in suitable habitat. Maximum distance between transects is 10 metres in open vegetation. (OEH 2016) With about 8 hectares of potential aquatic habitat in the construction footprint, survey time is around 2.5 hours.	All wetland habitat in the construction footprint, specifically around the Hunter River floodplain, Tomago and Heatherbrae.	PCT1716 PCT1717 PCT1736 PCT1742 PCT1071	Fringes of the wetlands and shallow depressions.	Parallel transects about 10 metres apart	Between December 2014 and April 2016 April 2018	30km of transects 32 person hours
Persicaria elatior (Tall Knotweed)	V	-	*Persicaria elatior* is an erect herb that is best detected during its flowering period from December to May. Maximum distance between transects 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat (OEH 2016). With as much as 70 hectares of potential habitat in the construction footprint (however much of this habitat is dry and unsuitable), survey time is around 25 to 67 hours.	All wetland habitat in the construction footprint, specifically around the Hunter River floodplain, Tomago and Heatherbrae.	PCT1716 PCT1717 PCT1727 PCT1736 PCT1742 PCT1071	Fringes of the wetlands and shallow depressions.	Parallel transects about 10 metres apart	Between December 2014 and April 2016 April 2018	30km of transects 32 person hours
Rhodamnia rubescens (Scrub Turpentine)	CE	CE	*Rhodamnia rubescens* is a shrub or small tree that can be readily detected year-round within suitable habitats. The recommended approach is parallel field transects in suitable habitat. As a medium shrub the maximum distance between transects in open vegetation is 20 metres, in dense vegetation is 10 metres. In open vegetation, field traverse length is 0.5 kilometres per hectare of potential habitat in open vegetation (OEH 2016). With about 8 hectares of potential habitat in the construction footprint, survey time is 6.67 hours in dense vegetation.	Intersection of Old Punt Road and the Pacific Highway at Tomago.	PCT 1724	Littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils	Parallel transects about 10-20 metres apart	Between December 2014 and September 2018	8km of transects 12 person hours

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Length of transects
Rhodomyrtus psidioides (Native Guava)	CE	CE	*Rhodomyrtus psidioides* is a shrub or small tree that can be readily detected year-round within suitable habitats. The recommended approach is parallel field transects in suitable habitat. As a medium shrub the maximum distance between transects in open vegetation is 20 metres, in dense vegetation is 10 metres. In open vegetation, field traverse length is 0.5 kilometres per hectare of potential habitat in open vegetation (OEH 2016). With about 8 hectares of potential habitat in the construction footprint, survey time is 6.67 hours in dense vegetation.	Old Punt Road and the Pacific Highway at Tomago.	PCT 1724	Littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils	Parallel transects about 10-20 metres apart	Between December 2014 and September 2018	8km of transects 12 person hours
Rutidosis heterogama (Heath Wrinklewort)	V	V	*Cynanchum elegans* is a climber or twiner that can be readily detected year-round within suitable habitats. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). As a herb, maximum distance between transects is 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat in open to closed vegetation (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 6.5 and 33 hours in open to closed vegetation.	Sandy soil habitats at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road.	PCT 1646	Grows in heath on sandy soils and moist areas in open forest and has been recorded along disturbed roadsides.	Parallel transects about 10-20 metres apart	October 2015 September 2016 September 2018	80km of transects 80 person hours

V = Vulnerable, E = Endangered, CE = Critically Endangered

Table 4-6 Summary of targeted surveys for cryptic plant species

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Survey effort
Cryptostylis hunteriana (Leafless Tongue Orchid)	V	V	A terrestrial orchid that is best detected during the flowering period of November (early flowering in October observed) and February (late flowering in March observed). Maximum distance between transects 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat in open to closed vegetation (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 25 and 67 hours in open to closed vegetation.	Sandy soil habitats at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road as identified by Mark Clements.	PCT 1590	Swamp-heath on sandy soils, chiefly in coastal districts.	Visual detection of flowering plants. Plants are readily detected when in flower.	October 2015 September 2016 September 2018	80km of transects 80 person-hours
Diuris arenaria (Sand Doubletail)	V	-	A terrestrial orchid that is best detected during the flowering period of August and September. Maximum distance between transects 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat in open to closed vegetation (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 25 and 67 hours in open to closed vegetation.	Sandy soil habitats at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road as identified by Mark Clements. Known population at Masonite Road was re-visited to determine flowering, and a new population count completed and mapping of population extent. Flowering/budding by this species was confirmed by EES Group threatened species officer 11.09.18 (Antony von Chrismar, pers comm).	PCT 1646	Open grassland areas within the forest and all cleared areas of fire breaks and service tracks. Patches of damp stabilised sandy soil.	Visual detection of flowering plants. Plants are readily detected when in flower.	October 2015 September 2016 September 2018	80km of transects 80 person-hours

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Survey effort
Diuris pedunculata (Small Snake Orchid)	E	E	A terrestrial orchid that is best detected during its flowering period from late September to October. Maximum distance between transects 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat in open to closed vegetation (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 25 and 67 hours in open to closed vegetation.	Sandy soil habitats at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road as identified by Mark Clements.	PCT 1590	Grassy slopes or flats often on peaty soils in moist areas. Also on shale and trap soils, on fine granite, and among boulders.	Visual detection of flowering plants. Plants are readily detected when in flower.	October 2015 September 2016 September 2018	80km of transects 80 person-hours
Diuris praecox (Rough Doubletail)	V	V	A terrestrial orchid that is best detected during its flowering period from late July to early September. Maximum distance between transects 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat in open to closed vegetation (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 25 and 67 hours in open to closed vegetation.	Sandy soil habitats at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road as identified by Mark Clements. Known population in Adamstown Heights was visited to determine flowering. Flowering by this species was confirmed during Aug/Sept (correspondence 11.09.18 by EES Group threatened species officer (Antony von Chrismar per comm).	PCT 1646 PCT 1716 PCT 1717	Open grassland areas within the forest and all cleared areas of fire breaks and service tracks. Patches of damp stabilised sandy soil	Visual detection of flowering plants. Plants are readily detected when in flower.	September 2016 July 2018 August 2018	80km of transects 80 person-hours

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Survey effort
Corybas dowlingii (Red Helmet Orchid)	V	-	A terrestrial orchid that is best detected during its flowering period from June to August. Maximum distance between transects 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat in open to closed vegetation (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 25 and 67 hours in open to closed vegetation.	Clay soil habitats at Black Hill and on the sandy soils at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road as identified by Mark Clements. Known population at Soldiers Point and/or Pinny Beach was confirmed to be flowering prior to the survey (05.07.18).	PCT 1646	Focus on locating colonies of *Acianthus fornicatus* as *Corybas dowlingii* typically associates with this species as it utilises the same or similar mycorrhizal fungi.	Visual detection of flowering plants. Plants are readily detected when in flower. Very hard to distinguish from the common *Corybas aconitiflorus*. Any *Corybas* plants found will be examined and sent for to the RBG for confirmation of ID if possible (i.e. the population is large enough).	July 2018 August 2018	44km of transects 40 person-hours
Pterostylis chaetophora	V	-	A terrestrial orchid that is best detected during its flowering period from September to November. Maximum distance between transects 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about	Clay soil habitats at Black Hill and on the sandy soils at Heatherbrae between the Hunter Region Botanic Garden and Masonite Road as identified by Mark Clements. Known population on Hunter Water land at Ferodale was visited on 16.09.18 prior to the	PCT 1588 PCT 1590 PCT 1598 PCT 1649	Moist areas in forest	Visual detection of flowering plants. Plants are readily detected when in flower.	September 2018	31km of transects 32 person-hours

Species	TSC Act	EPBC Act	Minimum survey requirements	Survey locations	Associated PCT	Microhabitat	Technique	Seasonal timing	Survey effort
			1 kilometre per 1 hectare of suitable habitat (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 25 and 67 hours in open to closed vegetation.	survey and confirmed flowering.					
Rhizanthella slateri (Eastern Underground Orchid)	V	E	A terrestrial saprophytic orchid that is best detected during its flowering period from September to November, however flowers can remain visible most of the year. Maximum distance between transects 10 metres in open vegetation and 5 metres in dense vegetation. Field traverse is about 1 kilometre per 1 hectare of suitable habitat (OEH 2016). With about 50 hectares of suitable habitat, survey time is between 25 and 67 hours in open to closed vegetation.	Clay soil habitats at Black Hill and on the sandy soils at Tomago and Heatherbrae between the Hunter Region Botanic Garden and Masonite Road as identified by Mark Clements. Confirmation that this species was in flower at Bulahdelah was not received by EES Group.	PCT 1646	Focus on areas under Myrtaceae plants, Fabaceae (including *Acacia*) and *Casuarina* species. Associated with the fungus Ceratobasidium upon which other orchids such as Pterostylis sp. are dependent. Any areas with Pterostylis sp. colonies will be specifically targeted.	Plants are located by careful removal of the leaf litter to examine the exposed soil surface underneath plants that are ectomycorrhiza. One metre squared quadrats were surveyed wherever any *Pterostylis* species were encountered by raking away the leaf litter to expose the soil underneath.	September 2018	31km of transects (167 $1m^2$ quadrats) 32 person-hours

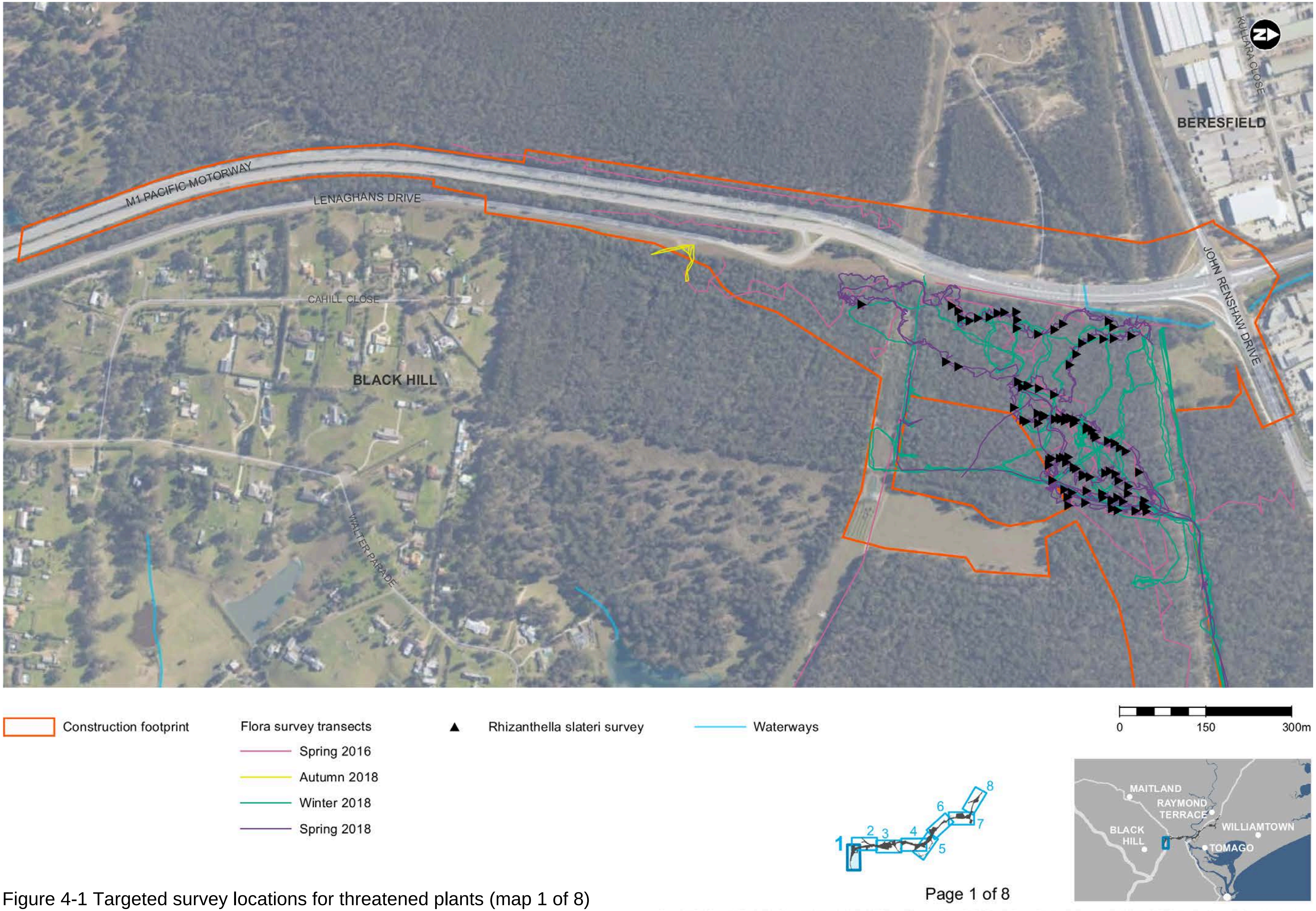

Figure 4-1 Targeted survey locations for threatened plants (map 1 of 8)

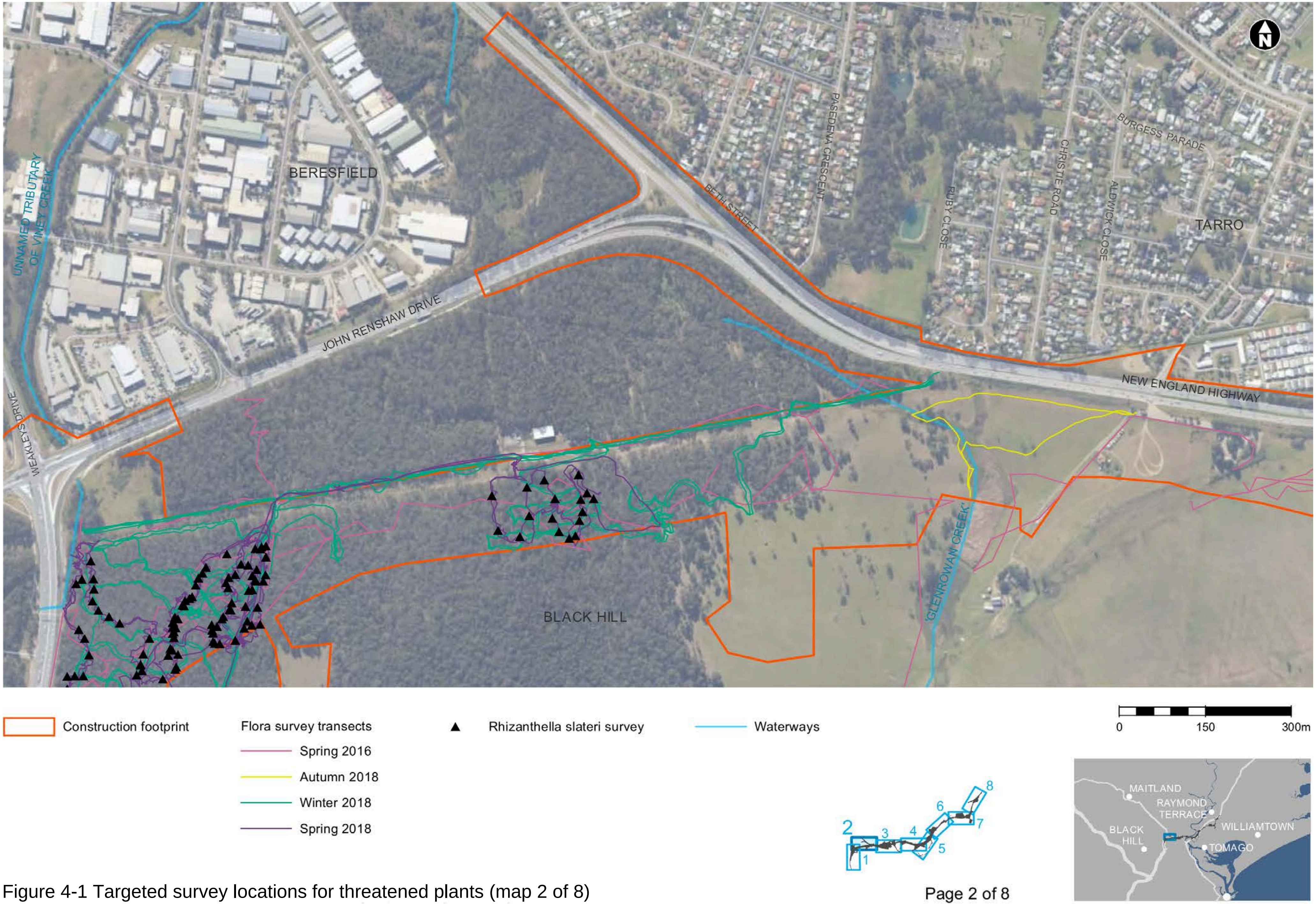

Figure 4-1 Targeted survey locations for threatened plants (map 2 of 8)

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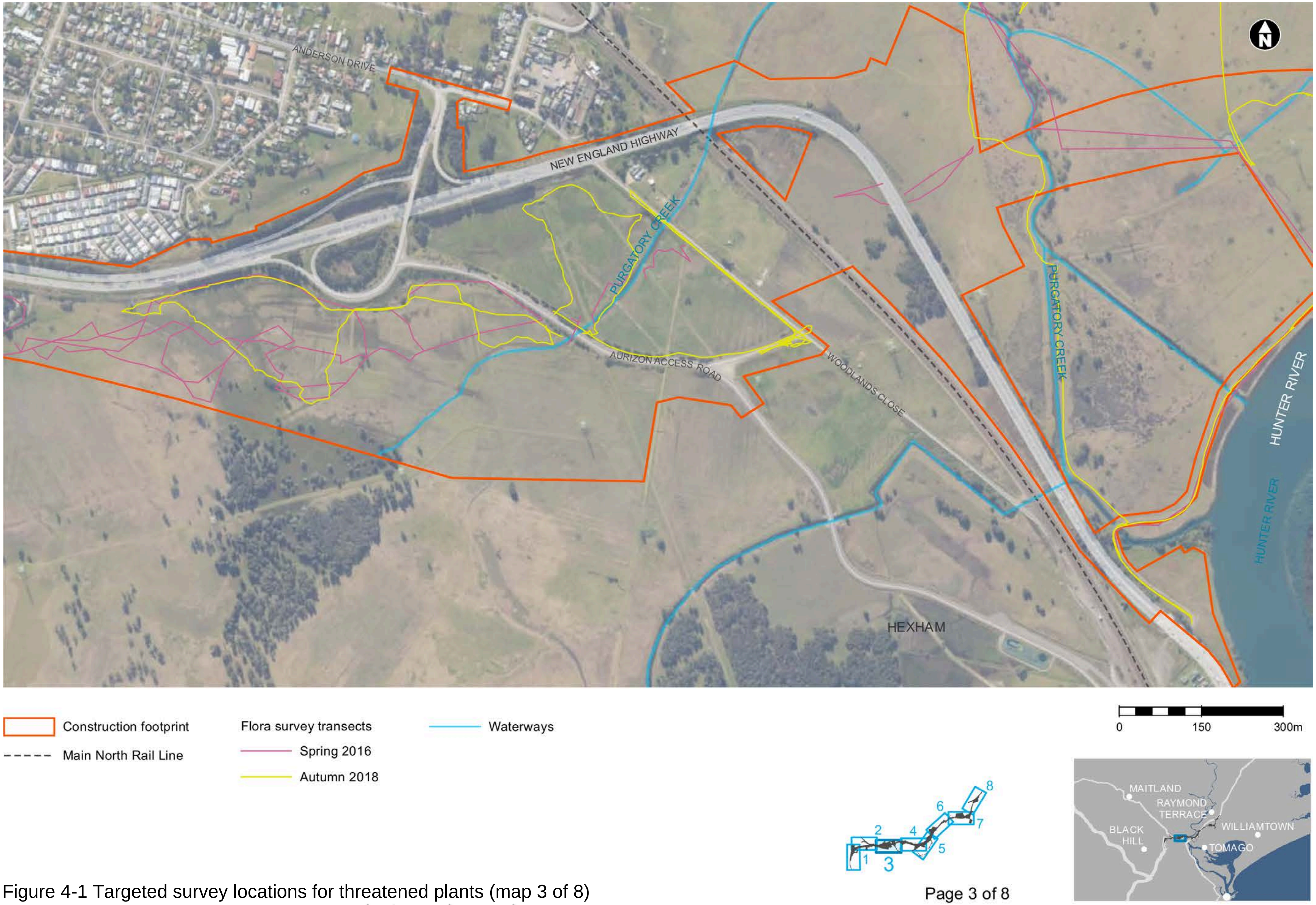
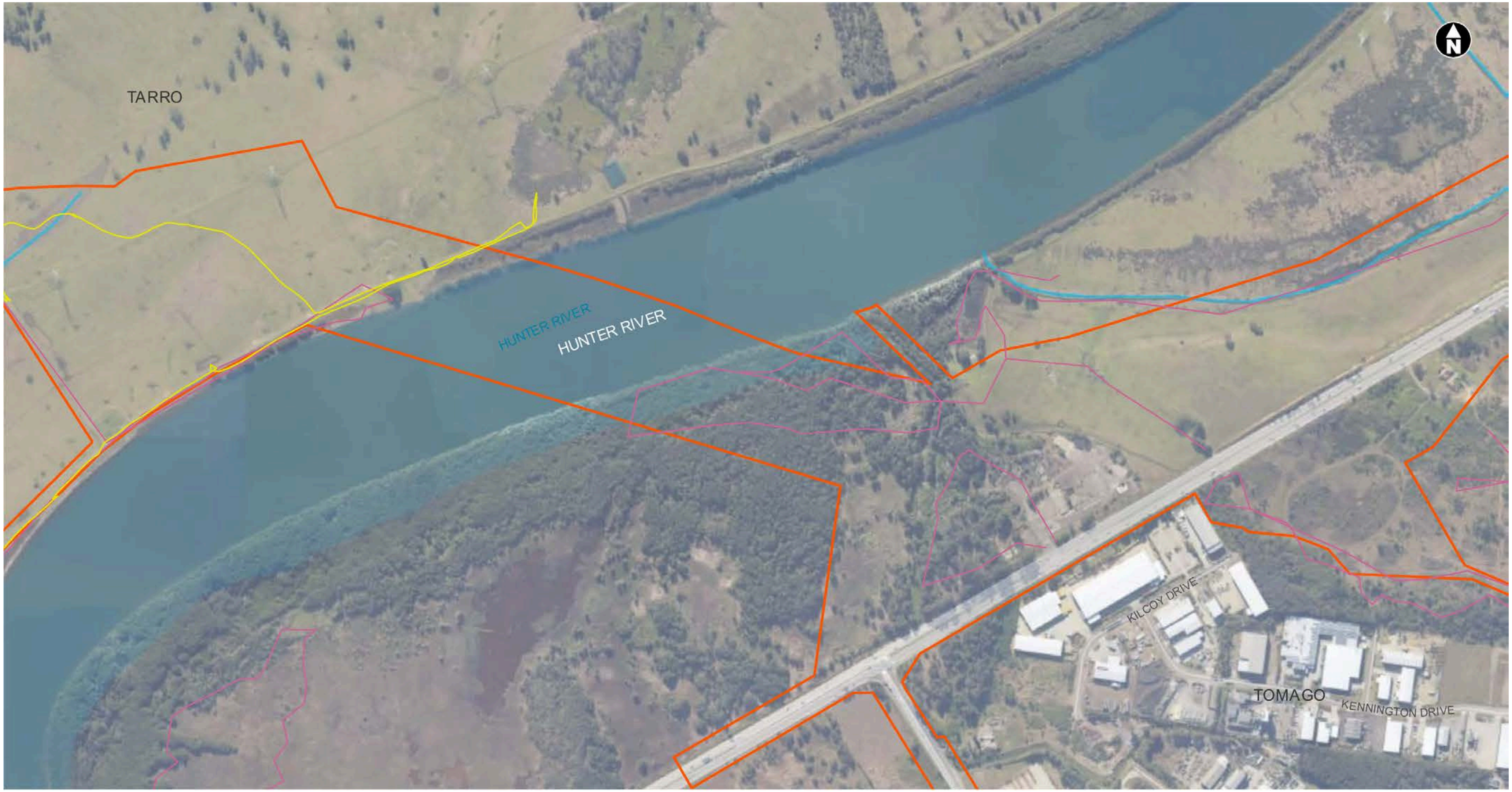


Figure 4-1 Targeted survey locations for threatened plants (map 3 of 8)



Construction footprint

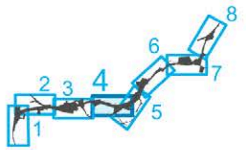
Flora survey transects

Spring 2016

Autumn 2018

Waterways

0 150 300m



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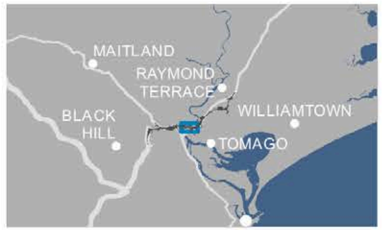

Figure 4-1 Targeted survey locations for threatened plants (map 4 of 8)

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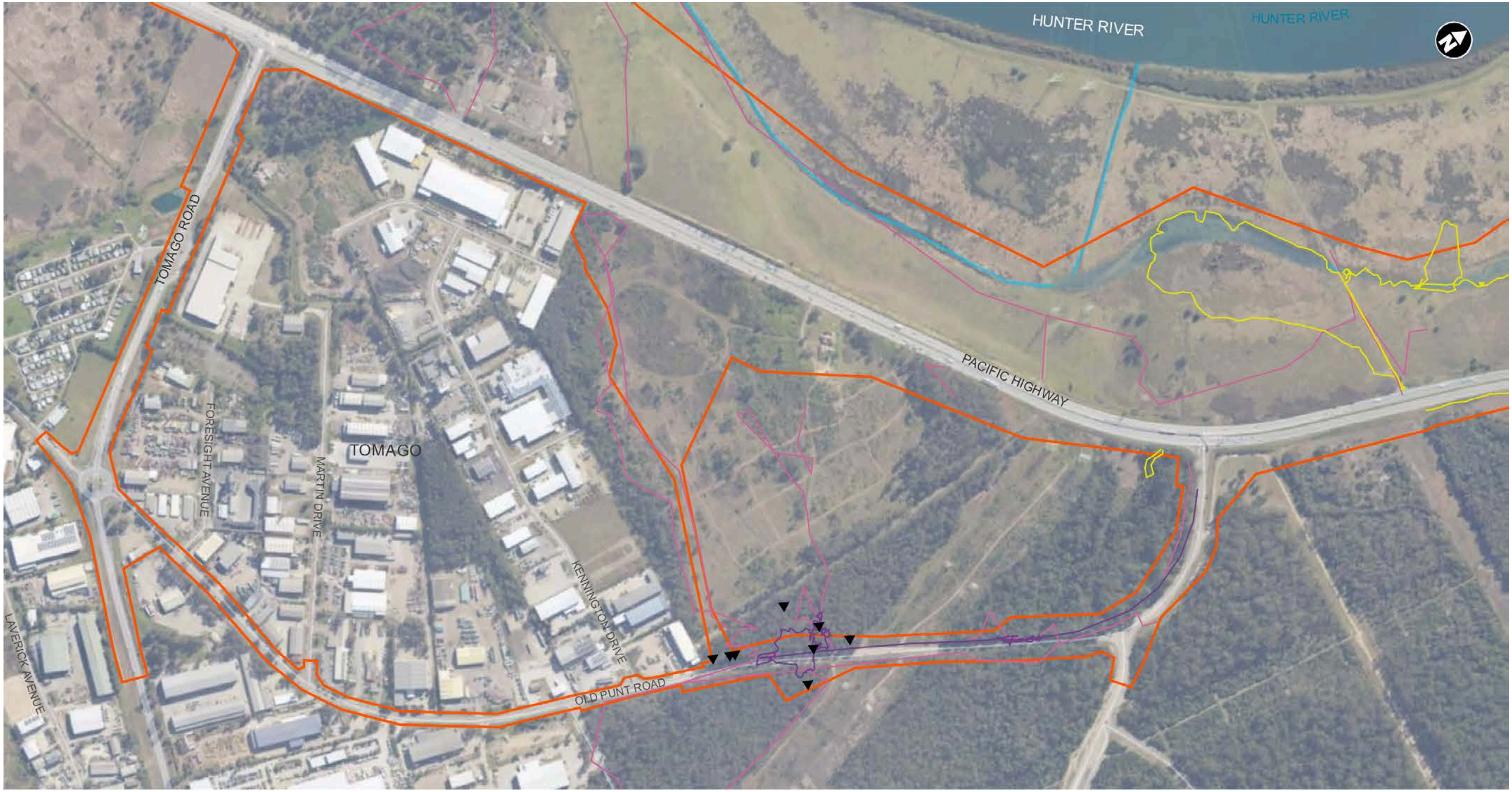


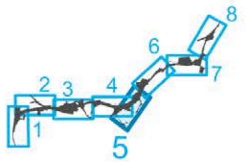
Construction footprint

Flora survey transects
- Spring 2016
- Autumn 2018
- Spring 2018

▲ Rhizanthella slateri survey

Waterways

0 150 300m



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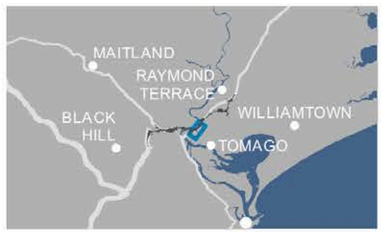

Figure 4-1 Targeted survey locations for threatened plants (map 5 of 8)

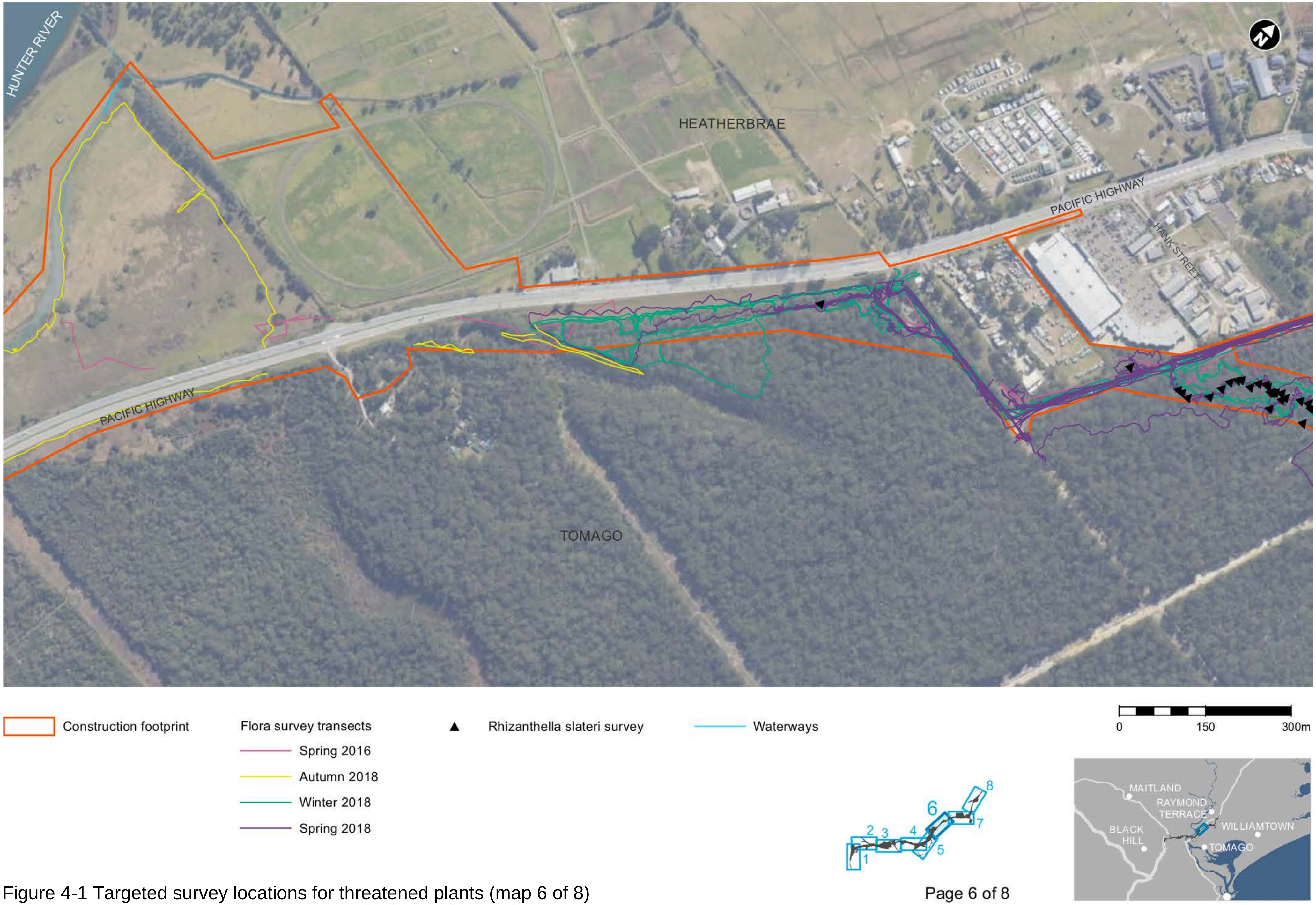

Figure 4-1 Targeted survey locations for threatened plants (map 6 of 8)

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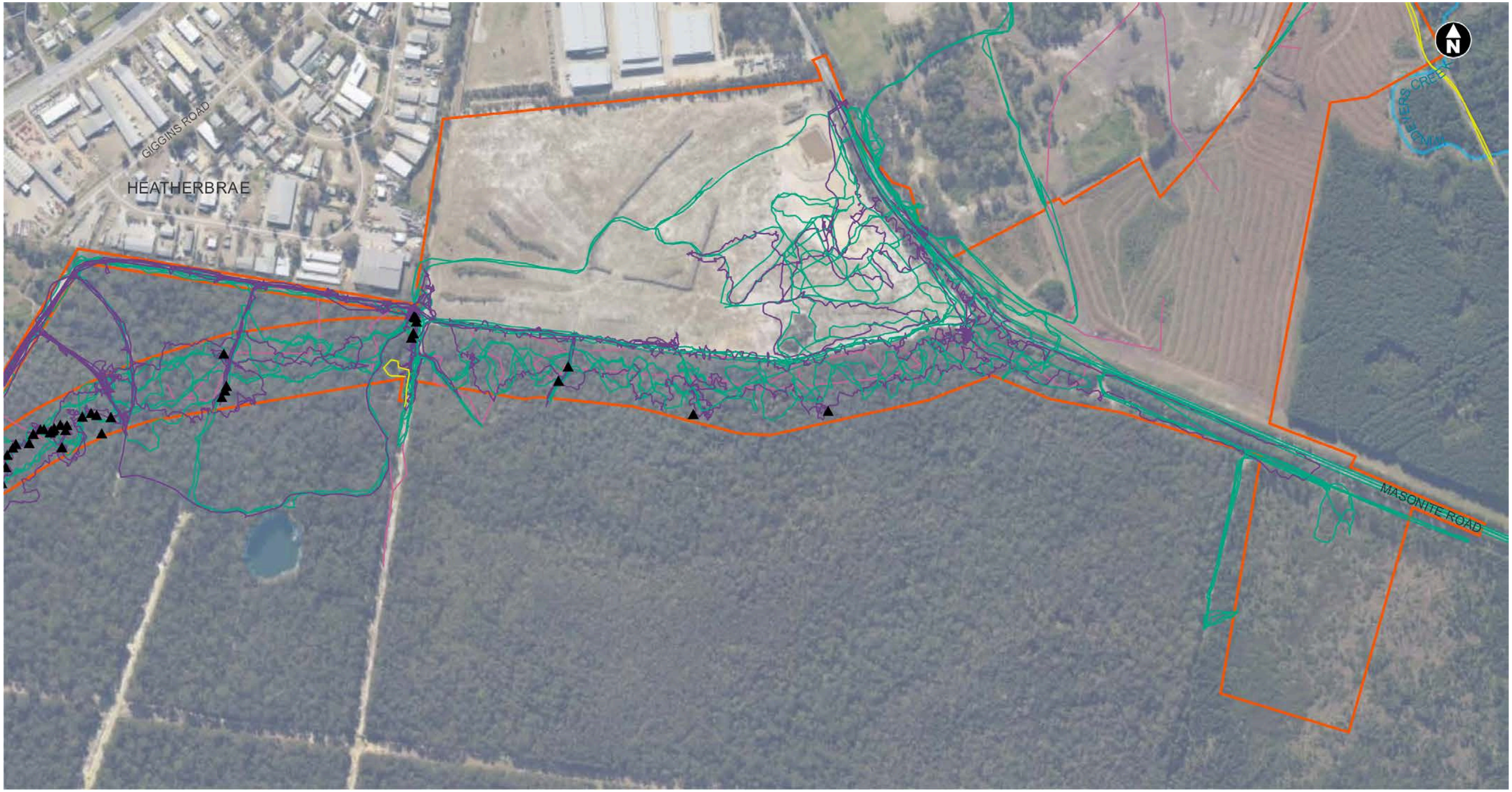
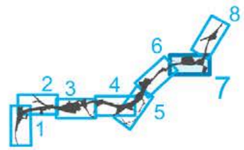


Construction footprint
Flora survey transects
Spring 2016
Autumn 2018
Winter 2018
Spring 2018
Rhizanthella slateri survey
Waterways

0 150 300m



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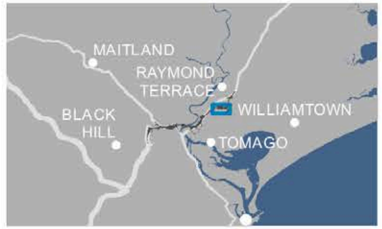

Figure 4-1 Targeted survey locations for threatened plants (map 7 of 8)

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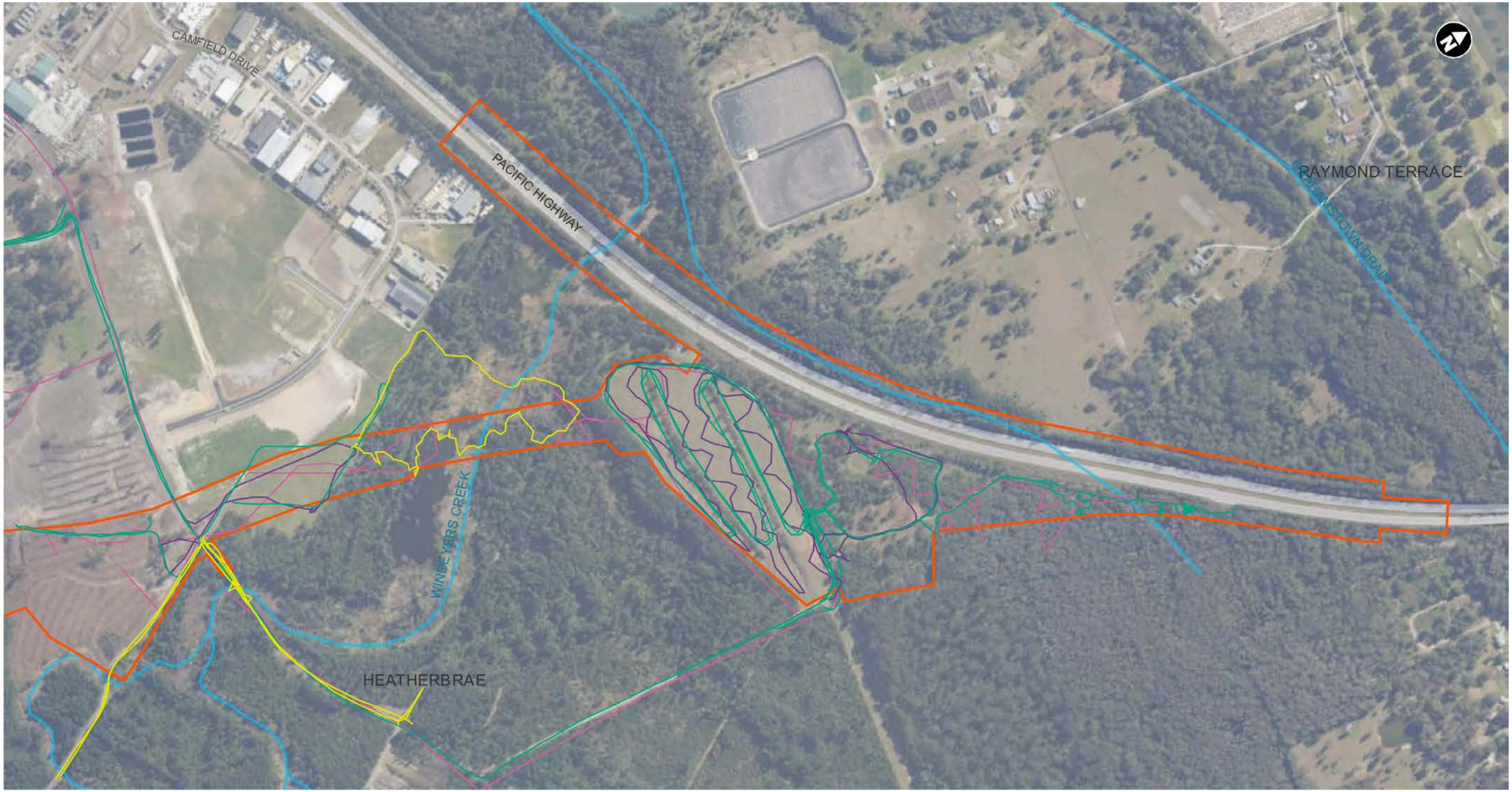
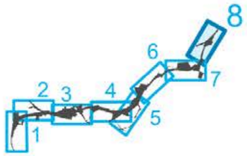


Construction footprint

Flora survey transects
- Spring 2016
- Autumn 2018
- Winter 2018
- Spring 2018

Waterways

0 150 300m



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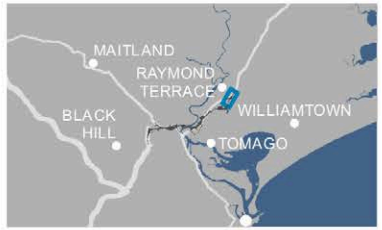


Figure 4-1 Targeted survey locations for threatened plants (map 8 of 8)

4.2.2 Threatened fauna

The list of potential threatened fauna species reported from the BBCC is discussed in **Section 4.1**. The objective was to target the species identified as having a moderate to high likelihood of occurring in the construction footprint. A number of combined ‘species credit and ecosystem credit’ species for the Hunter sub-region were not identified in the BBCC and were also considered to have potential to occur, including the Large Bent-winged Bat (*Miniopterus orianae oceanensis*), Little Bent-winged Bat (*Miniopterus australis*), Southern Myotis (*Myotis macropus*) and the Australasian Bittern (*Botaurus poiciloptilus*), which were targeted during the field survey. The Squirrel Glider (ecosystem credit species - BBCC) was also targeted to provide insight into potential impacts and appropriate connectivity management measures for this species.

The survey approach and methods were tailored to address the methods described in the Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft (DECC 2004) and the following guidelines:

- Amphibians – Threatened species survey and assessment guidelines: field survey methods for fauna – Amphibians (2009) **http://www.environment.nsw.gov.au/resources/threatenedspecies/09213amphibians.pdf**
- Threatened bats – Survey Guidelines for Australia’s Threatened Bats, Commonwealth of Australia (2010) **http://www.environment.gov.au/epbc/publications/threatened-bats.html**
- Threatened birds – Survey Guidelines for Australia’s Threatened Birds, Commonwealth of Australia (2010) **http://www.environment.gov.au/system/files/resources/107052eb-2041-45b9-9296-b5f514493ae0/files/survey-guidelines-birds.pdf**
- Threatened frogs – Survey Guidelines for Australia’s Threatened Frogs, Commonwealth of Australia (2011) **http://www.environment.gov.au/system/files/resources/ff3eb752-482d-417f-8971-f93a84211518/files/survey-guidelines-frogs.pdf**
- Koala Rapid Assessment Method (KRAM) (Woosnam-Merchez et al. 2012).

Habitat assessment

Rapid habitat assessments were conducted at vegetation plot sites to gather information on the type and condition of the fauna habitats present within the construction footprint. The assessments focused on identifying the suitability of the habitat for the list of predicted threatened species generated from the BBCC and to inform suitable locations for targeted surveys. At each survey site an assessment was made of the fauna habitat features including:

- Type and structure of the vegetation, including an assessment of the ‘naturalness’ in terms of the presence of remnant vegetation or planted and re-growth areas and the extent of modification
- Presence and frequency of large mature trees, tree hollows, standing dead trees (stags) and logs
- Presence of significant keystone species and critical habitat elements for threatened fauna
- Disturbance regimes, both past and ongoing including grazing and weed abundance
- Density of each vegetation strata (structural diversity)
- Presence and quality of wet areas or waterbodies, significant aquatic habitats where present
- Size of remnant patches and extent of connectivity, movement corridors and refuge value.

Target species and survey requirements

The target fauna species which were identified from the BBCC, background review and habitat assessment are outlined in **Table 4-7,** which also provides minimum survey requirements to target these species and a brief summary of the survey approach. Comprehensive details of the survey method, timing and weather details for each target group are provided in **Appendix F**, while a summary of the approach is provided in **Table 4-7** and **Table 4-8**.

Table 4-7 Targeted fauna, minimum survey requirements and summary of surveys completed

Target fauna species	Minimum survey requirements	Summary of surveys completed
Green and Golden Bell Frog, Green-thighed Frog, Wallum Froglet, Mahony's Toadlet	• All surveys should be carried out within 1 week of heavy rainfall (>50 mm in 7 days) during spring/summer (October – March) • Initial habitat assessment - surveys using a combination of call detection, call playback and spotlighting • A minimum of 4 nights under ideal conditions • Small wetlands (<50 metres at greatest length) should be covered in about 1 hour • Large sites should be sampled systematically.	All dams, wetlands and waterbodies within 100-200 metres of the construction footprint where assessed in the field for their habitat suitability for the target species. Potential habitats identified and each searched for 1 hour by two ecologists using call detection, call playback and spotlighting. Large habitat areas (e.g. Windeyers Creek) were surveyed systematically over 4 nights in January 2016 and 4 nights in March 2018. Seventeen different sites were surveyed over this period depending on local climatic conditions. Total survey effort was 13 nights and 2 days. All surveys were conducted within a week of heavy rainfall which reached up to 328 mm in January 2016 and 159.2 mm in March 2018.
Regent Honeyeater	• 20-minute surveys of 2-hectare plots per stratification unit • Area and targeted searches in woodland concentrating on flowering Eucalypts and where other nectar feeding birds are evident.	20-minute dedicated surveys of about 2 hectares plots in winter by two ecologists at each of 10 sites in 2016 (2 mornings in winter and 6 mornings over spring and summer) focussing on areas of flowering eucalypts. Additional surveys in 2018 included 2 mornings in winter and 2 mornings in spring. Plus, opportunistic surveys during all other site activities. Total of about 30 hours over 10 days.
Eastern Osprey and White-bellied Sea Eagle	• 20-minute surveys of 2-hectare plots per stratification unit, ensuring that tree tops are scanned for nests.	20-minute dedicated surveys of about 2 hectares plots by 2 ecologists at each of 18 sites in 2016 (half of the sites surveyed twice during winter) plus opportunistic surveys during all other site activities. Some sites were re-surveyed in 2018 over 4 days (total effort about 24 person hours over 8 days). Opportunistic observations for nest sites during all flora and fauna survey activities.
Black Bittern, Australasian Bittern, Black-necked Stork, Comb-crested Jacana, Terek Sandpiper	• A 1-hour bird observation must be conducted at dawn or dusk. A 20-minute census at dawn or an hour before dusk should also be conducted at each identified source of water in the survey area.	Evening and spotlighting surveys and call playback over 8 evenings / nights by 2 ecologists in 2016. Survey times varied between 0.5 to 2.0 hrs at each site. Additional spotlighting was carried out on 6 evenings in 2018. Total nocturnal survey effort of 14 nights and 20 hours. 20-minute dedicated diurnal surveys of about 2 hectares plots at 6 wetland sites. Plus, opportunistic surveys during all other site activities. Total diurnal survey effort of about 8 hours over 4 days.

Target fauna species	Minimum survey requirements	Summary of surveys completed
Koala	• Spotlighting - 1 hour and 1km up to 200 hectares of stratification unit on 2 separate nights per 50 hectares of stratification unit • Tracks, scats and scratches survey of 30 minutes per stratification unit	Habitat stratified by PCT and all forest habitats targeted. Spotlighting – 9 person hours across 3 separate nights in 2016 in all habitat strata including area-based searches and car spotlighting. An additional 3 nights were carried out in 2018. Total effort of about 20 person hours over 6 nights. Koala Rapid Assessment Method (KRAM) (scat search and tree species density identified), carried out in 2016 and again in 2018 at 61 sites across the construction footprint stratified by PCT. Koala food tree species identified.
Squirrel Glider, Brush-tailed Phascogale, Eastern Pygmy Possum	• Arboreal Elliot traps - 24 trap nights over 3-4 consecutive nights per 50 hectares of stratification unit • Spotlighting - 1 hour and 1 kilometre up to 200 hectares of stratification unit on 2 separate nights per 50 hectares of stratification unit	Large Elliot traps – 320 trap nights over 8 nights in 2016 and another 320 trap nights over 8 nights in 2018. Traps were attached to tree 3-4 metres above ground with a bracket. Mixture of honey-water sprayed on the tree each morning. Traps checked within 2 hours of sunrise every day. Camera traps – 20 individual motion-sensor cameras were deployed in 2018 both in trees and on the ground using bait stations for 10 nights each, totalling 200 trap nights. Nest boxes - targeting Eastern Pygmy Possum, 6 nest boxes were deployed at 3 locations (2 nest boxes per site) in October 2018 and collected in January 2019.Spotlighting – 9 person hours across 3 separate nights in all habitat strata including area-based searches and car spotlighting. An additional 3 nights were carried out in 2018. Total effort of about 20 person hours over 6 nights.
Common Planigale and New Holland Mouse	• Small Elliot traps - 100 trap nights over 3-4 consecutive nights per 50 hectares of stratification unit • Pitfall traps - 24 trap nights over 3-4 consecutive nights per 50 hectares of stratification unit	Small Elliot traps – 640 trap nights over 8 nights and 8 sites in 2016. Surveys again carried out in 2018 involving a further 640 trap nights over 8 nights and 8 sites. Pitfall traps – 60 trap nights over 3 nights at 4 sites in 2016. 60 trap nights over 3 nights at 4 sites in 2018. Camera traps - 10 individual motion-sensor cameras were deployed on the ground using bait stations for 10 nights each, totalling 100 trap nights. Spotlighting – 9 person hours across 3 separate nights in all habitat strata including area-based searches and car spotlighting. An additional 3 nights were carried out in 2018. Total effort of about 20 person hours over 6 nights.
Large-eared Pied Bat, Little Bent-winged Bat, Large Bent-winged Bat, Southern Myotis.	• Harp trapping - 4 trap nights over 2 consecutive nights (with 1 trap placed outside the flyways for 1 night) per 100 hectares of stratification unit • Call detection - 2 sound activated recording devices utilised for the entire night (a minimum of 4 hours), starting at dusk for 2 nights per 100 hectares of stratification unit	Harp traps – 12 trap nights over 6 separate nights at 5 different locations. Call detection – Two AnaBat™ II bat detectors used for 6 full nights each recording from 2000 hours to 0500 hours at 5 sites.

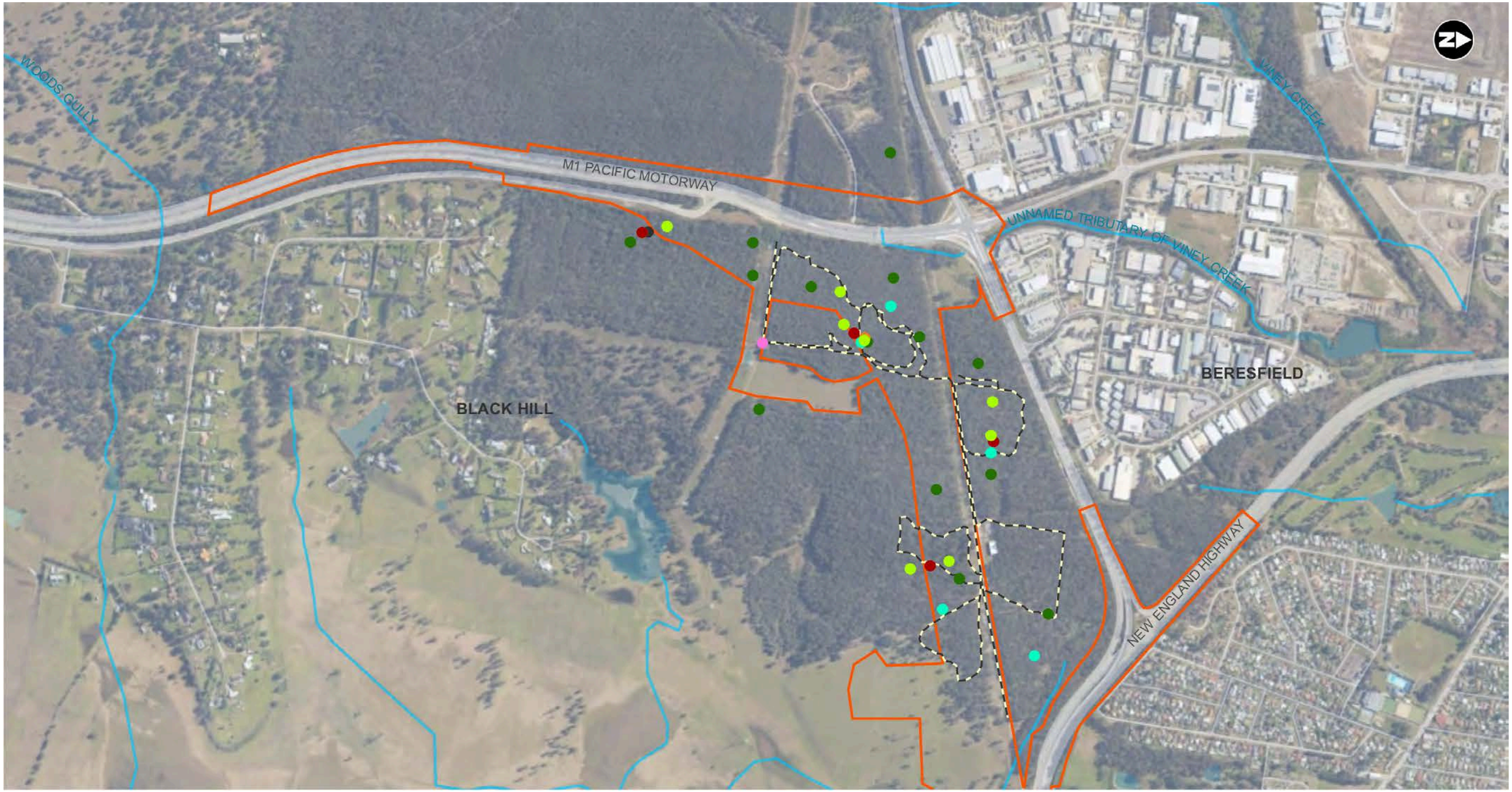
Target fauna species	Minimum survey requirements	Summary of surveys completed
Grey-headed Flying-fox	• Dual credits species, surveys focused on search of the project area for roost camps by searching all areas of the corridor that could comprise roosting habitat.	Habitat stratified by PCT and all forest habitats within the project corridor were targeted. The entire project corridor was traversed multiple times during all targeted flora and fauna surveys totalling over 60 person hours.
Pale-headed Snake	• Survey should be undertaken 1-2 days after rainfall and on humid nights.	Spotlighting – 9 person hours across 3 separate nights in all habitat strata including area-based searches and car spotlighting. An additional 3 nights were carried out in 2018. Total effort of about 20 person hours over 6 nights.

Summary of fauna survey effort

The threatened fauna survey locations are illustrated in **Figure 4-2**. A summary of the survey method used to target fauna species is provided in **Table 4-8.** This includes information on the species targeted, the survey technique and minimum effort documented in survey guidelines and a summary of the technique used within the construction footprint. Specific details of survey methods for all targeted groups in provided **Appendix F**.

Limitations

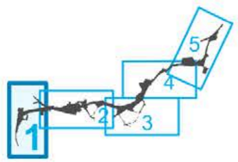
The survey timing adhered to the months detailed in the BBCC for each candidate species. The conclusions of this report are based upon available data and the field surveys and are therefore indicative of the environmental condition of the construction footprint at the time of each survey. It should be recognised that conditions, including the presence of threatened species, can change with time.



Construction footprint
Waterways
Spotlighting tracks

Survey location
- Anabat
- Camera trap
- Elliot trap array
- Frog search and call playback
- Harp trap
- Koala RAM
- Owl call playback
- Time-based bird transects

0 300 600m



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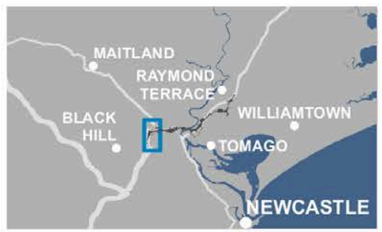

Figure 4-2 Threatened fauna survey locations (map 1 of 5)

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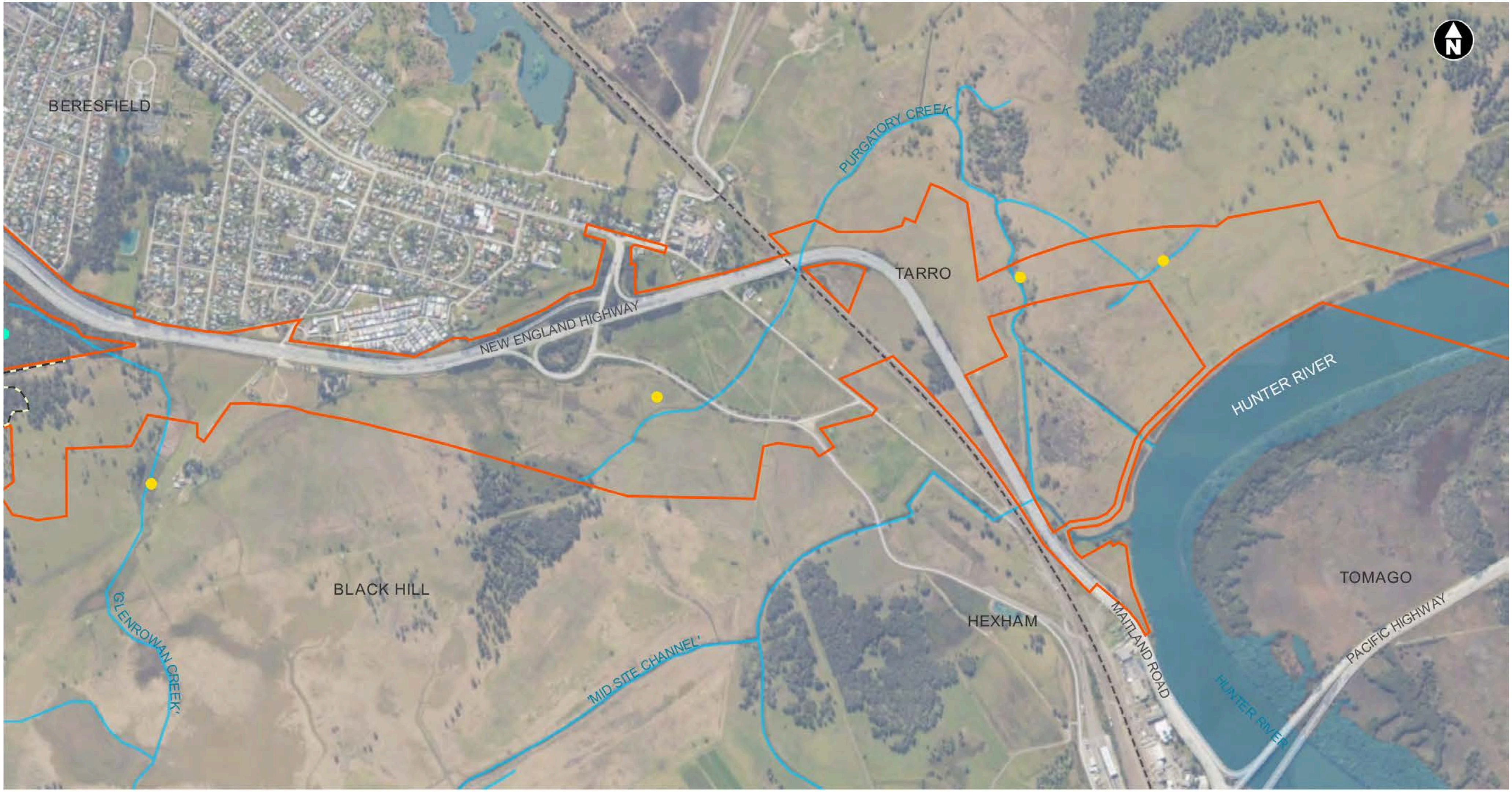

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Construction footprint

Waterways

Main North Rail Line

Spotlighting tracks

Survey location

Frog search and call playback

Time-based bird transects

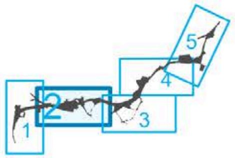

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Figure 4-2 Threatened fauna survey locations (map 2 of 5)

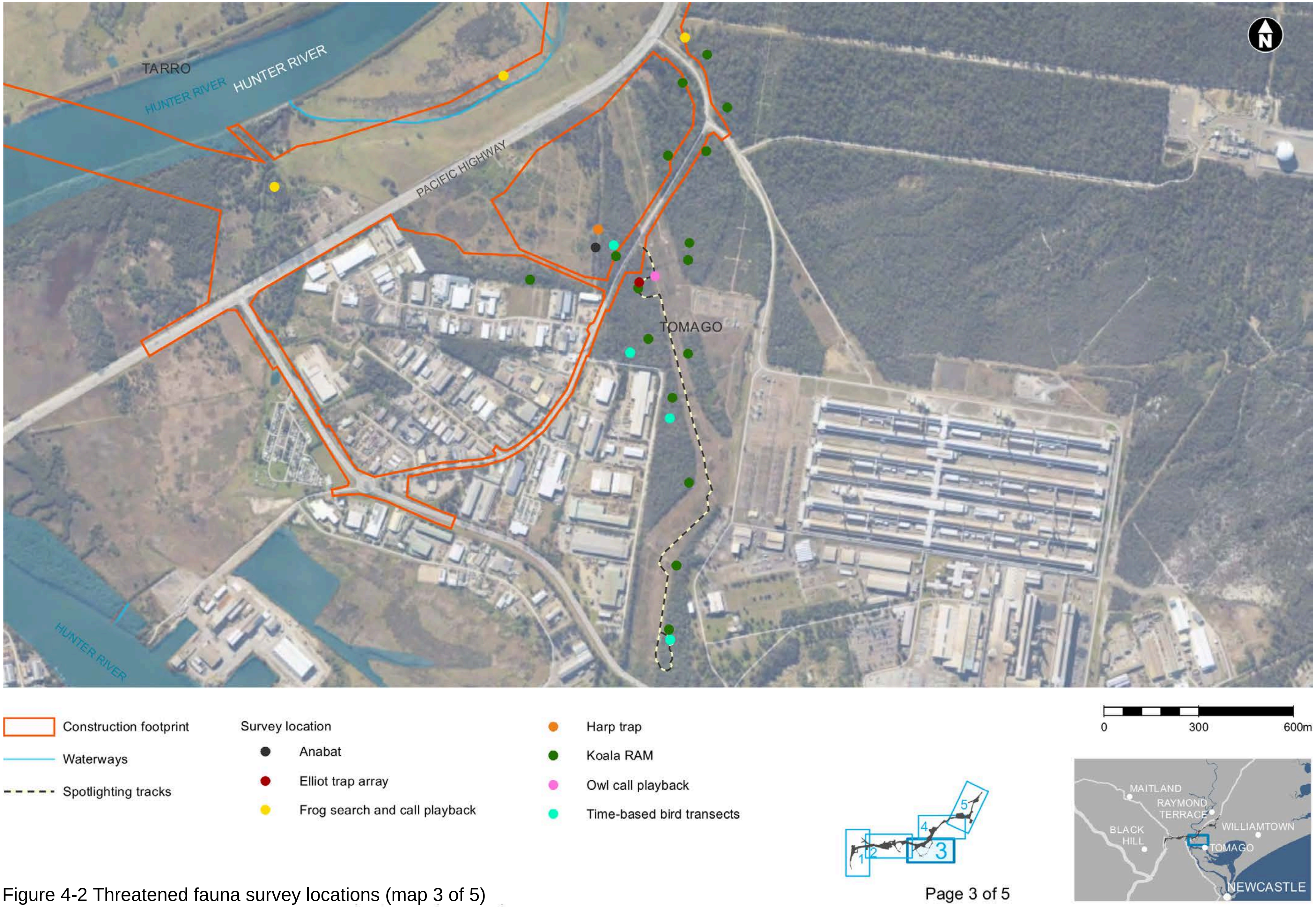
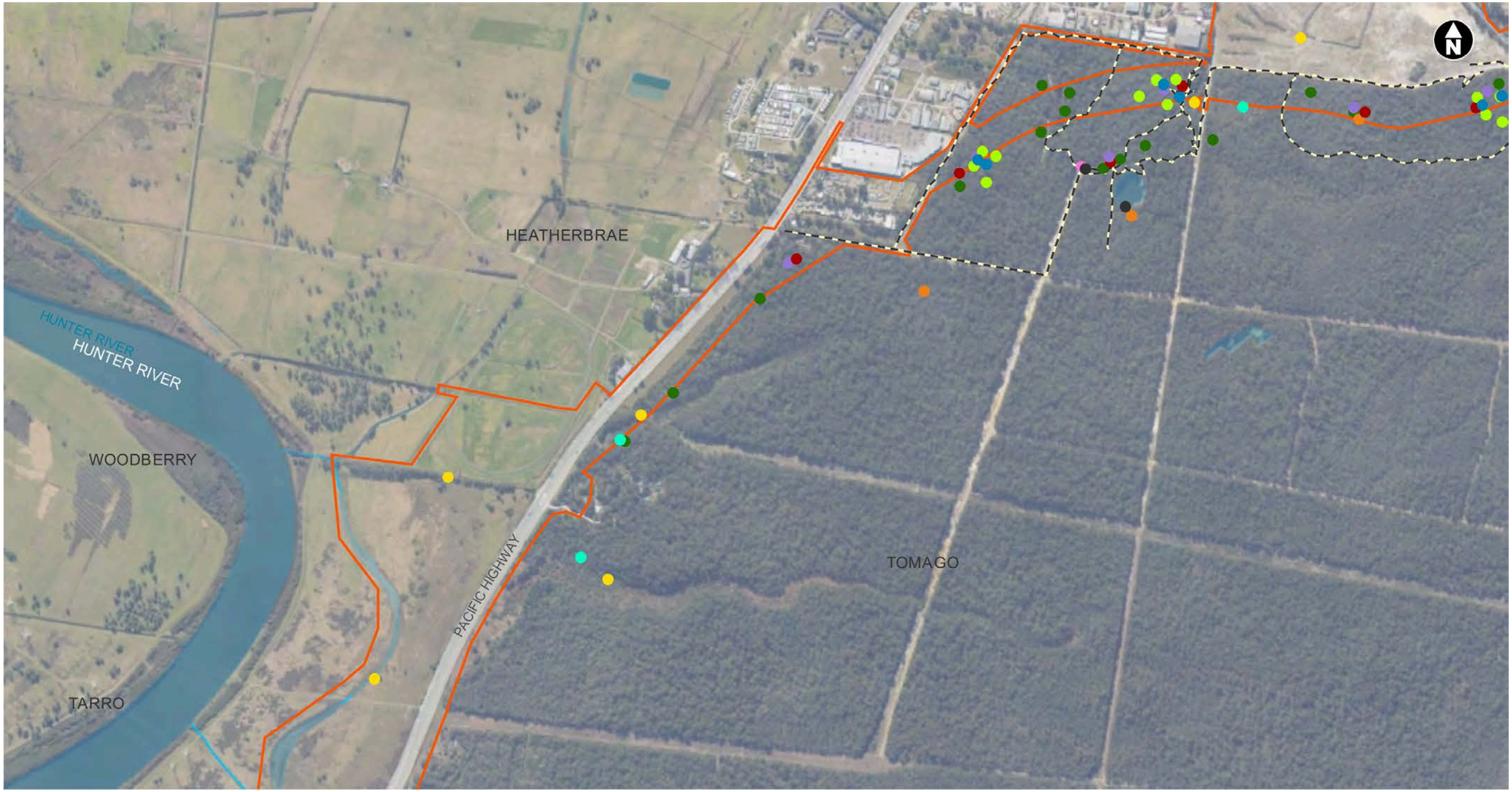


Figure 4-2 Threatened fauna survey locations (map 3 of 5)



Construction footprint
Waterways
Spotlighting tracks

Survey location
- Anabat
- Camera trap
- Elliot trap array
- Frog search and call playback
- Harp trap
- Koala RAM
- Pitfall trap array
- Nest box
- Owl call playback
- Time-based bird transects

0 300 600m

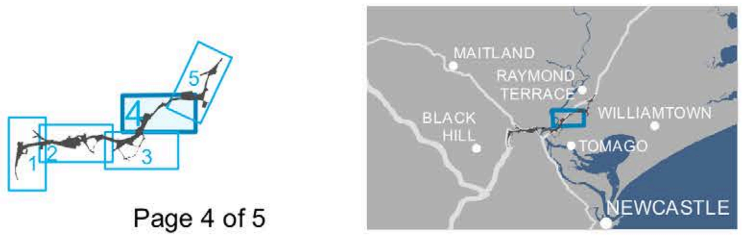


Figure 4-2 Threatened fauna survey locations (map 4 of 5)

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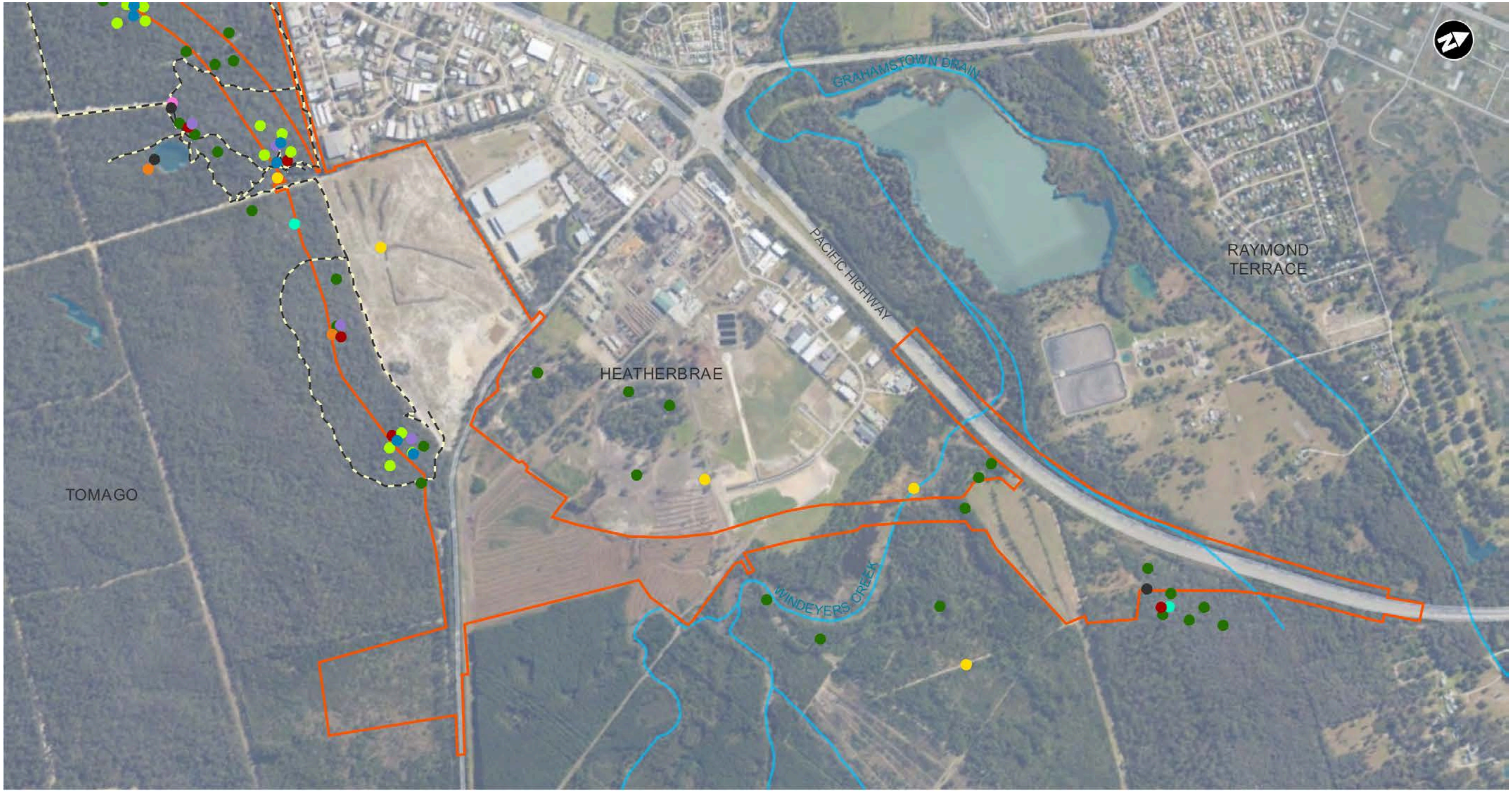
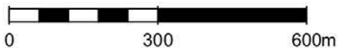


Construction footprint	Survey location	Koala RAM	
Waterways	Anabat	Pitfall trap array	
Spotlighting tracks	Camera trap	Nest box	
	Elliot trap array	Owl call playback	
	Frog search and call playback	Time-based bird transects	
	Harp trap		



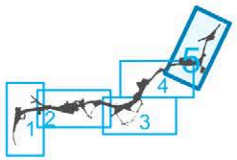


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Figure 4-2 Threatened fauna survey locations (map 5 of 5)

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Table 4-8 Summary of fauna survey methods, targeted species, survey effort and timing

Survey method	Target species	Habitat strata (area)			
		Swamp forest	Dry forest on clay	Dry forest on sand	Freshwater Wetland
		Sites: 1, 2, 10, 12, 18, A1, A3, F1, F4, F6 & F8	Sites: 3, 4, 5, 6, 7, 8, 9, 15, 17, H3, H4 & A4	Sites: 11, 13, 14, 16, H1, H2 & A2	Sites: 19, 20, F2, F3, F5, F7, F9, F10, F11 & F12
Tree-based Elliot traps	Brush-tailed Phascogale, Squirrel Glider, Eastern Pygmy-possum	2016 - 80 trap nights (Site 12 & 18) 2018 - 80 trap nights (Site 12 & 18) Total: 160 trap nights	2016 - 80 trap nights (Site 15 & 17) 2018 - 80 trap nights (Site 15 & 17) Total: 160 trap nights	2016 - 160 trap nights (Site 11, 13, 14 & 16) 2018 - 160 trap nights (Site 11, 13, 14 & 16) Total: 320 trap nights	-
Ground-based Elliot traps	Common Planigale, New Holland Mouse, Eastern Pygmy Possum	2016 - 160 trap nights (Site 12 & 18) 2018 - 160 trap nights (Site 12 & 18) Total: 320 trap nights	2016 - 160 trap nights (Site 15 & 17) 2018 - 160 trap nights (Site 15 & 17) Total: 320 trap nights	2016 - 320 trap nights (Site 11, 13, 14 & 16) 2018 - 320 trap nights (Site 11, 13, 14 & 16) Total: 640 trap nights	-
Pitfall trapping	Common Planigale, New Holland Mouse, Eastern Pygmy Possum	-	-	2016 - 60 trap nights (Site 11, 13, 14 & 16) 2018 - 60 trap nights (Site 11, 13, 14 & 16) Total: 120 trap nights	-
Camera trapping	Brush-tailed Phascogale, Squirrel Glider, Eastern Pygmy-possum, Common Planigale, New Holland Mouse	-	80 trap nights (Site 15 & 17)	120 trap nights (Site 13, 14 & 16)	-
Nest boxes	Eastern Pygmy-possum, Squirrel Glider	-	-	6 nest boxes deployed for 4 months (Site 13, 14 & 16)	-

Survey method	Target species	Habitat strata (area)			
		Swamp forest	Dry forest on clay	Dry forest on sand	Freshwater Wetland
		Sites: 1, 2, 10, 12, 18, A1, A3, F1, F4, F6 & F8	**Sites: 3, 4, 5, 6, 7, 8, 9, 15, 17, H3, H4 & A4**	**Sites: 11, 13, 14, 16, H1, H2 & A2**	**Sites: 19, 20, F2, F3, F5, F7, F9, F10, F11 & F12**
Harp traps	Eastern Bent-winged Bat, Little Bent-winged Bat, Southern Myotis,	-	Six trap nights (Sites H3 & H4)	Six trap nights (Sites H1 & H2)	-
Bat call recording	Eastern Bent-winged Bat, Little Bent-winged Bat, Southern Myotis,	96 hours (Site A1 & A3)	48 hours (Site A4)	48 hours (Site A2)	-
Time and area-based bird surveys	Regent Honeyeater, Swift Parrot, Australasian Bittern, Australian Painted Snipe, Black Bittern, Black-necked Stork	2016 - 240 person minutes (Site 1, 2 & 10) over two surveys each site (winter & spring). 80 person minutes (Sites 12 & 18) over one survey each site (spring) 2018 - 240 person minutes (Site 1, 2 & 10) over two surveys each site (winter & spring). 80 person minutes (Sites 12 & 18) over one survey each site (spring)	2016 - 480 person minutes (Site 3, 4, 5, 6, 7, 8 & 9) over two surveys each site (winter & spring). 80 person minutes (Sites 15 & 17) over one survey each site (spring) 2018 - 480 person minutes (Site 3, 4, 5, 6, 7, 8 & 9) over two surveys each site (winter & spring). 80 person minutes (Sites 15 & 17) over one survey each site (spring)	2016 - 160 person minutes (Sites 11, 13, 14 & 16) over one survey each site (spring) 2018 - 160 person minutes (Sites 11, 13, 14 & 16) over one survey each site (spring)	2016 - 240 person minutes (Site 19 & 20) 2018 - 240 person minutes (Site 19 & 20)
Walked and vehicle spotlighting transects	Koala, Brush-tailed Phascogale, Squirrel Glider, Eastern Pygmy-possum, Pale-headed Snake, Grey-headed Flying-fox	-	2016 – 2 nights including 2 person hours (Site 3, 4 & 15) and 3 person hours (Site 6, 7, 8, 9 & 17) 2018 - 1 night, 6 person hours	2016 - 2 nights including 3 person hours (Site 13 & 14) and 1 person hour (Site 16) 2018 – 2 nights, 12 person hours	-
Area-based frog searches / spotlighting / call playback	Green and Golden Bell Frog, Green-thighed Frog, Wallum Froglet, Mahony's Toadlet	2016 - 22 person hours (4 sites) 2018 - 22 person hours (4 sites)	-	-	2016 - 25 person hours (8 sites) 2016 - 16 person hours (5 sites)

Survey method	Target species	Habitat strata (area)			
		Swamp forest	Dry forest on clay	Dry forest on sand	Freshwater Wetland
		Sites: 1, 2, 10, 12, 18, A1, A3, F1, F4, F6 & F8	**Sites: 3, 4, 5, 6, 7, 8, 9, 15, 17, H3, H4 & A4**	**Sites: 11, 13, 14, 16, H1, H2 & A2**	**Sites: 19, 20, F2, F3, F5, F7, F9, F10, F11 & F12**
Koala (K)RAM & habitat assessment	Koala	2016 - 12 KRAM survey sites 2018 - 12 KRAM survey sites	2016 - 21 KRAM survey sites 2018 - 21 KRAM survey sites	2016 - 28 KRAM survey sites 2018 - 28 KRAM survey sites	-

4.2.3 Threatened species identified

Threatened flora

Four threatened flora species (species credit) were identified within the construction footprint during the field surveys (refer to **Figure 4-3** for locations), these included:

- *Eucalyptus parramattensis* subsp. *decadens* (listed as vulnerable TSC Act and EPBC Act)
- *Diuris arenaria* (listed as endangered TSC Act)
- *Callistemon linearifolius* (listed as vulnerable TSC Act)
- *Persicaria elatior* (listed as vulnerable TSC Act and EPBC Act).

A description of the threatened flora species within and immediately adjacent to the construction footprint are described in the following sections.

(1) A small isolated stand of ***Eucalyptus parramattensis* subsp*. decadens*** was identified at the northern end of the construction footprint on the eastern side of the existing Pacific Highway, in proximity to the proposed connection with the existing Pacific Highway (refer to **Figure 4-3**). A total of 34 plants were confirmed in this location and a targeted survey of a two-kilometre radius confirmed the extent of the population was restricted to a small area of about 2.3 hectares on the edge of a large fragment of Swamp Sclerophyll and Open forest, which continues to the east and north. The habitat is largely contiguous to the east towards Williamtown and is therefore connected to the large Tomago Sandbeds sub-population of *E. parramattensis subsp. decadens*. The population is usually associated with the Tomago Swamp Woodland as defined by the NSW NPWS (2000) and is in the Tomago Sandbeds area. The habitat next to the Pacific Highway is not typical of the species, which prefers deep low nutrient soils. Rather the habitat in the construction footprint at this location is heavy clay soil. It is unknown whether these have been planted as part of the restoration of the previously completed M1 Raymond Terrace bypass. All 34 trees are within the construction footprint.

(2) ***Diuris arenaria*** occurs in sandy soil dominated dry sclerophyll forest and on cleared land and tracks south-east of the Pacific Highway at Heatherbrae. At the time of the Transport surveys, the majority of plants were identified across areas that had been previously cleared (all structural layers) under a separate light industrial precinct Development Application (DA) approval or on existing vehicle access tracks and cleared power easements. It was evident that these plants had colonised the disturbed and cleared land (refer to **Figure 4-3**). Transport conducted targeted surveys for this species over two spring periods in different years to capture temporal variation. This resulted in different abundance counts that was thought to be influenced by variation in conditions prior to the survey, including September 2016 (1,447 individuals recorded) and September 2018 (329 individuals recorded in a drier season). These surveys covered the construction footprint and adjoining areas in order to survey the extent of the population. Using a precautionary approach and taking the larger count from the survey years as the population size estimate (2016 – 1,447 plants), there is an estimated 721 plants within the construction footprint. Of this 721 plants, 560 plants are located on parcel of land that may be used by Transport as a temporary ancillary facility (AS16), however it is noted that this parcel of land is subject to the above mentioned approved DA and has subsequently been maintained and modified by civil works. As such, the project would only directly impact the remaining 161 plants identified in the construction footprint.

(3) Two populations of ***Callistemon linearifolius*** were identified within the construction footprint, the largest around Beresfield / Black Hill in the west of the construction footprint and one small stand, along a track next to Pacific Highway north of Heatherbrae (refer to **Figure 4-3**). This species has been confirmed on several occasions by samples sent to the Royal Botanic Gardens. The population at Black Hill is estimated at 247 plants, of which 150 (about 61 per cent) are within the construction footprint. The seven individuals near Heatherbrae are also in the construction footprint resulting in a total impact to 157 plants.

(4) Three ***Persicaria elatior*** plants were recorded at the edge of an ephemeral shallow tributary in the floodplain on the south side of the Hunter River, within the construction footprint (refer to **Figure 4-3**).

Threatened fauna

Ten threatened fauna species were recorded during the field surveys (refer to **Figure 4-2**), these are:

- **Threatened birds:** Varied Sittella, Grey-crowned Babbler, White-bellied Sea-Eagle and Masked Owl (vulnerable TSC Act)
- **Threatened amphibian:** Wallum Froglet (vulnerable TSC Act)
- **Threatened mammals:** Squirrel Glider (vulnerable TSC Act), Grey-headed Flying-Fox (vulnerable TSC Act and EPBC Act), Little Bent-winged Bat, Eastern False Pipistrelle, Eastern Coastal Free-tail Bat (vulnerable TSC Act).

Further discussion on these, and other species assumed present, are detailed below.

Birds

The Varied Sittella and Grey-crowned Babbler were both recorded during winter bird surveys in open grassy woodland in Beresfield (August 2015). Both species were observed feeding in small flocks (two to three individuals). The Grey-crowned Babbler was observed again at the same location during spring surveys (December 2015). Both species live in small family groups and it is likely that the individuals observed belong to a larger population.

The White-bellied Sea-Eagle was seen soaring high over the construction footprint in two locations. This species is expected to have been passing through the construction footprint, where it may forage. No large stick nests were identified during surveys, though large trees suitable for nesting are in low abundance around the Old Punt Road intersection in Tomago and in PCT 1646 around Heatherbrae.

The Masked Owl (*Tyto novaehollandiae*) was identified at two locations during spotlighting, in Smooth-barked Apple - Blackbutt - Old Man Banksia woodland (PCT 1646) on the edge of cleared land in Heatherbrae and at Black Hill in Spotted Gum – Broad-leaved Mahogany – Red Ironbark open forest (1590) where an individual responded to call playback in the 2018 survey. Extensive surveys have been carried out within the construction footprint for owl nest trees, however none have been located.

Amphibians

The Wallum Froglet (*Crinia tinnula*) was identified at two locations during surveys in January 2016, and again in 2018 with the addition of two more locations. To date, *Crinia tinnula* has been heard calling from the swamp forest wetland to the north and south of the Hunter Region Botanic Gardens, and several sites around Windeyers Creek, including soaked sandy depressions in cleared/burnt pine plantations. This species mostly calls in the winter (when it breeds), however it will call anytime of the year after heavy rainfall. The construction footprint contains some high-quality amphibian habitat with a total of 10 species recorded across all surveys. No other threatened frog species were identified.

Mahony's Toadlet (*Uperoleia mahonyi*) was not positively identified from surveys, however two other *Uperoleia* species were identified during surveys in 2016 in sandy habitat around Heatherbrae, including *U. laevigata* and *U. tyleri*. These surveys were done before *Uperoleia mahonyi* was described and listed under the BC Act. Survey conditions in 2018 were less ideal due to lower rainfall and these other *Uperoleia* species were not identified again. One *Uperoleia* species was heard calling in 2018 from the large swamp drainage line south of the Hunter Botanic Gardens, however it is currently not possible to identify *Uperoleia mahonyi* on call alone. Although *Uperoleia mahonyi* was not listed under the TSC Act, assessment of impact in accordance with Section 9 of the FBA was specified as an agency requirement to the SEARs from EES Group. Considering the proximity of locations where this species is known to occur in Tilligerry State Conservation Area east of the construction footprint, and the presence of suitable sandy wallum habitat, a conservative approach has been taken to assume *Uperoleia mahonyi* is present. Suitable habitat for Wallum Froglet (*Crinia tinnula*) has been used to assess the potential impact on Mahony's Toadlet.

Despite the presence of a population in the locality and the presence of suitable habitat in the study area, the Green and Golden Bell Frog was not identified from surveys. This species is therefore considered to have a low likelihood of occurring in the construction footprint and unlikely to be impacted by the project.

Mammals

Two Squirrel Gliders (*Petaurus norfolcensis*), one male and one female, were caught in tree traps over two consecutive nights near Heatherbrae in 2016. Evidence of gliders (v-shaped scars on *Corymbia gummifera* trees) was also observed about 700 metres west, however no gliders were caught here. Squirrel Glider has also been recently recorded near the AGL Gas Storage Facility in Tomago. Considering this species has a minimum patch size of four hectares (Fallding 2015), it is likely that the individuals trapped use much of that contiguous area of habitat and possibly as far down as Tomago near Old Punt Road. Squirrel Glider was also identified in the west of the construction footprint around Black Hill in 2018, where one individual was observed feeding in a large flowering Grey Ironbark. Suitable habitat for this species is widespread throughout woodland in the construction footprint.

Brush-tailed Phascogale (*Phascogale tapoatafa*), Eastern Pygmy-possum (*Cercartetus nanus*), Common Planigale (*Planigale maculata*) and Eastern Chestnut Mouse (*Pseudomys novaehollandiae*) were not identified from targeted field surveys despite an intensive targeted effort. These species are therefore considered to have a low likelihood of occurring in the construction footprint. Trapping also identified a range of common fauna species including Brush-tailed Possum (*Trichosurus vulpecula*), Sugar Glider (*Petaurus breviceps*) and Brown Antechinus (*Antechinus stuartii*).

The Grey-headed Flying-fox was recorded around Windeyers Creek on Weathertex land in the north of the construction footprint. Numerous individuals could be heard calling and were seen flying around over the water body. A couple of individuals were also observed foraging in tree during spotlighting near site 8. No Grey-headed Flying Fox camps were identified in the construction footprint, however there are five nationally important roost camps in proximity to the construction footprint (Raymond Terrace two kilometres from the construction footprint, Carrington Mangroves 10 kilometres from the construction footprint, Blackbutt Reserve 12 kilometres from the construction footprint, Glen William 28 kilometres from the construction footprint and Cessnock 34 kilometres from the construction footprint). All flowering trees and shrubs (particularly winter flowering species) are likely important foraging habitat for individuals that use these camp sites.

One threatened insectivorous bat was identified by trapping and survey of roosting habitat (i.e. culverts and bridges – refer to discussion below) and a further two species were recorded via Anabat: Little Bent-winged Bat (*Miniopterus australis*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) and Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*). Foraging habitat for these species is widespread throughout the construction footprint. These species are likely to fly across cleared land to move between habitat patches. Large trees with hollows in the construction footprint likely provide roosting habitat for the Eastern False Pipistrelle, and Eastern Coastal Free-tailed Bat.

Potential roosting habitat (i.e. culverts and bridges) in the construction footprint that may be impacted by construction work were inspected on numerous occasions throughout the survey period and most recently in June 2020. The following describes the results of the surveys:

- Survey identified one microbat roosting under the existing Pacific Highway bridge over Windeyers Creek at Heatherbrae. This species was identified as a Little Bent-winged Bat (*Miniopterus australis*) and was roosting in a shallow join between the concrete bridge sections (**Photograph 36**). This location presents good quality roosting habitat (**Photograph 37**), however is unlikely to be used as a breeding/maternity site as there are no large or deep areas available. The use of this roosting space is likely by low numbers of individuals as they travel around the locality foraging. Although the bridge is in the construction footprint, there is no design or works planned at this location and therefore the bridge would not be directly impacted by the project

- Two 1050-millimetre culverts underneath Old Punt Road with a small amount of water and surrounded by swamp forest (refer to Photographs 38 and 39). Two 1200-millimetre culverts are located under the northern end of Lenaghans Drive (refer to Photographs 40 and 41). These culverts were inspected in their entirety and no bats were identified at the time of surveys. Shallow culvert joins may offer suitable roosting habitat for individuals travelling through locality. No likely breeding/maternity sites were identified
- The existing culvert along the upper section of Purgatory Creek underneath the Aurizon Hexham Train Support Facility access road (around 400 metres south east of the Anderson Drive exit at Tarro) that would be removed for the realignment consists of two 1200-millimetre box culverts. Previous total flooding was evident, and all culvert joins were filled with expansion foam. There are no suitable roosting opportunities in this location
- Two sets of culverts near Old Punt Road that are planned to be decommissioned as part of the project were surveyed, however both were more than half flooded and had thick macrophyte vegetation. Considering this, these culverts are unlikely to provide suitable roosting opportunities
- Similarly, two sets of small twin culverts (600 millimetre) that connect the swamp wetlands north and south of the Hunter Region Botanic Gardens to the floodplain west of the construction footprint were surveyed. Both sets of culverts contained very thick vegetation at the entrance and evidence of complete flooding, therefore were considered unlikely to provide suitable roosting opportunities
- A 1200-millimetre box culvert below the access road to the Hexham Train Support Facility, this structure is completely filled during large rainfall events and there are no expansion joints or lift holes within the structure that could provide roosting opportunities
- All other culverts surveyed are small (less than 500 millimetres in diameter) and contained few roosting opportunities for bats and showed evidence of inundation during high rainfall and high sedimentation levels (refer to **Photograph 42** and **Photograph 43**).

Photograph 36: A single Little Bent-winged Bat (*Miniopterus australis*) roosting under the Pacific Highway bridge over Windeyers Creek

Photograph 37: Windeyers Creek bridge

Photograph 38: Double 1050 mm culvert under Old Punt Road provides the best roosting opportunities

Photograph 39: The view inside a 1050 mm culvert under Old Punt Road shows an abundance of cobwebs suggesting no recent use

Photograph 40: Double 1200 mm culvert under the northern end of Lenaghans Drive

Photograph 41: Shallow gaps where culvert sections are joined may provide roosting opportunities

Photograph 42: 500 mm culvert on Lenaghans Drive half filled with sediment

Photograph 43: The view inside a 500 mm culvert on Lenaghans Drive filled with sediment

Section 4.2.3 outlines the results of the threatened species surveys while recorded threatened species are shown on **Figure 4-3**.

Koala (*Phascolarctos cinereus*)

No Koalas were recorded by spotlighting or daytime searches. Call playback was used at the start of each spotlighting transect where the call of the species was played for five minutes from a loud speaker. No Koalas were recorded from call playback. From the 61 Koala Rapid Assessment Method (KRAM) scat plots searched in the survey area in 2016 and a repeat search in 2018, none of these plots showed evidence of Koala activity (scats) suggesting the absence of resident Koalas in the construction footprint, or very low and infrequent visitation by a small number of koalas. Importantly, the 2019 bushfires did not impact any potential koala habitat in the construction footprint.

Three primary feed tree species are present, Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*E. tereticornis*) and Drooping Red Gum (*E. parramattensis* subsp. *decadens*), from 21 plots (34.4 per cent) and two secondary Koala feed tree species are present Grey Gum (*E. punctata*) and Red Mahogany (*E. resinifera*), these were present in six plots (9.8 per cent). The remaining 34 plots (55.7 per cent) did not contain Koala feed tree species. These plots were surveyed again in 2018 to check for scats.

The Koala referral guidelines under the EPBC Act (DoE 2014) were reviewed and assessed in conjunction with the survey results to determine the status of the habitat in the construction footprint for the Koala and potential impacts of the project. The northern portion of the construction footprint occurs within the Port Stephens Council LGA within an area mapped as known Koala habitat by the Port Stephens CKPoM (PSC and AKF 2002). The construction footprint has also been identified in the Lower Hunter Koala Study as containing very high and high value Koala habitats (EcoLogical 2014). It should be noted that the proposed highway footprint significantly avoided koala habitat in the Heatherbrae to Raymond Terrace section Port Stephens Council LGA) by the fact that the highway would traverse the western edge of the existing urban infrastructure in this location. Importantly this would also result in very minimal fragmentation of habitat and is not expected to significantly impact on the movements of transient koalas.

While koala habitat is mapped in parts of the construction footprint from desktop data, the field data for this assessment indicates an absence of the species is these specific areas along the construction corridors. In order to make an assessment of whether the impacts of the action are likely to have a significant impact on the Koala, the background review and field survey data has been used to assess the sensitivity, value and quality of the Koala habitat in the impact area. These attributes have been assessed using the Koala habitat assessment tool (DoE 2013) to identify whether habitat critical to the survival of the species is present. According to the guidelines, impact areas that score five or more using the habitat assessment tool for the Koala contain habitat critical to the survival of the Koala (DoE 2013). The outcomes of the Koala habitat assessment tool are shown in **Table 4-9** which indicates that the habitat in the construction footprint between Tomago and Heatherbrae scores six and therefore meets the definition of critical habitat.

While it is noted that the majority of Koala recorded sightings in the locality are relatively old, occasional and infrequent koala sightings have been reported at the northern extent of the construction footprint, in proximity to the Pacific Highway, every year since 2011. The most recent records are from 2018. One recorded sighting from 2018 is located about two kilometres north of the construction footprint in Raymond Terrace east of the Pacific Highway. The consistent but relatively low number of sightings each year between Tomago, Raymond Terrace/Ferodale and Williamtown demonstrate the presence of a low density population accessing habitat close the construction footprint on the eastern side. The project is located in an area that likely represents the south western extent of the Port Stephens population and existing fragmentation in the landscape to the north and east may result in less Koala occupation within habitats in the construction footprint. However, the habitats within the construction footprint are connected to the east (suitable for a species known to exist in urban landscapes) and hence low numbers of Koalas are likely to occur on occasion. As the northern end of the project is located along the edge of cleared and industrial land, and there is no further habitat between the Pacific Highway and the Hunter River through Tomago and Heatherbrae, the project is not expected to significantly impact the movements of Koalas, and no targeted connectivity measures are required for Koalas.

While Koala feed tree species also occur at the south western end of the project around Black Hill (i.e. the primary feed tree *Eucalyptus tereticornis* and secondary feed trees *E. agglomerata* and *E. eugenioides*) there are no historic sightings at Black Hill and the scat surveys suggest no evidence of Koala presence in this portion of the construction footprint. Any loss of habitat at Black Hill is not expected to impact on the Koala.

Table 4-9 Koala habitat assessment tool applied to the project to assessment significance of habitat between Tomago and Heatherbrae (DoE 2013)

Attribute	Score	Coastal	Site assessment
Koala occurrence	+2 (high)	Evidence of one or more koalas within the last 2 years.	+1 (medium). Most recent records associated with the Port Stephens population are from 2018
	+1 (medium)	Evidence of one or more koalas within 5 kilometres of the edge of the impact area within the last 5 years.	
	0 (low)	None of the above.	
Vegetation composition	+2 (high)	Has forest or woodland with 2 or more known koala food tree species in the canopy.	+2 (high) survey results indicates 3 primary and 2 secondary feed tree species in patchy locations along the project
	+1 (medium)	Has forest or woodland with only 1 species of known koala food tree present in the canopy.	
	0 (low)	None of the above.	
Habitat connectivity	+2 (high)	Area is part of a contiguous landscape ≥ 500 hectares.	+2 (high) the construction footprint is on the western edge of a large contiguous area of habitat which stretches from Tomago/Heatherbrae to the east of the Pacific Highway. There is limited habitat to the west of the Pacific Highway. Pine forest around Heatherbrae does not form part of this contiguous habitat.
	+1 (medium)	Area is part of a contiguous landscape < 500 hectares, but ≥ 300 hectares.	
	0 (low)	None of the above.	
Key existing threats	+2 (low)	Little or no evidence of koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for koala occurrence.	+1 (medium) evidence of irregular vehicle strikes. Comprehensive Koala Management Plan (Port Stephens Council, 2002) states 325 koala were hit by cars in the LGA between 1987 and 1998.
	+1 (medium)	Evidence of infrequent or irregular koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for koala occurrence.	
	0 (high)	Evidence of frequent or regular koala mortality from vehicle strike or dog attack in the construction footprint at present, or Areas which score 0 for koala occurrence and have a significant dog or vehicle threat present.	
Recovery value	+2 (high)	Habitat is likely to be important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1-1.	0 (low). The area of potential habitat exists as fragments or along the edge of cleared land
		Score	**6 – Critical habitat***

*Scores of five or more represent habitat critical to the survival of the koala (DoE 2013)

Summary of threatened species survey results

Table 4-10 displays a summary of all the threatened species that have been assessed, including specific information for each species as identified by the BBCC.

Table 4-10 Threatened species survey results

Species	Ecosystem or species credit species	Identification method (assumed, survey, expert report)	Sensitivity to Loss	TS (Threatened Species) offset multiplier value	Habitat constraints (BBCC) Habitat feature/ component*	Within construction footprint (ha/ individuals)
Flora						
Drooping Red Gum (*Eucalyptus parramattensis subsp. decadens*)	Species	Survey	High (High level biodiversity concern)	1.4	A small population occurs in disturbed habitats within ecotone areas between elevated sandy soils and swampy areas at the northern end of the project in Heatherbrae. Associated PCTs include PCT ID: 1716, 1646, 1717.	34 plants
Maundia triglochinoides	Species	Survey	Moderate (High level biodiversity concern)	2.6	Small patch identified up-stream of the construction footprint in the aquatic habitats of Windeyers Creek Associated PCTs include PCT ID: 1742, 1716, 1717, 1071, 1736	0 - avoided
Netted Bottlebrush (*Callistemon linearifolius*)	Species	Survey	Moderate (Moderate level biodiversity concern)	1.4	Three populations totalling 259 plants within Spotted Gum Ironbark forest (primary occurrence) and Swamp Sclerophyll forest in the construction footprint occurring with numerous hybrid plants (not counted). Associated PCTs include PCT ID:1590, 1646	157 plants
Sand Doubletail (*Diuris arenaria*)	Species	Survey	Very High (Very High-level biodiversity concern)	7.71	Identified in woodland and cleared easements/tracks with sandy soils around Heatherbrae. Associated PCTs include PCT ID:1646. The largest portion of the population has been reported in land that was cleared of vegetation as part of a separate approved DA, adjacent, and outside the project with other individuals located along tracks and power easements.	161 plants
Small-flower Grevillea (*Grevillea parviflora subsp. parviflora*)	Species	Survey	Moderate (High level biodiversity concern)	1.4	Occurs on the edge of a small isolated remnant patch of Spotted Gum-Ironbark forest at Tomago Associated PCTs include PCT ID:1590	0 - avoided

Species	Ecosystem or species credit species	Identification method (assumed, survey, expert report)	Sensitivity to Loss	TS (Threatened Species) offset multiplier value	Habitat constraints (BBCC) Habitat feature/ component*	Within construction footprint (ha/ individuals)
Tall Knotweed (*Persicaria elatior*)	Species	Survey	High (High level biodiversity concern)	1.3	3 plants identified on the edge of a floodplain drainage line. Associated PCTs include PCT ID: 1716, 1717, 1727, 1736, 1742 and 1071	3 plants
Fauna						
Australasian Bittern (*Botaurus poiciloptilus*)	Species	Assumed	High	1.3	Land containing brackish or freshwater wetlands. heaths. Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1742, 1746, 1727, 1071, 1736 Disturbed and modified examples of these PCTs (e.g. 1736 – Moderate and 1717 – Poor) do not represent suitable potential habitat and were excluded from calculations)	43.64 ha of potential habitat
Australian Painted Snipe (*Rostratula australis*)	Ecosystem	Assumed	High	1.3	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1742, 1746, 1727, 1071, 1736 Disturbed and modified examples of these PCTs (e.g. 1736 – Moderate and 1717 – Poor) do not represent suitable potential habitat and were excluded from calculations)	43.64 ha of potential habitat
Black Bittern (*Ixobrychus flavicollis*)	Species	Assumed	Moderate	1.3	Land within 40 metres of freshwater and estuarine wetlands, in areas of permanent water and dense vegetation or emergent aquatic vegetation Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1724, 1747, 1742, 1716, 1746, 1717, 1727, 1071, 1736 Disturbed and modified examples of these PCTs (e.g. 1736 – Moderate and 1717 – Poor) do not represent suitable potential habitat and were excluded from calculations)	61.95 ha of potential habitat

Species	Ecosystem or species credit species	Identification method (assumed, survey, expert report)	Sensitivity to Loss	TS (Threatened Species) offset multiplier value	Habitat constraints (BBCC) Habitat feature/ component*	Within construction footprint (ha/ individuals)
Black-chinned Honeyeater (eastern subspecies) (*Melithreptus gularis subsp. gularis*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590 and 1746	43.1 ha of potential habitat
Brown Treecreeper (eastern subspecies) (*Climacteris picumnus subsp. victoriae*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1588, 1590 and1598	49.9 ha of potential habitat
Corben's Long-eared Bat (*Nyctophilus corbeni*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID: 1646	28.59 ha of potential habitat
Diamond Firetail (*Stagonopleura guttata*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590	41.88 ha of potential habitat
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	Ecosystem	Survey	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1716, 1590, 1646, 1717	82.78 ha of potential habitat
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	Ecosystem	Survey	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1716, 1590, 1646, 1717	82.78 ha of potential habitat

Species	Ecosystem or species credit species	Identification method (assumed, survey, expert report)	Sensitivity to Loss	TS (Threatened Species) offset multiplier value	Habitat constraints (BBCC) Habitat feature/ component*	Within construction footprint (ha/ individuals)
Glossy Black-Cockatoo (*Calyptorhynchus lathami*)	Ecosystem	Assumed	Moderate (High level biodiversity concern)	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590 and 1646	70.47 ha of potential habitat
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590, 1646, 1716, 1717 and 1747	85.05 ha of potential habitat
Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)	Ecosystem	Survey	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590, 1646	70.47 ha of potential habitat
Grey-headed Flying-fox (*Pteropus poliocephalus*)	Ecosystem	Survey	Moderate (High level biodiversity concern)	-	Land within 40 metres of rainforest, coastal scrub, riparian or estuarine communities Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1747, 1716, 1590, 1646, 1717	85.05 ha of potential foraging habitat, no roost camps located
Hooded Robin (south-eastern form) (*Melanodryas cucullata subsp. cucullata*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID: 1590 and 1646	70.47 ha of potential habitat

Species	Ecosystem or species credit species	Identification method (assumed, survey, expert report)	Sensitivity to Loss	TS (Threatened Species) offset multiplier value	Habitat constraints (BBCC) Habitat feature/ component*	Within construction footprint (ha/ individuals)
Koala (*Phascolarctos cinereus*)	Species	Assumed	Moderate (High level biodiversity concern)	2.6	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID: Primary feed trees: 1727, 1590, 1646, 1717, 1724, 1598 Disturbed and modified examples of these PCTs (e.g. 1717 – Poor) do not represent suitable potential habitat and were excluded from calculations Areas of PCT ID 1590 and 1588 in the west of the construction footprint were excluded from the impact area calculation as there is no known Koala population in Black Hill west of the M1 Pacific Motorway. No evidence of koalas was identified within this portion of the construction footprint despite extensive scat searches, and nocturnal surveys. This impact is determined on a precautionary basis considering the presence of known feed trees, and a wider koala population in the Port Stephens Council LGA. Impacts are described in the area from Tomago to Heatherbrae	51.1 ha of potential habitat
Little Bent-winged Bat (*Miniopterus australis*)	Ecosystem and Species credit (breeding habitat)	Survey	Moderate (Very High-level biodiversity concern)	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1716, 1590, 1646, 1717	82.78 ha of potential foraging habitat, no roosting / breeding sites identified
Little Eagle (*Hieraaetus morphnoides*)	Ecosystem	Assumed	Moderate (Moderate level biodiversity concern)	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590, 1646, 1716, 1717, 1727, 1736, 1071, 1742, 1746 and 1747	163.27 ha of potential habitat

Species	Ecosystem or species credit species	Identification method (assumed, survey, expert report)	Sensitivity to Loss	TS (Threatened Species) offset multiplier value	Habitat constraints (BBCC) Habitat feature/ component*	Within construction footprint (ha/ individuals)
Little Lorikeet (*Glossopsitta pusilla*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1588, 1590, 1598, 1646, 1716 and 1717	90.84 ha of potential habitat
Mahony's Toadlet (*Uperoleia mahonyi*)	Newly listed species under the BC Act – Not listed under TSC Act or included in the BBCC	Assumed	High	-	No habitat constraints. This species was not positively identified during surveys, however, is assumed to be present on a precautionary basis based on proximity of records in Tilligerry State Conservation Area and presence of suitable habitat. This species has the same associated PCTs as *Crinia tinnula* listed above, therefore the same habitat polygons were used.	3.21 ha of potential habitat
Masked Owl (*Tyto novaehollandiae*)	Ecosystem	Survey	Moderate (High level biodiversity concern)	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590 and 1646	70.47 ha of potential habitat
Powerful Owl (*Ninox strenua*)	Ecosystem	Assumed	Moderate (High level biodiversity concern)	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590 and 1646	70.47 ha of potential habitat
Regent Honeyeater	Ecosystem	Assumed	Very High (Very High-level biodiversity concern)	-	No mapped important areas within the construction footprint and habitat within the construction footprint is considered low-quality for this species (Birdlife Australia 2013). Impact has been calculated by the area of associated within the construction footprint, including PCT ID: 1590, 1646, 1649, 1717, 1724 and covers areas of fragmented vegetation which are likely to be of low value if used.	81 ha of potential habitat

Species	Ecosystem or species credit species	Identification method (assumed, survey, expert report)	Sensitivity to Loss	TS (Threatened Species) offset multiplier value	Habitat constraints (BBCC) Habitat feature/ component*	Within construction footprint (ha/ individuals)
Scarlet Robin (*Petroica boodang*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590 and 1598	42.3 ha of potential habitat
Speckled Warbler (*Chthonicola sagittata*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1588, 1590, 1598 and 1646	78.53 ha of potential habitat
Spotted Harrier (*Circus assimilis*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1727, 1736, 1071, 1742 and 1746	78.22 ha of potential habitat
Spotted-tailed Quoll (*Dasyurus maculatus*)	Ecosystem	Assumed	High	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1588, 1590, 1646, 1649, 1716 and 1717 This species is considered to have a lower chance of occurring west of the Hunter River, so these areas have been excluded from the impact. Area of PCT 1727 have also been excluded as they are not considered likely to provide suitable habitat.	50 ha of potential habitat
Square-tailed Kite (*Lophoictinia isura*)	Ecosystem	Assumed	Moderate (Moderate level biodiversity concern)	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590 and 1646	70.47 ha of potential habitat
Squirrel Glider (*Petaurus norfolcensis*)	Ecosystem	Captured in Elliot trap and spotlighting	Moderate (High level biodiversity concern)	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1716, 1646, 1717, 1588, 1590, 1724, 1649	93.36 ha of potential habitat

Species	Ecosystem or species credit species	Identification method (assumed, survey, expert report)	Sensitivity to Loss	TS (Threatened Species) offset multiplier value	Habitat constraints (BBCC) Habitat feature/ component*	Within construction footprint (ha/ individuals)
Swift Parrot (*Lathamus discolor*)	Ecosystem	Assumed	Very High (Very High-level biodiversity concern)	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590, 1646, 1716 and 1717. No mapped important areas within the construction footprint and habitat within the construction footprint is considered low-quality for this species (Birdlife Australia 2013). Impact has been calculated by the area of associated within the construction footprint and covers areas of fragmented vegetation which are likely to be of low value if used.	82.78 ha of potential habitat
Varied Sittella (*Daphoenositta chrysoptera*)	Ecosystem	Survey	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1598, 1588, 1716, 1590, 1646, 1649, 1717, 1727	100.96 ha of potential habitat
Wallum Froglet (*Crinia tinnula*)	Species	Survey	Moderate (Moderate level biodiversity concern)	1.3	Land within 40 metres of coastal swamps and wet heaths. This species was identified at three locations within the construction footprint. Habitat polygons were generated by applying a 40m buffer around these three swamps (Windeyers Creek and the two drainage lines surrounding the Hunter Region Botanic Gardens). Associated PCTs within this habitat polygon include PCT ID: 1646, 1717, 1071 This also includes 0.89 ha of sandy pine plantation on the edges of Windeyers Creek.	3.21 ha of confirmed habitat
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	Newly listed species under the BC Act – Not listed under TSC Act or included in the BBCC	Survey	Moderate	-	No habitat constraints identified by the BBCC. The BioNet Threatened Biodiversity Classification Database states breeding habitat is live large old trees within 1km of a rivers, lakes, large dams or creeks, wetlands and coastlines AND the presence of a large stick nest within tree canopy; or an adult with nest material; or adults observed duetting within breeding period.	174.3 ha of potential foraging habitat. No large stick nests identified.

Species	Ecosystem or species credit species	Identification method (assumed, survey, expert report)	Sensitivity to Loss	TS (Threatened Species) offset multiplier value	Habitat constraints (BBCC) Habitat feature/ component*	Within construction footprint (ha/ individuals)
White-fronted Chat (*Epthianura albifrons*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1736, 1071, 1742, 1746 and 1747	71.7 ha of potential habitat
Yellow-bellied Glider (*Petaurus australis*)	Ecosystem	Assumed	Moderate	-	No habitat constraints Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID: 1590 and 1646	70.47 ha of potential habitat

*Habitat constraints come from the BBCC. Not all species have specific habitat constraints identified. Additional information has been provided where available from the BioNet TBDC, including associated PCTs.

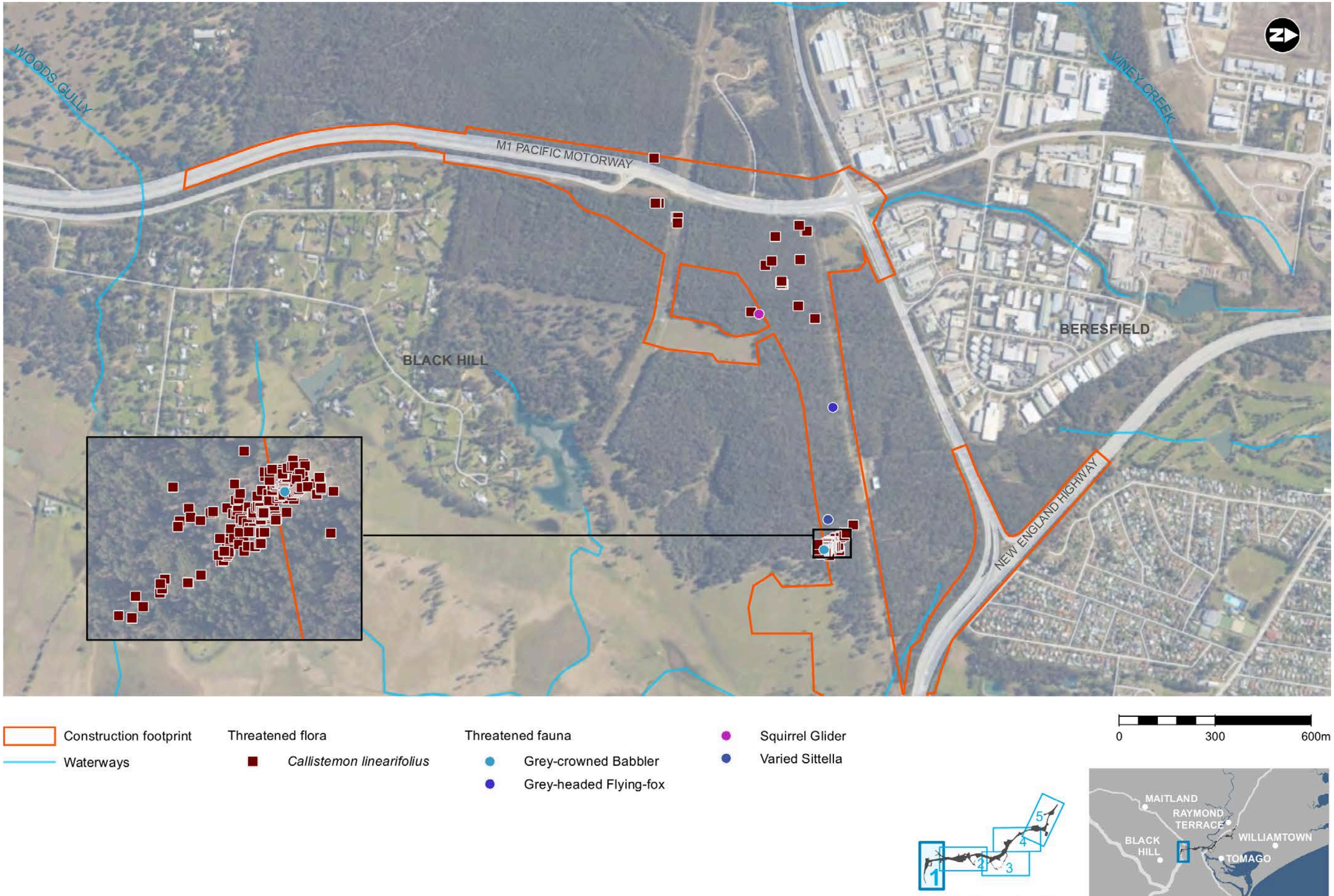


Figure 4-3 Recorded threatened species (map 1 of 5)

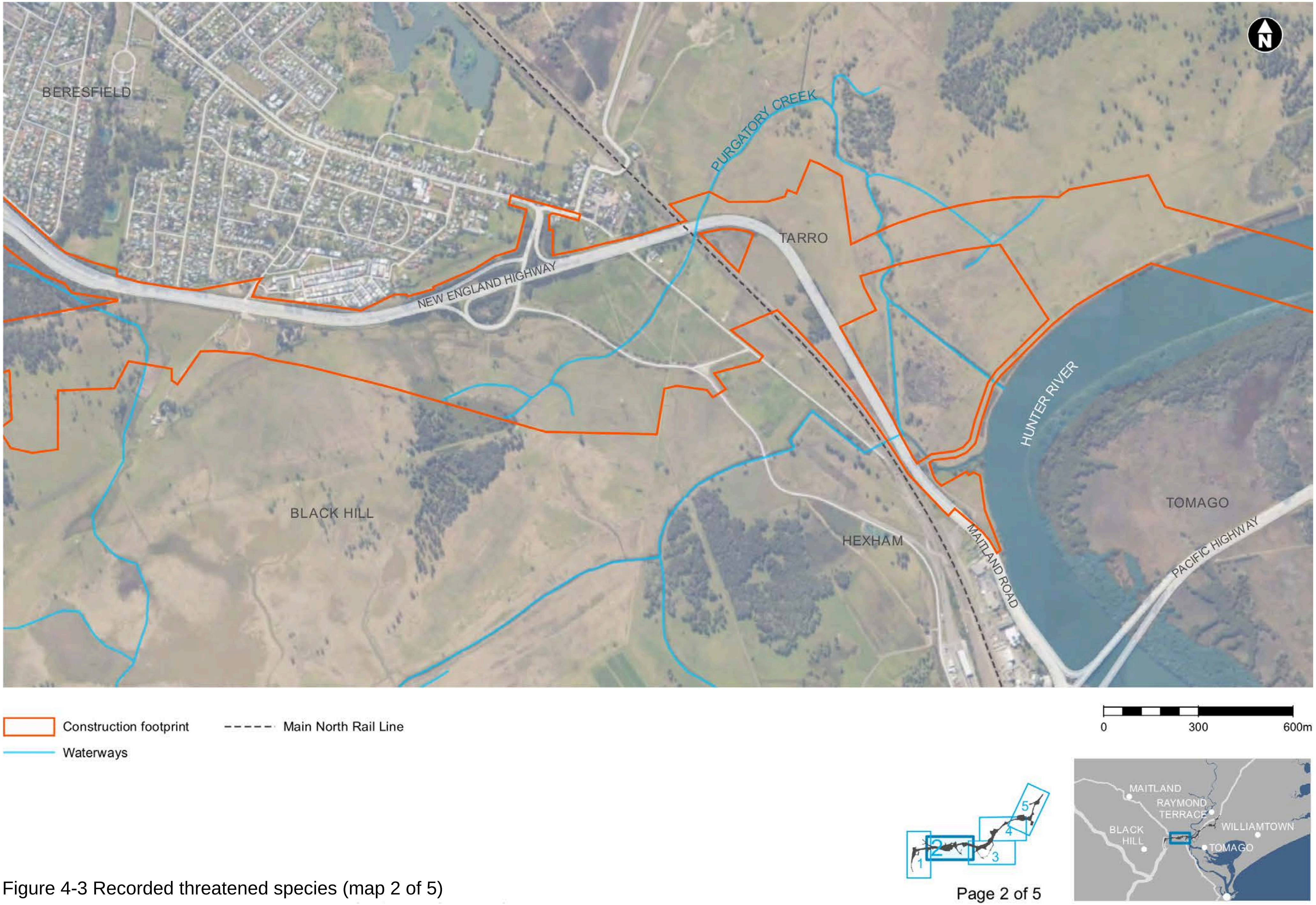


Figure 4-3 Recorded threatened species (map 2 of 5)

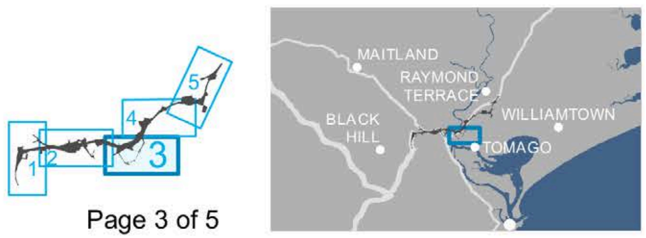


Figure 4-3 Recorded threatened species (map 3 of 5)

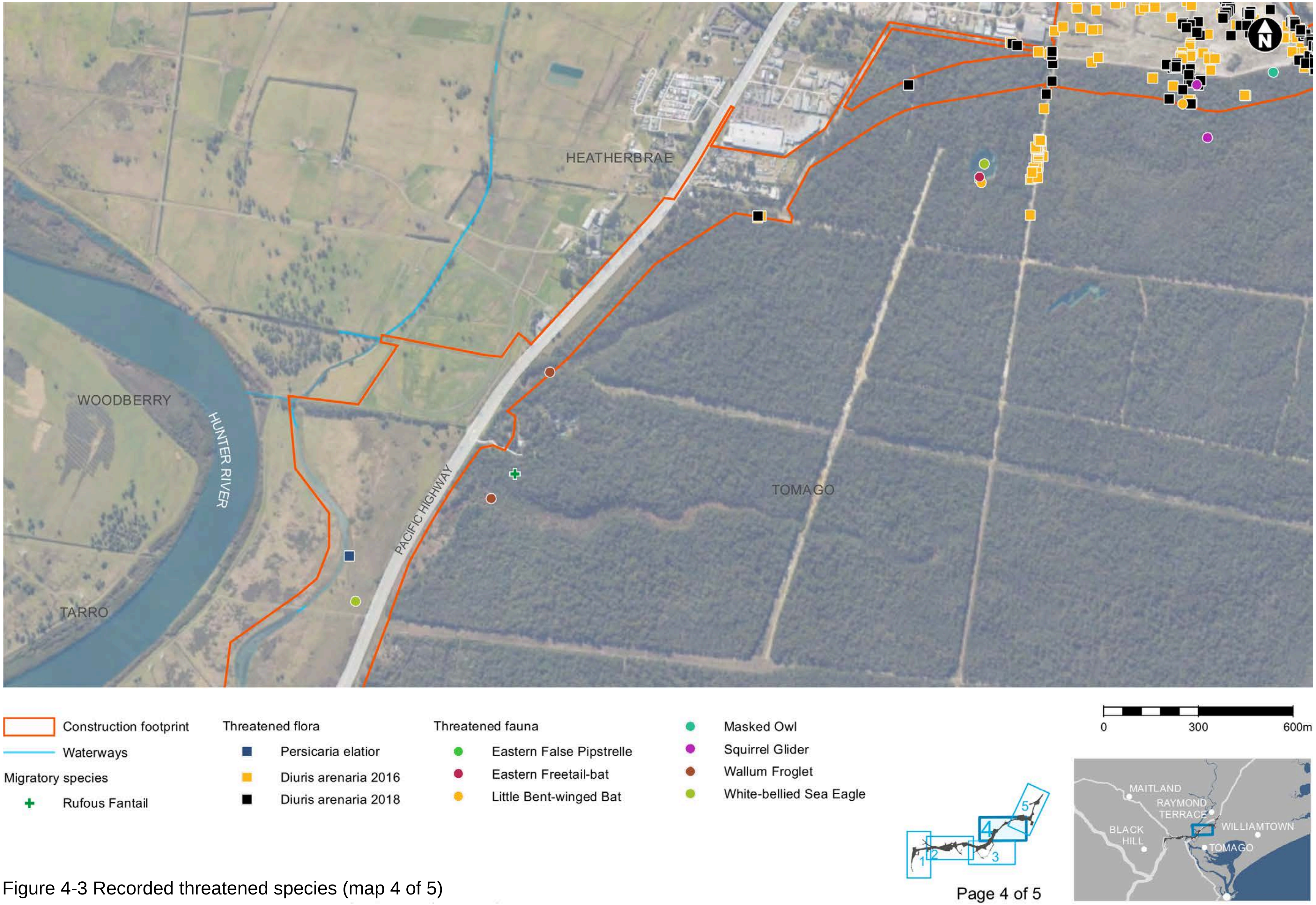


Figure 4-3 Recorded threatened species (map 4 of 5)

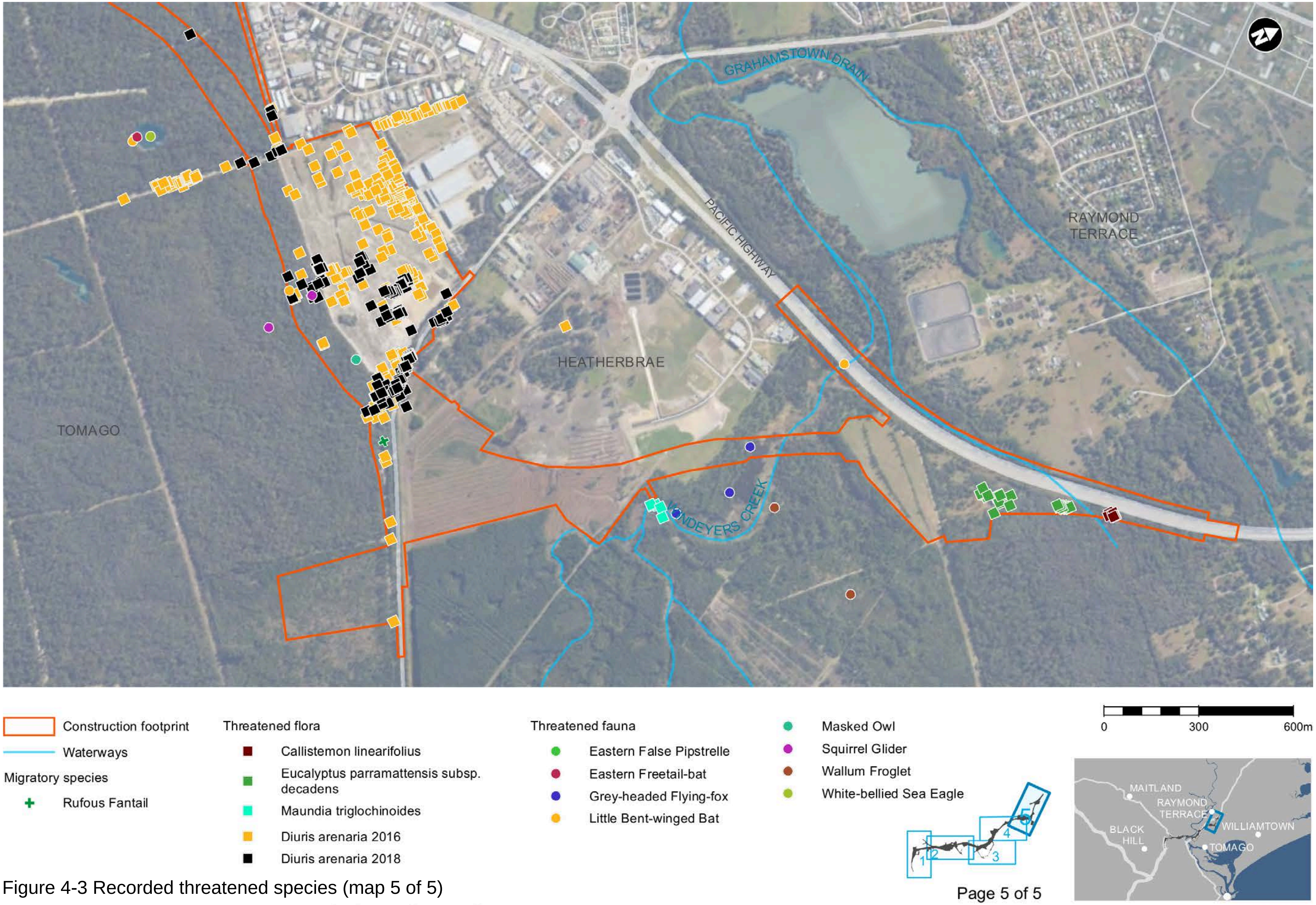


Figure 4-3 Recorded threatened species (map 5 of 5)

4.3 Aquatic habitat and threatened species

Threatened aquatic species

As discussed above, no targeted threatened fish surveys were conducted as part of this assessment. Database review of threatened fish species habitat and distribution identified three species with potential to occur in the construction footprint:

- Purple Spotted Gudgeon (*Mogurnda adspersa*) – listed as endangered under FM Act
- Black Rock Cod (*Epinephelus daemelii*) – listed as vulnerable under the FM Act and EPBC Act
- Green Sawfish (*Pristis zijsron*) – listed as vulnerable under EPBC Act, though presumed extinct in NSW.

According to DPI Threatened species distribution mapping, the Purple Spotted Gudgeon is predicted to occur within the Hunter River and Ironbark Creek (refer to **Figure 4-4**). The Purple Spotted Gudgeon is a benthic species that are usually found in freshwater rivers, creeks and billabongs with slow-moving or still waters, or in streams with low turbidity. They generally prefer to take refuge within aquatic vegetation, under cover of overhanging vegetation from river banks, leaf litter, rocks or snags (DPI, 2017a). Due to the highly disturbed and largely saline conditions of the Hunter River and tributaries, it is considered unlikely that this species inhabits waterways within the construction footprint. Further, there have been no sightings of the species recorded within the construction footprint, according to publicly accessible databases (ALA, 2020; DPIE, 2020).

The NSW coastline forms the Black Rock Cod's main range, both in Australia and internationally. Black cod generally inhabit near-shore rocky and offshore coral reefs at depths down to 50 metres. In coastal waters adult black cod are found in rock caves, rock gutters and on rock reefs. Recently settled juvenile black cod (i.e. individuals that have recently completed the pelagic, drifting larval stage) are often found in coastal rock pools while slightly older juvenile black cod are often found in estuary systems. The use of estuaries may be an important part of the ecology of juvenile black cod, at least in NSW waters (Department of Sustainability, Environment, Water, Population and Communities 2012). As discussed above, the reaches of the Hunter River in the construction footprint would be unlikely to provide suitable habitat for the Black Rock Cod.

The Green Sawfish is presumed extinct in NSW (last observed in 1972 in the Clarence River).

Based on habitat present, no protected or threatened fish species are expected to occur within the construction footprint. An assessment of all freshwater aquatic habitats has been conducted consistent with the Aquatic Ecology in Environmental Impact Assessment - EIA guideline (Marcus Lincoln Smith 2003).The results are discussed below and in **Appendix G**.

Fisheries habitat

A number of waterways within and next to the construction footprint are identified as Key Fish Habitat (KFH) in accordance with the definitions in Department of Primary Industries (DPI) Policy and Guidelines for Fish Habitat Conservation and Management (2013), and have been mapped by DPI Water (DPI Fisheries 2007. The habitat types and sensitivity classes used by DPI (2013) for classifying fish habitat and assessing potential impacts of certain activities and developments on KFH types are detailed in **Appendix G**. In addition to the habitat type, the waterway class is also used to assess the functionality and determine the requirement to maintain long term fish passage. The criteria by which the waterway class is derived are also outlined in **Appendix G.**

The aquatic habitat assessment has formed the basis for classifying KFH occurring within and near the construction footprint. Outcomes of the aquatic habitat assessment at monitoring sites are detailed in **Appendix G**, and are summarised in **Table 4-11** and shown in **Figure 4-4**.

Following consultation with DPI Fisheries (S. Carter, pers comm, 24 November 2017) (now DPIE) aquatic fauna were not assessed through targeted field surveys (i.e. macroinvertebrate surveys) and were assessed through desktop review of available literature, threatened species distribution mapping (DPI, 2016) and species sightings recorded in public databases listed in **Section 4.1.1**.

Potential impacts to aquatic environments are addressed in **Section 8.4**.

Table 4-11 Summary of aquatic habitat assessment at monitoring sites (sites are listed in order of most upstream site to most downstream site per waterway)

Waterway / wetland	Site name	Strahler stream order (Strahler, 1952)	Mapped as KFH (DPI, 2007)	Threatened aquatic species predicted to occur (DPI, 2016)	KFH type and sensitivity (DPI, 2013)	Waterway class (Fairfull and Witheridge, 2003)	Key considerations and observations
Glenrowan Creek	M12RT1 'Glenrowan Creek' at crossing	One	No	No	Not KFH	Class 4 – Unlikely fish habitat	• Drainage channel through cleared farmland • Limited channel definition • Disconnected from any major waterways • No aquatic habitat features observed • Mostly dry at the time of inspection
Purgatory Creek	M12RT2 Purgatory Creek Crossing 1	One	No	No	Not KFH	Class 4 – Unlikely fish habitat	• Swampy environment in paddock that has been largely cleared for grazing • Poor channel definition • Aquatic habitat features present at the time of inspection were poor and sparse. • Mapped as Coastal Wetland under the Coastal Management SEPP but does not present favourable wetland habitat features • Disconnected from Hunter River downstream by multiple culverts and a floodgate at the confluence
	M12RT2b Purgatory Creek (west of Woodlands Close)	Two	No	No	Not KFH	Class 4 – Unlikely fish habitat	• Drainage depression through cleared farmland • Minimal channel definition • Minimal aquatic habitat features observed, although a small number of mangroves remaining • Disconnected from Hunter River downstream by multiple culverts and a floodgate at the confluence

Waterway / wetland	Site name	Strahler stream order (Strahler, 1952)	Mapped as KFH (DPI, 2007)	Threatened aquatic species predicted to occur (DPI, 2016)	KFH type and sensitivity (DPI, 2013)	Waterway class (Fairfull and Witheridge, 2003)	Key considerations and observations
Purgatory Creek	M12RT2a Purgatory Creek (at crossing/ ancillary site location)	Three	Yes	No	Not KFH	Class 3 – Minimal fish habitat	• Mapped as KFH at this location, however, has been modified to be an artificial drainage channel and is completely isolated from downstream waterways therefore does not meet the minimum criteria of KFH (DPI, 2013) • Highly modified, incised drainage channel through cleared farmland • Minimal aquatic habitat features observed, although a small number of mangroves remaining • Water was present at the time of inspection and is likely to permanently have water. • Disconnected from Hunter River downstream by multiple culverts and a floodgate at the confluence
	M12RT2c Purgatory Creek downstream	Three	Yes	No	Not KFH	Class 3 – Minimal fish habitat	• Mapped as KFH at this location, however, has been modified to be an artificial drainage channel and is completely isolated from downstream waterways therefore does not meet the minimum criteria of KFH (DPI, 2013) • Highly modified, incised drainage channel through cleared farmland • Minimal aquatic habitat features observed, although a small number of mangroves remaining • Disconnected from Hunter River downstream by multiple culverts and a floodgate at the confluence
	M12RT2d Purgatory Creek downstream at	Three	Yes	No	Type 1 – Highly sensitive KFH	Class 2 – Moderate fish habitat	• Highly modified, incised drainage channel, however, is downstream of the floodgate and close to the confluence with Hunter River therefore has good connectivity with important aquatic habitat

Waterway / wetland	Site name	Strahler stream order (Strahler, 1952)	Mapped as KFH (DPI, 2007)	Threatened aquatic species predicted to occur (DPI, 2016)	KFH type and sensitivity (DPI, 2013)	Waterway class (Fairfull and Witheridge, 2003)	Key considerations and observations
	junction with Hunter River						• Good channel definition and some aquatic habitat features present, although not good quality and riparian zone was largely cleared of vegetation (only some planted vegetation less than one metre from riverbank) • Some mangroves and saltmarsh present in the intertidal zone that may be utilised by marine/aquatic species for refuge and spawning
Hunter River Estuary	M12RT3 Hunter River at crossing	Nine	Yes	Yes – although not expected in this section of the Hunter River	Type 1 – Highly sensitive KFH	Class 1 – Major fish habitat	• Major waterway and estuarine system which is expected to be utilised by marine/aquatic species for refuse and spawning • Upstream of Ramsar listed wetland site • Mangroves and saltmarsh present in the intertidal zone • Modified banks (rock armouring and constructed bank levee on western bank)
	M12RT3a Hunter River midstream	Nine	Yes	Yes – although not expected in this section of the Hunter River	Type 1 – Highly sensitive KFH	Class 1 – Major fish habitat	• Major waterway and estuarine system • Bank had been raised with additional imported and compacted fill deposited on the floodplain from historic works • Upstream of Ramsar listed wetland site • Mangroves and saltmarsh present in the intertidal zone which is expected to be utilised by marine/aquatic species for refuge and spawning • Modified banks (rock armouring and constructed bank levee on western bank)
	M12RT3b Hunter River downstream	Nine	Yes	Yes – although not expected in this section	Type 1 – Highly sensitive KFH	Class 1 – Major fish habitat	• Major waterway and estuarine system • Existing Hexham Bridge and boat ramp located at the site • Upstream of Ramsar listed wetland site

Waterway / wetland	Site name	Strahler stream order (Strahler, 1952)	Mapped as KFH (DPI, 2007)	Threatened aquatic species predicted to occur (DPI, 2016)	KFH type and sensitivity (DPI, 2013)	Waterway class (Fairfull and Witheridge, 2003)	Key considerations and observations
				of the Hunter River			• Mangroves and saltmarsh present in the intertidal zone which is expected to be utilised by marine/aquatic species for refuge and spawning • Modified banks (rock armouring and constructed bank levee on western bank)
Hunter River Drain	M12RT4 Hunter River Drain (upstream of Hunter River)	Two	No	No	Not KFH	Class 3 - Minimal fish habitat	• Highly modified, incised drainage channel located in cleared farm land • Minimal habitat features observed • Highly turbid water present • Within 50 metres of Coastal Management SEPP listed wetland • Disconnected from the Hunter River by a floodgate
	M12RT5 Unnamed tributary of Hunter River Drain (at water quality basin outlets)	Two	No	No	Not KFH	Class 4 – Unlikely fish habitat	• Highly modified, incised drainage channel in cleared farm land • Minimal habitat features observed • Highly turbid water present • Disconnected from the Hunter River by a floodgate
Windeyers Creek	M12RT6a Windeyers Creek (Upstream)	Two	No	No	Not KFH	Class 3 - Minimal fish habitat	• Located downstream of the Tomago Sandbeds Catchment Area • High water levels at the time of inspection and good channel definition • Some good habitat aquatic habitat and wetland features observed including large trees, woody debris, macrophytes and overhanging/trailing vegetation • Permanent water although is disconnected from downstream by multiple culverts and a floodgate at the confluence with Hunter River.

Waterway / wetland	Site name	Strahler stream order (Strahler, 1952)	Mapped as KFH (DPI, 2007)	Threatened aquatic species predicted to occur (DPI, 2016)	KFH type and sensitivity (DPI, 2013)	Waterway class (Fairfull and Witheridge, 2003)	Key considerations and observations
	M12RT6 Windeyers Creek (east of Pacific Highway)	Two	No	No	Not KFH	Class 3 - Minimal fish habitat	• Located downstream of the Tomago Sandbeds Catchment Area • Limited channel definition however exhibited residual, isolated pools and boggy wetland • Some aquatic and wetland habitat features observed including woody debris, macrophytes and overhanging/trailing vegetation • Permanent water although is disconnected from downstream by multiple culverts and a floodgate at the confluence with Hunter River.
	M12RT6b Downstream of Windeyers Creek and tributary of Windeyers Creek	Two	No	No	Not KFH	Class 3 - Minimal fish habitat	• High water levels at the time of inspection and good channel definition • Some aquatic habitat present including macrophytes and woody debris, however vegetation was dominated by terrestrial weeds and a pine plantation. • Water quality appeared to be poor (lots of algae) and stagnant water
Tributary of Windeyers Creek	M12RT7 Tributary of Windeyers Creek at crossing	One	No	No	Not KFH	Class 4 – Unlikely fish habitat	• Good channel definition • Had some large trees within the channel and along the banks. Instream aquatic features were minimal. • Bordered a major road and cleared residential land.
Hunter River wetland	M12RT8 Wetland adjacent to Botanic Gardens	One	No	No	Not KFH	Class 3 - Minimal fish habitat	• Ephemeral freshwater wetland. Expected to be a groundwater dependent ecosystem. • Had minimal bank definition • Had some habitat features including large woody debris, dense vegetation and macrophytes.

Waterway / wetland	Site name	Strahler stream order (Strahler, 1952)	Mapped as KFH (DPI, 2007)	Threatened aquatic species predicted to occur (DPI, 2016)	KFH type and sensitivity (DPI, 2013)	Waterway class (Fairfull and Witheridge, 2003)	Key considerations and observations
							• Not a recognised wetland or mapped stream however had aquatic features which may be utilised by aquatic species such as dragonflies or macroinvertebrates
Unnamed waterbody	M12RT9 Waterbody opposite Old Punt Road	Two	Yes	No	Not KFH	Class 3 - Minimal fish habitat	• Despite being mapped as KFH (DPI 2007), the waterway is a second order artificial drainage line, therefore it does not meet the minimum criteria for KFH (DPI, 2013). • Artificially constructed inlet connected to the Hunter River. • Water quality appeared to be highly degraded with industrial activity present on the adjacent shoreline (shipyard) likely to influence water quality • Despite the waterbody containing some mangrove habitat and being mapped as KFH, the waterbody is in a highly degraded state and has been artificially built for industrial use. Therefore, according to the KFH guidelines (DPI 2013) which state that urban and artificial ponds are not considered KFH, this waterbody is not considered KFH.
Grahamstown Drain	M12RT10 Grahamstown Drain	Two	Yes	No	Not KFH	Class 3 – Minimal fish habitat	• Despite being mapped as KFH (DPI 2007), the waterway is a second order artificial drainage line, and has no significant aquatic habitat features therefore it does not meet the minimum criteria for KFH (DPI, 2013) • Artificial drainage channel primarily utilised for transporting treated effluent from the Raymond Terrace Wastewater Treatment Works • Disconnected from downstream by multiple culverts and a floodgate on Windeyers Creek at the confluence with Hunter River

Waterway / wetland	Site name	Strahler stream order (Strahler, 1952)	Mapped as KFH (DPI, 2007)	Threatened aquatic species predicted to occur (DPI, 2016)	KFH type and sensitivity (DPI, 2013)	Waterway class (Fairfull and Witheridge, 2003)	Key considerations and observations
Unnamed Coastal Wetland (Coastal Management SEPP)	M12RT11 Inside bend of Hunter River within unnamed Coastal Wetland	One	Yes	No	Type 1 – Highly sensitive KFH	Class 1 – Major fish habitat	• Mapped Coastal Wetland under the Coastal Management SEPP • Swampy wetland environment surrounded by mangrove forest which is considered to be important fish refuge habitat and potential to be utilised as habitat for spawning. • Lots of aquatic habitat present including dense macrophyte beds
	M12RT11a Unnamed tributary of Hunter River, flowing through unnamed Coastal Wetland	Two	No	No	Not KFH	Class 3 – Moderate fish habitat	• Highly modified, incised drainage channel • Minimal habitat features observed • Highly turbid water present • Disconnected from the Hunter River by a floodgate however flows to an area classified as Coastal Wetland under the Coastal Management SEPP
Viney Creek	M12RT12 Viney Creek	Four	Yes	No	Type 2 – Moderately sensitive KFH	Class 3 – Minimal fish habitat	• Creek and marshy wetland environment with limited channel definition. • Aquatic habitat was observed including dense macrophyte beds and overhanging vegetation. • The creek flowed to Woodberry Swamp (Coastal Wetland under the Coastal Management SEPP). • Generally isolated from upstream and downstream due to presence of culverts and other barriers including a ponded waterbody,

Waterway / wetland	Site name	Strahler stream order (Strahler, 1952)	Mapped as KFH (DPI, 2007)	Threatened aquatic species predicted to occur (DPI, 2016)	KFH type and sensitivity (DPI, 2013)	Waterway class (Fairfull and Witheridge, 2003)	Key considerations and observations
Tributary to Viney Creek	M12RT13 Tributary to Viney Creek	Unmapped at site although is first order about 50 downstream where mapping begins	No	No	Not KFH	Class 4 – Unlikely fish habitat	• Artificial stormwater drainage channel constructed for the M1 Pacific Motorway • No water was present at the time of inspection • Dominated by terrestrial vegetation and weed species including *Lantana Camara*. Unlikely to hold water for long following rainfall and runoff.

Hunter River estuary

While no threatened fish species are expected, the Hunter River estuary supports a substantial fishery, particularly for Sydney Rock Oysters (*Saccostrea glomerate*), School Prawn (*Metapenaeus macleayi*) and is known to provide habitat for juvenile Eastern King Prawn (*Melicertus plebejus*).

The Hunter River contains oyster leases located near Stockton Bridge about 13 kilometres downstream of the project and other commercial fishing activities occur from the ocean to Raymond Terrace (about 30 kilometres from the ocean), including in the vicinity of the proposed river crossing, where School Prawn and Eastern King Prawn (as well as several other species of prawn and squid species which are permitted as 'by-product' species in the estuary) are harvested (DPI, 2017). Prawn harvesting has historically included bottom trawling which has likely resulted in modification of the riverbed and disturbance of instream aquatic habitat.

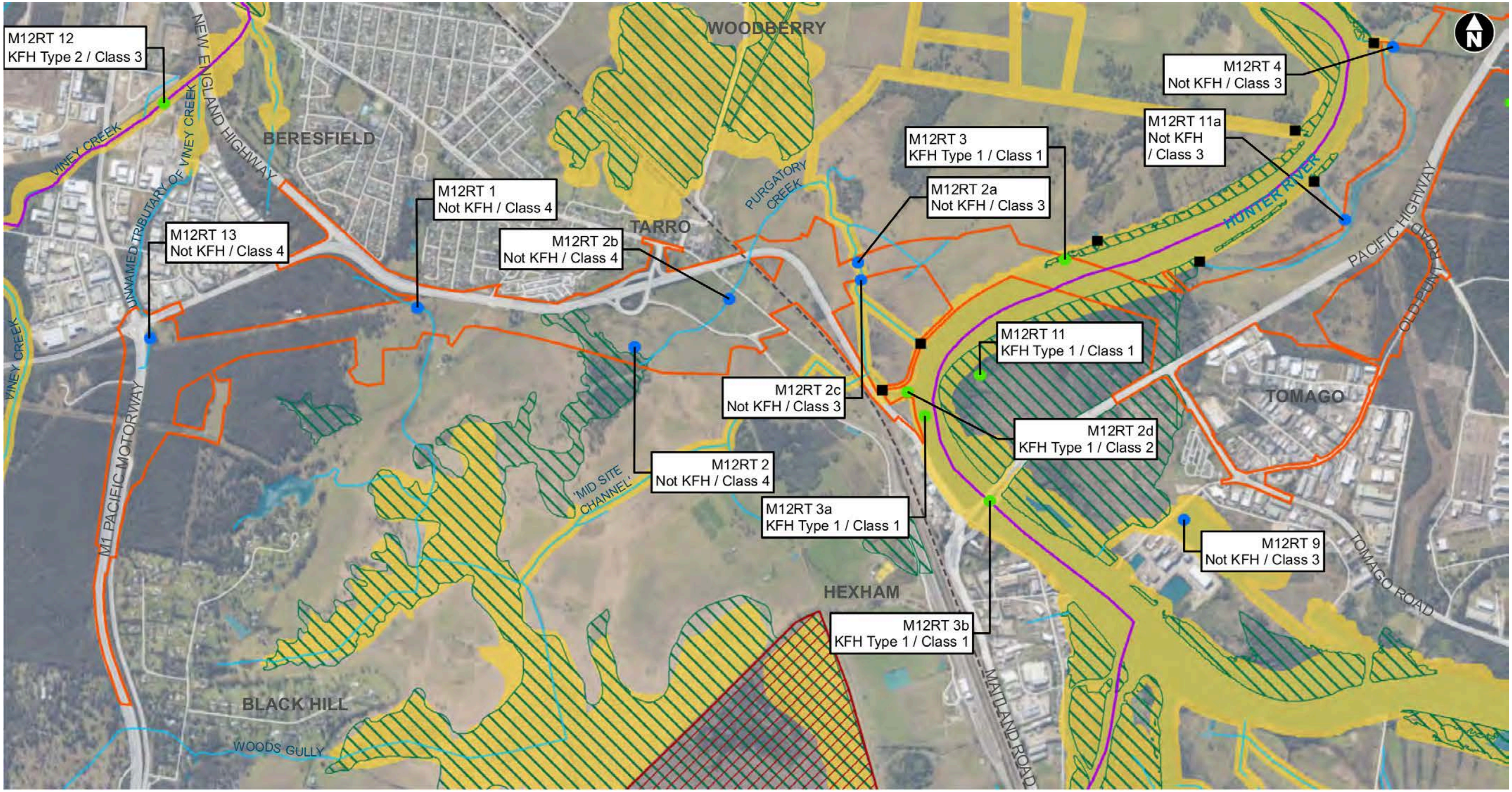
The Hunter River estuary within the construction footprint exhibits water quality and physical attributes that are typical of an estuarine environment, however, these characteristics of the estuary and surrounding wetland systems of the lower Hunter River have also become degraded due to instream activities such as bottom trawling, as well as from surrounding industrial and waste water discharges, agricultural practices in the upper catchment and the installation of dykes and floodgates associated with the Flood Mitigation Scheme that have removed connectivity between wetlands and the main estuary channels (Taylor et al. 2019) creating an existing modified environment. Despite this, the lower estuary has abundant mangrove and saltmarsh habitats which provide important nursery habitat for marine organisms and shorebird species. In addition to the two main arms of the channel, the estuary exhibits large expansive shallow embayment's that are connected to the north arm and the Kooragang Nature Reserve on Kooragang Island which make up the Hunter Estuary Wetland Ramsar site. These embayment's and island also have extensive mangrove and saltmarsh habitat (Taylor et al. 2019). No shallow embayment's were identified within the construction footprint. No seagrass is present within the estuary (DPI 2000).

In general, the benthic habitats of the Hunter River estuary are considered disturbed from the surrounding land use and history, and flood mitigation scheme though still provide important habitat. No threatened invertebrates have been recorded in the area. Marine species within the broader Hunter River estuary are similar to those of other lower and mid-North Coast estuaries.

Floodplains and waterways

The construction footprint traverses highly modified waterways including a tributary of Viney Creek, Glenrowan Creek, Purgatory Creek and Windeyers Creek which are located on the Hunter River floodplain either side of the Hunter River estuary. While most of these waterways would have naturally been estuarine and influenced by tidal flows, they are now classified as freshwater aquatic environments because they are disconnected from the Hunter River due to floodgates and therefore receive freshwater flows from upstream, and this has changed the habitat value and quality. An exception to this rule, as described in the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS), is Purgatory Creek and the Coastal Wetland (Coastal Management SEPP) that is located south of the existing New England Highway which exhibit water quality that is atypical of a freshwater stream or ecosystem because shallow, saline groundwater is likely to influence the water quality within the waterway and wetland.

These floodplain environments have been modified to become artificial drainage channels which are highly degraded and disturbed (both physically and exhibiting poor water quality) due to the surrounding land uses and site history and are therefore unlikely to constitute important aquatic ecosystems. Species which are known to inhabit the perennial sections of these degraded waterways are the invasive Mosquito Fish (*Gambusia holbrooki*) and Long-finned Eels (*Anguilla reinhardtii*). The ephemeral sections of the waterways which have some aquatic and wetland habitat features may be utilised by non-benthic organisms such as dragonfly species.



Construction footprint

Main North Rail Line

Coastal wetlands (Coastal Management SEPP 2018)

Key Fish Habitat DPI 2007

Hexham Swamp Nature Reserve

Southern Purple Spotted Gudgeon (current predicted distribution DPI 2015)

Monitoring site - Sensitive Receiving Environment

Monitoring site - Non Sensitive Receiving Environment

Floodgates

0 0.5 1 km

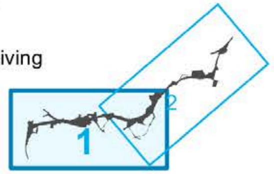


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Figure 4-4 Aquatic habitat and key fish habitat assessment sites (map 1 of 2)

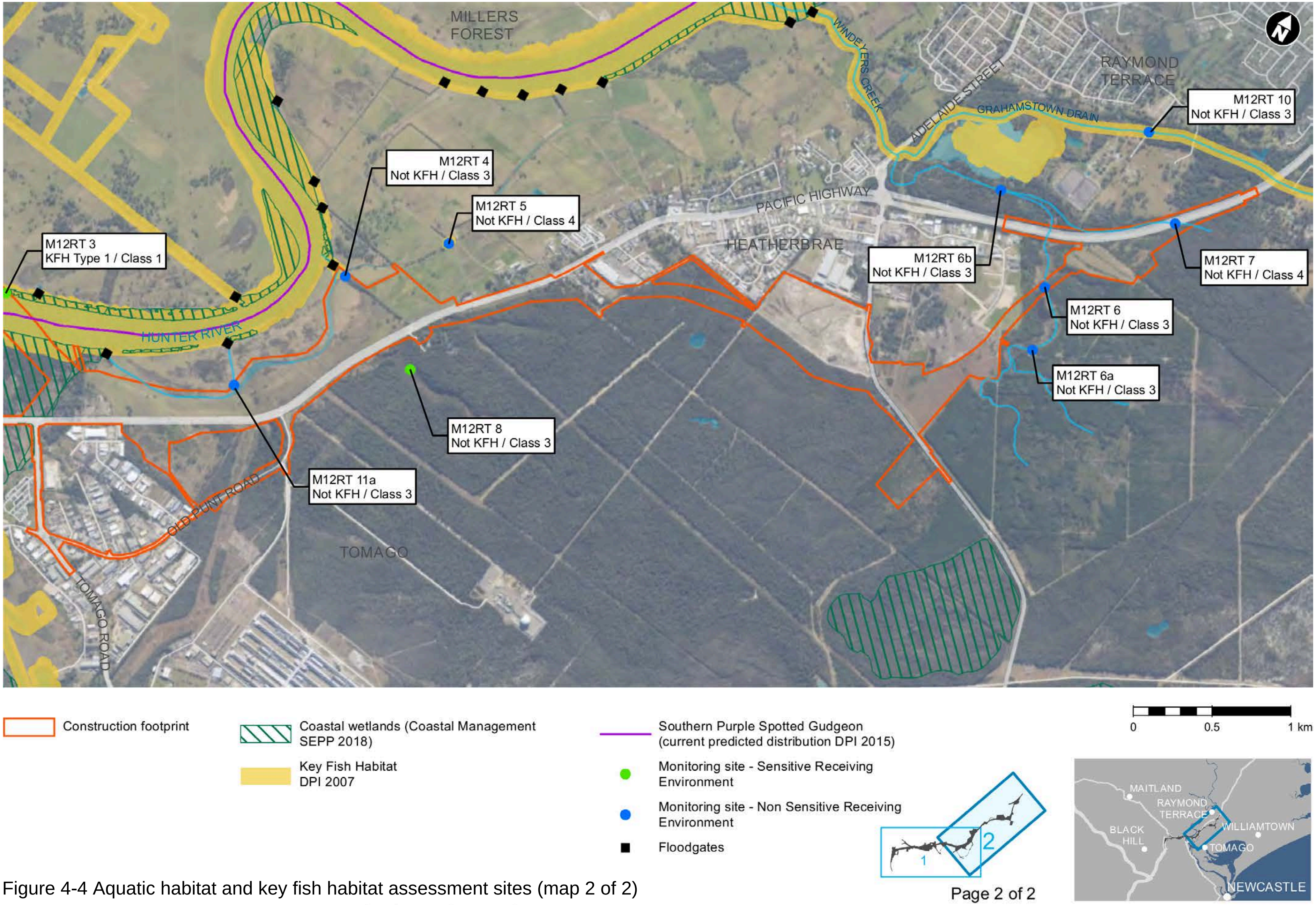


Figure 4-4 Aquatic habitat and key fish habitat assessment sites (map 2 of 2)

5. Matters of National Environmental Significance

Chapter 5 identifies the MNES that are of relevance to the area within the construction footprint.

A referral under the EPBC Act (2018/8288) was submitted to the then Commonwealth Department of the Environment and Energy in October 2018. On 14 January 2019, the delegate for the Australian Minister for the Environment confirmed the project would be a controlled action under section 75 of the EPBC Act. According to the DoEE, the MNES of relevance to the project included the following threatened species and ecological communities (section 18 and 18A of the EPBC Act):

- Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community – endangered under the EPBC Act
- Koala (*Phascolarctos cinereus*) (combined populations of Queensland, NSW and the ACT) – vulnerable under the EPBC Act
- Swift Parrot (*Lathamus discolor*) – critically endangered under the EPBC Act
- Regent Honeyeater (*Anthochaera phrygia*) – critically endangered under the EPBC Act
- Grey-headed Flying-fox (*Pteropus poliocephalus*) – vulnerable under the EPBC Act.

The project has developed further since the referral of the project to the Commonwealth in 2018, resulting in a refined design and construction footprint that warranted further survey and assessment for impacts on biodiversity. In addition to the impacts assessed in the referral, the assessment process has identified one new impacted species (*Persicaria elatior*) and increased impacts on five threatened species compared to the impacts described in the referral, as follows:

- *Persicaria elatior* (vulnerable species) – three individuals of this species were identified during supplementary surveys. All occur within the construction footprint and will be directly impacted
- Impacts on the identified *Eucalyptus parramattensis* subsp*. decadens* (vulnerable species) has increased from 16 individuals to 34 individuals
- Impacts on Australasian Bittern habitat has increased from about five hectares to up to around 43.64 hectares of associated PCTs that may provide suitable habitat
- Impacts on Australian Painted Snipe has increased from 33 hectares to up to around 43.64 hectares of associated PCTs that may provide suitable habitat
- Impacts on Spotted-tailed Quoll has increased from 45 hectares to up to around 47 hectares of associated PCTs that may provide suitable habitat
- Impacts on New Holland Mouse has increased from 20.4 hectares to 28.6 hectares of associated PCTs that may provide suitable habitat.

This assessment addresses the stated new or increased impacts on species compared to the impacts described in the 2018 referral. This includes a revised Assessment of Significance to account for the minor changes and a new Assessment of Significance for the Tall Knotweed (*Persicaria elatior*) which was not previously identified in the construction footprint in 2018 (**Appendix D**).

With respect to threatened biodiversity, the EES Group considered that under the FBA any impacts to *Diuris arenaria, Pterostylis chaetophora, Rhodamnia rubescens*, *Rhodomyrtus psidioides*, Mahony's Toadlet and Regent Honeyeater are matters that require further consideration. As such, these matters are addressed in this report and detailed further in **Appendix E**.

All Assessments of Significance addressing increased and changed impacts from those previously assessed in the EPBC referral are provided in **Appendix D**. For completeness, the Assessment of Significance for Small-flowered Grevillea (*Grevillea parviflora* subsp. *parviflora*) and Green and Golden Bell Frog (*Litoria aurea*) have also been included in **Appendix D** despite not having an increased or changed impact since the original referral.

The following discussion considers relevance of MNES.

5.1 World heritage properties

No World heritage properties occur within the 10 kilometre search area around the project, including any downstream areas that may be impacted indirectly. This MNES is not considered further in this report.

5.2 National heritage places

No National Heritage Places occur within the 10 kilometre search area around the project, including any downstream areas that may be impacted indirectly. This MNES is not considered further in this report.

5.3 Wetlands of international importance (Ramsar wetlands)

As described in **Section 2.2.4**, the Hunter Estuary Wetlands Ramsar site is located within 10 kilometres of the project (refer to **Figure 1-1** and **Figure 2-1**). It is made up of two components, the Hunter Wetlands National Park on Kooragang Island (Kooragang Nature Reserve) and the Hunter Wetlands Centre Australia in Shortland.

Geographically, the Kooragang Nature Reserve is located about 1.9 kilometres to the south east of the construction footprint, however, is about 5.1 kilometres downstream from the project at the proposed Hunter River crossing. The potential impact of construction of the project on the Hunter River is addressed in **Section 8.4**, however no indirect water quality impacts to Kooragang Nature Reserve are anticipated because the Hunter River is expected to provide sufficient dilution to basin discharges entering the waterway prior to reaching the site. Dilution modelling is provided in the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS).

The Hunter Wetlands Centre Australia is located about 3.8 kilometres south of the project. Given the distance from the construction footprint and the very low likelihood that surface water flows generated from the project could reach this section of the Ramsar site due to substantial flow barriers, the Hunter Wetlands Centre Australia is not considered to be subject to potential impacts as a result of the project and is therefore not discussed further in this report.

5.4 Listed ecological communities

Six nationally listed TECs under the EPBC Act were identified from the PMST and desktop assessment for consideration in the construction footprint:

1. Subtropical and Temperate Coastal Saltmarsh (vulnerable)
2. Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community (endangered)
3. Central Hunter Valley eucalypt forest and woodland ecological community (critically endangered)
4. Lowland Rainforest of Subtropical Australia (critically endangered)
5. *Posidonia australis* seagrass meadows of the Manning-Hawkesbury ecoregion (endangered)
6. River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria.

The assessment aimed to confirm the presence or absence of these communities in the construction footprint through desktop assessment and field survey. This involved a review of the Approved Conservation Advice for each community for correlation with the construction footprint. Where a comparable vegetation types was identified further consideration of key diagnostic characteristics and condition thresholds was assessed.

The descriptions below explain that TECs 3 to 6 described above are not present in the construction footprint. Vegetation types consistent with TECs 1 and 2 are present and a detailed assessment and consideration of the presence of these listed communities is provided below.

Following a detailed assessment, only about 0.55 hectares of the saltmarsh community in the construction footprint is consistent with the Subtropical and Temperate Coastal Saltmarsh TEC. Impacts on this community are described in **Chapter 8**.

Condition thresholds for Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland TEC are considered of insufficient condition to meet the condition threshold and eligibility for the listed community.

5.4.1 Subtropical and Temperate Coastal Saltmarsh

The vegetation classification assessment confirmed and mapped Saltmarsh Estuarine Complex (PCT 1746) along the north and western banks of the Hunter River just above the mean high tide mark (refer to **Figure 3-2**).

Detailed floristic plots carried out within these patches found varying levels of condition. The condition of patches was assessed according to the criteria provided in the Commonwealth Listing Advice on Subtropical and Temperate Coastal Saltmarsh (Threatened Species Scientific Committee, 2008). The listing under the EPBC Act only includes patches that meet specific condition criteria, including patch sizes larger than 0.1 hectares, connection to tidal areas and cover of mangroves less than 50 per cent. Some of the patches identified in the construction footprint meet these condition criteria while some areas of lower condition (i.e. high cover of exotic species) are not consistent with the EPBC Act listing criteria.

Of the 1.26 hectares of the PCT Saltmarsh Estuarine Complex (PCT 1746) present within the construction footprint, about 0.55 hectares is consistent with the listed Subtropical and Temperate Coastal Saltmarsh community listed as vulnerable under the EPBC Act (refer to **Figure 3-2**).

5.4.2 Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community

Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community was assessed according to the criteria provided in the Approved Conservation Advice (incorporating listing advice) for the Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community (Department of the Environment and Energy 2018). Swamp Oak - Sea Rush - *Baumea juncea* swamp forest on coastal lowlands of the Central Coast and Lower North Coast (PCT 1727) was confirmed and mapped in the construction footprint.

In accordance with the condition thresholds, small patches require greater than 80 per cent native midstorey species. Plot 13 was carried out at a small patch within the construction footprint (refer to **Table 5-1**), which had only about 67 per cent native midstorey and does not meet the condition criteria. The largest patch of Coastal Swamp Oak close to the construction footprint is about 25 hectares in area, consisting of three contiguous patches and occurs on the southern side of the Hunter River, from the river bend to the north east where the floodplain has been cleared (refer **Figure 3-1**). In accordance with the condition thresholds large patches require greater than 20 per cent native midstorey species. Three plots (Plot 43, 45 and 46) were carried out in this patch (refer to **Table 5-1**), which recorded between 0.1 per cent and nine per cent native midstorey species and did not meet the condition criteria.

Whilst the project referral identified this community as potentially occurring on a precautionary basis, the subsequent review and analysis of the field data conducted for this biodiversity assessment indicates that, none of the occurrences of PCT 1727 within the construction footprint are of sufficient size or condition to meet the eligibility for the listed community.

Table 5-1 Proportion of native and non-native midstorey species in PCT 1727 vegetation plots

Species composition	Plot 13	Plot 43	Plot 45	Plot 46
Patch size (hectares)	0.5-2 ha	>5 ha	>5 ha	>5 ha
Proportion of native midstorey (per cent)	67%	5%	0.1%	9%
Proportion of non-native midstorey (per cent)	33%	95%	99.9%	91%
Meets TEC condition threshold criteria?	No	No	No	No

5.4.3 Central Hunter Valley Eucalypt Forest and Woodland

The EPBC Act listed Central Hunter Valley eucalypt forest and woodland ecological community corresponds, in large part, to three New South Wales listed ecological communities (NSW Scientific Committee, 2010a, 2010b, 2010c). These communities are:

- Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions (Endangered)
- Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions (Endangered)
- Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion (Vulnerable).

In contrast to this, the community identified in the construction footprint is the ‘Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin Bioregion’ listed as endangered in NSW (NSW Scientific Committee, 2010d).

According to the Commonwealth Listing Advice for the Lower Hunter Spotted Gum-Ironbark Forest’ community there are some outliers of the ‘Central Hunter’ endangered ecological community which occur in the Lower Hunter Valley region. However, these ‘Lower Hunter’ outliers of the Central Hunter community typically occur in elevated areas on soils derived from Permian sedimentary strata and also meet the other Key diagnostic characteristics and Condition thresholds of the Central Hunter Valley eucalypt forest and woodland. The occurrence of the ‘Lower Hunter’ community confirmed in the construction footprint is not consistent with the outlier examples.

Much of the ‘Lower Hunter Spotted Gum-Ironbark Forest’ has *Allocasuarina torulosa* (forest oak), and/or *Eucalyptus acmenoides* (white mahogany) and/or *Eucalyptus fibrosa* (red/broad-leaved ironbark) amongst its canopy species. These species are characteristic of the community identified in the construction footprint and it has been concluded that the vegetation in the construction footprint is not part of the nationally listed ‘Central Hunter Valley eucalypt forest and woodland ecological community’ (MNES). Given that the communities in the construction footprint did not fit the general location criteria for the ‘Central Hunter’ community, no further consideration of the condition thresholds for this community were considered.

5.4.4 Lowland Rainforest of Subtropical Australia

The Lowland Rainforest of Subtropical Australia ecological community primarily occurs from Maryborough in Queensland to the Clarence River in northern NSW. The ecological community also includes isolated areas between the Clarence River and Hunter River such as the Bellinger and Hastings Valley. The vegetation classification and mapping assessment in the construction footprint identified 14 different PCT types from seven different vegetation classes according to Keith (2006), these include:

- Hunter-Macleay Dry Sclerophyll Forests
- Coastal Dune Dry Sclerophyll Forests
- Coastal Swamp Forests
- Coastal Floodplain Wetlands
- Coastal Freshwater Lagoons
- Saltmarshes
- Mangrove Swamps.

None of the vegetation types confirmed in the construction footprint are consistent with the rainforest classes and formations from Keith (2006) and the Lowland Rainforest of Subtropical Australia TEC is not present.

5.4.5 *Posidonia australis* seagrass meadows of the Manning-Hawkesbury ecoregion

This ecological community is the assemblage of plants, animals and micro-organisms associated with seagrass meadows dominated by *Posidonia australis* occurring in the warm temperate Manning Shelf and Hawkesbury Shelf bioregions.

The section of the Hunter River within the construction footprint is within the known distribution of this ecological community and meets to description of suitable habitat. Surveys of the Hunter River banks have been conducted for seagrass vegetation as part of this assessment, however this ecological community has not been identified.

Survey and assessment of the Hunter River estuarine communities and habitats have been conducted by numerous organisations in recent years which have all concluded that seagrass is not present and has been absent for many years, the following text refers:

- ‘Kooragang Ramsar Wetland Ecological Character Description’ (Bereton and Taylor-Wood 2010)
  - In describing the Hunter Estuary Wetland this report states it “contains subset of the range of biological diversity (including habitat types) occurring in a region (notably seagrass is absent which is a particularly high value habitat for fish and marine invertebrates).
- ‘Lower Hunter River Health Monitoring Program’ (Swanson et al. 2017)
  - The report states in the conclusion that “There have been no formal observations of seagrass in the Hunter River since European settlement. Anecdotal stories from the late 1800s of the species of fish previously caught in the Hunter imply that seagrass was once present in the estuary. The loss of seagrass from the Hunter estuary was probably the result of increased turbidity in estuary waters. The extensive land and bank erosion in the catchment lead to large amounts of sediment entering the estuary after rainfall. High levels of sediment in the water reduces the amount of light that can penetrate the water for plant growing on the riverbed. Excess sediment can also smother submerged plants.

- 'Habitat – Fishery Linkages and Implications for Habitat Repair' (Taylor et al. 2019)
  - This study undertook extensive survey using combination of novel chemical techniques, extensive field work, and numerical modelling in Hunter River, Clarence River and Lake Macquarie between 2013-2016. When describing the Hunter River estuary, the report states, "There is no seagrass present within the estuary.

Considering the conclusion of these assessments, it is considered unlikely that *Posidonia australis* seagrass meadows of the Manning-Hawkesbury ecoregion is present in the construction footprint and as such would not be impacted by the project.

5.4.6 River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria

The EPBC Act listed River-flat eucalypt forest on coastal floodplains occurs on alluvial landforms related to coastal river floodplains and associated sites where transient water accumulates, including floodplains, riverbanks. Riparian zones, lake foreshores, creek lines (including the floors of tributary gullies) floodplain pockets, depressions, alluvial flats, fans, terraces and localised colluvial fans.

The canopy is dominated by eucalypt species, often with several species present. When intact, the canopy typically has between 40 and 60 per cent crown cover, with large trees often containing hollows, but crown cover can be as low as 20 per cent.

The local expression of the ecological community is influenced by its location relative to the riparian areas of the floodplain, frequency of inundation by stream flows, local climate, latitude, and the contribution of biota from surrounding areas. Hence there is regional variation and intergradation of key species, although structure and function remain similar throughout the extent.

The composition of the tree canopy varies across the extent of the ecological community. It may be dominated by a single eucalypt species, or by a mix of several eucalypt species. However, the two genera that characterise the ecological community are Eucalyptus and Angophora, notably: Angophora floribunda (Rough-barked Apple), A. subvelutina (Broad-leaved Apple), and members of the 'red gum' group of eucalypts (Exsertaria), notably E. tereticornis (Forest Red Gum, Red Irongum) and Eucalyptus amplifolia (Cabbage Gum).

Non-eucalypt tree species may be part of the ecological community, mostly as an open sub-canopy. These include: Allocasuarina littoralis (Black Sheoak), Elaeocarpus reticulatus (Blueberry Ash, Blue Olive-berry), Brachychiton populneum (Kurrajong), Casuarina cunninghamiana (River Oak, River Sheoak), Casuarina glauca (Swamp Oak, Swamp Sheoak) and Pittosporum undulatum (Sweet Pittosporum).

A range of paperbarks may occur in the sub-canopy and shrub-layer of this ecological community, such as *Melaleuca decora* (White Feather Honey Myrtle), *Melaleuca linariifolia* (Flax-leaved Paperbark, Snow-in-summer) and *Melaleuca styphelioides* (Prickly-leaved Paperbark).

Important to note, is that this ecological community does not occur on soils that are primarily marine sands or aeolian sands.

River-flat eucalypt forests are notably absent from the floodplain areas of the construction footprint, and indeed the surrounding Hunter River floodplain landscape. One PCT, Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598), has been identified in and mapped in the vicinity of Old Punt Road. This community occurs on the edge of the Hunter River floodplain at Tomago, comprising fragmented patches of modified forest. The vegetation supports an open canopy of Eucalyptus tereticornis (Forest Red Gum) and Broad-leaved Paperbark (*Melaleuca quinquenervia*) with an open to dense midstorey up to five metres in height dominated by *Melaleuca nodosa* and *Breynia oblongifolia* and the vine species *Parsonsia straminea*. The floristics of this community are comparably with the diagnostic characteristics of this CEEC, however, the sub-dominance of *Melaleuca quinquenervia* (25 per cent cover from two plots) along with cover of *Eucalyptus tereticornis* (10 per cent and 25 per cent) is not characteristic of a eucalypt dominated community. Importantly the soil landscape mapping for this location where the community is mapped is clearly of aeolian sand process. For these reasons, the small area of PCT 1598 mapped in the construction footprint is not characteristic of the CEEC River-flat eucalypt forest on floodplains. No further consideration of the condition thresholds for this community were considered.

5.5 Threatened flora under the EPBC Act

The PMST identified 26 threatened flora species (or their habitats) in the 10 kilometre search radius around the construction footprint (refer to Table B-2 in **Appendix B**). Eleven threated flora species listed in **Table 4-5** and **Table 4-6** were considered to have a moderate to high likelihood of occurring in the construction footprint and were targeted by surveys (refer to **Section 4.2.1**).

The targeted field surveys confirmed two nationally listed threatened flora species in the construction footprint:

- *Eucalyptus parramattensis* subsp. *decadens* (vulnerable – EPBC Act)
- *Persicaria elatior* (vulnerable – EPBC Act).

The recorded distribution and abundance of these species are shown on **Figure 4-3**. Further discussion on the impacts to these listed species is provided in **Section 8.1.2**.

5.6 Threatened fauna listed under the EPBC Act

The PMST identified 53 threatened fauna species with habitat in the 10 kilometre search radius around the project. An assessment of the likelihood of each species occurring in the construction footprint has been carried out and is presented in **Appendix B**. From this assessment, nine species were identified as having a moderate to high likelihood of occurring within the construction footprint (refer to **Table 5-2** and **Appendix B**). These species were targeted in field surveys as described in **Section 4.2**.

From these field surveys, one species listed under the EPBC was confirmed, the Grey-headed Flying-fox (*Pteropus poliocephalus*) (listed as vulnerable). This species was observed flying overhead and foraging at multiple locations within the construction footprint, which is to be expected given that food resources for this species are common and widespread. Importantly, no known roosting camps were identified within the construction footprint.

A summary of the EPBC Act listed threatened fauna species at least moderately likely to occur in the construction footprint is provided in **Table 5-2** and impacts to these species are discussed in **Section 8.1.3**.

Table 5-2 Threatened fauna listed under the EPBC Act considered to have moderate to high likelihood of occurrence

Species name	Common name	EPBC Act	No. records in locality	Likelihood of occurrence
Birds				
Anthochaera phrygia	Regent Honeyeater	CE, M	1 – Atlas PMST	Moderate
Botaurus poiciloptilus	Australasian Bittern	E, M	25 – Atlas PMST	Moderate
Lathamus discolor	Swift Parrot	E, M	9 – Atlas PMST	Moderate
Rostratula australis	Australian Painted Snipe	E, M	11 – Atlas PMST	Moderate

Species name	Common name	EPBC Act	No. records in locality	Likelihood of occurrence
Mammals				
Dasyurus maculatus	Spotted-tailed Quoll	E	10 – Atlas PMST	Moderate
Phascolarctos cinereus	Koala	V	1985 – Atlas PMST	Moderate
Pseudomys novaehollandiae	New Holland mouse	V	36 – Atlas PMST	Moderate
Pteropus poliocephalus	Grey-headed Flying-fox	V	109 – Atlas PMST	Recorded
Amphibians				
Litoria aurea	Green and Golden Bell Frog	V	3954 – Atlas PMST	Moderate

V = Vulnerable, E= Endangered, CE= Critically Endangered, M = Migratory

5.7 Listed migratory species

A search of the PMST identified 59 listed migratory species or predicted habitat for these species as occurring within 10 kilometres of the project. The 10 kilometre search area encompasses the lower Hunter River estuary, Hunter Wetlands National Park and the Hunter Estuary Wetlands Ramsar site, all of which are not impacted by this project. The likelihood of these listed migratory species occurring within the construction footprint was assessed by considering the habitats present and confirmed.

The assessment for each species is provided as **Appendix B** and has identified 16 listed migratory species (migratory wetland species and migratory forest bird species) with a moderate to high likelihood of occurring, these are included in **Table 5-3**. Four species were recorded within the construction footprint during targeted bird surveys and opportunistically, including White-bellied Sea-Eagle, Latham's Snipe, Satin Flycatcher and Rufous Fantail.

Table 5-3 Listed migratory bird species with a moderate to high likelihood of occurring

Migratory wetland species	Migratory forest species
Latham's Snipe (recorded)	Rufous Fantail (recorded)
Sharp-tailed Sandpiper	Satin Flycatcher (recorded)
Pectoral Sandpiper	White-bellied Sea-Eagle (recorded)
Double-banded Plover	Fork-tailed Swift
Pin-tailed Snipe	White-throated Needletail
Broad-billed Sandpiper	Eastern Osprey
Marsh Sandpiper	
Common Greenshank	
Pacific Golden Plover	
Terek Sandpiper	

Latham's Snipe was observed in an open grassy floodplain ephemeral wetland next to the Coastal Management SEPP wetlands at the western end of the construction footprint. These wetlands are contiguous with the Hexham Swamp Nature Reserve. Suitable habitat for this species and other migratory wetlands birds is most widespread in the Hexham wetlands which continue south of the project at Tarro through to Shortland. These wetlands extent for several hundred hectares to the south of Tarro connecting with Hexham Swamp Nature Reserve (900 hectares) and are known to be important for Latham’s Snipe.

The Rufous Fantail and Satin Flycatcher were recorded at Black Hill near the proposed interchange with the M1 Pacific Motorway within Spotted-Gum – Ironbark Forest with a paperbark understorey. Rufous Fantail was also recorded in the sandy Blackbutt dominated forest at the northern end of the project. Suitable habitat for these species is widespread across the construction footprint and wider area. The impact to these species would be minimal and affect non-breeding habitat.

The White-bellied Sea-Eagle was seen soaring high over the construction footprint in two locations around Tomago and Heatherbrae (refer to **Figure 4-3**). This species is expected to have been passing through the construction footprint, where it may forage. No large stick nests were identified during surveys, though large trees suitable for nesting are in low abundance around the Old Punt Road intersection in Tomago and in PCT 1646 around Heatherbrae.

Further discussion on the impacts to these listed species is provided in **Section 8.3**.

6. Summary of biodiversity values

6.1 Biodiversity values assessed under the FBA

This section provides a summary of biodiversity values that occur in the construction footprint and require assessment under section 9.3 of the FBA. This includes threatened species, populations and communities listed under the TSC Act and EPBC Act (refer to **Table 6-1**). Saltmarsh Estuarine Complex (1746) (HU960) and Grey Mangrove low closed forest (1747) (HU961) are not included in **Table 6-1** as saline marine environments are not assessed as ecosystem credits under the FBA. These two PCTs are discussed in **Table 6-3**.

Table 6-1 Summary of biodiversity values assessed under the FBA (i. Ecosystem credits)

Plant Community Types (PCT) (BVT)	Identification method (assumed, recorded)	Area/individuals within construction footprint (ha)
Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590) (HU804)	Recorded	41.88
Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (1588) (HU802)	Recorded	7.6
Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646) (HU860)	Recorded	28.59
Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649) (HU863)	Recorded	1.36
Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598) (HU812)	Recorded	0.45
Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716) (HU930)	Recorded	1.82
Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717) (HU931)	Recorded	10.49
Broad-leaved Paperbark – Swamp Oak – Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1724) (HU938)	Recorded	1.61
Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727) (HU941)	Recorded	8.76
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736) (HU950)	Recorded	59.04
Jointed Twig-rush sedgeland (1742) (HU938)	Recorded	1.45
Phragmites australis and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (1071) (HU673)	Recorded	7.71

Table 6-2 Summary of biodiversity values assessed under the FBA (ii. Species)

Threatened Species	Ecosystem or species credit species (BBCC)	Identification method (assumed, recorded)	Area/individuals within construction footprint
Threatened flora			
Eucalyptus parramattensis subsp. decadens	Species	Recorded	34 plants
Callistemon linearifolius	Species	Recorded	157 plants
Sand Doubletail (*Diuris arenaria*)	Species	Recorded	161 plants
Tall Knotweed (*Persicaria elatior*)	Species	Recorded	3 plants
Threatened fauna			
Wallum Froglet (*Crinia tinnula*)	Species	Recorded	Up to 3.21 ha of habitat (land 40m around waterways where this species was detected during surveys)
Squirrel Glider (*Petaurus norfolcensis*)	Ecosystem	Recorded	93.36 ha of potential habitat (associated PCTs)
Grey-crowned Babbler (*Pomatostomus temporalis temporalis)*	Ecosystem	Recorded	70.47 ha of potential habitat (associated PCTs)
Varied Sittella (*Daphoenositta chrysoptera*)	Ecosystem	Recorded	100.96 ha of potential habitat (associated PCTs)
Little Bent-winged Bat (*Miniopterus australis*)	Ecosystem and species	Recorded	82.78 ha of potential foraging habitat (associated PCTs)
Grey-headed Flying-fox (*Pteropus poliocephalus*)	Ecosystem	Recorded	About 85.05 ha of potential foraging habitat (associated PCTs)
Masked Owl (*Tyto novaehollandiae*)	Ecosystem	Recorded	70.47 ha of potential habitat (associated PCTs)
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	Ecosystem	Recorded	82.78 ha pf potential habitat (associated PCTs)
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	Ecosystem	Recorded	82.78 ha pf potential habitat (associated PCTs)
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	Newly listed species under the BC Act – Not listed under TSC Act or included in the BBCC	Recorded	174.3 ha of potential foraging habitat. No large stick nests identified.
Mahony's Toadlet (*Uperoleia mahonyi*)	Newly listed species under the BC Act – Not listed under TSC Act or included in the BBCC	Assumed	Up to 3.21 ha of potential habitat expected
Australasian Bittern (*Botaurus poiciloptilus*)	Species (FBA/BBCC)	Assumed	43.64 ha of potential habitat

Threatened Species	Ecosystem or species credit species (BBCC)	Identification method (assumed, recorded)	Area/individuals within construction footprint
Black Bittern *(Ixobrychus flavicollis*)	Species	Assumed	61.95 ha of potential habitat
Koala (*Phascolarctos cinereus*)	Species	Assumed	51.12 ha of potential habitat (associated PCTs excluding the Black Hill / Beresfield area)

Of the 174.3 hectares of native vegetation removal, about 136 hectares (78 per cent) comprises the following TECs listed under the TSC Act:

- Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions (Endangered)
- Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)
- Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions (Endangered)
- Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)
- Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)
- Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregion (Endangered).

In addition, about 0.55 hectares of Subtropical and Temperate Coastal Saltmarsh TEC, listed as vulnerable under the EPBC Act would be removed.

6.2 Biodiversity values outside the FBA

Table 6-3 provides a summary of biodiversity values that occur in the construction footprint that have not been assessed under the FBA.

Table 6-3 Summary of biodiversity values outside the FBA

Biodiversity value	Overview of presence within the construction footprint and identification method (assumed, recorded, expert report)	Area within construction footprint
Wetland Migratory Bird Species (EPBC Act) (Latham's Snipe)	Recorded - Latham's Snipe Suitable habitat for this species and other migratory wetlands birds is most widespread in Hexham swamp wetlands which continue south of the project at Tarro through to Shortland.	16.4 hectares of freshwater wetlands habitat
Terrestrial Migratory Bird Species (EPBC Act) (Rufous Fantail and Satin Flycatcher)	Recorded - The Rufous Fantail and Satin Flycatcher were recorded at Black Hill	70.47 hectares of associated habitat (PCT 1590 and PCT 1646)
Marine Migratory Bird Species (EPBC Act) (White-bellied Sea-Eagle)	Recorded flying over the construction footprint at multiple locations	174.3 hectares of potential foraging habitat

Biodiversity value	Overview of presence within the construction footprint and identification method (assumed, recorded, expert report)	Area within construction footprint
Saltmarsh Estuarine Complex (PCT 1746) (saline vegetation type)	Section 5.1.1.12 of the FBA indicates that PCTs that are classified under the VIZ Classification Database as being in the saline wetlands vegetation formation must be assessed according to the Fisheries NSW policy and guidelines.	1.26 hectares
Grey Mangrove low closed forest (PCT 1747) (saline vegetation type)		2.27 hectares

7. Avoiding and minimising impacts

7.1 Avoiding impacts to biodiversity

Transport has carried out an extensive options development process for the project since 2004, including the consideration of alternatives to the project including the ‘do nothing/do minimum option’ and the development of route and alignment options. Following selection of a preferred route, the construction footprint of the project was further refined with due consideration of environmental data, including biodiversity field data gathered between 2014 and 2020. This data was also important in identifying appropriate management measures to mitigate impacts on biodiversity.

The environmental focus of the route selection for the project was to align the construction footprint with existing development and infrastructure and thereby avoid biodiversity impacts where possible. Specifically, the construction footprint aligns with existing infrastructure associated with the Hunter Water Chichester Gravity Trunk Main, the New England Highway and existing Tarro Interchange, the Pacific Highway at Tomago and the Heatherbrae light industrial land. This has resulted in a construction footprint that has minimal impact to vegetation connectivity at a landscape scale due to the fact that the route follows along the edge of existing vegetation, particularly north of Tomago Road. For this reason, potential impacts to large areas of koala habitat between Tomago and Raymond Terrace have been avoided and the project is not expected to impact on the movements of koalas.

Other specific impacts to biodiversity that have been avoided over the course of project development include:

- Aligning the construction footprint between the Black Hill and Tarro interchange with the Hunter Water trunk main and the New England Highway has avoided most of the direct impacts to the floodplain’s wetlands (west of Woodlands Close) and the Hunter Wetlands National Park
- Design of a viaduct crossing the Hunter River and adjacent floodplain, in contrast to a built formation option, has resulted in avoiding a lengthy direct impact to floodplain wetlands and associated biodiversity and maintained connectivity for fauna associated with the floodplain habitats
- Moving the proposed viaduct (B05) crossing the Hunter River from about 260 metres upstream of the existing Hexham Bridge to about 1.6 kilometres upstream of the existing Hexham Bridge, has resulted in:
  - Reducing the length of the construction footprint in the Coastal Management SEPP coastal wetland located on the northern bank of the Hunter River, north of the Pacific Highway, from about 1,457 metres to about a 770-metre disturbance
  - Reducing the extent of impacts on two TECs listed under the TC Act: Saltmarsh TEC and Freshwater Wetland TEC.
- Moving the main alignment north between Black Hill and the Hunter River closer to the New England Highway has:
  - Reduced the area of land to be fragmented and completely surrounded by road infrastructure. The 2010 LEP alignment would have fragmented about 134 hectares, compared to about 24 hectares that is being fragmented by the current design. The land that would have been fragmented includes a 15-hectare area that includes Freshwater Wetlands TEC and Swamp Oak Floodplain Forest TEC. Fragmentation of this area may have reduced its suitability as habitat for some migratory and wetland species
  - Reduced impacts to the Coastal Wetland directly south of the Tarro interchange, as this Coastal Wetland was previously bisected by the 2010 LEP alignment.

- The scope and functionality of the project was challenged to remove a previously considered new road at Tomago that would have linked Old Punt Road to Tomago Road. The functionality of the road has been provided by minor upgrades to the existing Old Punt Road. This has avoided impacts to remnant vegetation, potential habitat for threatened species, connectivity impacts and a population of *Grevillea parviflora subsp. parviflora* (avoiding a direct impact to about 150 individuals)
- The locations of ancillary sites have been positioned, where possible, to avoid impacts to biodiversity by placing within previously cleared and disturbed land such that there would be minimal vegetation disturbance required. Where some minor clearing is required (i.e. AS10 and AS11) much of this is planted or disturbed vegetation.

7.2 Minimising impacts to biodiversity

Following the avoidance process, where it has not been possible to avoid impacts to biodiversity by the preferred corridor location, the project has been designed to minimise impacts as far as possible. These measures are described below:

- Raymond Terrace – Removal of the northbound exit ramp. This design change allowed the project to minimise impacts on native vegetation in this area
- Locating the northern abutment of Hunter River bridge across former industrial land that is a known contamination site, resulting in minimising vegetation loss and removing the contamination source to limit future ongoing contamination risk
- Inclusion and design of fauna fencing and fauna crossing opportunities designed to minimise impacts to localised movements of fauna.

7.3 Mitigating impacts to biodiversity

Once all practicable steps to avoid or minimise impacts have been implemented during the design phase, management measures would be implemented during construction to further lessen the potential ecological impacts of the project. Transport have a long history of designing and implementing management measures of road projects that are known to be effective. Proposed management measures are outlined in **Chapter 9** and are summarised from the document ''Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (NSW Roads and Traffic Authority 2011).

8. Impact assessment

8.1 Areas requiring assessment

The FBA identifies impact thresholds for landscape features, native vegetation and threatened species and populations. Areas that do not require assessment include land without native vegetation (as per the definition under the *Native Vegetation Act 2003* (NV Act)), unless the area of land requires assessment under the SEARs. In line with the thresholds identified in the FBA, areas that do not require offsets to be calculated include:

- Impacts on PCTs that:
  - Have a site value score, less than 17
  - Are not identified as CEECs or EECs.
- Impacts on PCTs that are not associated with threatened species habitat and are not identified as CEECs/EECs
- Impacts on non-threatened species and populations that do not form part of a CEEC or TEC
- Impacts on threatened species habitat associated with a PCT within a vegetation zone with a site value score, less than 17.

No areas within the construction footprint meet any of these criteria. There is no requirement in the project SEARs (SSI 7319) to assess any land without native vegetation.

Areas of cleared land, planted vegetation and exotic vegetation within the construction footprint (refer to **Section 3.3** for description and **Figure 3-1** for locations) that were not able to be assigned to a PCT do not require offsetting in accordance with the FBA.

The areas that require assessment and offset are described in the following sections.

8.1.1 Removal of native vegetation and threatened ecological communities

The construction footprint for this assessment includes all areas proposed to be impacted, cleared and/or disturbed for the project. This assessment has assumed that there would be complete vegetation clearance within the construction footprint. This precautionary approach has been applied to the assessment of the impacts of the concept design to ensure all potential 'worst case' impacts are assessed. If approved, the project would undergo detailed design phase, during which impacts would be further reviewed and minimised as far as practicable.

The project would result in the removal of about 174.3 hectares of native vegetation from 14 different PCTs (refer to **Table 8-1**). This represents about 13.6 per cent of the native vegetation within the assessed landscape (1,277 hectares) described by the FBA for assessing landscape values for linear shaped developments.

Vegetation clearance and habitat loss are likely to be the largest detrimental impacts for terrestrial biodiversity that arise from the project. The impact may be direct in the form of vegetation and habitat removal, or indirect, in the form of fragmentation of habitat and edge effects to retained areas of vegetation.

Table 8-1 Proposed clearing of native vegetation

Vegetation zone	Plant community type (PCT) (BVT)	Threatened Ecological Community		Site value score	Project impact (ha)
		TSC Act	EPBC Act		
1. 1590 - Good	Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590) (HU804)	Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions (Endangered)	-	77.08	25.16
2. 1590 - Moderate				64.58	8.35
3.1590 - Regenerating				29.17	8.37
4.1588 - Moderate	Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (1588) (HU802)	-	-	79.69	6.78
5.1588 - Regenerating				49.48	0.82
6. 1646 - Good	Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646) (HU860)	-	-	59.9	20.76
7.1646 - Poor				50	7.83
8.1649 - Good	Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649) (HU863)	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	61.33	1.36
9.1598 - Poor	Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598) (HU812)	Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions (Endangered)	-	71.33	0.45
10.1716 - Good	Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716) (HU930)	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	66.67	1.82
11.1717 - Good	Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717) (HU931)	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	62	3.85
12.1717 – Poor				44	6.64
13.1724 - Good	Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1724) (HU938)	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	53.33	1.61

Vegetation zone	Plant community type (PCT) (BVT)	Threatened Ecological Community		Site value score	Project impact (ha)
		TSC Act	EPBC Act		
14.1727 - Moderate	Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727) (HU941)	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	Does not meet size or condition criteria for a listed community under EPBC Act	55.33	8.76
15.1736 - Good	Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736) (HU950)	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	-	48.06	33.23
16.1736 - Moderate				36.43	25.81
17.1742 - Good	Jointed Twig-rush sedgeland (1742) (HU956)	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	-	82.17	1.45
18.1071 - Good	*Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (1071) (HU673)	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered – in part 7.67 ha)	-	47.29	7.71
19.1746 - Good	Saltmarsh Estuarine Complex (1746) (HU960)	Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregion (Endangered)	Subtropical and Temperate Coastal Saltmarsh (vulnerable – in part 0.55 ha meets condition criteria)	49.07	1.26
20.1747 - Good	Grey Mangrove low closed forest (1747) (HU961)	-	-	100	2.04
21.1747 - Moderate				42.42	0.23
Total area of clearing		**136 ha**	**0.55 ha**	**-**	**174.3 ha**

Threatened ecological communities

Of the 174.3 hectares of native vegetation removal, about 136 hectares (78 per cent) comprises the following TECs listed under the TSC Act (refer to **Table 8-1**):

- Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions (Endangered) – 41.88 hectares
- Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered) – 15.79 hectares

- Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions (Endangered) – 0.45 hectares
- Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered) – 8.76 hectares
- Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered) – 68.2 hectares
- Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregion (Endangered) – 1.26 hectares.

In addition, about 0.55 hectares of Subtropical and Temperate Coastal Saltmarsh, listed as vulnerable under the EPBC Act would be removed (refer to **Table 8-1**). Management measures designed to reduce the impact of vegetation removal are provided in **Chapter 9**.

The quantum of vegetation clearing proposed for each TEC relative to the remaining extent of each EEC within the broader lower Hunter region is discussed under the following subsections.

Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions (Endangered)

The project would result in clearing of 41.88 hectares of the Lower Hunter Spotted Gum Ironbark Forest in the Sydney Basin and NSW North Coast Bioregions TEC. This represents about 0.8 per cent of the potential 5,242 hectares of this TEC mapped in the locality (VIS_ID 2225). Any impact to this TEC would further threaten its existence and directly affect its ability to persist in the locality, however the proportional impact is relatively low and unlikely to lead to its extinction. Further to this, offsetting of associated PCTs is required.

Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)

The project would result in clearing of 15.79 hectares of the Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC. This represents about 0.9 per cent of the potential 1,765 hectares of this TEC mapped in the locality (VIS_ID 2225). Any impact to this TEC would further threaten its existence and directly affect its ability to persist in the locality, however the proportional impact is relatively low and unlikely to lead to its extinction. Further to this, offsetting of associated PCTs is required.

Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions (Endangered)

The project would result in clearing of 0.45 hectares of the Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions TEC. This impact is small and represents very minor portion of the potential 72 hectares of this TEC mapped in the locality (VIS_ID 2225). This impact is unlikely further threatened this TEC or lead to its extinction. Further to this, offsetting of associated PCTs is required.

Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered) – 8.76 hectares

The project would result in clearing of 8.76 hectares of the Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC. This represents about 0.9 per cent of the potential 943 hectares of this TEC mapped in the locality (VIS_ID 2225). Any impact to this TEC would further threaten its existence and directly affect its ability to persist in the locality, however the proportional impact is relatively low and unlikely to lead to its extinction. Further to this, offsetting of associated PCTs is required.

Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered) – 68.2 hectares

The project would result in clearing of 68.2 hectares of the Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC. This represents about two per cent of the potential 3,366 hectares of this TEC mapped in the locality (VIS_ID 2225). Any impact to this TEC would further threaten its existence and directly affect its ability to persist in the locality. The proportional impact of two per cent is higher than what the real proportional impact would be, considering most of the freshwater wetlands identified by this assessment are low condition located on agricultural land that does not appear in the regional vegetation mapping. Therefore, the proportional impact is likely to be relatively low and unlikely to lead to its extinction. Further to this, offsetting of associated PCTs is required.

Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregion (Endangered) – 1.26 hectares

The project would result in clearing of 1.26 hectares of the Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregion TEC. This community has been combined with mangroves in regional mapping (VIS_ID 2225) and has an occurrence in the locality of 2,615 hectares (Mangrove-Estuarine Complex). This project impact represents about 0.05 per cent of the potential occurrence of this TEC mapped in the locality (VIS_ID 2225), however the condition of this TEC within the construction footprint is low and the larger high-quality patches within the locality would not be impacted. Any impact to this TEC would further threaten its existence and directly affect its ability to persist in the locality, however the proportional impact is relatively low and unlikely to lead to its extinction. Further to this, offsetting of associated PCTs is required.

Impacts to existing Biobank site

The construction footprint has a minor intersection with land under a conservation agreement (i.e. BioBank site) owned by Hunter Water Corporation (Lot 1 DP 748716), and associated with the Hunter Region Botanic Gardens, east of the existing Pacific Highway (refer **Figure 4-4**). Although the project has purposefully avoided and minimised direct impacts where possible, the construction footprint intersects a very minor area (about 0.6 hectares) of the western edge of the BioBanking site, next to the existing Pacific Highway. This would result in impacts to 0.5 per cent of the 106 hectare BioBank site and include minor impacts to native vegetation (PCT 1598, PCT 1071 and PCT 1717). The vegetation impacts within the BioBanking site are included in the total native vegetation impact calculations, as listed in **Table 8-1**, and are not additional. Transport will acquire this impacted land and offset the impacts to the existing BioBanking site.

8.1.2 Removal of threatened flora

The project would impact on the following threatened plant species:

- *Eucalyptus parramattensis* subsp. *decadens* (Vulnerable – TSC Act and EPBC Act)
- *Diuris arenaria* (Vulnerable – TSC Act)
- *Callistemon linearifolius* (Vulnerable – TSC Act)
- *Persicaria elatior* (Vulnerable – TSC Act and EPBC Act).

Project design refinements have avoided impacting on small populations *Maundia triglochinoides* and *Grevillea parviflora* subsp. *parviflora* also recorded during project surveys (refer to **Section 7.2**).

***Eucalyptus parramattensis subsp. decadens* (vulnerable TSC Act and EPBC Act)**

The current design of an off-ramp at the northern end of the project would directly impact 34 individuals. The habitat is contiguous to the east towards Williamtown and is therefore connected to the large Tomago

Sandbeds sub-population of *E. parramattensis subsp. decadens* (refer to **Figure 8-1** for records of this species to the east of the project). The plants within the construction probably represent the western extent of this large population as there is no further habitat available to the west or north at this location and no further trees were located to the west. Given the condition and location of the habitat where these trees are located on the edge of the Pacific Highway, the loss of 34 plants from this large Tomago Sandbeds population is unlikely to lead to the decline of the local population and is not considered to be a significant impact.

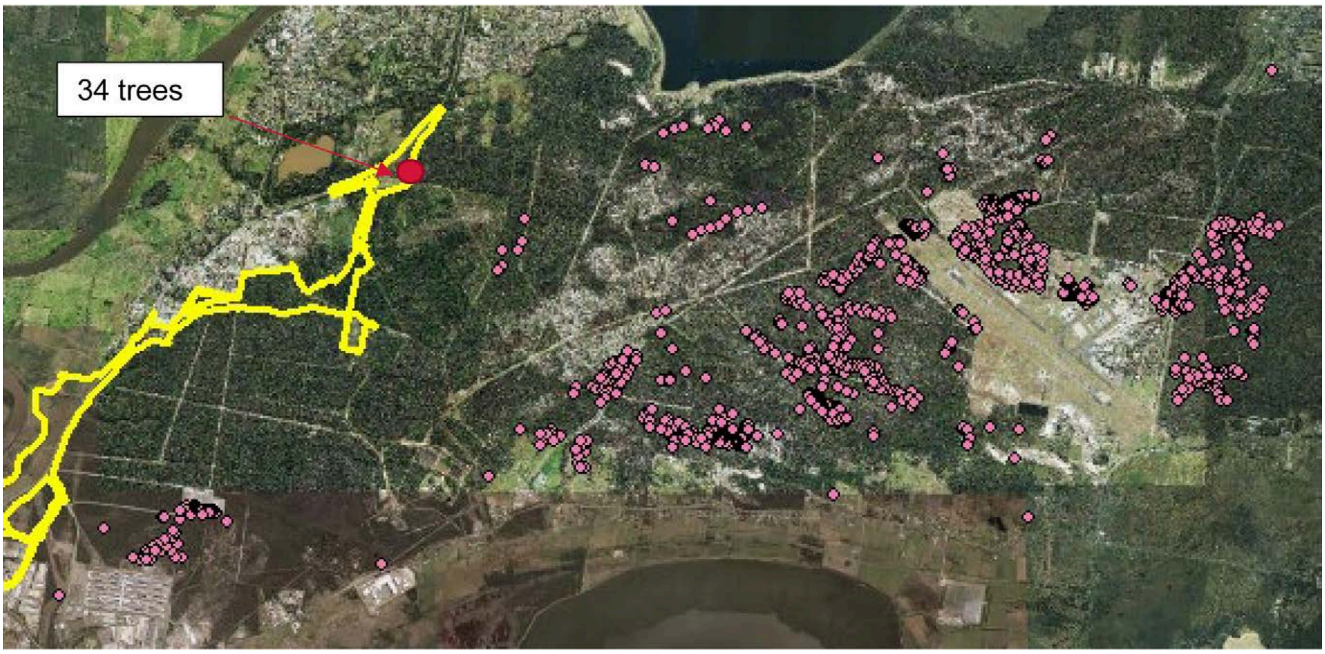


Figure 8-1 BioNet Atlas records of *Eucalyptus parramattensis* subsp. *decadens* within 10 kilometres of the construction footprint show some of the extent of the Tomago Sandbeds sub-population

Diuris arenaria

The majority of the identified population (89.2 per cent) occurs on land previously cleared for an approved industrial development off Masonite Road, and the plants have colonised this cleared site. Given its cleared status and development approval, the site was selected for an ancillary area for the project. The impact from this project and offset requirement has been calculated by subtracting all plants within the approved development area (560 plants). Therefore, the project would directly impact an estimated 161 plants (about 10.8 per cent of the known local population) and fragment habitat occupied by the population. A small number of plants would remain outside the project on the industrial site (along adjoining easement and tracks within Hunter Water Corporation land), however the cumulative loss from the two sites represents a significant loss of plants from this local population.

Callistemon linearifolius

A total of 157 plants are located within the construction footprint and would be cleared. Whether this population extends much further to the south of the project towards Black Hill or further west of the M1 Pacific Motorway towards Brandy Hill has not been determined. The loss of plants from the Black Hill end of the project (considering only known individuals) is likely a large portion of the known population located east of the M1 Pacific Motorway. This population has previously been impacted from clearing and disturbance for the M1 Pacific Motorway, agricultural land, and water pipeline infrastructure, so this impacts is will contribute to the cumulative loss of plants at this location. Other populations and suitable habitat occur to the west of the project. The remaining plants at the southern end of the population would be subject to indirect impacts through edge effects, with many located on the edge of the new road, suggesting the long-term viability of the remainder of the population would also be impacted.

Persicaria elatior

Three *Persicaria elatior* plants were recorded from the edge of a drainage line in the floodplain on the south side of the Hunter River. These plants were recorded in March 2018 following months of below average rainfall. The drainage line presents more suitable habitat for this species, although the land on which the plants occur is subject to ongoing cattle grazing and impacts from weed invasion and is in generally poor condition. All three plants identified would be directly impacted by the project. This represents a small number of plants, and the full extent of a local population is not known. The three individuals likely represents a small isolated population that have dispersed from nearby large areas of swamp forest and wetlands to the east. Given this, the habitat that would be impacted by the project is not considered likely to be habitat critical to the survival of the species.

8.1.3 Removal of threatened fauna species habitat and habitat features

Ten threatened fauna species were confirmed in the construction footprint by surveys carried out for this assessment. While the survey effort and methods used were considered comprehensive and suited to identification of the target species, some species may occur that were not recorded, and this is due to the limitations of surveys described in **Section 4.2.2**. These species are assumed present and include three additional species-credit species. The species are assumed present on the basis that there are associated habitats (PCTs present) in the construction footprint and reliable and recent records of these species in the locality suggesting there is a high likelihood of occurring (refer to **Table 8-2**).

An additional threatened species Mahony's Toadlet (*Uperoleia mahonyi*) (identified in SEARs) is listed as vulnerable under the BC Act. This species was not recorded in the construction footprint, although is assumed present on the basis of reliable records in proximity to the study area, and presence of suitable habitat. Impacts have been included and assessed in this BAR in order the meet the SEARs. Note, however that this species is not included in the BBCC.

Similarly, the White-bellied Sea-Eagle is not included in the BBCC (or under the TSC Act) as it was listed under the BC Act in December 2016, however this species was recorded within the construction footprint during the assessment.

Table 8-2 Threatened fauna species confirmed by surveys or assumed present

Fauna species	Status	Credit type	Presence in the construction footprint
Wallum Froglet (*Crinia tinnula*)	Vulnerable (TSC Act)	Species	Confirmed
Squirrel Glider (*Petaurus norfolcensis*)	Vulnerable (TSC Act)	Ecosystem	Confirmed
Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)	Vulnerable (TSC Act)	Ecosystem	Confirmed
Varied Sittella (*Daphoenositta chrysoptera*)	Vulnerable (TSC Act)	Ecosystem	Confirmed
Little Bent-winged Bat (*Miniopterus australis*)	Vulnerable (TSC Act)	Ecosystem	Confirmed
Grey-headed Flying-fox (*Pteropus poliocephalus*)	Vulnerable (TSC Act and EPBC Act)	Ecosystem	Confirmed
Masked Owl (*Tyto novaehollandiae*)	Vulnerable (TSC Act)	Ecosystem	Confirmed
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	Vulnerable (BC Act – not listed under the TSC Act, Migratory EPBC Act)	Not listed in BBCC	Confirmed

Fauna species	Status	Credit type	Presence in the construction footprint
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	Vulnerable (TSC Act)	Ecosystem	Confirmed
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	Vulnerable (TSC Act)	Ecosystem	Confirmed
Koala (*Phascolarctos cinereus*)	Vulnerable (TSC Act and EPBC Act)	Species	Assumed present
Australasian Bittern (*Botaurus poiciloptilus*)	Endangered (TSC Act and EPBC Act)	Species	Assumed present
Black Bittern (*Ixobrychus flavicollis*)	Vulnerable (TSC Act)	Species	Assumed present
Mahony's Toadlet (*Uperoleia mahonyi*)	Endangered (BC Act – not listed under the TSC Act)	Not listed in BBCC	Assumed present

The loss of habitat is a key threatening process listed under the TSC Act also described as land clearance under the EPBC Act. The loss of habitat for threatened fauna species would equate to about 174.3 hectares of native vegetation within the construction footprint. This loss is dominated by freshwater wetland habitat across the Hunter River floodplain component of the project (about 39.1 per cent), followed by dry sclerophyll forests with a shrub and grass understorey (about 28.4 per cent), the both combined make up about 67.5 per cent of the area impacted. The remaining comprises dry sclerophyll forests with a shrubby understorey, as well as forested and saline wetlands (refer **Table 8-3**). The project would also result in the removal of about 13.04 hectares of planted native vegetation, which provide a foraging resource for a range of mobile nectarivores species (i.e. birds and bats). The context of the loss of habitat in terms of the habitat resources and anticipated loss of connectivity for fauna is described in the following.

Table 8-3 Summary of clearing of fauna habitat types

Vegetation formation / fauna habitat type	Vegetation Zone	Direct loss (construction footprint)	Proportion of direct loss (per cent)
Dry Sclerophyll Forests (Shrub/grass sub-formation)	1-5	49.49 ha	28.4 %
Dry Sclerophyll Forests (Shrubby sub-formation)	6-7	28.59 ha	16.4 %
Forested Wetlands	8-14	24.49 ha	14.1 %
Freshwater Wetlands	15-18	68.2 ha	39.1 %
Saline Wetlands	19-21	3.53 ha	2 %
	Total fauna habitat cleared	**174.3 ha**	

Hollow-bearing trees

The loss of hollow-bearing trees is a key threatening process listed under the TSC Act. Hollow bearing trees are a critical habitat feature for a number of threatened species (Gibbons & Lindenmayer 2002), providing breeding and/or sheltering habitat. Gibbons and Lindenmayer (2002) found that hollow bearing trees were more common in older stands, gullies, vegetation not logged and on flat terrain. Habitats with high productivity were also noted to support a higher number of hollow bearing trees.

Hollow-bearing trees were found to be present in the construction footprint being most common in the dry sclerophyll forests, but also noted in lower abundance in the forested wetlands and mangrove forests (saline wetlands). These three habitats account for around 59 per cent of the habitat loss proposed.

Loss of hollow-bearing trees is likely to be greatest in the dry sclerophyll forest with shrubby understorey located from the Hunter Botanic Gardens through to Masonite Road this is due to the dominance of Smooth-barked Apple, Blackbutt and Scribbly Gum which readily form hollows, and the mature age of the forests in this location. The dry sclerophyll forests with shrub / grassy understorey at Black Hill have been subject to disturbance over a long period including selective logging and firewood removal, and senescent trees and tree hollows occur at lower densities than the open forests at the northern end of the construction footprint.

In NSW, terrestrial vertebrate species that are reliant on tree hollows for shelter and nesting include at least 46 mammals, 81 birds, 31 reptiles and 16 frogs (Gibbons and Lindenmayer 1997, Gibbons and Lindenmayer 2002). Of these, nine species listed as threatened have either been identified in the construction footprint or are considered likely to occur, these are identified in **Table 8-4**.

Table 8-4 Threatened fauna expected in the construction footprint and impacted by the loss of hollow-bearing trees

Common name	Scientific name	TSC Act	EPBC Act
Glossy Black-cockatoo	*Calyptorhynchus lathami*	V	-
Little Lorikeet	*Glossopsitta pusilla*	V	-
Powerful Owl	*Ninox strenua*	V	-
Masked Owl	*Tyto novaehollandiae*	V	-
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V	-
Eastern Coastal Free-tailed Bat	*Micronomus norfolkensis*	V	-
Squirrel Glider	*Petaurus norfolcensis*	V	-
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	V	-
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V	-

Foraging resources

There are a number of potential impacts on fauna associated with the loss of foraging resources. These relate to the direct loss of vegetation biomass available to herbivores and frugivores and the extent to which remaining resources could potentially be exploited and the consideration of increased competition for patchy resources. The latter type of impact is likely to decline with increasing risk of disturbance associated with road operation, edge effects and fragmentation and weed infestation.

The direct loss of foraging resources in the form of foliage, nectar and sap exudates equates coarsely to the clearing impacts for forested habitats described in **Table 8-1**. The indirect impacts of this clearing relate to loss of habitat for prey species, in particular insects. However, this may over-estimate the impact by assuming that all habitats being lost have equal value as foraging habitat and equal accessibility and does not consider competition for resources and forage quality and quantity per habitat type.

The potential consequence of these losses on the size of fauna populations cannot be quantified using the short-term field survey data collected at this scale. For example, other factors to consider are the adaptations of species over time associated with accessing fragmented resources in the landscape, such as nectivorous bats and birds, as opposed to sedentary species that require a habitat patch size threshold to maintain viable populations. As such, not all fauna species are affected by loss of foraging resources equally.

Foliage and nectar foraging resources are present in multiple strata including the upper canopy, mid to lower and ground level strata. Relevant threatened species potentially impacted at the patch scale are forest dependent species such as Squirrel Glider, Eastern Pygmy Possum and Koala and small insectivorous bats. Species expected to be impacted at the landscape level include Little Lorikeet and Grey-headed Flying-fox. The latter are responsible for cross-pollination and genetic diversity in many plant species.

Winter flowering resources

A number of the discussed threatened fauna species require winter flowering food resources to supply food when there are resource bottlenecks, or to coincide with migratory movements. As such, the presence of annually reliable winter-flowering plant species is considered a limiting factor in the distribution of a number of threatened species, particularly Squirrel Glider, Regent Honeyeater, Little Lorikeet and Grey-headed Flying-fox. The Squirrel Glider relies on a tree species composition that provides year-round continuity of nectar and pollen.

Of the 14 PCTs impacted by the project, at least six are dominated by winter-flowering tree species, these include Spotted Gum (*Corymbia maculata*), Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*E. tereticornis*), Grey Ironbark (*E. siderophloia*) and Broad-leaved Paperbark (*Melaleuca quinquenervia*). The loss of these habitats equates to around 62.97 hectares (37 per cent) of the total loss of native vegetation. Spotted Gum and Forest Red Gum are also commonly planted along the road edge within the construction footprint, of which around 13.04 hectares would also be cleared. The diversity of PCTs present in the construction footprint combine to provide seasonal year-round nectar resources for dependent fauna. **Table 8-5** lists the flowering periods for dominant trees and shrubs within the PCTs that would be removed in the construction footprint.

Other foraging resources available within the construction footprint include plant exudates (Acacia and Eucalyptus sap), foraging substrates such as tree trunks and fallen logs, creek lines (insect prey source) and Koala feed tree species (including Forest Red Gum (*E. tereticornis*), and Swamp Mahogany (*E. robusta*). Koalas are also known to browse on Broad-leaved paperbark (*Melaleuca quinquenervia).*

Table 8-5 Flowering periods of dominant trees and shrubs within the construction footprint

Scientific name	Common name	PCT ID where species may be dominant	Flowering period
Acacia irrorata	Mountain Cedar Wattle	1717	Spring to summer
Acacia longifolia	Sydney Golden Wattle	1717	Winter
Angophora costata	Smooth-barked Apple	1646, 1649	Spring and summer
Angophora floribunda	Rough-barked Apple	1598	Spring to summer
Banksia serrata	Old Man Banksia	1646	Summer
Corymbia gummifera	Red Bloodwood	1646	Summer
Corymbia maculata	Spotted Gum	1590, 1588	Winter
Eucalyptus acmenoides	White Mahogany	1590, 1588	Spring to summer
Eucalyptus fibrosa	Red Ironbark	1590	Spring to summer
Eucalyptus globoidea	White Stringybark	1588	Autumn
Eucalyptus pilularis	Blackbutt	1646	Spring
Eucalyptus piperita	Sydney Peppermint	1646, 1717	Early summer
Eucalyptus resinifera	Red Mahogany	1716, 1649	Summer
Eucalyptus robusta	Swamp Mahogany	1649, 1717, 1724, 1742	Winter
Eucalyptus siderophloia	Northern Grey Ironbark	1588	Winter to spring
Eucalyptus tereticornis	Forest Red Gum	1598	Winter to spring

Scientific name	Common name	PCT ID where species may be dominant	Flowering period
Eucalyptus umbra	White Mahogany	1588	Early spring
Leptospermum polygalifolium	Lemon-scented Teatree	1649	Spring
Melaleuca decora	White-feather Honeymyrtle	1716	Summer
Melaleuca linariifolia	Snow-in-summer	1716, 1717	Summer
Melaleuca nodosa	Ball Honeymyrtle	1590, 1588, 1716, 1649, 1598	Early spring
Melaleuca quinquenervia	Broad-leaved Paperbark	1649, 1717, 1724, 1742	Autumn to winter
Melaleuca sieberi	White Paperbark	1649	Summer
Melaleuca styphelioides	Prickly-leaved Paperbark	1588, 1071	Summer
Syncarpia glomulifera	Turpentine	1716	Spring to summer

Koala

The Koala inhabits a range of eucalypt forest and woodland communities where favoured food trees are present (Phillips 2000b) which may also include isolated paddock trees (White 1999). The quality of the habitat for Koalas is influenced by a range of factors (Reed et al. 1990), such as:

- Species and size of trees present
- Structural diversity of the vegetation
- Soil nutrients
- Climate and rainfall
- Size and disturbance history of the habitat patch.

Important Koala populations and preferred Koala habitat have been modelled across the Port Stephens Council LGA and identified in the Port Stephens Koala Plan of Management (PSC and AKF 2004). Supplementary habitats and smaller areas of preferred habitat have been modelled in the northern portion of the construction footprint and associated with the Tomago Sandbeds, these extend extensively to the east of the project. Further work to model the distribution of important Koala habitat in the region has been reported in Eco Logical (2013), and these reports also map moderate to high quality habitat on the Tomago Sandbeds which mainly occur to the east and north of the construction footprint, with some smaller isolated patches intersecting the construction footprint at Tomago and Heatherbrae.

The targeted surveys identified no evidence of frequent use of the habitats in the construction footprint by Koala. However, based on the density of Koala records in the surrounding areas to the east and north of the project and the presence of suitable habitat within parts of the construction footprint, it is likely that portions of the dry sclerophyll forest habitat from Tomago to Heatherbrae provide for transient movements for Koalas and are therefore important for dispersal or temporary refuge. The description of potential impacts on the species that follow describe the impacts on this northern section of the construction footprint. In contrast while Koala feed tree species occur to the south around the Black Hill end of the project (i.e. the primary feed tree *Eucalyptus tereticornis* and secondary feed trees *E. agglomerata* and *E. eugenioides*) there are no historic sightings and no evidence of Koalas was identified from the targeted surveys on the western side of the M1 Pacific Motorway. This suggests a low probability that there is a resident Koala population occurring in this portion of the construction footprint, and any loss of habitat at Black Hill is not expected to impact on a local Koala population east of the M1 Pacific Motorway.

Primary food trees exhibit a level of use that is significantly higher than that of other *Eucalyptus* sp. while also demonstrating use by Koalas that is independent of density. Secondary and/or supplementary food trees invariably exhibit (on average) a significantly lower level of use than a primary food tree (Phillips 2000). **Table 8-6** lists the primary, secondary and supplementary Koala food tree species (*Eucalyptus* sp.) reported for the broader NSW North Coast (DECC 2008) and the Port Stephens area (PSC / AKF 2002, Mitchell 2012). The table also identifies the tree species confirmed in the construction footprint from the vegetation surveys and respective PCTs.

Table 8-6 Koala feed tree species and associated PCTs in the construction footprint

Koala food tree species	Presence in PCT in construction footprint	Category (feed tree)		
		DECC (2008)	Mitchell (2012)	PSC / AKF (2002)
Eucalyptus robusta	1727, 1717, 1646, 1724	Primary	Primary	Preferred
Eucalyptus tereticornis	1598, 1590, 1646, 1717	Primary	Primary	Preferred
Eucalyptus parramattensis	1727, 1717	Primary	Primary	Preferred
Eucalyptus resinifera	1593, 1717	Secondary	Important	Important
Eucalyptus punctata	1646	-	Important	Important
Eucalyptus eugenioides	1588, 1590	Supp.	-	-
Eucalyptus globoidea	1590, 1588	Supp.	Important	-
Eucalyptus crebra	1590, 1588	-	Important	Important
Eucalyptus grandis	1724	-	Important	Important
Eucalyptus piperita	1646	-	Important	Important
Eucalyptus siderophloia	1590, 1588, 1717	-	Important	-

The area of Koala habitat to be removed from the construction footprint that contains primary Koala food tree species in the canopy is about 51.12 hectares and associated with open forest from Tomago to Heatherbrae. An additional 40 hectares of PCT 1588 and PCT 1590 in the Black Hill area were excluded from impact calculations for the Koala due to the absence of a population in this location. It is evident from the position of the project in the landscape, being located adjoining existing roads and industrial areas that the project is expected to have minimal impact on the movements of koalas. The loss of habitat is considered of low impact to the broader Port Stephens Koala population. Specific management measures for the Koala are described in **Chapter 9** and include prevention of mortalities on the new road through fauna fencing in key areas.

Wallum Froglet and Mahony's Toadlet

The Wallum Froglet (*Crinia tinnula*) was identified at three locations during surveys, including the swamp forest wetland to the north and south of the Hunter Region Botanic Gardens, and several sites around Windeyers Creek. According to the BBCC, habitat for the Wallum Froglet includes "Land within 40 metres of coastal swamps and wet heaths". To calculate the impact on this species, a 40 metre buffer was placed on these three waterways (i.e. Windeyers Creek and the two drainage lines north and south of the Hunter Region Botanic Gardens) to capture the land around the edges.

Area of habitat impact for Wallum Froglet is around 3.21 hectares and includes:

- Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598) – 0.96 hectares
- Pine plantation – about 0.9 hectares (due to conformed presence of the species in parts of the pine forest
- Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646) – about 0.03 hectares
- Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717) – about 2.1 hectares.

Although *Uperoleia mahonyi* was not listed under the TSC Act, assessment of impact in accordance with Section 9 of the FBA was specified as an agency requirement to the SEARs from EES Group. Considering the proximity of locations where this species is known to occur in Tilligerry State Conservation Area east of the construction footprint, and the presence of suitable sandy wallum habitat, a conservative approach has been taken to assume *Uperoleia mahonyi* is present. Suitable habitat for Wallum Froglet (*Crinia tinnula*) has been used to assess the potential impact on Mahony's Toadlet and expected credit requirements for this species.

These impacts, both known and assumed, would reduce the extent of available habitat for local populations of both species. Around 3.21 hectares of an available 72 hectares would be removed (around 4.5 per cent) within the 1,500 metre landscape buffer. However, the impacts would not completely remove any occurrences of habitat, as all impacted areas constitute only a small portion of the available habitat within the water bodies affected. Therefore, habitat would remain in each location following the completion of the project. These impacts are unlikely to cause the local populations of these species to decline.

Australasian Bittern and Black Bittern

The Australasian Bittern and Black Bittern were not were not recorded within the construction footprint during surveys however these species are considered likely to occur due to the extensive amount of wetland habitat with dense vegetation throughout the Hunter estuary and Windeyers Creek which represent favoured habitat for these species. There are 29 Australasian Bittern recorded sightings and one Black Bittern recorded sighting in the locality (BioNet Atlas).

Habitat has been calculated for these two species using associated PCTs, though excluding disturbed and modified areas (i.e. PCT 1736 – Moderate and PCT 1717 – Poor) that provide few habitat opportunities. The total areas of impact to potential habitat are:

- Australasian Bittern: about 43.64 hectares
- Black Bittern: about 61.95 hectares.

These impacts, both known and assumed, would reduce the extent of available habitat for local populations of both species. The proportional impacts include around 27 per cent of available habitat for both species within the area (1,500 metre landscape buffer). However, these proportional impacts are likely higher than actual proportional impacts due to the marginal quality of most of the wetland habitat that would be impacted, and the large extent of higher quality habitat in the locality (i.e. Hunter Wetlands National Park). These impacts are unlikely to cause the local populations of these species to decline.

8.1.4 Summary of impacts to threatened species

A summary of impacts to threatened species is outlined in **Table 8-7**.

Table 8-7 Summary of threatened species impacts

Threatened species	Ecosystem or species credit species	TSC Act	EPBC Act	Habitat or individuals in construction footprint (direct impact)	Potential habitat in the 550-metre landscape buffer area
Flora					
Eucalyptus parramattensis subsp. decadens	Species	V	V	34 individuals, isolated group of trees adjacent to the existing Pacific Highway, western extent of the larger Tomago sand plains population	This is the extent of the population identified in the landscape buffer. About 395 hectares of potential habitat occurs.
Callistemon linearifolius	Species	V	-	157 individuals within construction footprint. Most are part of a population in the Black Hill / Beresfield area. 259 individuals identified in population. Remaining plants would be subject to indirect impacts from edge effects adjacent to the new road.	Surveys not extended to the landscape buffer and a larger local population at Black Hill / Beresfield could be reasonably expected. About 250 hectares of potential habitat present within this buffer in the Black Hill / Beresfield area
Diuris arenaria	Species	V	-	161 plants impacted within the construction corridor, and a further 560 plants would be impacted at the ancillary site location. The ancillary site has been positioned on land previously cleared for an approved development application and offsets are not required for this part of the population. Plants would remain outside the project along an existing power easement through Hunter Water Corporation land.	1772 plants have been recorded over two surveys (2016 and 2018), with the largest count 1443 (2016). Up to 200 hectares of suitable habitat occurs in the landscape buffer that may include additional individuals.
Persicaria elatior	Species	V	V	Estimated 3 plants would be lost from the construction footprint. The species is rare in the construction footprint, and only three plants have been confirmed.	This is the extent of the population recorded in the construction footprint, up to 16 hectares of suitable habitat sandy swamp habitat occurs in the landscape buffer around Tomago. Although no further individuals have been recorded,

Threatened species	Ecosystem or species credit species	TSC Act	EPBC Act	Habitat or individuals in construction footprint (direct impact)	Potential habitat in the 550-metre landscape buffer area
Fauna					
Wallum Froglet (*Crinia tinnula*)	Species	V	-	3.21 hectares of confirmed habitat based on a 40m buffer around the waterways where this species was identified.	About 73 hectares of potential habitat may occur in the surrounding landscape buffer
Squirrel Glider (*Petaurus norfolcensis*)	Ecosystem (BBCC)	V	-	93.36 hectares of potential habitat, populations recorded at Black Hill and Heatherbrae	About 396 hectares of potential habitat present, very large areas of contiguous habitat for this species extend east to Tomago, Williamtown and Tilligerry
Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)	Ecosystem	V	-	70.47 hectares of potential habitat based on associated PCTs, prefer dry sclerophyll forest with grassy/shrubby understorey.	Extent of population and occurrence not known, although up to 511 hectares of potential habitat present
Varied Sittella (*Daphoenositta chrysoptera*)	Ecosystem	V	-	100.96 hectares of potential habitat based on associated PCTs, prefer dry sclerophyll forest with grassy/shrubby understorey. Consistently recorded at Black Hill at western end of the construction footprint	Up to 511 hectares of potential habitat within landscape buffer
Little Bent-winged Bat (*Miniopterus australis*)	Ecosystem and Species credit	V	-	82.78 hectares of potential foraging habitat impacted. No roosting habitat identified in the construction footprint. Roosting habitat identified at Windeyers Creek bridge, which is outside the construction footprint and would not be impacted.	May forage over all forested and open habitats including cleared and modified lands, urban and industrial areas. Over 1000 hectares of forest habitat present plus very large areas of contiguous habitat for this species extend east to Tomago, Williamtown and Tilligerry
Grey-headed Flying-fox (*Pteropus poliocephalus*)	Ecosystem	V	V	85.05 hectares of potential foraging habitat based on associated PCTs and habitat modelling data for the locality	Over 1000 hectares of potential foraging habitat present. Very large areas of contiguous habitat for this species extend east to Tomago, Williamtown and Tilligerry

Threatened species	Ecosystem or species credit species	TSC Act	EPBC Act	Habitat or individuals in construction footprint (direct impact)	Potential habitat in the 550-metre landscape buffer area
Masked Owl (Tyto novaehollandiae)	Ecosystem	V	-	70.47 hectares of potential habitat. The species was confirmed at Black Hill and Heatherbrae and is likely to comprise separate individuals and home range area. No nesting trees identified, although suitable large trees hollows are present in the landscape at Heatherbrae and there is potential to remove trees used for nesting.	About 396 hectares of potential habitat present, very large areas of contiguous habitat for this species extend east to Tomago, Williamtown and Tilligerry very large areas of contiguous habitat for this species extend east to Tomago, Williamtown and Tilligery
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	Ecosystem	V	-	82.78 hectares of potential habitat based on associated PCTs this includes all forested habitats of the construction footprint.	Occupies a diversity of forest habitat with tree hollows for roosting, may forage over all forested and open habitats. Over 1000 hectares of forest habitat present plus very large areas of contiguous habitat for this species extend east to Tomago, Williamtown and Tilligerry
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	Ecosystem	V	-	82.78 hectares of potential habitat based on associated PCTs this includes all forested habitats of the construction footprint.	Occupies a diversity of forest habitat with tree hollows for roosting, may forage over all forested and open habitats. Over 1000 hectares of forest habitat available plus very large areas of contiguous habitat for this species extend east to Tomago, Williamtown and Tilligerry
Koala (*Phascolarctos cinereus*)	Species	V	V	Impacts to about 51.12 hectares from Tomago to Heatherbrae, predominantly impacts on edge habitats and fragmented habitat, no impacts to koala movements anticipated. Up to 5.3 hectares of potential habitat would be isolated at Heatherbrae, however this is on the edge of the existing industrial area, and no evidence of koala use was recorded.	Large areas of potential habitat across the Tomago Sandbeds through to Williamtown and north to Grahamstown Dam. About 670 hectares mapped within the landscape buffer
Australian Bittern (*Botaurus poiciloptilus*)	Species	V	-	43.64 hectares of potential habitat based on associated PCTs. Historical record from Windeyers Creek	Known from Hunter Wetlands National Park and Hexham Swamp Nature Reserve. Up to 160 hectares of potential habitat mapped within the landscape buffer

Threatened species	Ecosystem or species credit species	TSC Act	EPBC Act	Habitat or individuals in construction footprint (direct impact)	Potential habitat in the 550-metre landscape buffer area
Black Bittern (*Ixobrychus flavicollis*)	Species	V	-	61.95 hectares of potential habitat based on associated PCTs could occur in freshwater and saline wetlands. High quality habitat occurs to the east of the project in the Botanic Gardens outside of the construction footprint, and also south of the project at Black Hill, which would not be impacted.	Known from Hunter Wetlands National Park. Up to 233 hectares of potential habitat mapped within the landscape buffer
Mahony's Toadlet (*Uperoleia mahonyi*)	Newly listed species - Not listed under the TSC Act or included in the BBCC	E (BC Act)	-	3.21 hectares of confirmed habitat based on a 40 metres buffer around the waterways where this species was identified. Habitat is widespread for this species and the extent of the population unknown.	About 73 hectares of potential habitat may occur in the surrounding landscape buffer.
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	Newly listed species - Not listed under the TSC Act or included in the in BBCC	V (BC Act)	M	174.3 hectares of potential foraging habitat largely associated with vegetation surrounding the Hunter River and small tributaries. No nest sites identified in the construction footprint during surveys.	May forage over all forested and open habitats including cleared and modified lands. Over 1000 hectares of forest habitat present plus very large areas of contiguous habitat for this species extend east to Tomago, Williamtown and Tilligerry.

8.2 Impacts on biodiversity that require further consideration

Impacts that are considered to be complicated or severe are classified in the FBA as matters that require further consideration (according to Section 9.2.3 to 9.2.5 of the FBA), these include:

- Impacts on landscape features
- Impacts on native vegetation (CEECs and TECs nominated in the SEARs) – none present
- Impacts on threatened species (Critically Endangered species or species specifically nominated in the SEARs). The SEARs identified impacts on the following species that require further consideration and provision of the information specifically to address section 9.2 of the FBA:
  - *Diuris arenaria* (Sand Doubletail)
  - *Pterostylis chaetophora* (Tall Rustyhood)
  - *Rhodamnia rubescens* (Scrub turpentine)
  - *Rhodomyrtus psidioides* (Native Guava)
  - *Uperoleia mahonyi* (Mahony's Toadlet).

These species are addressed in **Section 8.2.3** and **Appendix E**. Additional matters not relating to threatened species are discussed below.

8.2.1 Landscape features

Impacts on landscape features are in accordance with Section 9.2.3 of the FBA. For aquatic biodiversity impacts, the FBA refers to the requirements guided by the Fisheries NSW Policy and guidelines for fish habitat conservation and management (Department of Primary Industries 2013) and this is addressed in **Section 8.2.1** and **Section 8.4**.

Landscape features that are matters for further consideration include:

- Impacts that would substantially reduce the width of vegetation in the riparian buffer zone bordering rivers and streams 4th order or greater
- Impacts in state biodiversity links – not present in the construction footprint
- Impacts on important wetlands and their buffers
- Impacts in the buffer zone along estuaries.

These matters are discussed further in the following sections.

Impacts reducing width of riparian buffer of important rivers, streams and estuaries

The project involves the construction of a 2.6 kilometre viaduct across Hunter River and bridges to cross other important wetlands and waterways in the construction footprint. As described in **Section 2.2.4** and **Section 4.3**, the project would cross KFH as identified in DPI KFH Mapping (2007), including the Hunter River (ninth order waterway) which has been classified as "Type 1 – Highly Sensitive KFH" (DPI 2013) and the Coastal Wetland (Coastal Management SEPP) east of the Hunter River. All other waterways in the construction footprint are third order or below and have been described in **Section 4.3** and mapped on **Figure 4-4**. **Photograph 44** and **Photograph 45** show the east and west bank of the Hunter River at the proposed bridge crossing point.

Photograph 44: Western bank of the Hunter River at the proposed bridge location looking upstream

Photograph 45: Mangrove forest on the eastern bank of the Hunter River at the proposed bridge location looking upstream

Vegetation clearance

The position of the proposed viaduct (B05) over the Hunter River was located to avoid substantial impacts on the large Coastal Management SEPP wetland located on the southern bank of the Hunter River, north of the Pacific Highway, and riparian vegetation comprising Grey Mangrove low closed forest (PCT 1747), Saltmarsh Estuarine Complex (PCT 1746), Swamp Oak forest (PCT 1727) and *Phragmites australis* and *Typha orientalis* freshwater wetland (PCT 1071) (refer to **Figure 3-1**). As a consequence, the impacts to the riparian zone have been substantially reduced to:

- Western bank (immediate western edge):
  - Mangrove forest (PCT 1747) – about 0.18 hectares
  - Saltmarsh complex (PCT1746) – about 0.48 hectares.
- Eastern bank (floodplain between Hunter River and existing highway):
  - Mangrove forest (PCT 1747) – about 1.86 hectares
  - Swamp Oak forest (PCT 1727) – about 6.28 hectares
  - Swamp Mahogany - Flax-leaved Paperbark swamp forest (PCT 1717) – about 0.36 hectares
  - *Phragmites australis* and *Typha orientalis* freshwater wetlands (PCT 1071) – about 3.39 hectares.

Impacts on important wetlands

With respect to important wetlands, the Hexham Swamp Nature Reserve is part of the Hunter Wetlands National Park and under natural conditions would have been contiguous with the wetlands on the floodplain to the north. However, the reserve has been artificially separated from wetlands on the floodplain to the north by a disused rail embankment that now forms the northern boundary of the Hexham Swamp Nature Reserve.

As described in **Section 2.2.4**, the Hexham Swamp Nature Reserve is located about two kilometres from the construction footprint. Therefore construction activities and operation of the project would not directly impact or discharge directly into the reserve. Indirect water quality impacts from the project are also not expected because surface water flow from the construction footprint would not reach Hexham Swamp Nature Reserve except during a 20% or greater AEP flood event when the northern and southern floodplain at Hexham become hydrologically connected via culverts under the rail embankment or when flood water overtops the rail embankment (during a 2% AEP event). Any water quality impacts which are associated with the project during a flood event would be negligible due to flooding from the greater catchment which would provide dilution to any runoff from the project. Therefore any observable changes to water quality in Hexham Swamp Nature Reserve, during and following a flood event, would be representative of the broader catchment pollutant loads and not directly attributable to the project.

Further to this, around 16.4 hectares of Coastal Management SEPP coastal wetlands are directly impacted by construction footprint. This is concentrated in three distinct areas and the extent of impact to the wetland and buffer area is described below:

- Riparian vegetation on the eastern bank of the Hunter River (about 11.2 hectares), which includes PCTs Mangrove forest (PCT 1747), Swamp Oak forest (PCT 1727) and *Phragmites australis* and *Typha orientalis* wetlands (PCT 1071)
- A thin strip of riparian vegetation on the eastern bank of the Hunter River (about 0.29 hectares), including Mangroves (PCT 1747) and Saltmarsh (PCT 1746)
- An area of wetland that is contiguous with the northern extent of the Hexham Swamp Nature Reserve (about 4.95 hectares), which consists of vegetation identified as Water Couch – Tall Spike Rush freshwater wetland (PCT 1736). This area includes two conditions classes of this PCT, including good condition areas dominated by *Carex appressa* and moderate condition areas subject to disturbance from agricultural practices. The area of PCT 1736 in this area covers a larger area than mapped coastal wetlands. There are no direct drainage features / structures connecting this wetland to the reserve, and the impact to this section of PCT 1736 is not expected to indirectly impact upon the reserve.

The condition of these wetlands subject to direct impacts are described in **Section 4.3**. It is evident from the assessment that mapped important wetlands associated with the Hunter River floodplain in this location have a long history of impacts associated with clearing and modification for past agricultural land use, including flood mitigation. These land uses have resulted in altered surface hydrology, reduced cover of macrophytes and corresponding reduced wetland health.

Further, indirect impacts may result from overshadowing of the bridge over the Hunter River on in situ mangroves located next to the bridge structure (described in **Section 8.5.3**). Other indirect impacts that may occur as a result of the project include changes to hydrological regimes (i.e. flooding) resulting in changes in species assemblages, further reduction in water quality and weed invasion, establishment and spread of new and existing exotic flora species. This is discussed further in **Section 8.4** and **Section 8.5.5** respectively.

Overall, the potential for downstream impacts is considered minor in the short-term and can be mitigated through the implementation of effective management measures. Long-term downstream impacts are also expected to be minor as the proposed viaduct (B05) generally avoids impacts to the aquatic environment by bridging the Hunter River and any impacts would be similar to those from the existing bridge structures downstream of the construction footprint. Measures proposed to mitigate impacts on wetlands, including no-go zones adjacent to the construction / wetland boundaries and installing best practice sediment controls during construction, are described in **Chapter 9**.

Impacts on species movement along corridors

No state significant or regionally significant biodiversity links have been identified in a plan approved by the Chief Executive of OEH within the construction footprint.

The regional corridor referred to as Richardson Road (Scotts 2003) has been mapped as a link from the Hexham Swamp Nature Reserve north and east across the Hunter River to Grahamstown Dam. This corridor includes the northern portion of the construction footprint and is mapped on **Figure 2-1**.

There are two coastal climate change corridors present in the locality (i.e. Newcastle and Karuah-Hunter) joining at the Hunter River (DECC 2007), these corridors identify a very large north-south regional link traversing to the west of Newcastle within the construction footprint (refer to **Figure 2-1**).

The Watagan to Stockton Green Corridor has been identified in the Hunter Regional Plan 2036 (Department of Planning and Environment 2016) and the construction footprint is wholly within this large regional green corridor construction footprint.

This suite of large corridors has been identified as large landscape links and traverse across the existing road network including Pacific Highway, New England Highway and M1 Pacific Motorway. These corridors may only be important for large and mobile fauna species, and the addition of the project would not impact on the movements of these species. On a local scale, a connectivity strategy was developed to provide effective mitigation in areas of the project that may become fragmented and therefore impact on the movements of fauna species. Discussion of the range of connectivity and fauna protection measures provided in detailed in **Chapter 9**.

8.2.2 Native vegetation

There are no CEECs located in the construction footprint and no EECs were identified in the SEARs as a matter for further consideration. The impact of the project on native vegetation and TECs is presented in **Section 8.1.1**.

8.2.3 Impacts on threatened species

In accordance with Section 9.2.5.1 of the FBA, this category includes further consideration of the impacts of development:

a) On any critically endangered species, unless the critically endangered species is specifically excluded in the SEARS
b) On a threatened species or population that is specifically nominated in the SEARs as a species or population that is likely to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted on by the development, or
c) Where the survey or expert report undertaken in Section 6.6 confirms that a threatened species is present on the proposed development site, and the threatened species has not previously been recorded the IBRA subregion according to records in the NSW Wildlife Atlas.

Point a) would apply to the Regent Honeyeater, *Rhodamnia rubescens* and *Rhodomyrtus psidioides* (Native Guava) listed as Critically Endangered under the TSC Act.

In relation to point b) the SEARs identify impacts on the following species that require further consideration and provision of the information specific in section 9.2 of the FBA:

- *Diuris arenaria* (Sand Doubletail)
- *Pterostylis chaetophora* (Tall Rustyhood)
- *Rhodamnia rubescens* (Scrub turpentine)
- *Rhodomyrtus psidioides* (Native Guava)
- *Uperoleia mahonyi* (Mahony's Toadlet).

Point c) does not apply to this project.

Detailed assessment on the potential impacts on each of these species described above is provided as **Appendix E** and addresses the criteria described in section 9.2.5.2 of the FBA.

8.2.4 Critical habitat

The project would not impact on any areas of land that the Minister for the Environment has declared 'critical habitat' in accordance with section 47 of the TSC Act and that are listed on the Register of Critical Habitat in NSW.

As this project is being assessed under the Transitional Arrangements and therefore the former TSC Act applies, the critical habitat register applies and pre-dates the Areas of Outstanding Biodiversity Value. There are no Areas of Outstanding Biodiversity Value in the construction footprint.

8.3 Matters of National Environmental Significance

A referral under the EPBC Act was prepared for this project and submitted to the then Commonwealth Department of the Environment in October 2018 (now the Department of Agriculture, Water and environment (DoAWE)).

The project was determined to be a controlled action based on its potential to impact on the following MNES:

- Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community – endangered under the EPBC Act
- Koala (*Phascolarctos cinereus*) (combined populations of Qld, NSW and the ACT) – vulnerable under the EPBC Act
- Swift Parrot (*Lathamus discolor*) – critically endangered under the EPBC Act
- Regent Honeyeater (*Anthochaera phrygia*) – critically endangered under the EPBC Act
- Grey-headed Flying-fox (*Pteropus poliocephalus*) – vulnerable under the EPBC Act.

The referral to DoAWE, determined that significant impacts would be unlikely for Earp's Gum (*Eucalyptus parramattensis* subsp. *decadens*), Small-flowered Grevillea (*Grevillea parviflora* subsp. *parviflora*), Tall Knotweed (*Persicaria elatior*), Australasian Bittern (*Botaurus poiciloptilus*), Australian Painted Snipe (*Rostratula australis*), Spotted-tailed Quoll (*Dasyurus maculatus*), New Holland Mouse (*Pseudomys novaehollandiae*) and Green and Golden Bell Frog (*Litoria aurea*).

As discussed in **Chapter 5**, this assessment process identified one new impacted species (*Persicaria elatior*) and increased impacts on five threatened species (*Eucalyptus parramattensis* subsp. *decadens*), Australasian Bittern, Australian Painted Snipe, Spotted-tailed Quoll and New Holland Mouse.

All Assessments of Significance addressing increased and changed impacts from previously assessed in the referral are provided in **Appendix D** in accordance with the MNES: Significant impact guidelines 1.1 (DoE 2013). For completeness, the Assessment of Significance for Small-flowered Grevillea (*Grevillea parviflora* subsp. *parviflora*) and Green and Golden Bell Frog (*Litoria aurea*) have also been included in **Appendix D** despite not having an increased or changed impact since the original referral.

Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community is not listed in **Appendix D** as none of the occurrences of PCT 1727 within the construction footprint are considered of sufficient size, condition and connectivity to meet the condition thresholds and eligibility for the listed community (refer to **Section 8.3.1**).

The Assessments of Significance in **Appendix D** conclude that a significant impact to any of the above-listed species is considered unlikely.

The following sections provide a summary of assessment outcomes regarding the presence / absence and impacts to nationally listed TECs.

8.3.1 Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community (endangered under the EPBC Act)

This community was discussed in the referral as having potential to occur, this was identified on a precautionary basis and noted that subject to further assessment in the field in accordance with the condition thresholds criteria for this community. The precautionary approach was used because this community was listed during the referral preparation and was not assessed on site. Further consideration on of the presence of this community has been conducted for this BAR and is provided in **Section 5.4.2**. The assessment has concluded that none of the occurrences of PCT 1727 within the construction footprint are considered of sufficient size, condition and connectivity to meet the condition thresholds and eligibility for the listed community.

8.3.2 Subtropical and Temperate Coastal Saltmarsh (vulnerable under the EPBC Act)

Of the 1.26 hectares of the PCT Saltmarsh Estuarine Complex (PCT 1746) present within the construction footprint, about 0.55 hectares is consistent with the listed Subtropical and Temperate Coastal Saltmarsh community listed as vulnerable under the EPBC Act (refer to **Figure 3-2**). As this community is listed as vulnerable under the EPBC, an Assessment of Significance is not required.

8.3.3 River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria (Critically Endangered under the EPBC Act)

The PCT 1598 mapped in the construction footprint is not characteristic of the CEEC River-flat eucalypt forest on floodplains. No further consideration of the condition thresholds for this community were considered. Refer to discussion in **Section 5.4.6**.

8.3.4 Threatened flora (EPBC Act)

The project has developed further since the referral resulting in a refined construction footprint that warranted further survey and assessment for impacts on biodiversity and MNES. In addition to the impacts assessed in the referral (which have not changed), there are additional impacts which have been identified and assessed compared to the impacts described in the referral, as follows:

- *Persicaria elatior* (vulnerable species) – three individuals of this species were identified during supplementary surveys in 2018. All three individuals occur within the construction footprint and would be directly impacted by the project (refer to **Figure 4-3**)
- Impacts on the identified *Eucalyptus parramattensis* subsp. *decadens* (vulnerable species) has increased from 16 individuals to 34 individuals (refer to **Section 8.1.2** and **Figure 4-3**).

To address these changed impacts, a revised Assessment of Significance under the MNES Significant impact guidelines 1.1 (DoE, 2013) was completed for both species and are presented in **Appendix D**. The assessments concluded that a significant impact is not likely for either flora species. On this basis, re-referral is not deemed to be required. Further to this, the recently listed River-flat eucalypt forest of coastal floodplains of southern New South Wales and eastern Victoria (CEEC) has been considered and deemed not present in the construction footprint.

8.3.5 Threatened fauna (EPBC Act)

For listed threatened fauna species, the Assessment of Significance presented was provided in the project referral which concluded that the project was unlikely to have a significant impact on threatened fauna species. Changes to the construction footprint since the referral submission has resulted in an increase in the area of habitat impact for all listed threatened fauna species that were assessed in the referral.

On 14 January 2019, DoAWE determined that there would be a significant impact on Koala, Swift Parrot, Regent Honeyeater and Grey-headed Flying Fox therefore Assessments of Significance have not been completed again for these species. Updated Assessments of Significance have been completed for the following species due to a change in in impacts between the referral and this EIS:

- Impacts on Australasian Bittern habitat has increased to around 43.64 hectares of associated PCTs that may provide suitable habitat
- Impacts on Australian Painted Snipe has increased to around 43.64 hectares of associated PCTs that may provide suitable habitat
- Impacts on Spotted-tailed Quoll has increased to around 50 hectares of associated PCTs that may provide suitable habitat
- Impacts on New Holland Mouse has increased to around 28.6 hectares of sandy open forest.

Assessment of Significance under the MNES Significant impact guidelines 1.1 (DoE, 2013) were completed to address these revised impacts and species associated with final construction footprint, these are presented in **Appendix D**. The assessments concluded that a significant impact is not likely for any of these species. On this basis, re-referral is not required.

8.3.6 Migratory species (EPBC Act)

No migratory waders were recorded and habitat for these species is poorly represented within the construction footprint. There a no areas of exposed mudflats or sand flats during low tide along the subject area of the Hunter River at this location, which is characterised by deep banks. Small areas of saltmarsh and the larger expanses of freshwater marsh in the floodplain areas does however provide suitable habitat for some waders which favour the shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. This includes the Sharp-tailed Sandpiper, Pectoral Sandpiper, and Double-banded Plover.

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

- 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
- 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
- Seriously disrupt the life cycle (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 use habitats within the construction footprint and locality, the construction footprint would not be classed as an 'important habitat' as defined under the EPBC Act Policy Statement 1.1 Significant Impact Guidelines (DoE, 2013), in that the construction footprint 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 proposed 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 construction footprint (refer to **Section 5.7**).

There are no additional impacts for listed migratory species from those presented in the referral. The assessment provided with the referral remains current and no additional species or impacts are expected for migratory species.

8.4 Aquatic impacts and changes to hydrology

Construction and operational activities associated with the project have the potential to impact aquatic ecosystems and result in changes to existing hydrology. Aquatic impacts could occur due to changes in water quality, habitat loss, temporary instream barriers and potential impacts to KFH. Impacts to these environmental values and KFH have been considered in this section.

Given the downstream presence of the Hunter Wetlands National Park, aquatic impacts have also been reported with consideration of relevant issues raised in the Developments adjacent to NPWS: Guidelines for consent and planning authorities (NPWS, 2020). In particular, the assessment has considered the following sections of the guideline, Section 2.1 – Erosion and sediment control, Section 2.2 – Stormwater runoff, and Section 2.8 – Threats to ecological connectivity and groundwater-dependent ecosystems.

8.4.1 Bridge crossings over waterways or wetlands

The project involves three bridge structures over waterways or wetlands. Waterway crossings include:

- A 2.6 kilometre viaduct (B05) over the Hunter River floodplains, Hunter River and areas classified as Coastal Wetland (Coastal Management SEPP) on either side of Hunter River
- A single bridge (B11) over Windeyers Creek
- Twin bridges (B02) over Glenrowan Creek and in proximity to a Coastal Wetland (Coastal Management SEPP), located south of the existing New England Highway.

The locations of proposed bridge structures are shown in **Figure 8-2**.

Project-specific impacts associated with these three bridge crossings are provided in the sections below.

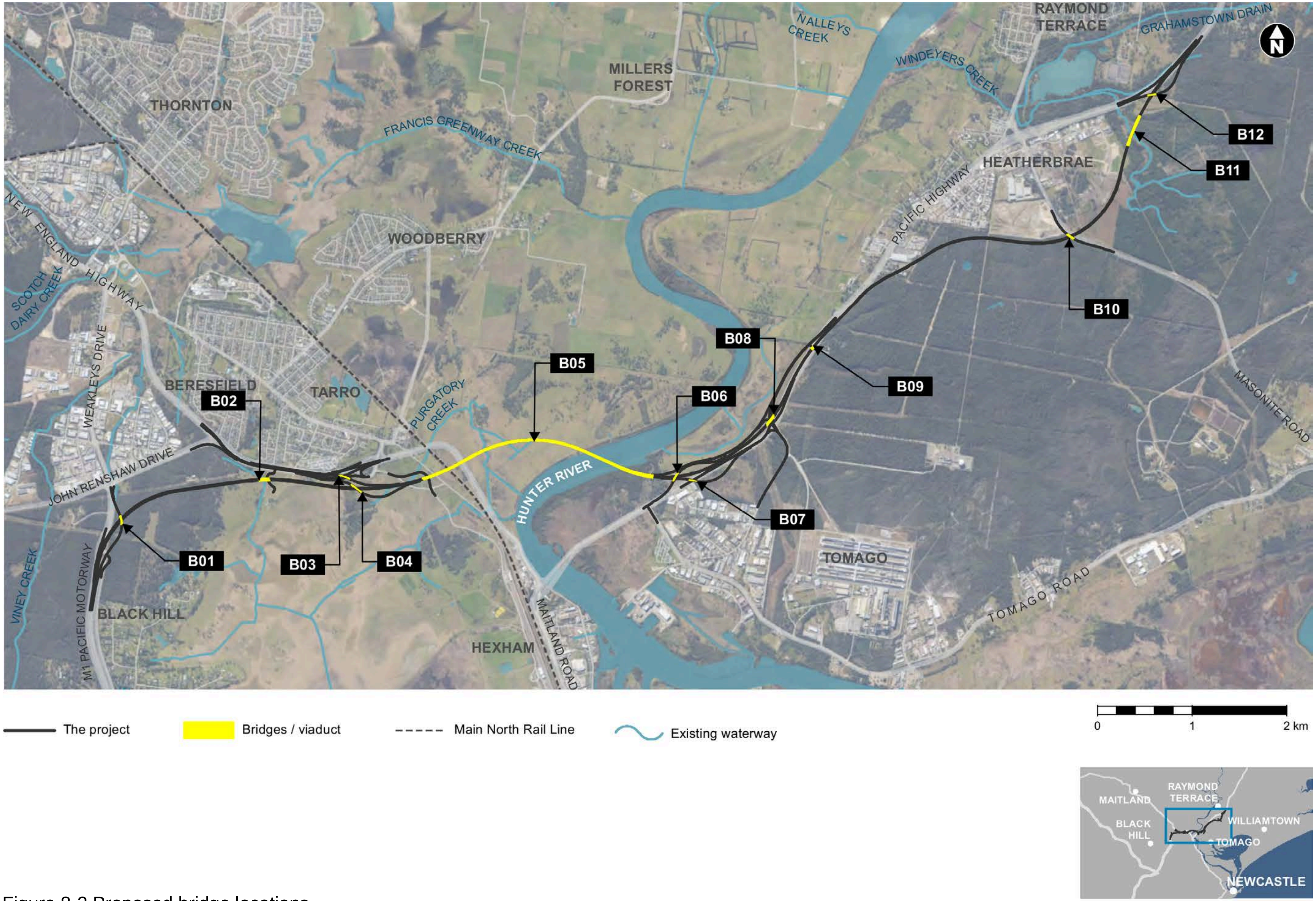


Figure 8-2 Proposed bridge locations

Date: 15/01/2021 Path: J:\IE\Projects\04_Eastern\IA230000\22_Spatial\GIS\Directory\Templates\Figures\EIS\2_Chapters\Chapter_5\IA230000_CD_EISCH5_005_Bridges_JAC_A4L_50000_V02.mxd

Viaduct over the Hunter River (B05)

The proposed 2.6 kilometre viaduct (B05) over the Hunter River, as well as the associated scour protection and drainage infrastructure, has been designed to result in operational environmental outcomes that include protecting water quality, minimising instream and riparian vegetation clearing and ensuring there are no permanent barriers to fish passage (Fairfull and Witheridge, 2004). Aquatic risks are therefore primarily associated with the bridge construction activities, such as:

- Vegetation clearing in the riparian zones of the Hunter River which would directly remove a section of dense mangrove vegetation located on the eastern bank of the river inside the construction footprint. There are no mangroves on the western bank of the river at the bridge site, however small areas of saltmarsh would be directly impacted on the western bank
- Piling for installation of instream and riparian bridge foundations
- Dredging of a limited area of the riverbed to allow shallow water access for barges during construction
- Installation of temporary instream structures which may include rock platforms with sheet piled retaining walls (or similar) that would be built out from the banks at each side of the river, two wharf structures which would be built out from the banks at each side of the river, floating barge platforms (that would be anchored and docked at the wharf structures or mid channel) and silt curtains around piling and dredging locations
- Movement and use of heavy vehicles and machinery over water and on the banks of the river
- Construction of in-situ steel reinforced concrete piers and bridge structure above water. This may also include the installation of off-site precast pier and bridge components
- Extraction of surplus spoil and construction wastes and transfer from waterway to land for management. Wastewater may also be transferred to land for management
- Removal of temporary construction structures and material from the river channel and riparian areas.

Without the implementation of controls and management measures related to the proposed construction activities, there is potential for direct and indirect impacts to estuarine flora and fauna. Potential impacts associated with the proposed planned and unplanned activities at bridge crossings include:

- The loss of aquatic habitat features such as large woody debris, overhanging or trailing bank vegetation, loss of benthic aquatic flora, mangroves and riparian vegetation
- A reduction in local water quality associated with elevated suspended solid content within the water column and the potential re-mobilisation of contaminants bound within riverbed sediments disturbed by the proposed in-water construction activities (i.e. piling, dredging and rock placement)
- Exposure of acid sulfate soils (ASS) to the air after extracted from the waterway (either on barges or on land)
- Impacts to local river bank morphology due to destabilisation/erosion as a result of clearing of existing riparian vegetation or removal of imported riparian armouring materials
- Introduction of invasive aquatic species to the local environment from the construction vessels and equipment
- A reduction in local water quality associated with the uncontrolled release of concrete dust, concrete slurries or waste water associated with work overwater
- A reduction in local water quality values associated unplanned release of hydrocarbons (i.e. fuel for plant equipment and vessels on barges) as a result of accidental spills or leaks
- A reduction in local water quality associated with the unplanned loss of solid waste and construction materials (e.g. litter and equipment) within the river and surrounding wetland habitats.

As a result of these impacts, there is also potential for the following subsequent impacts to occur:

- Mortality or a reduction in range of aquatic fauna due to habitat loss
- Impacts to aquatic flora due to reduced light penetration from increased suspended sediments
- Physiological impact on aquatic fauna (e.g. clogging of fish gills and ingestion of contaminants from suspended sediments)

- Reduction in local water quality of aquatic ecosystems
- Contamination of aquatic ecosystems by acidic runoff from ASS exposure
- Establishment of invasive aquatic species, resulting in the displacement or reduction in distribution of native fauna and flora species
- A decrease in trophic interactions due to decreased visibility.

With the implementation of appropriate mitigation and management measures outlined in **Chapter 9**, as well as employing erosion and sediment controls during both construction and operation to protect downstream water quality, the risk of impacts to aquatic biodiversity within the Hunter River are considered to be low and any residual impacts that are expected would be localised and minor. In addition, the project would implement management measures to mitigate impacts to water quality (see the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS)).

Further, with regard to dredging within the Hunter River, it is important to note that the location where the proposed viaduct crosses the Hunter River does not support gravel beds, snags or other fish spawning areas. There are also no significant areas of instream vegetation in the deep section of channel. Potential impacts to mangroves areas due to dredging are discussed in the **Section 8.1.1**, and management measures would be in place to minimise and offset this impact. Specific management measures related to dredging activities are planned to avoid or minimise potential direct and indirect impacts to estuarine fauna. These measures would include a dredging management plan and would be detailed in the CEMP.

Glenrowan Creek (B02) and Windeyers Creek (B11) bridge crossings

Based on habitat assessment, both Glenrowan Creek (B02) and Windeyers Creek (B11) were not considered to be KFH. Nevertheless, the design of the bridge structures, scour protection and drainage infrastructure at Glenrowan Creek and Windeyers Creek has aimed to preserve the existing aquatic habitat values of the waterways in the long term by protecting downstream water quality, minimising vegetation clearance and minimising permanent instream structures as much as practicable. As such, risk of aquatic impacts would be associated with construction only.

Construction activities which have potential to cause temporary impacts to these waterways include:

- Vegetation clearing in the riparian zone of creeks
- Preparation of instream bridge work areas including, piling and crane pads, as well as construction of site access roads
- Temporary instream access tracks to allow haulage of material across waterways. Temporary access tracks may remain in place for up to two years
- Associated civil works for the bridges, including cut and fill earthworks, as well as movement and use of heavy vehicles and machinery within and on the banks of the waterway
- Dewatering of pile locations (if water is present) and temporary construction sediment basins.

As a result, the following potential aquatic impacts, if unmitigated, may occur:

- Mortality or a reduction in range of aquatic fauna due to habitat loss
- Impacts to aquatic flora due to reduced light penetration from increased suspended sediments from instream civil works
- Physiological impact on aquatic fauna (e.g. ingestion of contaminants from suspended sediments)
- Reduction in local water quality due to increased suspended sediment and unplanned release of contaminants
- A reduction in location water quality associated with the uncontrolled release of concrete dust, concrete slurries or washout water associated with concrete work
- A reduction in location water quality associated with the unplanned release of hydrocarbons (i.e. fuel for plant equipment and vessels on barges) as a result of accidental spills or leaks
- A reduction in local water quality associated with the unplanned loss of solid waste and construction materials (e.g. litter and equipment) within the river and surrounding wetland habitats

- A reduction in local water quality associated with the discharge of water downstream.

While there is potential for these impacts occurring in the waterways, construction of the project has aimed to minimise disturbance to the creeks and wetland environments by implementing appropriate management measures (as outlined in **Chapter 9**), as well as employing erosion and sediment controls during both construction and operation to protect downstream water quality. In addition, the project would implement management measures to mitigate impacts to water quality (see Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS)).

Any residual impacts that may occur are likely to be highly localised and temporary. As such, it is expected that there would be minimal impacts to aquatic biodiversity as a result of bridge crossings at Glenrowan Creek or Windeyers Creek.

8.4.2 Potential impacts to fish habitat

The project crosses mapped KFH (as identified by DPI and based on field observations), which are shown on **Figure 4-4** and described in **Section 4.3**.

The most sensitive fish habitats (Type 1) within the construction footprint are associated within the Hunter River estuary, including the Hunter River itself, the Coastal Wetland (Coastal Management SEPP) on the eastern side of the Hunter River, and Purgatory Creek (downstream of the floodgate) as these environments consist of mangrove forests or have mangrove and saltmarsh vegetation along the banks and in the intertidal zone.

All other waterways within the construction footprint have been identified as Minimal (Type 3) or Unlikely (Type 4) fish habitat as they are generally disconnected from the Hunter River due to the managed environment (i.e. the Hunter River Flood Mitigation Scheme) and therefore currently do not exhibit aquatic habitat features that would support key fish habitat.

Although several waterways in the area are ephemeral or modified drainage channels, and disconnected from the Hunter River estuary as part of the flood mitigation scheme, the central portion of the construction footprint is a floodplain that contains patches of terrestrial features and wetland habitat. These areas are mapped as Coastal Wetland under the Coastal Management SEPP (2018) and are potential habitat for dragonfly species and aquatic macroinvertebrates. Infrequent flushing of these areas has resulted in extended residence times for sediments or contaminants (if present). Therefore changes to water quality, aquatic habitat and natural flow regimes due to the project could result in the degradation of the wetlands and may reduce the available habitat for these aquatic species.

Construction and operation of the project has potential to impact aquatic ecosystems. In general, impacts to waterways may include:

- Barriers to fish passage
- Displacement or removal of existing of large wood debris or snags
- Clearing of mangroves and riparian vegetation
- Interaction with equipment and machinery
- Changes to water quality resulting from, but not limited to:
  - Mobilisation of sediment-laden or contaminated water associated with construction activities
  - Water discharges from construction basins.
- Removal of instream macrophytes and habitat features
- Unplanned introduction and establishment of aquatic pest species and/or weeds.

The above risks for aquatic ecosystems are discussed in the context of the project in the sections below.

Barriers to fish passage

The installation of temporary and permanent instream structures has the potential to hinder and possibly prevent movement of fish in the short and long-term, depending on the location and installation of the barrier. The construction of the proposed viaduct (B05) over the Hunter River is unlikely to result in short-term barriers to fish passage due to the following:

- The floating silt curtains would be limited to installations around individual piling locations and dredging sites and installed in a manner that facilitates fish movement throughout the river channel
- The barges are floating platforms, anchored to the riverbed via cables (or similar) therefore no physical barriers to fish passage is anticipated
- The rock platforms and wharf structures (or similar) would result in some obstruction of the waterway; however, they are anticipated to be built from / connected to the riverbank (to a distance of about 20 metres) and therefore would not significantly obstruct fish movement within the waterway.

The design of the bridges and culverts over waterways has complied with DPI Fisheries design guidelines reported in Fairfull & Witheridge (2003) to ensure that barriers to fish passage are not created in the short or long-term. Based on the assessment of waterway 'class' (Fairfull & Witheridge, 2003) (see **Table 4-11** and **Appendix G**), fish-friendly bridge crossings are only required over the Hunter River and the unnamed Coastal Wetland (Coastal Management SEPP) located east of the Hunter River (B05). These waterways were classified as Class 1 – Major fish habitat and therefore require a minimum crossing type of a bridge, arch structure or tunnel (Fairfull & Witheridge, 2003).

All other waterways where there would be temporary or permanent crossings (Glenrowan Creek, Purgatory Creek at two locations, Windeyers Creek and the tributary of Viney Creek) were classified as either 'Class 4 – Unlikely fish habitat' or 'Class 3 - Minimal fish habitat' which only require a minimum crossing type of a culvert or ford (Fairfull & Witheridge, 2003). Bridge structures have been designed at all of these waterway crossing locations, with the exception of Purgatory Creek (upstream ephemeral section) and tributary of Viney Creek where culverts have been proposed (discussed below).

Removal of large woody debris or snags

The removal of large woody debris or snags is listed under Schedule 6 of the FM Act as a Key Threatening Process. Woody debris plays an important role in freshwater and marine ecosystems by providing essential habitat for aquatic organisms, providing a refuge from predation and a resting place away from the main flow of the waterway and providing important refuge and breeding habitat for fish including threatened species. Woody debris also provides habitat for a number of plants, algae, microorganisms and invertebrates. Tree trunks and fallen branches are structurally important for stabilising stream beds and banks.

Visual assessment during field investigations revealed that large woody debris was not a significant component of the aquatic habitat along waterways traversed by the project (excluding eastern bank of the Hunter River or Windeyers Creek). However, there is potential for large woody debris to be submerged and therefore not recorded, or to become deposited prior to construction within Purgatory Creek, tributary of Viney Creek, Glenrowan Creek, and Windeyers Creek.

To minimise any impacts to aquatic environments due to removal of instream woody debris, any woody debris that is identified within the construction footprint prior to construction would be preserved and re-established at the site following construction or relocated downstream in consultation with a qualified ecologist. Further details on proposed mitigation are provided in **Chapter 9**.

Clearing of mangroves / riparian vegetation

The project would require clearance of some patches of mangrove vegetation on the eastern side of the Hunter River within the area classified as unnamed Coastal Wetland (Coastal Management SEPP), as well as an area of native riparian vegetation around Windeyers Creek (refer to **Section 8.1.1**).

Riparian vegetation on the banks of waterways and mangroves that are established in the intertidal zone, banks and floodplain areas of estuaries are structurally important for stabilising stream beds and riverbanks, can be utilised as shelter or refuge habitat for aquatic species and provide nursery habitat. The extent of mangroves in the lower Hunter River estuary is widespread and in the areas adjacent to the project, there are substantial patches of mature Grey Mangrove low closed forest present. Clearance of a portion of the mangroves on the eastern side of Hunter River is required to facilitate the installation of the temporary wharf structure, as well as other temporary assets which will be used to construct the viaduct over Hunter River (B05) and bridge abutments in the area. Additionally, there may be a limited clearance of mangroves associated with the remediation of the former mineral sands processing facility from the eastern bank of the Hunter River. Clearance of portions of the riparian zone around Windeyers Creek is required to facilitate the road and bridge footprint and provide access during construction.

To minimise impacts to aquatic environments due to clearance of riparian vegetation and mangroves, temporary riparian and instream construction equipment would be removed, and disturbed areas would be stablilised and rehabilitated progressively or prior to demobilisation. Where practicable, site rehabilitation would include re-planting appropriate vegetation types in the disturbed areas. As such, removal of riparian vegetation and mangroves within the construction footprint area is expected to be localised is considered unlikely to result in a long term impact on the associated aquatic habitat.

Interaction with construction equipment and machinery

There is potential for fish and other aquatic species in KFH to be harmed through interaction with equipment and machinery that would be utilised instream. For the proposed viaduct (B05), aquatic species could be harmed by direct interaction with plant and equipment, or by noise and vibration caused by piling works. Impacts to fish and other aquatic species would be managed through minimising the impact area and the use of typical exclusion controls as well as by employing standard management measures for underwater piling (further detailed in **Chapter 9**).

For other waterways where temporary and permanent crossing structures would be installed, aquatic species may be harmed (where water is present) if they are in proximity of the instream construction areas. However, this would be avoided as fauna salvage would be carried out prior to water being pumped out of the waterway as per pre-clearing survey requirements outlined in **Chapter 9**.

Changes to water quality

Mobilisation of sediments and contaminated water have the potential to reduce water quality within KFH and subsequently directly or indirectly harm native species that are unable to tolerate changes to water quality. Direct and indirect impacts from the mobilisation of sediment-laden or contaminated water to KFH may result in:

- Decreased visibility through the water column from higher turbidity, resulting in decreased trophic interactions
- Reduced light penetration which can limit growth of aquatic vegetation
- Increased risk of algal blooms from higher nutrient concentrations, which may result in reduced oxygen content in the water, or may block out sunlight and clog fish gills
- Potential loss of range or reduced suitability of habitat for native fauna that are sensitive to changes in water quality.

Changes to water quality in perennial waterways may also favour aquatic pest species, such as the Plague Minnow (*Gambusia holbrooki*), which can then predate on native species. Predation by the Plague Minnow (*Gambusia holbrooki*) is a key threatening process listed under the TSC Act. This fish species is a significant predator on native fish and tadpoles. Gambusia is known to occur in the freshwater waterways in the construction footprint. This species proliferate in disturbed aquatic habitats and can out-compete and predate upon native species less tolerant of disturbed environments and poor water quality.

While there is potential for these impacts to KFH, the project has proposed to implement erosion and sediment controls to capture and treat runoff prior to entering waterways, as well as other management measures which aim to mitigate impacts to water quality (see Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS)). Importantly, the project has been designed to include permanent water quality controls in order to mitigate long-term water quality impacts to downstream KFH. These controls include permanent water quality basins and vegetated swales. Water quality basins within 500 metres of an aquatic environmentally sensitive area have been designed to contain a 20,000 litre spill (with the exception of the Tomago Sandbeds Catchment Area where the minimum containment volume is 30,000 litres) and would promote settlement of sediments by slowing down and temporarily detaining flows.

Due to these controls during construction and operation, risk of potential changes to water quality within KFH would be minimised therefore aquatic flora and fauna are is also not expected to be significantly impacted. This is discussed further in the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS).

Purgatory Creek adjustment

While the project has been designed to minimise impact on waterways where practicable, Purgatory Creek would be permanently adjusted over a distance of 320 metres to accommodate the Tarro interchange. The area of direct impact and adjustment commences at a non-channelised ephemeral headwater dominated by exotic grassland that is currently used for livestock grazing. Downstream of Woodlands Close, the waterway becomes artificially channelised.

The creek is proposed to be adjusted 90 metres to the south of its current location to avoid the Tarro Interchange and other substantial water supply utilities in the immediate area. Adjustment of this waterway may include temporary dams and water diversion to facilitate instream works. The adjusted section of creek would generally be comprised of 10 metre wide grassed channel. As per the surrounding floodplain topography, the creek adjustment shall be generally flat in gradient and would include installation of culverts to convey the surface water flows under two existing roads (Aurizon access road and Woodlands Close) in a north easterly direction. The adjusted section of the waterway will connect into the existing culvert under the Main North Rail line and subsequently under the New England Highway before it connects to the downstream section of waterway that contains more permanent surface water.

Potential impacts to aquatic biodiversity in Purgatory Creek may include localised removal of instream habitat features such as aquatic macrophytes and large woody debris and disruption of aquatic species which may utilise these features. These temporary impacts to the localised habitat are not expected to have a significant impact on aquatic biodiversity because the location is largely isolated from downstream sections of the waterway that have been identified as KFH, and aquatic fauna that may be present would typically be mobile due to the ephemeral character of the waterway therefore would be able to relocate to similar surrounding habitat during the temporary instream works. Further, large woody debris, if present, would be preserved and relocated downstream at an appropriate location.

Following the installation of the new drainage channel, the project landscaping of the impacted area is anticipated to generally replicate the existing vegetated form.

Viney Creek tributary adjustment

The ephemeral upper section of the tributary of Viney Creek is to be adjusted to enable to the construction and operation of the western interchange at M1 Pacific Motorway (Weakleys Drive and John Renshaw Drive). The section of tributary was modified during the construction of the existing motorway and is presently an ephemeral, partially rock armoured drainage line that flows through culverts under the motorway and later under John Renshaw Drive before flowing through an industrial area with a water level that is controlled by several constructed wiers.

The realignment of the drainage channel would commence at the existing upstream culvert under the existing motorway and would extend for about 150 metres to flow under various components of the new Black Hill interchange before it links to the existing culvert under John Renshaw Drive. Temporary damming and bypassing of the existing drainage channel may be required during construction if water is present.

Since this part of Viney Creek tributary is situated at the headwaters of an artificial drainage path and largely receives water input from stormwater runoff from the M1 Pacific Motorway, it is expected that it would be dry most of the time, and when water is present, water quality would reflect the modified catchment and aquatic species are highly unlikely to inhabit the waterway. Further, it is largely isolated from downstream environments due to the presence of several culverts and weirs, therefore upstream migration by aquatic fauna to this area is considered unlikely.

Potential impacts of the drainage line adjustment is the localised loss of existing habitat features such as macrophyte vegetation and potential disruption of aquatic species that may utilise those habitat features. As the drainage channel is highly disturbed and isolated from downstream waterways due to instream barriers, the permanent loss of the existing localised ephemeral features is unlikely to have a significant impact on the downstream aquatic environment of Viney Creek. Furthermore, following the installation of the new drainage channel, associated features and landscaping the existing environment within the project impact area is anticipated to be replicated over time during operation of the project.

While risk to aquatic ecology in the tributary of Viney Creek and Viney Creek downstream is unlikely to be significant, the project has aimed to protect the downstream receiving environment (i.e. Viney Creek) by minimising disturbance to the tributary of Viney Creek. This would be achieved by implementing appropriate management measures (as outlined in **Chapter 9**), as well as employing erosion and sediment controls during construction to protect downstream water quality.

Construction water discharges

Treated construction runoff is proposed to be discharged (controlled discharge) from temporary sediment basins and other minor locations. Waterways which have been deemed KFH and would receive controlled discharges include the Hunter River and the Unnamed Coastal Wetland (Coastal Management SEPP) east of the Hunter River. Adverse impacts to these aquatic ecosystems are not expected from controlled discharges because sediment basins would capture and treat runoff prior to being released downstream, and as presented in the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS), the treated discharges would have similar water quality to the existing surface water quality of these receiving environments.

Other waterways which would receive controlled discharges are not KFH and the existing water quality of these waterways is indicated to be highly variable, generally poor and currently not meeting the relevant NSW Surface Water Quality Objectives (refer to Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS) for further detail), therefore the limited biodiversity present in the waterways are likely to be habituated poor water quality conditions. As such, the water quality that would be discharged from temporary sediment basins is expected to be similar to or better than existing water quality of the receiving environment and therefore aquatic ecosystems are likely to remain unchanged.

In the event of extreme rainfall (greater than 38.9 millimetres) however, basins are anticipated to overflow and untreated runoff would be discharged to downstream waterways. These overflows are considered to be partially controlled as the basins would still be able to contain and treat the volume of runoff they have been sized for. Despite there being potential for aquatic impacts during these overflows, the risk is considered low (based on historic rainfall data for the region) that the frequency of these events occurring is likely to be minimal (about seven occurrences per year). As such, it is expected that any changes to water quality caused by releases during partially controlled discharges are likely to be temporary and would settle or become diluted within the surrounding environment in a relatively short timeframe. Aquatic biodiversity within these waterways is therefore expected to be able to tolerate the changes in the short term. as the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS) reported.

Operational discharges

While permanent water quality basins are not subject to a dewatering regime during operation, surface water runoff during and following rainfall may result in operational water quality basins occasionally discharging to downstream receiving environments during large rainfall events that exceed the detention capacity of the basin. Operational discharges from the water quality basins may potentially contain contaminants associated with surface water runoff from new impervious surfaces, including sediment and other contaminants (hydrocarbons etc.). Operational discharges would be limited to periods of higher rainfall, when the wider catchment is also at peak surface water flows (which is when water typically has higher concentrations of contaminants). As per the project design, the operational surface water quality controls and drainage shall predominately direct basin discharge into the local minor waterways which are not KFH.

Ten of the permanent water quality basins would interact with the groundwater table where groundwater quality is saline (greater than 2000 µs/cm). For these basins with saline groundwater inflows, the discharge may be more saline than the receiving environment. This risk is most likely at the three basins (PB05, PB06 and PB07) which would discharge into Glenrowan Creek and the tributary of Viney Creek as these waterways are freshwater and typically have lower salinity levels than groundwater. Since both of the waterways are not KFH and do not present significant aquatic habitat features, risks to aquatic biodiversity from saline discharge is considered low.

Further, any overflow of the structures would occur during a period of peak charge in the system, suggesting that the influence of saline water would be minimal. The discharge of operational surface water is quantified in the Surface Water and Groundwater Quality Working Paper however with the implementation appropriate management measures (as outlined in **Chapter 9**), the quality of the operational discharges shall be generally consistent with the range of existing surface water quality and hence is unlikely to have a significant impact of aquatic biodiversity within the waterway. Further, discharges to the Hunter River are reasonably attenuated by dilution and shall not result in significant impact to that aquatic environment or the downstream Ramsar Listed Wetland (Kooragang Nature Reserve). Further information on the dilution assessment are provided in the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS).

8.4.3 Aquatic biosecurity risks

Instream works and discharges to aquatic environments may create the potential for the introduction and/or spread of aquatic biosecurity hazards.

The Hunter River is a shallow-water, nutrient rich, estuarine habitat which may be conducive to the establishment of invasive species. The biosecurity risk to the Hunter River estuary is heightened as it hosts an active prawn fishery which extends from the river mouth to about 30 kilometres upstream to Raymond Terrace, and an established oyster farm which is located about 13 kilometres downstream of the project.

The key environmental risks associated with the introduction of pest species include:

- **Competition for natural resources:** Invasive flora or fauna species may compete with native species for available resources and space (e.g. food, shelter and benthic light) and, assuming native species are unable to attain the resource elsewhere, result in a reduction in survival probability. Displacement of native species is more likely to occur should invasive species occupy a similar niche or use similar resources
- **Predation:** Non endemic fauna may predate on existing flora or fauna resulting in lower levels of Endemic populations

- **Change nutrient cycling processes:** Establishment of invasive species can result in local changes in nutrient cycles as a product of variations in nutrient uptake. Alteration of available nutrients can impact the species who use them, with cascading impacts throughout the wider ecosystem
- **Change in habitat:** Establishment or spread of existing invasive species may change habitat composition leading to creation of new habitats, or fragmentation of existing habitats. A new habitat type may allow other native species to increase distribution or range, influencing population process of existing species. In species with limited dispersal, habitat fragmentation can result in isolation of subpopulations with secondary impacts to population genetics, population dynamics, species distribution, ecosystem processes, resource consumption and nutrient cycling processes
- **Spread of disease:** Invasive species may be a virus or pathogen, or may be vector to viruses, bacteria or pathogens. The introduction of disease through non endemic or invasive species could impact native species or species used for commercial purposes which lack inherent resistance to introduced diseases. The impacts could result in decreased viability of existing endemic flora/fauna or productivity of species harvested for commercial purposes.

Project activities within the Hunter River including the movement and use of the instream floating barge platforms and other vessels required for dredging presents the highest risk to aquatic biosecurity due to the potential for biofouling organisms on the external surfaces of vessels and/or within the vessel's ballast water to be introduced into the river by vessels.

Potential marine pests include seaweeds (*Caulerpa taxifolia* and *Undaria pinnatifida*), crustaceans (*Carcinus maenas*), polychaetes (*Sabella spallanzanii*), gastropods (*Maoricolpus roseus*), bivalve molluscs (*Musculista senhousia* and *Perna viridis*) and fish (*Tridentiger trigonocephalus*, *Oreochromis mossambicus* and *Acanthogobius flavimanus*).

Instream activities including piling, installation and use of temporary crossing structures, as well as in situ concrete pouring and installation of precast concrete structures also present a minor risk to aquatic biosecurity should equipment and/or materials be contaminated.

Other project activities such as vegetation clearing and movement of existing spoil on site has the potential to further distribute existing weeds or pathogens. The spread of these weeds or pathogens may result in further reduced biodiversity productivity in aquatic environments.

Direct and indirect impacts to aquatic ecosystems from introduction or spread of pest species is considered relatively minor and manageable with the application of recommended management measures (outlined in **Chapter 9**) which would comply with in force Commonwealth and state legislation including the Commonwealth *Biosecurity Act 2015*, NSW *Biosecurity Act 2015* and Australian Ballast Water Management Requirements.

8.4.4 Impacts from changes to hydrology

Construction

Construction of the project has the potential to change surface water hydrology as it would involve creek adjustments at Purgatory Creek and a tributary of Viney Creek, bridge/viaduct construction over waterways and a wetland and the upgrade of existing and new highway cross drainage. Potential changes include moderate increases to the rate, volume and velocity of stormwater discharged, changes to the existing flow regime at or immediately downstream of stormwater discharge locations during construction, as well as changes to drainage (refer to the Hydrology and Flooding Working Paper (Appendix J of the EIS) for further detail). These changes may result in indirect impacts to aquatic biodiversity and aquatic ecosystems due to:

- Increased stream flow discharge and velocities that may lead to reduced bank stability, subsequent erosion (e.g. scouring, undercutting, slumping) and downstream sedimentation which could result in infilling aquatic habitat features or smothering of aquatic vegetation

- Increased water turbidity due to suspended material may lead to clogging fish gills or smothering aquatic vegetation. Increased turbidity could also reduce light penetration through the water column which may impact growth of sensitive aquatic vegetation
- Increased flow velocities, reduced water levels or physical obstructions may result in obstruction to fish passage.

Minor changes to the hydrological regime of ephemeral waterways that are not KFH are unlikely to result in long term impacts to aquatic biodiversity and impacts to aquatic habitat within waterways would be highly localised and temporary. Importantly, construction activities are not expected to significantly alter flow in the Hunter River therefore long term impacts to aquatic species and aquatic habitat within the waterway are not anticipated. Despite the low likelihood of impacts, the project proposes to employ environmental management measures that aim to protect the existing aquatic values of all waterways within the construction footprint by minimising or avoiding hydrological changes. This would be achieved by implementing appropriate erosion and sediment controls, site-specific drainage design for the construction footprint, as well as temporary erosion and scour protection and flow dissipation where required.

With respect to the creek adjustments of Purgatory Creek and the tributary of Viney Creek, temporary damming and bypassing of the existing drainage channels may be required during construction if water is present, however temporary erosion and scour protection, as well as flow dissipation will be implemented where required.

In addition, temporary waterway crossings have been designed to be in accordance with the NSW Fisheries guidelines ‘Why do fish need to cross the road? Fish passage requirements for waterway crossings’ (Fairfull & Witheridge 2003) in order to ensure conditions for fish passage are maintained where required. Regular monitoring of key waterways for evidence of initiation of erosion and scour would be conducted for the duration of construction and, if required, appropriate remediation measures would be carried out.

With the implementation of measures, it is expected that impacts to aquatic ecosystems from hydrological changes during construction would be minimal and temporary, and long-term impacts are not anticipated.

Operation

During operation, there would be potential impacts to aquatic ecosystems resulting from the changes in hydrology caused by road paving and soil compaction, changes to drainage paths and catchments, and stormwater discharge from water quality basins. There may also be potential impacts to aquatic ecosystems resulting from the changes in water quality caused by the additional stormwater runoff that may occur as a result of the project (refer to the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS) and the Hydrology and Flooding Working Paper (Appendix J of the EIS) for further detail).

Similar to the construction phase, potential changes to hydrology include moderate increases to the rate, volume and velocity of stormwater discharged, changes to the existing flow regime at or immediately downstream of stormwater discharge locations during operation, as well as changes to existing drainage. These changes have potential to impact on the aquatic ecosystems of the downstream receiving environment from potential increased erosion and sedimentation of riverbanks and/or streambeds, impacts on aquatic organisms such as clogging fish gills or smothering aquatic vegetation, or may result in physical or behavioural barriers to fish passage due to increased velocities, reduced water levels or physical obstructions.

During operation, environmental management measures have been proposed which aim to minimise or avoid hydrology impacts to downstream waterways, including appropriate erosion and sediment controls, site-specific drainage design, scour protection and flow dissipation where required. Further, the adjusted Purgatory Creek and tributary of Viney Creek have been designed with controls to minimise potential areas of erosion and scour and any subsequent downstream impacts.

Permanent waterway crossings have been designed in accordance with NSW Fisheries guidelines 'Why do fish need to cross the road? Fish passage requirements for waterway crossings' (Fairfull & Witheridge 2003) in order to ensure conditions for fish passage are maintained where required. Regular monitoring of key waterways downstream of the project discharge locations for evidence of initiation of erosion and scour would be conducted for a minimum of twelve months after construction and, if required, appropriate remediation measures would be carried out.

With the implementation of these measures, changes to hydrology within downstream waterways is anticipated to be minor and would not result in a long-term impact to downstream aquatic ecosystems.

8.5 Other impacts not covered by the FBA

8.5.1 Groundwater dependent ecosystems

Potential impacts to GDEs would be predominately associated with the following activities:

- Direct clearing of GDE vegetation (see **Table 3-4**)
- Localised ground-water drawdown during construction
- Permanent lowering of the water table (i.e. lower availability of groundwater) during operation.

The likely impact of the project on surface water and groundwater quality is detailed in the Surface Water and Groundwater Working Paper (Appendix K of the EIS). Further, an assessment of volumetric dewatering requirements and impacts associated with temporary construction dewatering is provided in the Hydrology and Flooding Working Paper (Appendix J of the EIS).

Based on a review of these assessments, the above risks on GDEs are discussed in the context of the project in the sections below. It should be noted that potential contamination of groundwater during construction and operation of the project would be minimised and managed via the environmental management measures outlined in the Surface Water and Groundwater Quality Working Paper and Soils and Contamination Working Paper (Appendix K and Appendix P of the EIS respectively)).

GDE vegetation clearing

As described in **Section 3.5**, based on the PCTs identified in the construction footprint during field surveys and a review of Bell and Driscoll (2006), Kuginis et al*.* (2012) and the GDE Atlas, it is likely that some of the PCTs present in the construction footprint would have a degree of groundwater dependence (refer to **Table 3-4**). Impacts associated with vegetation clearance is described in **Section 8.1.1**.

Impacts to GDEs associated with temporary or permanent groundwater drawdown are discussed in the sections below.

Localised groundwater drawdown during construction

The Surface Water and Groundwater Working Paper (Appendix K of the EIS) identifies that the drawdown effect on groundwater would be short-term and localised. For example, temporary construction dewatering of excavations may be required where excavations are required below the water table. These would typically be of short duration, however, may still result in localised, short term, changes to the water table during some construction activities. The only Coastal Management SEPP coastal wetland with more than negligible temporary water level change during some construction activities is located south of the Tarro interchange on the New England Highway, where a predicted decrease in water level between 0.75 and 2.0 metres may occur within the northern extent of the wetland adjacent to the construction footprint. However, this level of impact is a conservative modelled maximum predicted drawdown and the actual drawdown would likely be less and occur over a short duration (less than 10 days). These short term construction impacts are consistent with fluctuating groundwater levels typically experienced by these floodplain wetlands. As such, these short term changes are not expected to significantly impact on the extent or condition of any of the potential GDEs in or adjacent to the construction footprint, particularly as the GDEs identified are not obligate GDEs, and therefore predominantly rely on surface water.

Permanent lowering of the water table

The Surface Water and Groundwater Working Paper identified that the project shall not result in ongoing lowering of the water table during operation of the project suggesting no long-term, permanent impacts on GDEs.

The Hydrology and Flooding Working Paper (Appendix J of the EIS) also assesses potential short term increased flooding heights on the floodplain where PCT1736 Water Couch – Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter has been mapped. The assessment discusses minor increases to the duration and depth of inundation for overbank events adjacent to the Hunter River as a result of finished road levels (i.e. the embankment/fill). These localised changes would likely have a negligible impact to the wetland vegetation which is already subject to periodic inundation of different levels and duration. This is further supported by the high groundwater levels in the floodplain surrounding the Hunter River, and the fact that there is no anticipated drawdown.

Minor changes to operational drainage structures that service the wetland south of the Hunter Region Botanic Gardens may result in changes of water levels upstream of the existing Pacific Highway of up to 0.2 metres. The area potentially impacted by this change in design is currently a wetland community (sedge spp, typha spp, paperbark spp) that is subject to rainfall dependent changes in water level based and possibly changes in groundwater levels (although not an obligate GDE). The potential changes to water levels due to operational drainage upgrades would generally reflect the existing variations in the hydrological regime and is unlikely to significantly impact on this aquatic environment.

8.5.2 Fragmentation of identified biodiversity links and habitat corridors

Habitat fragmentation

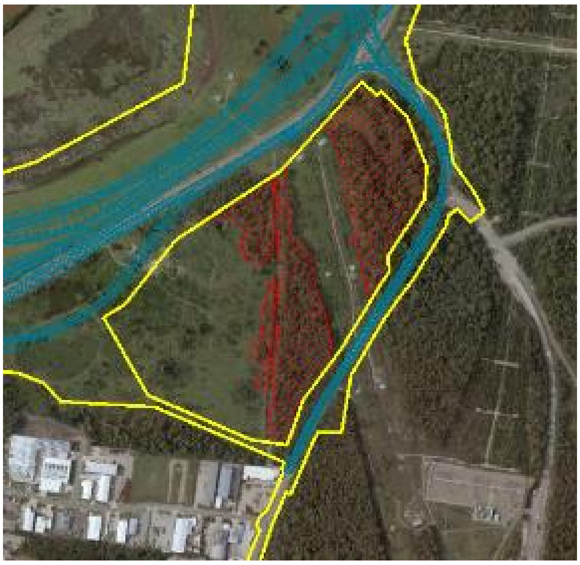
Habitat fragmentation relates to the physical dividing up of once continuous habitats into separate smaller 'fragments' (Fahrig 2002). The habitat fragments created by fragmentation tend to be smaller and separated from each other by a matrix of less suitable habitat. The divided habitat type between fragments is often artificial and less suitable to the species remaining within these newly created fragments (Bennett 1990, 1993; MacNally 1999, Lindenmayer & Fischer 2006) or is generally only used by adaptive and aggressive generalist species (e.g. Noisy Miners, Loyn et al. 1983) which further decreases population levels of other species remaining in the fragments.

The project would not result in excessive landscape scale habitat fragmentation, due to there already being a high degree of fragmentation in the landscape associated with a long history of clearing floodplain forests, and development of roads, rail, water and power networks in the area. The project has also been designed to minimise fragmentation by aligning closely to existing infrastructure and land uses, and in this way avoids large-scale fragmentation. However, the project would result in minor small-scale localised fragmentation of habitat including habitat used by threatened flora and fauna. These small-scale fragmentation impacts would be addressed by habitat connectivity measures as described in **Section 9.1**.

Examples of local fragmentation include the following:

1. About 26 hectares of dry sclerophyll forest with a grassy / shrubby understorey would be fragmented at Black Hill with the habitat surrounded by roads (shown in red hatching). This habitat is part of a larger area of vegetation about 130 hectares that would be divided in two. A small patch (four hectares) would also be temporarily isolated by construction access and an ancillary site (AS2), however this patch is already somewhat disconnected by the clearing due to the Hunter Water Corporation Trunk Main and overhead electrical corridors to the south. Glider crossing structures, bridge underpass and fencing have been added to the design at this location to reconnect this area for arboreal fauna during operation.

2. Habitat in the area of the Old Punt Road at Tomago is already fragmented by exiting roads and cleared power easements. Further development of the road network in this location would contribute to the cumulative fragmentation of smaller patches of isolated vegetation (around 9.5 hectares) due to widening of the existing Old Punt Road corridor. Sugar Gliders were confirmed in this location from the trapping surveys and the Squirrel Glider has been recorded one kilometre east of this patch (Kleinfelder 2019). Glider crossing structures have been added to the design at this location to reconnect this area for arboreal fauna during operation. This fragmented vegetation would remain in the context of development of the approved AGL Newcastle Power Station in this location.



3. The project would result in the fragmentation of blackbutt open forest (around 5.3 hectares) providing potential habitat for the Squirrel Glider, New Holland Mouse and Koala near Heatherbrae. This small area of habitat is already bound by industrial land to the north and west and therefore movements for fauna to the north are already limited. Given the small size of the area, and surrounding development, a crossing at this location may draw fauna into a sub-optimal patch and is not warranted, particularly given the extent of habitat to the south. Fauna fencing would be used at this location.

Barrier effects

Barrier effects occur where particular species are either unable or are unwilling to move between suitable areas of habitat due to the imposition of a 'barrier' (for example, a newly created inhospitable habitat type or physical barrier such as a fence). Species most vulnerable to barrier effects include uncommon species, smaller ground-dwelling species, and relatively sessile species with smaller home ranges.

In general, the project has been well positioned to avoid fragmentation of habitat and disruption of connectivity for fauna. This is particularly evident where the project has been placed along the edge of the existing Pacific Highway and industrial land in the area from Old Punt Road to Masonite Road. The land to the west of the project comprises cleared floodplain habitats, and industrial or urban land and impacts to the movements of fauna from east to west in this area are not expected, and no dedicated underpass crossing structures are required.

Further north of Masonite Road existing industrial land and proposed future industrial subdivisions occur on both sides of the project. This future subdivision would remove any small areas of habitat isolated to the north of the project. The small-scale examples of potential barriers to fauna movements from this project are described above and these areas have been the subject of a targeted fauna connectivity strategy, the outcomes of which are provided in **Chapter 9**.

8.5.3 Edge effects on adjacent native vegetation and habitat

The development of linear infrastructure is known to cause disturbance in terms of reducing habitat quality and patch size. This is due to the greater potential for edge effects and habitat fragmentation and barrier effects associated with these forms of development due to their impact footprint and perimeter. There is potential for a high magnitude residual impact to occur to habitats within the construction footprint from edge effects in the form of reduced habitat quality and reduced patch size which is irreversible and permanent.

Edge effects refer to the changes in environmental conditions (for example 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 & 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 kilometre from an edge (Forman et al. 2000) and stopping as little as 50 metres from an edge (Bali 2005).

Edge effects have the potential to impact on the range of flora and fauna species identified as potentially occurring in the construction footprint and would be felt greatest in more sensitive species with specific micro-habitat requirements and which are less tolerant to disturbance, for example some ground-dwelling reptiles and mammals, smaller birds and some plants.

Within the construction footprint edge effects may be difficult to identify in the expansive areas of floodplain freshwater wetlands which have been extensively cleared, drained and grazed. Similarly, some forested areas are already edge affected next to the Pacific Highway and at the far northern end of the project. Conversely, the greatest potential for edge effects would be within the newly created edges traversing the dry sclerophyll forests and forested wetland habitats, in particular at the following locations:

- **Black Hill:** where the project deviates from the M1 Pacific Motorway across to the bridge crossing of the Glenrowan Creek. All habitat in this location has already been degraded over time by track development, extensive rubbish dumping, selective clearing, grazing and construction of water pipeline infrastructure. Edge effects from the new road would contribute to this general degradation and could include up to 140 hectares of PCT1593 and PCT1588. This area is calculated based on a 50-metre

edge effect from the construction footprint and has been calculated for the southern edge only as the northern edge would largely adjoin the existing cleared Hunter Water Corporation easement
- **Heatherbrae:** from the entrance to the Hunter Region Botanic Gardens north to Masonite Road a potential edge effect of up to 180 hectares of PCT1646 has been calculated, this is based on a 50 metre buffer on the construction footprint mostly on the southern and eastern boundary which would be a newly created edge.

The potential indirect impacts from edge effects were included in the overall calculation of impacts and offsets for this project, as the broader construction footprint includes a buffer around the design to allow for all potential construction activity.

Overshadowing

Shading caused by artificial structures has been highlighted as an important human disturbance, affecting both productivity and community organization. Sunlight shading affects the structure and functioning of biological communities in natural ecosystems, through a reduction in the incidence of solar radiation, thus disturbing the growth and biomass production by autotrophs in both terrestrial and aquatic environments (Pardal-Souza et al*.* 2017).

Potential impacts to surrounding vegetation caused by shading of new bridges has been guided by a shadow analysis carried out for the Urban Design, Landscape Character and Visual Amenity Working Paper (Appendix O of the EIS). The analysis identified four main areas where overshadowing of the proposed bridge structures would occur, including Tarro, Tomago industrial area, Hunter Region Botanic Gardens and Heatherbrae industrial/commercial area. The overshadowing caused by the bridge structures in these areas is predominantly contained within the proposed construction footprint and there is unlikely to be any additional indirect impacts on terrestrial vegetation as a result.

Shading of aquatic habitat would occur where bridges cross waterways in the construction footprint, including the Hunter River, and Windeyers Creek. Shading from the bridge structures can impact on water quality by influencing temperature and biomass growth (Pardal-Souza et al*.* 2017). This impact would be unlikely to occur in the Hunter River due to the height of the proposed viaduct and the large and dynamic nature of the waterway. These impacts would be more likely to occur in slow moving aquatic environments, such as Windeyers Creek. However, the area of shading is only a small proportion of the relatively large wetland system, which is already subject to shading from surrounding woodland and pine vegetation. The impacts associated with shading on aquatic environments would be likely to be minor.

8.5.4 Injury and mortality of fauna

Fauna injury or death has the greatest potential to occur during construction from vegetation clearing and the extent of this impact would be proportionate to the extent of vegetation that is cleared. Some mobile species, such as birds, may be able to move away from the path of clearing and may not be greatly affected unless they are nesting. However, other species that are less mobile (for example, ground dwelling reptiles), or those that are nocturnal and nest or roost in trees during the day (for example arboreal mammals and microchiropteran bat species), may find it difficult to move rapidly when disturbed. Common fauna species such as possums, reptiles and frogs are the most likely to be affected.

Entrapment of wildlife in any trenches that are dug is a possibility if the trenches are deep and steep sided. Wildlife may also become trapped in machinery that is stored in the construction footprint overnight that may result in injury or death.

Locations where the project would involve clearing mature vegetation and habitat have the greatest potential for direct injury, mortality and displacement of fauna. In particular this includes a 1.7 kilometre stretch of remnant vegetation east of the Heatherbrae industrial area through to Masonite Road. The

Squirrel Glider and Masked Owl were identified in this location, and both species uses tree hollows for shelter and breeding. A diversity of common mammals, birds, reptiles and amphibians were also recorded.

Injury and mortality of fauna would be minimised and prevented through the implementation of management and management measures, such as pre-clearing surveys and fauna handling procedures, as outlined in **Chapter 9**.

During operation, 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 road verges as foraging habitat. These potential impacts would be mitigated with proposed fauna fencing measures described in **Chapter 9**.

A population of Eastern Grey Kangaroo (*Macropus giganteus*) was noted in the Black Hill area during the survey. Individuals and small groups were observed using the forested, grassland and wetlands habitat to the east of the M1 Pacific Motorway and within the construction footprint. Forested habitat in this location would be fragmented as a result of the project and this population may be at an increased risk over the medium to long term of kangaroo vehicle strike during the operation of the new motorway at the Black Hill and Beresfield area. The fauna connectivity strategy discussed in **Chapter 9** is aimed at addressing the risks to fauna and the connectivity issues discussed in this report. Proposed fauna connectivity and protection measures are shown in **Figure 9-1**.

8.5.5 Invasion and spread of weeds

Weed and pest species pose some of the greatest threats to biodiversity as these species displace native species through predation and competition, and damage vegetation by grazing and trampling (Adair & Groves 1998; Clarke, G. M. et al. 2000; Thorp & Lynch 2011). Consequently, proliferation of weed and pest species due to the project may be a key impact to biodiversity in the construction footprint.

Proliferation of weed and pest species is an indirect impact and key biosecurity risk that may have cumulative effects as each project activity may act together to increase the chances of weed and pest proliferation throughout the construction footprint. Proliferation of weed and pest species is likely to occur during all project phases from all project activities. The effects of proliferation of weed and pest species may not be experienced immediately or even in the short-term, however, would likely commence a few months after the project construction commences and gradually increase over months and seasons. This impact pathway has potential to impact on areas adjacent to those being cleared within the construction footprint and greatest impacts to the quality and integrity of receptors including TECs, remnant vegetation, habitat for threatened species, wetlands and waterways.

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

Weed species were recorded in the construction footprint during the field survey as discussed in **Chapter 3** and **Appendix A**. A total of 32 high threat exotic weed species (associated with the BAM), were identified in the construction footprint. Five of these species are listed as Weeds of National Significance (WoNS) and include *Alternanthera philoxeroides* (Alligator weed), *Asparagus aethiopicus* (Asparagus weed), *Lantana camera* (Lantana), *Rubus fruticosus* agg. (Blackberry) and *Senecio madagascariensis* (Fireweed). These are presented in **Table 8-8** which also identifies the legal obligation duties associated with priority weeds in the Hunter region and the abundance of each of the 32 high threat exotic species.

Table 8-8 High threat weeds, priority weeds and Weeds of National Significance recorded in the construction footprint

High threat exotic species (BAM)	Priority weed duties (Hunter region)	Weed of National Significance?	Abundance in construction footprint and occurrence in plots
Ageratina adenophora	Not a priority weed	No	Low abundance Plots: 5
Alternanthera philoxeroides	Prohibition on dealings Must not be imported into the State or sold Biosecurity Zone The Alligator Weed Biosecurity Zone is established for all land within the state except land in the following regions: Greater Sydney; Hunter (but only in the LGAs of City of Lake Macquarie, City of Maitland, City of Newcastle or Port Stephens Council). This project is not in the Alligator weed biosecurity zone.	Yes	Moderate abundance in wetland habitats and low-lying areas Plots: 0, 7, 8, 10, 22, 23, 31
Andropogon virginicus	Not a priority weed	No	Moderate abundance scattered in woodland habitats Plots: 20, 54, 55, 64, 65, 67, 68
Araujia sericifera	Not a priority weed	No	Low abundance Plots: 31
Asparagus aethiopicus	Must not be imported into the State or sold	Yes	Low abundance Plots: 6
Axonopus fissifolius	Not a priority weed	No	Moderate abundance in cleared areas Plots: 29, 61
Baccharis halimifolia	Regional Recommended Measure Land Area 1: core infestation within Newcastle, Greater Taree and Lake Macquarie. Land Area 2: rest of region Land Area 1: Land managers should mitigate the risk of new weeds being introduced to their land. Land Area 2: The plant should be eradicated from the land and the land kept free of the plant. Notify the Local Control Authority if found. The plant should not be bought, sold, grown, carried or released into the environment.	No	Low abundance Plots: 13, 26, 64, 65
Chloris gayana	Not a priority weed	No	Moderate abundance in cleared areas Plots: 62, 64, 69
Cinnamomum camphora	Not a priority weed	No	Low abundance scattered Plots: 31, 52, 68
Cortaderia selloana	Not a priority weed	No	Moderate abundance in disturbed sites around Heatherbrae Plots: 12, 31, 38, 44, 54, 67

High threat exotic species (BAM)	Priority weed duties (Hunter region)	Weed of National Significance?	Abundance in construction footprint and occurrence in plots
Ehrharta erecta	Not a priority weed	No	Moderate abundance in disturbed shaded areas Plots: 13, 38, 44, 45, 46, 53, 57, 63, 67, 69
Eragrostis curvula	Not a priority weed	No	Moderate abundance in cleared areas along road edges Plots: 43, 54, 59, 61
Hyparrhenia hirta	Regional Recommended Measure The plant should not be bought, sold, grown, carried or released into the environment. Land managers should mitigate the risk of the plant being introduced to their land. Land managers should mitigate spread from their land. Land managers to reduce impacts from the plant on priority assets.	No	Moderate abundance in cleared areas, mostly around Heatherbrae Plots: 29, 54, 55, 62
Ipomoea cairica	Not a priority weed	No	Moderate abundance at several sites Plots: 12, 46, 68, 69
Juncus acutus	Not a priority weed	No	Moderate to high abundance is freshwater and saline wetlands Plots: 10, 13, 24, 44, 45, 57
Lantana camara	Prohibition on dealings Must not be imported into the State or sold	Yes	Moderate to high abundance across the entire project Plots: 2, 4, 5, 6, 17, 30, 31, 36, 38, 40, 42, 43, 45, 49, 50, 53, 54, 54A, 55, 58, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70
Ligustrum sinense	Not a priority weed	No	Low abundance at several locations Plots: 31, 49, 52
Megathyrus maximus	Not a priority weed	No	Low abundance at several locations Plots: 62, 63
Ochna serrulata	Not a priority weed	No	Low abundance at several locations Plots: 4, 63
Olea europaea subsp. *cuspidata*	Regional Recommended Measure Land managers mitigate the risk of the plant being introduced to their land. Land managers reduce impacts from the plant on priority assets. Land managers prevent spread from their land where feasible. The plant or parts of the plant are not traded, carried, grown or released into the environment	No	Low abundance at several locations Plots: 13, 50, 66

High threat exotic species (BAM)	Priority weed duties (Hunter region)	Weed of National Significance?	Abundance in construction footprint and occurrence in plots
Paspalum dilatatum	Not a priority weed	No	Moderate abundance in cleared areas Plots; 0, 8, 9, 10, 11, 13, 15, 23, 31, 45, 54, 55, 64, 65
Paspalum quadrifarium	Not a priority weed	No	Only recorded from one site Plot: 67
Pennisetum clandestinum	Not a priority weed	No	Moderate abundance in cleared areas Plots: 10, 11, 22, 25, 66
Phyla nodiflora	Not a priority weed	No	Moderate abundance in cleared wet areas Plots: 0, 7, 9, 10, 22, 25, 26
Pinus radiata	Not a priority weed	No	High abundance in some areas around plantations in Heatherbrae Plots: 29, 30, 31, 52, 54A, 61, 63, 64, 67, 68
Ricinus communis	Not a priority weed	No	Moderate abundance around Heatherbrae Plots: 0, 69
Rosa rubiginosa	Not a priority weed	No	Only recorded from one site Plots: 25
Rubus fruticosus agg.	Prohibition on dealings Must not be imported into the State or sold All species in the Rubus fruiticosus species aggregate have this requirement, except for the varietals Black Satin, Chehalem, Chester Thornless, Dirksen Thornless, Loch Ness, Murrindindi, Silvan, Smooth Stem, and Thornfree Regional Recommended Measure The plant should not be bought, sold, grown, carried or released into the environment. Land managers should mitigate the risk of the plant being introduced to their land. Land managers should mitigate spread from their land. Land managers to reduce impacts from the plant on priority assets.	Yes	Moderate abundance in cleared wetland habitats Plots: 30, 64, 65, 69
Senecio madagascariensis	Prohibition on dealings Must not be imported into the State or sold	Yes	Moderate to high abundance in cleared areas Plots: 7, 10, 13, 25, 26, 31, 54, 57, 65, 67

High threat exotic species (BAM)	Priority weed duties (Hunter region)	Weed of National Significance?	Abundance in construction footprint and occurrence in plots
Senna pendula	Not a priority weed	No	Low to moderate abundance at several locations Plots: 5, 6, 38, 43
Stenotaphrum secundatum	Not a priority weed	No	Low abundance in cleared areas Plots: 13, 24, 26, 46
Tradescantia fluminensis	Not a priority weed	No	Only recorded from one site Plots: 13

During construction and operation there would be potential to disperse these weed and plant material into adjoining areas of vegetation or off site. The most likely causes of weed dispersal occur during construction while clearing of vegetation and potentially stockpiling weed contaminated mulch and topsoil. The subsequent movement of weed contaminated mulch and soil during earthworks and during site rehabilitation, including ancillary areas by construction vehicles and machinery can lead to broad dispersal and establishment of weeds. During operation, the risk of weed dispersal into adjoining bushland is lower as landscaping activities would have covered bare ground adjacent to the road however the road verge environment may create a modified landscape whereby weeds become prolific.

Pre-clearing, hygiene and spoil management measures would be implemented to limit the spread and germination of weeds is provided in **Chapter 9**. These measures address the general biosecurity duty, as defined by Part 3 of the *Biosecurity Act 2015*.

8.5.6 Invasion and spread of pests

The construction footprint is currently habitat for a range of pest species including rabbits and Plague Minnow that present a risk with the potential for dispersal from the construction footprint to adjoining areas. Project activities have the potential to disperse pest species out of the construction footprint across the surrounding landscape and increase the ability of pest species to utilise habitats due to habitat removal, noise, and human presence during construction and operation.

Construction of linear infrastructure through large patches of intact vegetation can result in the establishment of pest species (particularly predators such as foxes and cats) into areas where they are currently absent or in low numbers. However, in the context of the project this impact is predicted to be minimal as all vegetation in the construction footprint is likely to be impacted by foxes and cats. The magnitude of this impact would be low.

Management measures designed to limit the spread of pest species are provided in **Chapter 9**.

8.5.7 Invasion and spread of pathogens and disease

Several pathogens known from NSW have the potential to impact on biodiversity as a result their movement and infection during construction of the project. 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 construction footprint the potential for pathogens to occur should be treated as a risk during construction as these diseases can be transported by machinery. While forested areas are likely at greater risk from plant disease than the freshwater wetland areas of the project, all areas should be treated equally in terms of the potential risk and managing the spread of pathogens and disease.

Management measures to mitigate the potential introduction and spread of pathogens, and associated potential impacts on native vegetation, threatened species habitat and threatened fauna are provided in **Chapter 9**.

8.5.8 Noise, dust, light and contaminants

Noise, dust, light and contaminant pollution are direct impacts that are likely to result from project activities. These impacts are likely to have cumulative effects particularly during a lengthy construction period. Noise, dust, light and contaminant pollution are likely to occur during all phases of the project from all project activities, although would be greatest where construction activities take place near vegetated areas and during construction. These impacts would likely be greatest around vegetation in the Black Hill area across to Tarro (about 2 kilometres of construction adjoining forested vegetation), and from Tomago (old Punt road) through to Masonite Road (a further 1.7 kilometres of construction adjoining remnant vegetation).

Noise pollution

Anthropogenic noise can alter the behaviour of animals or interfere with their normal functioning (Bowles 1997). During all phases of the project there would be increased noise and vibration levels in the construction footprint 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 project would potentially disturb fauna and may disrupt foraging, reproductive (calling behaviour), or movement behaviours. The impacts from noise emissions would likely be localised to the construction areas and not considered likely to have a significant, long-term, impact on wildlife populations outside the area of impact. Within the area of impact, some sensitive species may avoid the noise and some more tolerant species, including small mammals, would habituate over the longer-term (Byrnes et al. 2012). However, considering most of the construction would be located along existing road infrastructure, the impacts of noise pollution on wildlife populations would likely be low. All areas of the project are subject to noise impacts on resident fauna, including common and threatened species.

Dust pollution

Elevated levels of dust during construction has potential to impact on the foliage of vegetation that is retained next to construction activities. Dust deposits of foliage has the potential to reduce photosynthesis and transpiration and cause abrasion and radioactive heating resulting in reduced growth rates and decreases in overall health of the vegetation (Grantz et al*.* 2003). Consequently, changes in the structure and composition of plant communities and consequently the grazing/foraging patterns of dependent fauna may occur (Auerbach et al*.* 1997; Walker & Everett 1987).

Dust pollution would be greatest during construction due to earthwork, vegetation clearing, vehicle movements for construction and decommissioning activities and during adverse weather conditions. Areas at greatest risk would be Black Hill and Heatherbrae, where remnant vegetation is to be retained next to the construction footprint. Dust impacts may also occur at the bridge crossing of Hunter River, where adjacent saltmarsh and mangrove forest would remain. The deposition of dust on foliage would likely be highly localised, intermittent, and temporary (can be removed by rain) and is therefore not considered likely to be a major impact of the project. Most of the construction would be carried out along existing road infrastructure so the impact of dust pollution in these areas would likely be low.

Project operation would generate litter and transport dust as part of road use by vehicles. Gross pollutants may result in increased levels of nutrients and toxicants which may be harmful to aquatic life and reduce visual amenity in receiving waterways and wetlands. With the implementation of the environmental management measures, dust and litter, if managed correctly, are not likely to result in a significant impact to water quality. Potential impacts and management measures associated with dust and litter generation during project operation are described in the Surface Water and Groundwater Quality Working Paper (Appendix K of the EIS).

Light pollution

Ecological light pollution is the descriptive term for light pollution that includes direct glare, chronic or periodic increased illumination, and temporary unexpected fluctuations in lighting (including lights from a passing vehicles), that can have potentially adverse effects on wildlife (Longcore & Rich 2004).

The construction footprint would be subject to artificial lighting, essentially creating ‘daylight’ conditions during the works. Ecological light pollution may potentially affect nocturnal fauna by interrupting their life cycle. Some species (i.e. light tolerant microchiropteran bats) may benefit from the lighting due to increased food availability (insects attracted to lights) around these areas. Considering most of the construction would take place over a relatively short period of time, the impacts of light pollution on fauna activity and movements would likely be low and short-term in nature.

During operation, the project would include artificial lighting at interchanges, associated ramps, and roads in the vicinity of interchanges, essentially creating permanent ‘daylight’ conditions. Ecological light pollution may potentially affect nocturnal fauna by interrupting their life cycle. Some species (i.e. 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 would habituate to the light disturbance and a long-term impact in the area of lighting is likely.

It is difficult to quantify the area affected by light and these have been considered in the section on edge effects. Impacts on fauna activity and movements may be restricted to areas where light is concentrated such as interchanges, ramps and intersections. However, considering most of the temporary and permanent lighting would be located along the existing road corridor, the impacts of light pollution on fauna activity and movements would likely be low. The need for artificial lighting during construction and operation will be minimised where feasible, including directing lighting away from vegetated areas where practicable (see **Chapter 9**).

Contaminant pollution

During the construction phase localised release of contaminants (i.e. hydraulic fluids, oils, drilling fluids, etc.) into the surrounding environment (including drainage lines and freshwater wetlands) may accidentally occur. The most likely result of contaminant discharge would be the localised contamination of soil and potential direct physical trauma and or death to flora and fauna that come into contact with contaminants. The risk of this occurring is very low and able to be mitigated effectively during construction.

8.5.9 Cumulative impacts

Cumulative impacts are caused by the accumulation and/or interaction of multiple stresses affecting the parts and the functions of ecosystems. For the purposes of this assessment, cumulative impacts are defined as the changes to the environment within the locality caused by an activity in combination with other past, present, and reasonably foreseeable human activities.

Table 8-9 lists the estimated historical loss of vegetation across NSW for each of the three landscapes that occur in the construction footprint. These data are expressed as an estimated percentage of the original (pre-European) vegetation that has been cleared. This is shown to provide some context to the cumulative impacts that have been experienced by these landscapes over the last 230 years.

Table 8-9 NSW (Mitchell) Landscapes in the construction footprint with historical per cent cleared estimates for the Hunter Central Rivers CMA region

Mitchell (2003) ecosystems	Landscape characteristics (geomorphic, pedologic and vegetation)	Historical percentage cleared
Coastal barriers	Newcastle Barriers and Beaches	50%
Hunter	Lower Hunter Channels and Floodplains	78%
	Newcastle Coastal Ramp	54%

The majority of all historical vegetation clearing in the Hunter IBRA sub-region has occurred in the fertile lower Hunter River alluvial plains landscape, a portion of which is traversed by the project and is equally the largest impact. Data from the over-cleared vegetation types database (DECC 2010a) was reviewed for assessing vegetation clearing as part of the project, specifically relating to the proposed clearing of TECs. Portions of the following six TECs would be cleared by the project as discussed previously. The estimate of the historical clearing of these vegetation types from the known former distribution is shown in **Table 8-10**. The area of each TEC cleared by the project is listed in the table in order of magnitude.

Table 8-10 Estimates historical clearing of NSW threatened ecological communities that are relevant to this project

Threatened ecological community	Estimated cleared to date	Estimated clearing for the project
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregion	70%	1.26 ha
Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	40% to 80%	68.18 ha
Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions	73%	0.45 ha
Lower Hunter Spotted Gum Ironbark Forest of the Sydney Basin	60%	41.88 ha

Threatened ecological community	Estimated cleared to date	Estimated clearing for the project
Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions	75%	8.76 ha
Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	75%	15.28 ha
Total		**135.6 ha**

Approved and proposed projects

The contribution made by the project to the potential long-term cumulative impacts to biodiversity in the region has been assessed by considering the extent of native vegetation clearing associated with other regional projects that make up the Pacific Highway Upgrade Program (PHUP) (refer to **Table 8-11**).

The total clearing of native vegetation completed for the two Pacific Highway upgrades from the M1 Pacific Motorway near Raymond Terrace to Karuah is estimated to be about 47 hectares (refer to **Table 8-11**). The project would refer to an additional 174 hectares cleared and increase the total clearing for the Pacific Highway upgrade from the M1 Pacific Motorway to Karuah to 221 hectares. This total includes 142 hectares of listed TECs (including the project i.e. 136 hectares). In addition to direct clearing of vegetation and fauna habitat, the cumulative impacts on biodiversity from the long-term upgrade of the highway is responsible for increased fragmentation of habitats and potential loss of connectivity, edge effects and weed invasion, loss of threatened flora and fauna and potentially increased predation of native fauna by introduced species, as discussed.

Table 8-11 Extent of native vegetation clearing associated with Pacific Highway upgrades from Hexham to Karuah (including the project)

Project	Direct native vegetation clearing (hectares)	Threatened ecological community clearing (hectares)
M1 Pacific Motorway extension to Raymond Terrace (the project)	174	136
Raymond Terrace bypass duplication	5	2
Raymond Terrace to Karuah	42	4
Total	**221 ha**	**142 ha**

The cumulative impacts to biodiversity in the locality of the project were further assessed by identifying the expected loss of vegetation and TECs associated with other approved and proposed projects (refer to **Table 8-12**). The project is located within a landscape that is already highly developed and is this trend of vegetation and habitat removal is likely to continue in the shirt and long term at this location, and the removal of vegetation for this project would contribute to the cumulative loss of vegetation in the surrounding landscape. The M1 Pacific Motorway Extension to Raymond Terrace would involve removal of around 174 hectares of vegetation. In addition to this there is an estimated 180 hectares also proposed for removal associated with a range of projects in the surrounding landscape (refer **Table 8-12**). This is a conservative estimate only based on publicly available information.

Table 8-12 Extent of native vegetation disturbance from projects within the locality

Project	Location	Status	Reported impacts
Black Hill Employment Lands (Northern Estates)	Lot 30 DP 870411, John Renshaw Drive, Black Hill	In planning	This project would result in the removal of 132.92 hectares of the Lower Hunter Spotted Gum Ironbark Forest (TEC listed under TSC Act). The ecological assessment report (RPS, 2011) also identified four threatened fauna species (Powerful Owl, Masked Owl, Grey-headed Flying-fox and Little Bent-winged Bat) in the construction footprint and determined that this project would impact 132.92 hectares of potential habitat for four threatened flora species (*Diuris praecox, Caladenia tessellata, Callistemon linearifolius and Grevillea parviflora subsp. parviflora*).
Hexham Straight	Pacific Highway between the Newcastle Inner City Bypass and Hexham Bridge.	Concept design contract awarded. Preferred options to be displayed for community comment in the second half of 2020.	This project would result in the removal of around 7.33 hectares of native vegetation, representing three PCTs and three TECs. Native vegetation includes habitat for threatened fauna species. The project also includes removal of 0.38 hectares of Coastal Wetlands.
Black Hill Hunter Business Park	337 Black Hill Road Black Hill and at John Renshaw Drive.	Under assessment	Impact assessment is not publicly available for this project. The site is around 450 hectares in size and includes a large patch of native vegetation, including riparian vegetation associated with Viney Creek. Aerial imagery shows around half of the site has been previously cleared.
Kinross Industrial / Weathertex, Heatherbrae	470 Masonite Road, Heatherbrae	Approved	About 25 hectares of native vegetation (Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast) was cleared in 2014. Clearing for this project has already occurred and removed 25 hectares of remnant vegetation next to the project, including habitat for threatened fauna species and *Diuris arenaria*.
Newcastle Power Station	1940 Pacific Highway, Tomago (Lot 3 DP1043561)	Approved	This project would result in the removal of around 15.5 hectares of native vegetation, three *Eucalyptus parramattensis* subsp. *decadens*, 0.18 hectares of habitat for Koala and 4.48 hectares of habitat for Squirrel Glider.
Lower Hunter Freight Corridor	Investigation area includes Hexham.	In planning	The Transport Lower Hunter Freight Corridor (LHFC) website (TfNSW, July 2018) indicates that in 2018 preliminary investigations were being carried out to assess options for a dedicated freight rail line between Fassifern and Hexham. An investigation areas figure between Fassifern and Hexham was available. As corridor options and environmental assessment are not available for the LHFC, the level of impact on biodiversity generated by this project is currently unknown. Consequently, cumulative impacts associated with the construction or operation of the project is unknown.

Project	Location	Status	Reported impacts
Richmond Vale Rail Trail to Shortland, including Shortland to Tarro cycleway	Intersects project Construction Footprint at Tarro	In planning	This project is not expected to result in cumulative biodiversity impacts with the project. The Richmond Vale Rail Trail to Shortland would encourage additional active transport use within the construction footprint.
Hunter Gas Pipeline	Intersects the project Construction Footprint at Tomago	Approved	This project would cross the project at Tomago. Construction is planned between 2023 and 2028. The gas pipeline impact assessment does not identify specific Biodiversity impacts within the construction footprint. However, it lists impacts on the following between Largs and Kooragang Island: • Lower Hunter Spotted Gum - Ironbark Forest in the Sydney Basin Bioregion EEC • Habitat for *Zannichellia palustris* and *Eucalyptus parramattensis* subsp. *decadens* • Habitat for green and golden bell frog • Habitat for wetland birds • Habitat for arboreal mammals • Threatened fish species • Hunter River estuary system. Minor cumulative impact to biodiversity values is expected in the vicinity of the construction footprint. However, the gas pipeline is proposed to perpendicularly cross the main alignment as well as passing through the AGL Gas-fired Power Station site, so the cumulative impact is expected to be minor.

8.6 Impact summary

A summary of the impacts described in **Chapter 8** is provided in the following **Table 8-13**. The summary has been tabulated to provide context to and direct the reporting of management measures required for the project to minimise impacts to biodiversity. The mitigation strategy is outlined in **Chapter 9**. The summary also provides context to the impacts on biodiversity values that require offsetting.

Table 8-13 Summary of impacts on biodiversity

Impact	Biodiversity values impacted	Nature of impact (Direct, indirect, consequential, cumulative)	Extent of impact (construction footprint) (Site based, Local, Regional, State, National)	Duration (Short term/ Long term, pre, during or post construction)	Does the project constitute or exacerbate a key threatening process?
Removal of native vegetation and habitat	Native vegetation (14 PCTs across three Mitchell landscapes, includes small area of riparian vegetation) comprising six Endangered Ecological Communities under the TSC Act (NSW), includes habitat for a range of ecosystem credit fauna species	Direct and cumulative	Local and regional loss of around 174 hectares of vegetation. Loss of around 136 hectares of state listed communities	Long term impact – permanent habitat loss, increased fragmentation, edge effects and weed invasion for remaining remnant areas	• Clearing of native vegetation (TSC Act) • Loss of hollow-bearing trees (TSC Ac) • Removal of dead wood and dead trees (TSC Act) • Land clearance (EPBC Act) • Degradation of native riparian vegetation along NSW water courses (FM Act)
Removal of threatened fauna species habitat and habitat features	Threatened species confirmed and species-credit species assumed present include (impact):	Direct impact	Total around 174 ha of potential habitat:	Long-term, permanent habitat loss and increased fragmentation	• Clearing of native vegetation (TSC Act) • Loss of hollow-bearing trees (TSC Act) • Removal of dead wood and dead trees (TSC Act) • Land clearance (EPBC Act)
	Wallum Froglet (vulnerable TSC Act) Mahony's Toadlet (endangered BC Act)		3.2 ha		
	Koala (vulnerable TSC Act and EPBC Act)		51.1 ha		
	Australasian Bittern (endangered TSC Act / EPBC Act)		43.6 ha		
	Black Bittern (vulnerable TSC Act)		61.9 ha		

Impact	Biodiversity values impacted	Nature of impact (Direct, indirect, consequential, cumulative)	Extent of impact (construction footprint) (Site based, Local, Regional, State, National)	Duration (Short term/ Long term, pre, during or post construction)	Does the project constitute or exacerbate a key threatening process?
Removal of threatened plants	Species confirmed or assumed present include:	Direct and indirect	Removal of individual plants	Long-term, the removal of plant ad habitat would directly decrease the population and area of habitat available for future recruitment	Clearing of native vegetation (TSC Ac) Land Clearance (EPBC Act)
	Diuris arenaria (vulnerable – TSC Act)		161 plants		
	Callistemon linearifolius (vulnerable TSC Act)		157 plants		
	Eucalyptus parramattensis subsp. *decadens* (vulnerable TSC Act and EPBC Act)		34 plants		
	Persicaria elatior (vulnerable TSC Act, EPBC Act)		3 plants		
Removal of migratory species habitat	Removal of habitat for wetland and terrestrial migratory species listed under the EPBC Act: (note river / estuarine habitat used by White-bellied Sea-Eagle would not be removed).	Direct	Local removal of habitat	Medium to long-term	Clearing of native vegetation (TSC Act) Land Clearance (EPBC Act)
	Latham's snipe (wetland species)		16.4 ha		
	Rufous Fantail and Satin Flycatcher (terrestrial species)		70.47 ha		
Aquatic impacts	Construction and operation of the project has the potential to impact aquatic ecosystems due to changes in water quality, habitat loss and instream barriers during construction. The project crosses Key Fish Habitat identified in the downstream stretch of Purgatory Creek and the Hunter River. Construction of the waterway crossings would also result in temporary localised disturbance and loss of riparian habitat along the western bank of the Hunter River	Direct and indirect	Local and regional impacts due to construction upstream of the hunter River estuary and Hunter Wetlands National Park	Medium to long-term	Removal of large woody debris from NSW Rivers and Streams (FM Act) Degradation of native riparian vegetation along NSW water courses (FM Act)

Impact	Biodiversity values impacted	Nature of impact (Direct, indirect, consequential, cumulative)	Extent of impact (construction footprint) (Site based, Local, Regional, State, National)	Duration (Short term/ Long term, pre, during or post construction)	Does the project constitute or exacerbate a key threatening process?
Groundwater dependent ecosystems	Fourteen PCTs likely to have some degree of groundwater dependence, including those located on the western extent of the Tomago Sandbeds aquifer and the Hunter River floodplain.	Indirect	Localised short-term impacts, known aquatic GDEs and potential terrestrial GDEs	Possibly short-term impacts only associated with localised drawdown of water table during construction, expected to be minimal and short-term	No
Changes to hydrology	If unmitigated, the highest risk would occur during construction: • Disturbance/mobilisation of sediment associated with the clearing of riparian vegetation along the Hunter River and Windeyers Creek as well as unnamed creek lines, especially where large cut and fill activities are required • Construction upstream of waterways such as the Hunter River, Purgatory Creek and Windeyers Creek, as well as the coastal wetlands on the floodplain near the Tarro interchange. • Construction of in-stream structures to cross the Hunter River and Windeyers Creek. • Temporary haulage road and culvert at bridge 2 • Construction of embankments / causeways over flat flood plains and soft soil areas – this would result in compaction/consolidation of soils resulting in reduced hydraulic properties and displacement of groundwater.	Direct and indirect	Local impacts, may include broader impact on downstream areas of Hunter River estuary	Short to medium term impacts during construction	No

Impact	Biodiversity values impacted	Nature of impact (Direct, indirect, consequential, cumulative)	Extent of impact (construction footprint) (Site based, Local, Regional, State, National)	Duration (Short term/ Long term, pre, during or post construction)	Does the project constitute or exacerbate a key threatening process?
	• General earthwork, including stripping of topsoil, excavation or filling, particularly larger fills at bridge abutments • Stockpiling of topsoil and vegetation • Transportation of cut and/or fill materials • Accidental spills of chemical or hazardous materials • Movement of heavy vehicles across exposed earth.				
Fragmentation of identified biodiversity links and habitat corridors	The project would result in minor small-scale localised fragmentation of small patches of habitat (five to 20 hectares), including habitat used by threatened flora and fauna.	Indirect	Fragmentation of habitat for local and regional populations of threatened species	Long-term impacts of reduced population viability and loss of genetic diversity	Clearing of native vegetation (TSC Act), Land Clearance (EPBC Act)
Edge effects on next native vegetation and habitat	Edge effects may be difficult to identify in the expansive areas of floodplain freshwater wetlands which have been extensively cleared, drain and grazed. Similarly, some forested areas are already edge affected next to the M1 Pacific Motorway and at the far northern end of the project. The greatest potential for edge effects would be within the newly created edges traversing the dry sclerophyll forests and forested wetland habitats, in particular at Black Hill and Heatherbrae	Indirect	Localised impacts	Long-term degradation of forest edges	No

Impact	Biodiversity values impacted	Nature of impact (Direct, indirect, consequential, cumulative)	Extent of impact (construction footprint) (Site based, Local, Regional, State, National)	Duration (Short term/ Long term, pre, during or post construction)	Does the project constitute or exacerbate a key threatening process?
Injury and mortality of fauna	If unmitigated, fauna injury or death has the greatest potential to occur during vegetation clearing resulting from direct disturbance to habitat trees, bushrock removal and ground cover removal. Injury and mortality could also increase during operation of the road through road-strike	Direct	Localised impacts	Short and long-term	• Clearing of native vegetation (TSC Act) • Loss of hollow-bearing trees (TSC Act) • Removal of dead wood and dead trees (TSC Act) • Land clearance (EPBC Act)
Invasion and spread of weeds	If unmitigated during construction, there is a high risk of dispersing weed seeds and plant material into adjoining areas of retained vegetation. The most likely causes of weed dispersal are associated with clearing of vegetation and stockpile of contaminated mulch and topsoil during earthwork, and movement of soil and attachment of seed (and other propagules) to construction vehicles and machinery.	Indirect	Localised impacts	Long-term	• Invasion and establishment of exotic vines and scramblers (TSC Act) • Invasion of native plant communities by African Olive (*Olea europaea L*. subsp. *cuspidata*) (TSC Act) • Invasion, establishment and spread of *Lantana camara* (TSC Act) • Invasion of native plant communities by Bitou bush and Boneseed (*Chrysanthemoides monilifera*) (TSC Act) • Invasion of native plant communities by exotic perennial grasses (TSC Act)

Impact	Biodiversity values impacted	Nature of impact (Direct, indirect, consequential, cumulative)	Extent of impact (construction footprint) (Site based, Local, Regional, State, National)	Duration (Short term/ Long term, pre, during or post construction)	Does the project constitute or exacerbate a key threatening process?
Invasion and spread of pests	The construction footprint is currently habitat for a range of pest species including rabbits, foxes, and dogs. Project activities have the potential to disperse pest species out of the construction footprint across the surrounding landscape and increase the ability of pest species to utilise habitats due to habitat removal, noise, and human presence during construction and operation. Construction of linear infrastructure through large patches of intact vegetation can result in the establishment of pest species (particularly predators such as foxes and cats) into areas where they are currently absent or in low numbers.	Indirect	Localised impact	Long-term	• Competition and grazing by the feral European rabbit (Oryctolagus cuniculus) (TSC Act and EPBC Act) • Predation and hybridisation of feral dogs *(Canis lupus familiaris)* (TSC Act) • Predation by the European red fox (*Vulpes vulpes*) (TSC Act and EPBC Act) • Predation by the feral cat (*Felis catus*) (TSC Act and EPBC Act) • Predation by Plague Minnow or Mosquito Fish (*Gambusia holbrooki*) (TSC Act)
Invasion and spread of pathogens and disease	Potential risk of plant and animal disease pathogens mobilising onto or transported around the project during construction	Indirect	Local	Long-term through introduction of disease pathogens	• Infection of native plants by *Phytophthora cinnamomi* (TSC Act and EPBC Act) • Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae (TSC Act) • Infection by psittacine circoviral (beak and feather) disease affecting

Impact	Biodiversity values impacted	Nature of impact (Direct, indirect, consequential, cumulative)	Extent of impact (construction footprint) (Site based, Local, Regional, State, National)	Duration (Short term/ Long term, pre, during or post construction)	Does the project constitute or exacerbate a key threatening process?
					endangered psittacine species and populations (TSC Act and EPBC Act) • Infection of frogs by amphibian chytrid causing the disease chytridiomycosis (TSC Act and EPBC Act)
Noise, dust, light and contaminants	Noise, dust, light and contaminant pollution are direct impacts that can occur during all phases of the project, although risk would be greatest where activities take place near vegetated areas and during construction	Direct/indirect	Local	Short to medium-term impact, only during construction	No
Cumulative impacts	Cumulative loss of vegetation and habitat, increased fragmentation and weed invasion for regional populations of threatened species, and endangered ecological communities	Direct/indirect	Local and regional	Long-term, contributes to cumulative loss of vegetation and habitat in the landscape	Clearing of native vegetation (TSC Act) and Land Clearance (EPBC Act)

9. Mitigation strategy

9.1 Habitat connectivity measures

The project has minimal impact on habitat connectivity at a landscape scale, however small-scale and isolated fragmentation impacts have been noted and are addressed by habitat connectivity measures proven to be effective. A review of connectivity structure options was considered at two dedicated design workshops aimed at identifying feasible fauna crossing opportunities and fencing requirements for the project.

It was noted that the land within and around the construction footprint is currently undergoing development, with some vegetated areas near the project likely to become cleared in the future (refer **Section 8.5.9**). The location of connectivity measures is therefore targeted at fragmented vegetation that is likely to be retained in the medium to long-term.

The goals of the habitat connectivity measures are to:

- Reduce and minimise roadkill to maintain viable fauna populations
- Promote gene flow and provide functional crossing opportunities in a fragmented landscape
- Maintain home range movements for individuals and maintenance of landscape connectivity for existing populations for dispersal and breeding.

The specifications of connectivity structures discussed in this section are presented in detail in the Draft Wildlife Connectivity Guidelines (Roads and Maritime, 2011). The structure types were identified based on their known effectiveness for the target species reported on other Transport highway upgrades and include:

- **Canopy bridges:** Canopy bridges connect habitat on both sides of a road, by passing over it. Canopy bridges come in many forms, including ropes, rope ladders, steel cables, or pipes suspended across the road. Canopy bridges can be suspended above traffic from vertical poles or can also be used under road bridges. The canopy bridges proposed are rope bridges or ladders
- **Glider poles:** Glider poles are suitable for arboreal mammals that glide between habitats such as sugar glider and squirrel glider (recorded on the project). Glide poles and landing points must be close enough together and high enough that glide trajectory does not intersect traffic or the ground. The height of structures and exact position would be determined at the final design stage
- **Under bridge crossings:** Underbridge crossings: Underbridge crossings are a type of underpass which allows wildlife to cross the road beneath a bridge or a viaduct. These crossings are suitable for a large range of terrestrial and aquatic species, as they are typically dual purpose (allow for both water flow and wildlife passage). Furthermore, the continuation of natural conditions such as soil and vegetation often occur under the bridge or viaduct
- **Fencing:** Fencing funnels fauna to the crossing structures, preventing fauna from accessing the road and as a result, animal-vehicle collisions. Fencing designs would differ, depending on characteristics of local fauna.

As the project has been identified as having minimal impact on landscape connectivity for ground-dwelling fauna, dedicated underpass crossing structures are not proposed. The viaduct proposed across the Hunter River and adjacent floodplain would allow the movement of fauna either side of the corridor and retains habitat connectivity of a large scale. Bridges proposed at Black Hill and Windeyers Creek would also provide for incidental movements by fauna across the project and would be combined with fauna exclusion fencing to aid fauna movements and minimise vehicle strike.

Details on the location of proposed arboreal crossing structures and fauna exclusion fencing are described in **Table 9-1** and illustrated on **Figure 9-1.**

Table 9-1 Summary of proposed fauna connectivity measures

Location	Target groups / species	Proposed structure	Corridor
Arboreal crossing structures			
North bound main carriageway alignment (CH280)	Arboreal mammals (Squirrel Glider, Sugar Glider, Common Brushtail Possum, Common Ringtail Possum, Feathertail Glider)	East-west rope crossing across the M1 Pacific Motorway linking large areas of Lower Hunter Spotted Gum ironbark Forest	Regional and local
Black Hill (CH2330)		North-south rope crossing linked to existing trees, to include strategic planting of Eucalypts to improve link to existing vegetation	Local
Heatherbrae (CH11100)		North-south rope crossing to link isolated patch of remnant Smooth-barked Apple –Blackbutt open forest	Local
Old Punt Road (CH850)		Glider poles linking east to west on Old Punt Road	Local
Old Punt Road (CH1100)		Glider poles linking east to west on Old Punt Road	Local
Fauna exclusion fencing			
From the location of the SB entry ramp to M1 at Black Hill to Tarro (CH900 – 3200)	All flightless fauna	Exclusion fencing (combined with property boundary / cattle fence)	Local
Heatherbrae (CH10600-12400)		Fauna exclusion fencing	Local
Joining existing Pacific Highway(CH13800-1500) eastern side of highway only		Fauna exclusion fencing to tie in within existing exclusion fence on start of Raymond Terrace Bypass)	Local

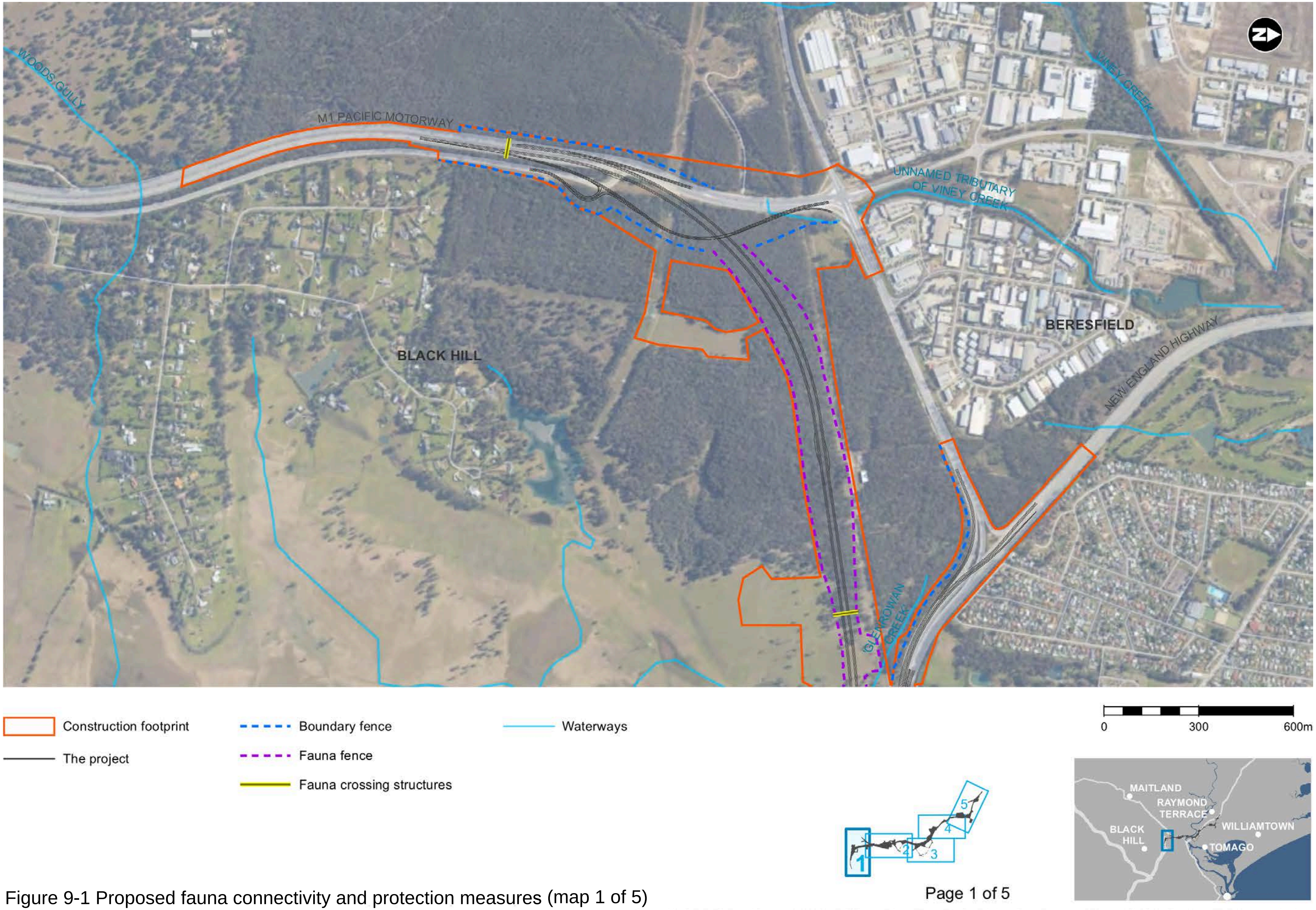


Figure 9-1 Proposed fauna connectivity and protection measures (map 1 of 5)

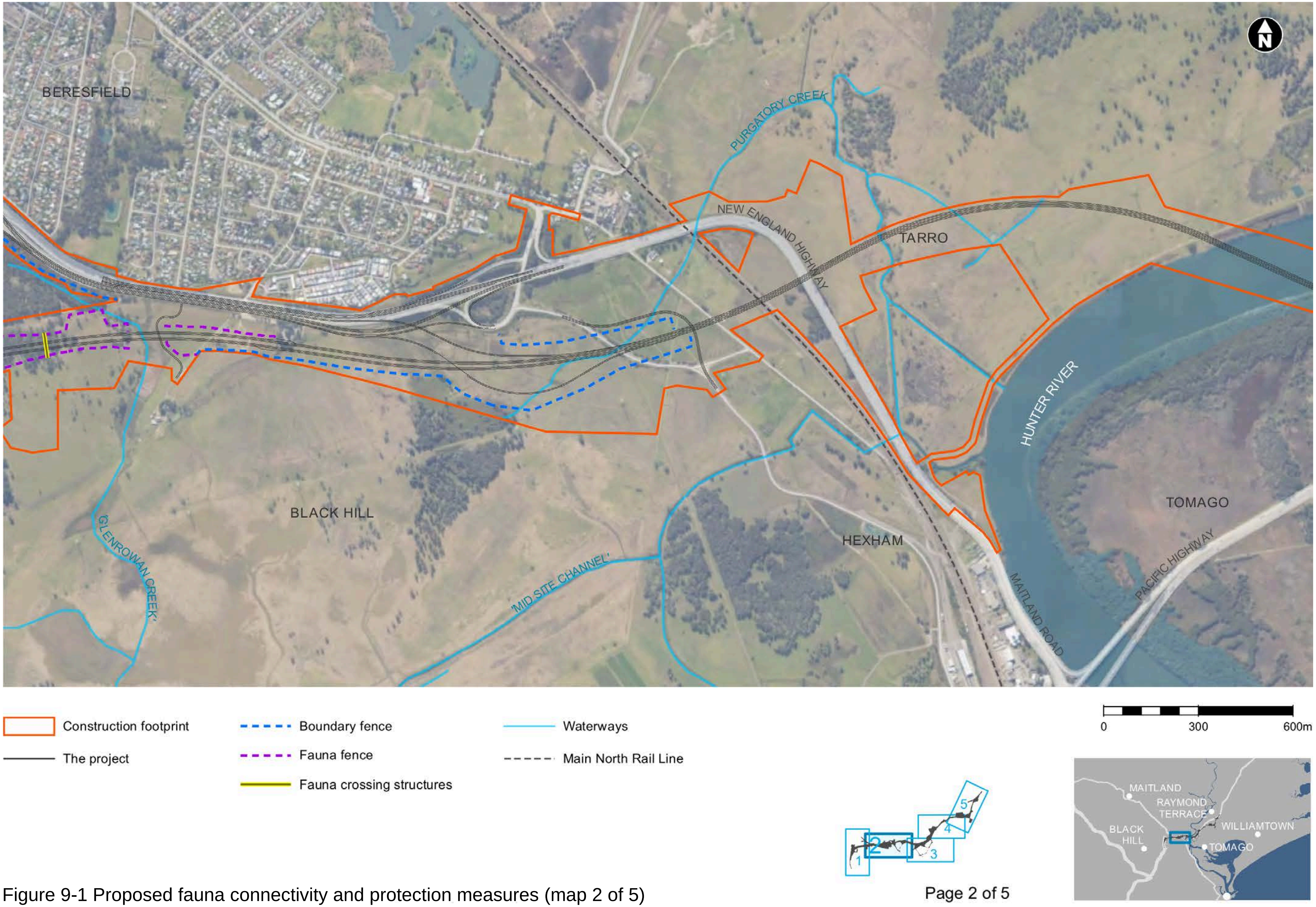


Figure 9-1 Proposed fauna connectivity and protection measures (map 2 of 5)

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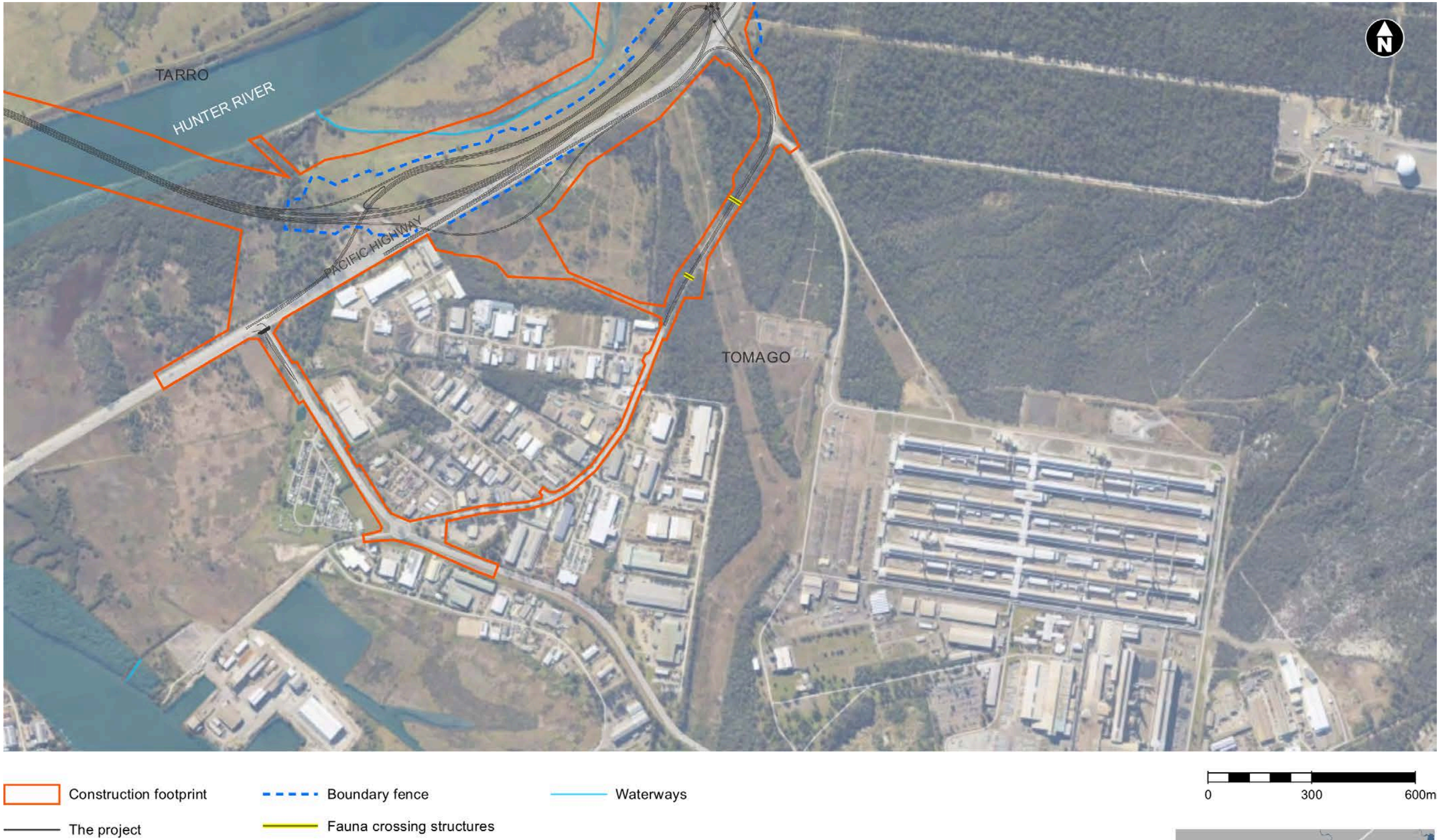


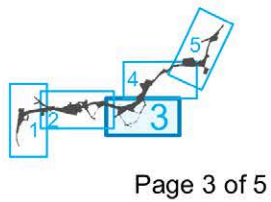
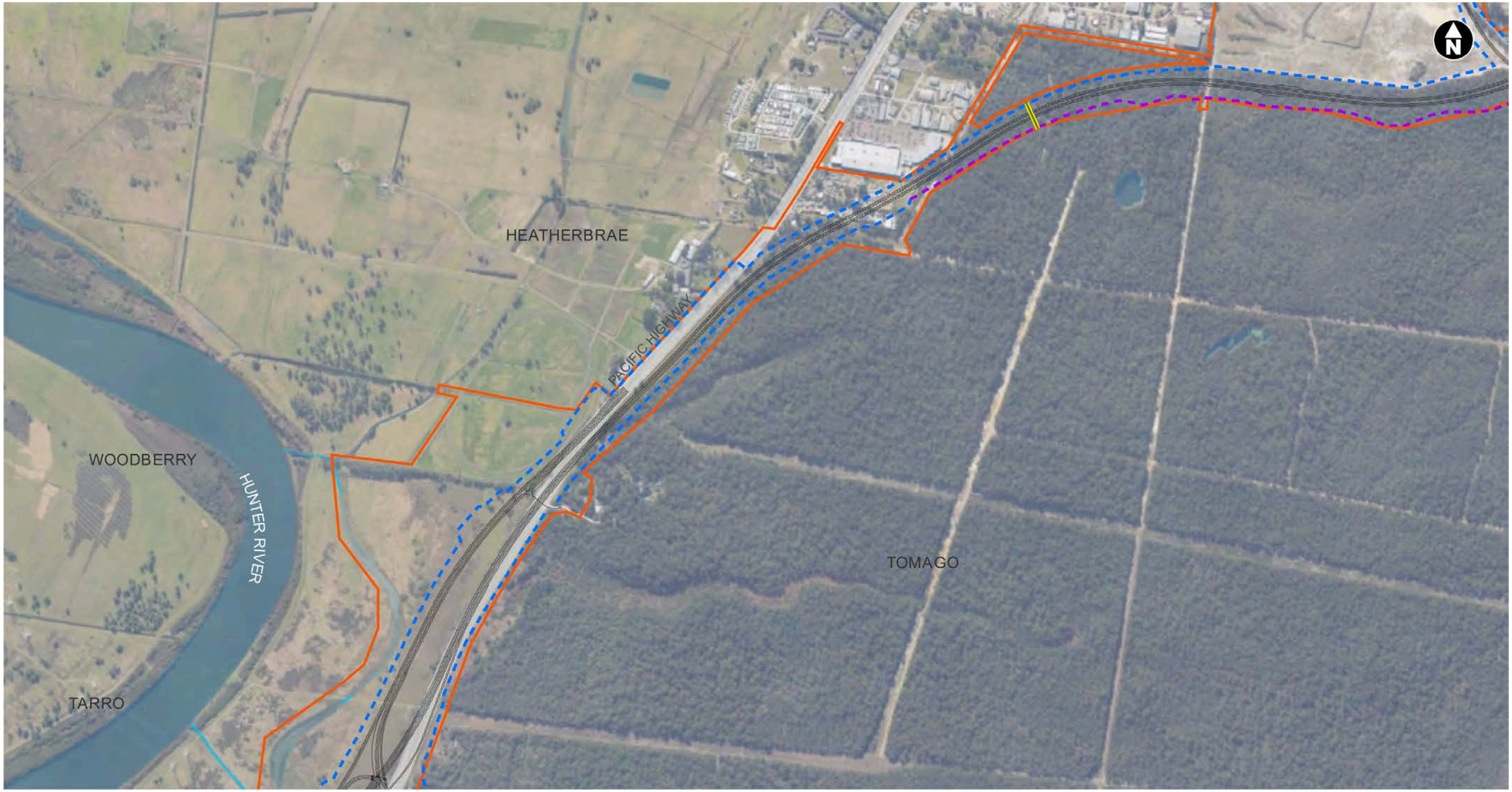
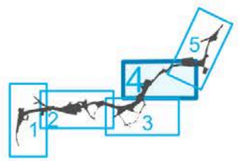


Figure 9-1 Proposed fauna connectivity and protection measures (map 3 of 5)





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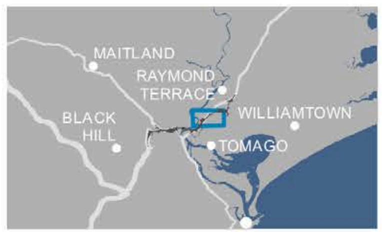

Figure 9-1 Proposed fauna connectivity and protection measures (map 4 of 5)

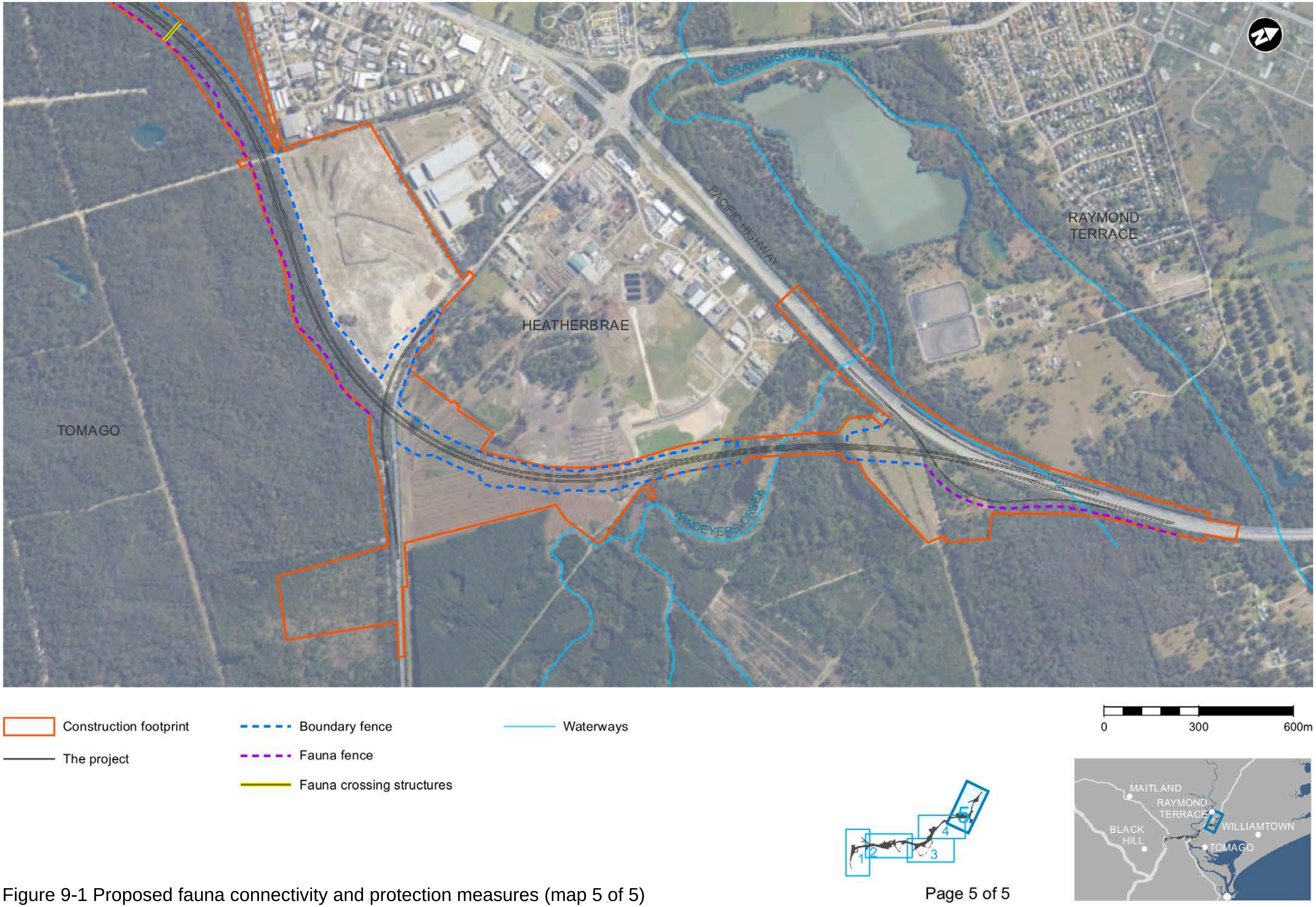

Figure 9-1 Proposed fauna connectivity and protection measures (map 5 of 5)

9.2 Biodiversity management measures

The following management measures detailed in **Table 9-2** have been developed to specifically manage potential biodiversity impacts which have been predicted during construction and operation of the project.

The impact assessment has described the proposed loss of vegetation and habitat, and range of potential impacts associated with the project. Management measures will be implemented during construction to further lessen the potential ecological impacts of the project. The potential residual impacts to biodiversity from the project that form the basis of the mitigation strategy can be summarised as:

- Potential inadvertent impacts to retained areas of vegetation adjacent to the project, including native vegetation, TECs, and habitat for flora and fauna
- Fauna injury and mortality during clearing of vegetation for construction and vehicle strike during operation
- Edge effects, and the potential introduction of weeds and disease pathogens into adjoining vegetation and habitat
- Habitat fragmentation, barrier effects and fauna mortality during operation
- Construction and operational impacts on aquatic habitats.

Transport for NSW have a long history of designing and implementing management measures of road projects that are known to be effective. The management measures outlined in **Table 9-2** are summarised from the document ‘‘Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects’ (NSW Roads and Traffic Authority 2011). Further to this, measures associated with protecting key fish habitat in **Table 9-2** been developed in accordance with the NSW DPI (Fisheries) document ‘Policy and Guidelines fish habitat conservation and management (2013 update)’ (Department of Primary Industries 2013).

Table 9-2 Biodiversity management measures

Impacts (refer to Chapter 8)	ID	Biodiversity management measures	Responsibility	Timing	Effectiveness
Loss of vegetation and habitat for flora and fauna including threatened species	B01	A Flora and Fauna Management Plan (FFMP) will be prepared in accordance with the 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (RTA, 2011a). It will address terrestrial and aquatic matters and include, but not necessarily be limited to: • Plans for the construction footprint and adjoining areas showing native vegetation, flora and fauna habitat, threatened species and endangered ecological communities • Procedures addressing relevant matters specified in the 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (RTA, 2011a) • Procedures for the protection of aquatic fauna associated with instream works. All personnel working on site will receive training to ensure awareness of requirements of the FFMP and relevant statutory responsibilities.	Contractor	Detailed design/ prior to construction	Known and proven effective document and procedure for managing impacts on road projects
	B02	Pre-clearing surveys will be carried out in accordance with 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (Guide 1: Pre-clearing process) (RTA, 2011).	Contractor	Prior to construction	Known and proven effective procedures
	B03	If any threatened species, not assessed in the biodiversity assessment, are identified in the construction footprint, the unexpected species find procedure is to be followed under 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (RTA 2011).	Contractor	Construction	
	B04	Vegetation and habitat removal will be carried out in accordance with 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (Guide 4: Clearing of vegetation and removal of bushrock) (RTA, 2011).			
	B05	Revegetation will be carried out in accordance with 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (RTA, 2011) (Guide 3: Re-establishment of native vegetation) and the Landscape Plan prepared for the project.			
	B06	Re-use of woody debris and bushrock and installation of nest boxes would be carried out in accordance with the 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (RTA, 2011), Guide 5 and Guide 8.			
Potential impacts to	B07	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 where practicable, Section 3.3.2 Standard precautions	Contractor	Construction	Known and proven effective procedures

Impacts (refer to Chapter 8)	ID	Biodiversity management measures	Responsibility	Timing	Effectiveness
aquatic habitat		and mitigation measures of the 'Policy and guidelines for fish habitat conservation and management Update 2013' (Department of Primary Industries 2013).			
Fragmentation of habitat and barrier effects and fauna mortality during operation	B08	Fauna crossing and exclusion fencing structures would be designed and constructed to facilitate fauna connectivity and exclusion across the project in accordance with the Biodiversity Assessment Report.	Transport for NSW and Contractor	Detailed design/ construction	Known and proven effective procedures
Edge effects on adjacent native vegetation and habitat	B09	Exclusion zones will be set up at the limit of clearing in accordance with 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (RTA, 2011) (Guide 2: Exclusion zones).	Contractor	Construction	Known and proven effective procedures
Injury and mortality of fauna during clearing and construction	B10	Fauna will be managed in accordance with 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (RTA, 2011) (Guide 9: Fauna handling).	Contractor	Construction	Known and proven effective procedures
Invasion and spread of weeds	B11	Weed species will be managed in accordance with 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (RTA, 2011) (Guide 6: Weed management).	Contractor	Construction	Known and proven effective procedures
Invasion and spread of pest animal, pathogens and disease	B12	Pest species and pathogens will be managed in accordance Guide 2: Exclusion zones of the 'Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects' (NSW RTA 2011), the Commonwealth *Biosecurity Act 2015,* NSW *Biosecurity Act 2015* and where relevant, the Australian Ballast Water Management Requirements.	Contractor	Construction	Known and proven effective procedures
Noise, light and vibration	B13	The need for artificial lighting during construction and operation will be minimised where feasible, including directing lighting away from vegetated areas where practicable.	Contractor	Detailed design/ construction	Known and proven effective procedures

10. Offsetting requirements

10.1 Biodiversity credits

This assessment has described the biodiversity values present in the construction footprint and the impact of the project on these values. Further to this, the assessment has identified all reasonable measures and strategies proposed to avoid and minimise impacts to biodiversity associated with the project. Any residual impacts would need to be offset, and the offset requirement is represented as a number and type of biodiversity credits determined in accordance with Chapter 10 of the FBA and presented in this section. The BBCC proposal ID for this project is 179/2020/5065MP.

The required ecosystem credits are outlined in **Table 10-1** and species credits in **Table 10-2**. The credits displayed have been calculated in accord with the FBA and therefore a case study was developed using the BBCC. A credit equivalency assessment is required to convert these credits to the current BAM credit values.

The ecosystem credits are calculated on the basis of a loss in landscape value score of 27.20, an TEC multiplier of 3.0 and threatened species multiplier of 3.0. The associated ecosystem species identified as the highest multiplier influencing the credits required is shown in the table for each PCT.

A Biodiversity Offset Strategy has been prepared that outlines how Transport intends to offset the impacts on the project and is provided in **Appendix I**.

Additional biodiversity offsets for threatened species and ecological communities also listed under the EPBC Act have not been calculated. The project is being assessed in accordance with the NSW Bilateral Agreement (2015), therefore provision of offsets in accordance with the EPBC Act environmental offsets policy (Department of Sustainability, Environmental, Water, Population and Communities 2012) is not required.

Table 10-1 Ecosystem credits summary

Vegetation zone	Plant community type (PCT) (BVT)	Threatened species with highest credit requirement	Loss in site value score	Project impact within construction footprint (ha)	Ecosystem credits required
1. 1590 - Good	Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590) (HU804)	Powerful Owl	77.08	25.16	1626
2. 1590 - Moderate			64.58	8.35	461
3.1590 - Regenerating			29.17	8.37	240
4.1588 - Moderate	Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (1588) (HU802)	Spotted-tailed Quoll	79.69	6.78	397
5.1588 - Regenerating			49.48	0.82	32
6. 1646 - Good	Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646) (HU860)	Powerful Owl	59.9	20.76	1074
7.1646 - Poor			50	7.83	347

Vegetation zone	Plant community type (PCT) (BVT)	Threatened species with highest credit requirement	Loss in site value score	Project impact within construction footprint (ha)	Ecosystem credits required
8.1649 - Good	Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649) (HU863)	Spotted-tailed Quoll	61.33	1.36	72
9.1598 - Poor	Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598) (HU812)	Spotted-tailed Quoll	71.33	0.45	27
10.1716 - Good	Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716) (HU930)	Spotted-tailed Quoll	66.67	1.82	103
11.1717 - Good	Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717) (HU931)	Spotted-tailed Quoll	62	3.85	205
12.1717 – Poor			44	6.64	264
13.1724 - Good	Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1724) (HU938)	Spotted-tailed Quoll	53.33	1.61	75
14.1727 - Moderate	Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727) (HU941)	Spotted-tailed Quoll	55.33	8.76	423
15.1736 - Good	Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736) (HU950)	Little Eagle	48.06	33.23	1424
16.1736 - Moderate			36.43	25.81	881
17.1742 - Good	Jointed Twig-rush sedgeland (1742) (HU956)	Little Eagle	82.17	1.45	99
18.1071 - Good	*Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (1071) (HU673)	Little Eagle	47.29	7.71	326
			Total	**170.76***	**8,076**

*This total is different to what is listed in **Table 8-1** as it does not include the saline communities Grey Mangrove low closed forest (HU961) or Saltmarsh Estuarine Complex (HU960). These are discussed in **Section 10.2**.

The species credits are calculated based on the impact of the project on the number of individuals in the case of the threatened plant species, and the area of impact for threatened fauna. Mahony's Toadlet (*Uperoleia mahonyi*) was listed under the BC Act in 2018 and the species has not been added to the

BBCC. However, assessment under Section 9 of the FBA was specified in the SEARs agency comments from EES Group. The species is assumed present in the construction footprint and as the area of impact is the same as for Wallum Froglet, therefore the same credit obligation is presented.

Table 10-2 Species credits summary

Species	Extent of impact (ha) or individuals	Species credits required
Eucalyptus parramattensis subsp. *decadens*	34 plants	476
Diuris arenaria	161 plants	12,397
Callistemon linearifolius	157 plants	2198
Persicaria elatior	3 plants	39
Australian Bittern	43.64 ha	567
Black Bittern	61.95 ha	805
Koala	51.12 ha	1329
Wallum Froglet	3.21 ha	42
Mahony’s Toadlet	3.21 ha	42
	Total	**17,895**

10.2 Offsets for impacts to aquatic habitats

According to the FBA, PCTs that are classified under the VIS classification database as being in the saline wetlands vegetation formation must be assessed according to the Fisheries NSW policy and guidelines. There are two PCTs impacted by this project that are saline wetland formations:

- Saltmarsh estuarine complex (PCT 1746) (TYPE 1 Key Fish Habitat) – Zone 19, removal of about 1.26 hectares
- Grey Mangrove low closed forest (1747) (TYPE 2 Key Fish Habitat) – Zone 20 and 21, removal of about 2.27 hectares.

NSW DPI enforces a ‘no net loss’ habitat policy as a condition of consent (DPI 2013). The policy and guidelines for fish habitat conservation and management (DPI 2013) identifies habitat compensation on a minimum 2:1 basis for all key fish habitat (TYPE1-3).

It is recognised that there may also be alternatives to a monetary compensation to provide an adequate offset or compensation (e.g. remediation work) for impacts to saline vegetation types. Consultation with NSW DPI would be carried out to discuss other potential alternative options for compensation that are consistent with meeting the 2:1 offset ratio applied.

The project would also impact around 16.4 hectares of mapped Coastal Management SEPP coastal wetlands, which includes about 3.53 hectares of the saltmarsh and mangrove communities (TYPE 1 and 2 habitats). The remaining areas of the Coastal Management SEPP coastal wetland impacted by the project are covered by the PCTs 1736 and 1071 and would be offset as per the ecosystem credit calculations for these respective PCTs shown in **Table 10-1**.

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Terms and acronyms

Term	Description
Assessment circles	Two circles (the inner and outer assessment circle) in which the per cent native vegetation cover in the landscape is assessed, considering both cover and condition of vegetation (OEH 2014).
Biodiversity credit report	The report produced by the BBAM Credit Calculator that sets out the number and type of biodiversity credits required to offset the remaining adverse impacts on biodiversity values at a development site or sets out the number and type of biodiversity credits that are created at an offset site (OEH 2014).
Construction footprint	The area of land that is directly impacted on by a proposed Major Project that is under the EP&A Act, including access roads, and areas used to store construction materials (OEH 2014). The construction footprint has the same meaning as 'development site' for the purposes of the FBA.
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 the project SEARs 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).
Ecosystem credit	Ecosystem or species credits (OEH 2014).
Ecosystem credit species	A measurement of the value of EECs, CEECs and threatened species habitat for species that can be reliably predicted to occur with a PCT. Ecosystem credits measure the loss in biodiversity values at a development site and the gain in biodiversity values at an offset site. (OEH 2014)
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).
Landscape buffer (550 metre)	An area around the construction footprint used to assess landscape value in accordance with Appendix 5 of the FBA. For linear developments, this is a 550 metre buffer from the boundary of the construction footprint.
Locality	Area within 10 kilometres from the construction footprint
Matters for further consideration	Impacts that are considered to be complicated or severe that will require further consideration by the consent authority (OEH 2014). The assessment is based on thresholds detailed in Section 9 of the FBA. These can also be included as part of the project SEARs.
MNES	A matter of national environmental significance (MNES) 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).
Management measure	Any measure that facilitates the safe movement of wildlife and/or prevents wildlife mortality.
Mitigation	Action to reduce the severity of an impact. (OEH 2014).
Population	All the individuals that interbreed within a given area.
Proposed action	Refers to the project. This terminology is specific to MNES and the EPBC Act Significant impact guidelines 1.1

Term	Description
Species credit species	Threatened species and populations that are assessed according to Section 6.4 of the FBA (OEH 2014).
Target species	A species that is the focus of a study or intended beneficiary of a conservation action or connectivity measure.

Abbreviations	Description
BAR	Biodiversity Assessment Report
BBAM	BioBanking Assessment Methodology
BBCC	BioBanking Credit Calculator
BC Act	*Biodiversity Conservation Act 2016* (NSW)
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
EES Group	Environment, Energy and Science Group (formerly OEH)
EIS	Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FBA	Framework for Biodiversity Assessment
FM Act	*Fisheries Management Act 1994*
GDE	Groundwater dependent ecosystem
IBRA	Interim Biogeographically Regionalisation of Australia
MNES	Matters of National Environmental Significance
OEH	Office of Environment and Heritage
PCT	Plant Community Type
PMST	The federal Department of Environment's Protected Matters Search Tool
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SSI	State Significant Infrastructure
TBDC	Threatened Biodiversity Data Collection
TECs	Threatened Ecological Communities
Transport	Transport for New South Wales
TSC Act	*Threatened Species Conservation Act 1995* (NSW – replaced by BC Act in August 2017)

Appendix A. Species recorded and BBAM plot data

Table A-1 Vegetation condition assessment table

Veg Zone	Zone name	Plot No.	Native plant species	Native overstorey cover (%)	Native midstorey cover (%)	Native ground cover - grass	Native ground cover – shrub (%)	Native ground cover – other (%)	Exotic plant cover (%)	Number of hollow trees	Canopy Regeneration (%)	Fallen logs (m)	Total score
1	1590 - Good	17	20	34	22.5	56	2	16	8	0	1	5	77.08
		2	27	14	23	32	0	18	0	0	0	36	
		4	33	33	8.5	52	0	12	0	1	1	37	
		40	16	37	7	60	10	26	2	0	1	5	
		6	18	17	10.5	12	6	4	0	0	1	47	
2	1590 - Moderate	1	22	37.5	0	58	0	22	0	0	1	15	64.58
		53	21	42	3.5	64	18	8	6	0	1	0	
		58	27	26	4.5	46	0	38	0	0	1	15	
3	1590 - Regenerating	54	33	0	26	24	6	28	20	0	1	40	29.17
		64	10	0	18	34	0	4	62	0	0	0	
		65	6	0	1	0	0	82	18	0	0	0	
		66	10	0	57	58	0	0	40	0	0	0	
4	1588 - Moderate	3	40	31	10.5	50	0	2	0	0	1	31	79.69
		42	20	20	3	32	16	16	10	2	1	6	
		70	30	16.5	2.5	72	2	4	6	0	1	13	
5	1588 - Regenerating	55	35	0	26	42	4	26	20	0	1	22	49.48
6	1646 - Good	21	19	15	27	0	24	26	0	0	0	16	59.9
		27	29	33.5	12.5	18	32	38	0	0	1	22	
		34	23	35	1.5	0	32	44	0	0	1	9	

Veg Zone	Zone name	Plot No.	Native plant species	Native overstorey cover (%)	Native midstorey cover (%)	Native ground cover - grass	Native ground cover – shrub (%)	Native ground cover – other (%)	Exotic plant cover (%)	Number of hollow trees	Canopy Regeneration (%)	Fallen logs (m)	Total score
		35	21	31.5	22	0	14	58	0	0	1	0	
7	1646 - Poor	59	23	22	8.5	6	0	32	22	0	0	7	50
		60	27	0.5	8.5	0	0	20	70	0	1	0	
		61	22	10	15.5	2	2	10	18	0	1	28	
8	1649 - Good	28	18	29	12	54	16	8	22	0	0	7	61.33
9	1598 - Moderate	15	14	19.5	0	70	0	4	26	0	1	0	71.33
		20	13	33.3	0	10	0	30	34	0	1	0	
10	1716 - Good	38	26	30	18	38	4	20	22	0	0	12	66.67
		5	26	3.5	27.5	74	0	20	0	0	0	30	
11	1717 - Good	36	12	12	2	0	0	100	0	0	1	6	62
		48	10	21	0.5	40	6	50	0	0	1	18	
12	1717 – Poor	29	10	6	0	46	0	0	24	0	1	13	44
		62	8	15	5.5	0	0	0	100	0	1	0	
		63	11	6	3.5	4	0	0	96	0	1	10	
13	1724 - Good	49	16	21	25.5	14	0	26	60	1	0	6	53.33
14	1727 - Moderate	13	5	33.5	0	50	0	0	48	0	1	3	53.33
		22	4	2	0	20	0	0	80	0	0	0	
		43	6	17	0	0	0	0	84	0	1	0	
		45	2	18	0	30	0	0	70	0	1	0	
		46	4	30.5	0	18	0	2	48	0	1	0	
15	1736 - Good	0	6	0	0	8	0	54	38	0	0	0	48.06
		23	6	0	0	4	0	40	56	0	0	0	
		33	4	0	0	0	0	100	0	0	0	0	

Veg Zone	Zone name	Plot No.	Native plant species	Native overstorey cover (%)	Native midstorey cover (%)	Native ground cover - grass	Native ground cover – shrub (%)	Native ground cover – other (%)	Exotic plant cover (%)	Number of hollow trees	Canopy Regeneration (%)	Fallen logs (m)	Total score
		7	7	0	0	2	0	74	16	0	0	0	
16	1736 - Moderate	10	3	0	0	70	0	6	24	0	0	0	36.43
		26	4	0	0	70	0	6	24	0	0	0	
		8	6	0	0	52	0	16	32	0	0	0	
		9	3	0	0	36	0	34	30	0	0	0	
17	1742 - Good	30	11	1	0	2	0	96	0	0	1	12	82.17
18	1071 - Good	11	8	0	0	0	0	80	10	0	0	0	47.29
		12	4	1	0.5	80	0	4	0	0	1	0	
		44	5	5.5	0	96	0	0	0	0	0	0	
19	1746 - Good	24	4	0	0	64	0	2	2	0	0	0	49.07
		57	5	0	0	54	0	16	24	0	0	0	
20	1747 - Good	14	5	67	0	0	30	14	6	0	1	1	100
		56	4	47.5	0	0	2	0	0	17	1	70	
21	1747 - Moderate	25	5	6.5	0	40	0	0	60	0	0	0	42.42

Note: The total score is calculated from the scoring presented in Table 2 of the FBA.

Table A-2 Flora species recorded in vegetation plots

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588					PCT 1646						PCT 1649	PCT 1598		PCT 1716		PCT 1717					PCT 1724	PCT 1727					PCT 1736								PCT 1742	PCT 1071				PCT 1746		PCT 1747		
	Zone 1				Zone 2			Zone 3				Zone 4			Zone 5		Zone 6				Zone 7		Zone 8	Zone 9		Zone 10		Zone 11		Zone 12			Zone 13	Zone 14					Zone 15				Zone 16				Zone 17	Zone 18				Zone 19		Zone 20		Zone 21
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Acacia falcata								0.3				15										0.3																																		
Acacia fimbriata									0.5																								5																							
Acacia irrorata			0.5																												0.5																									
Acacia longifolia				1				0.2	1	15	0.3	35	0.5								2	0.2	6	2		10					1						1																			
Acacia longissima								0.1														0.1																																		
Acacia mearnsii																																	0.2																							
Acacia stricta																																3																								
Acacia suaveolens																	0.5		0.1	0.1	0.1																																			
Acacia terminalis																		0.5		0.2	0.2			0.5																																
Acacia ulicifolia		0.1							0.1				1	0.4	0.1	0.5	1	5	0.2	0.2	0.3												0.1																							
Acianthus fornicatus													0.2																																											
Actinotus helianthi																		0.1	0.1		0.3																																			
Adiantum aethiopicum																											0.1							0.1																						
Aegiceras corniculatum																																																							1	
*Agave americana**																																					2																			
*Ageratina adenophora***																											0.5																													
Allocasuarina torulosa													4																																											
Alphitonia excelsa		8																					0.5									0.3																								
*Alternanthera philoxeroides***																																				10				10	0.3	0.5	2	8					10							
*Ambrosia artemisiifolia**																										0.1					0.5	1					0.1	0.1				0.1														
*Anagallis arvensis**											0.1	0.1																																												
*Andropogon virginicus***									0.5	0.1	1					0.2										25																														
Angophora costata		0.5															10	25	40	70				35																																
Angophora floribunda																				20					10				5																											
Aristida vagans		2		0.1		3	10	0.5					1	15	5	0.1						0.5																																		
Arthropodium milleflorum								0.1														0.1																																		
*Asparagus aethiopicus***			0.1																																																					
Asplenium australasicum																																							0.1																	
*Aster subulatus**						0.1																													0.2												0.1						0.1			0.1

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588					PCT 1646						PCT 1649		PCT 1598		PCT 1716		PCT 1717				PCT 1724		PCT 1727					PCT 1736								PCT 1742	PCT 1071			PCT 1746		PCT 1747		
	Zone 1				Zone 2			Zone 3				Zone 4			Zone 5		Zone 6				Zone 7		Zone 8		Zone 9		Zone 10		Zone 11		Zone 12		Zone 13		**Zone 14**					**Zone 15**				**Zone 16**				Zone 17	Zone 18			Zone 19		Zone 20		Zone 21
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Astroloma pinifolium																					1																																			
Atriplex australasica																																			0.1																					
*Atriplex prostrata**																																						0.1	4													1		0.1		0.1
*Avena fatua**																															1																									
Avicennia marina																																																						85	50	20
*Axonopus compressus**																																	1																							
*Axonopus fissifolius***																							0.1								2																									
*Baccharis halimifolia***										0.1	0.1																								0.1												0.1									
Bacopa monnieri																																																	0.1							
Baloskion tetraphyllum subsp. meiostachyum																													10																											
Banksia aemula																	10	15																																						
Banksia integrifolia																							6			5																														
Banksia serrata																			2	2			3																																	
Banksia spinulosa var. spinulosa																								15																																
Baumea articulata																													1																			2								
Bidens pilosa									0.1																							30	20																							
Billardiera scandens					0.1			0.2										0.1				0.2	0.1	0.1																																
Blechnum cartilagineum																													70																											
Blechnum indicum																																																2								
Bolboschoenus caldwellii																																																	20				0.1			
Boronia polygalifolia									0.1						0.1	0.1																																								
Bossiaea heterophylla																	1		0.2		0.1																																			
Bossiaea rhombifolia																		0.1																																						
Brachyscome multifida	1																																																							
Brachyscome sp.																0.1																																								
Breynia oblongifolia	0.1	0.1				0.1	1	0.2				0.3								0.1		0.2	0.3					0.1				0.2					0.2																			
*Briza minor**																															4																									
*Briza subaristata**																															1																									
*Bromus catharticus**																																																								0.5
Brunonia australis															0.1																																									

Species *Exotic **High-threat exotic	PCT 1590												PCT 1588			PCT 1646							PCT 1649	PCT 1598		PCT 1716		PCT 1717					PCT 1724		PCT 1727					PCT 1736								PCT 1742	PCT 1071		PCT 1746		PCT 1747			
	Zone 1					Zone 2			Zone 3				Zone 4		Zone 5	Zone 6				Zone 7			Zone 8	Zone 9		Zone 10		Zone 11		Zone 12			Zone 13		Zone 14					Zone 15				Zone 16				Zone 17	Zone 18		Zone 19		Zone 20		Zone 21	
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Brunoniella australis	0.2	0.1						0.2					0.1									0.2						0.1																												
Brunoniella pumilio						3	0.1																																																	
Bursaria spinosa	5	10	0.1	2	0.2	0.4	10						10	25	3	1											0.2	0.2																												
Caesia parviflora var. parviflora		0.1																																																						
Caladenia catenata		0.1											0.2																																											
Callistemon linearifolius																0.4																																								
Callistemon rigidus									5				0.1			10												0.1																												
Callistemon rigidus x linearifolius			0.3																																																					
Calochlaena dubia																																		40														30								
Carex appressa																													10							50				80	90	50	80	10												
Carex longebrachiata																											5																													
Carex sp.																							0.1																																	
Cassinia quinquefaria								0.2																																																
Cassytha glabella			0.1																																																					
Cassytha pubescens													0.1																																											
Casuarina glauca																							1		10					30	5	30	40	5	65	20	40	85	60	1										10	30			0.2		
Cayratia clematidea																											0.1																													
Centella asiatica		0.1						0.1	0.1	0.1	0.1	0.1										0.1			0.1		2			0.2	0.1											0.2	0.1					0.1								
Ceratopetalum gummiferum																	20	15																																						
Cheilanthes sieberi							0.2	0.3	0.2			0.4			1	0.2						0.3	0.1										0.1																							
Cheilanthes sieberi subsp. sieberi	0.1	0.1				1							0.1	0.1												0.1		0.1																												
Chenopodium glaucum																																																								0.2
*Chloris gayana***										5																						6																								
*Cirsium vulgare**										0.1																									0.4	0.1				0.1	0.1	0.2											0.1			0.1
Clematis aristata																												0.1																												
Clematis glycinoides									0.1																							0.5																								
Conospermum tenuifolium																					0.2																																			
*Conyza bonariensis**																									0.1						0.1				0.3	0.1				0.1		0.1	0.1									0.1				
*Cortaderia selloana***									0.5																			0.5																						5	30					
Corymbia gummifera																1	30	0.2	25		4																																			

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588				PCT 1646						PCT 1649		PCT 1598		PCT 1716		PCT 1717				PCT 1724		PCT 1727					PCT 1736								PCT 1742	PCT 1071			PCT 1746		PCT 1747		
	Zone 1				Zone 2			Zone 3				Zone 4			Zone 5		Zone 6			Zone 7			Zone 8		Zone 9		Zone 10		Zone 11		Zone 12		Zone 13		**Zone 14**					**Zone 15**				**Zone 16**				Zone 17	Zone 18			Zone 19		Zone 20		Zone 21
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Corymbia maculata		20	30	30	25	50	45	30	5				20	15	8	3						30					20	20																												
*Cotula coronopifolia**																																														1							5			
Cupaniopsis anacardioides																		0.1																																						
Cymbopogon refractus							60					0.5																																												
Cynodon dactylon									1	3	5	1				5					0.2				50	15					70		1		75				10	30	0.5	0.5	5	25	30	70	25					20				15
Cyperus exaltatus																															0.1																									
Cyperus haspan																											0.1																													
Cyperus polystachyos																																																	0.2							
Cyperus sp.																									0.1	0.1																														
Daviesia ulicifolia				1	0.1		5		0.1			0.1	1	1	0.5	2																																								
Denhamia silvestris	1		1			0.1																																																		
Desmodium gunnii		0.5																																																						
Desmodium rhytidophyllum	0.1	0.1														0.1								0.2																																
Desmodium varians	0.1												0.1				0.5																																							
Dianella caerulea							0.1	0.5							0.1						0.4	0.5	0.2																																	
Dianella caerulea var. caerulea	0.1	0.5											0.5				1	0.2	0.2	30						2		0.3																												
Dianella caerulea var. producta			0.1	0.5	0.1															0.1																																				
Dianella revoluta								0.3														0.3																																		
Dichondra repens	0.1					0.1	0.1					0.1	0.1		0.1	0.1									0.2		0.1	0.5		0.1				0.5																						
Digitaria parviflora													0.1																																											
Dillwynia retorta				2	0.2																																																			
Dillwynia sp.																					0.1																																			
Dodonaea triquetra																							1										1																							
Echinopogon caespitosus	2	1				5	4	0.5					0.1	5	5	0.5						0.5					0.1																													
*Ehrharta erecta***							0.1																					0.2					2		5			75	20												4		0.1			
Einadia hastata																																						0.2														1				
Entolasia marginata				5	0.2																			4			2			30																		5								
Entolasia stricta	20	20	0.2	5	1	0.3	0.5	10	5	2			40	15	5	10		0.2				10		2			0.5	5																												
Eragrostis brownii									0.5		0.5			0.5	5	0.5							0.1		0.1																															

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588				PCT 1646							PCT 1649	PCT 1598		PCT 1716		PCT 1717					PCT 1724	PCT 1727					PCT 1736								PCT 1742	PCT 1071			PCT 1746		PCT 1747			
	Zone 1				Zone 2			Zone 3				Zone 4			Zone 5	Zone 6				Zone 7			Zone 8	Zone 9		Zone 10		Zone 11		Zone 12			Zone 13	Zone 14					Zone 15				Zone 16				Zone 17	Zone 18			Zone 19		Zone 20		Zone 21	
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Eragrostis curvula**									1												30		15														5																			
Eucalyptus acmenoides			5										15																																											
Eucalyptus fibrosa	25		40	2	10	5	4		0.5				12																																											
Eucalyptus globoidea		0.5		5	10									5	15	0.2																																								
Eucalyptus paniculata								15														15																																		
Eucalyptus parramattensis subsp. decadens																															5																									
Eucalyptus pilularis																		65	10	5	20																																			
Eucalyptus resinifera subsp. hemilampra																											20	8						10																						
Eucalyptus robusta																								10					30	2	2																									
Eucalyptus siderophloia		10				5								10	3										5																															
Eucalyptus tereticornis							3																		10	25																														
Eucalyptus umbra					2									2																																										
Exocarpos cupressiformis			5																																																					
Facelis retusa*									0.1						0.1	1					0.1												0.1																							
Fimbristylis sp.															0.1																																									
Gahnia clarkei																													5	70				2														25								
Gahnia sieberiana									1							1																																								
Gamochaeta americana*									0.1																																															
Geitonoplesium cymosum		0.1																																0.1																						
Glochidion ferdinandi								0.2			0.3											0.2	1																																	
Glochidion ferdinandi var. ferdinandi																		0.2							0.2					1				60																						
Glycine clandestina	0.1	0.1				0.1		0.1		0.1				0.1	0.1	0.1	0.2					0.1	0.1					0.1																												
Gomphocarpus fruticosus*																																	0.1																							
Gompholobium latifolium																		0.2	0.2																																					
Goodenia hederacea	0.1			0.1	0.1	0.1			1						0.1	0.5			0.1							0.1																														
Goodenia heterophylla																								0.1																																
Hardenbergia violacea			0.1						0.1				0.1			0.1		0.1																																						
Hemarthria uncinata var. uncinata																								1		2																														

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588				PCT 1646								PCT 1649	PCT 1598		PCT 1716		PCT 1717					PCT 1724	PCT 1727					PCT 1736								PCT 1742	PCT 1071			PCT 1746		PCT 1747		
	Zone 1				Zone 2			Zone 3				Zone 4			Zone 5	Zone 6					Zone 7			Zone 8	Zone 9		Zone 10		Zone 11		Zone 12			Zone 13	Zone 14					Zone 15				Zone 16				Zone 17	Zone 18			Zone 19		Zone 20		Zone 21
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Hibbertia aspera				0.2					0.1				1																																											
Hibbertia scandens																																		0.1																						
Hydrocotyle laxiflora																																										0.2						0.5								
*Hyparrhenia hirta***																															0.5	10																								
*Hyparrhenia rufa***									1							0.5																																								
Hypericum gramineum																0.1																																								
*Hypochaeris glabra**																										0.1																														
*Hypochaeris radicata**									0.2							0.3					0.1										0.1																									
Hypolepis muelleri																																		4																0.1	0.1					
Imperata cylindrica										5								0.2					0.1	60			10	0.5																												
Indigofera australis	0.1																																																							
*Ipomoea cairica***																																							0.2											0.2						
Isolepis prolifera																																																	0.2							
Isolepis sp.																													15																											
*Juncus acutus***																																			10			0.2								1					7	10	5			
Juncus continuus																								2																																
Juncus kraussii																																																					15			
Juncus planifolius																																												2												
Juncus sp.																											0.1														0.2															
Juncus usitatus									0.1	0.1																	0.1				0.2				0.2	0.2				20	0.1	0.2		8	7	2	5									0.1
Kennedia rubicunda										0.1																																														
Lachnagrostis filiformis																									0.1										10									10	25		10		0.1							0.5
Lagenophora stipitata		0.2						0.1					0.1									0.1																																		
Lambertia formosa																	1	0.2																																						
*Lantana camara***	2	40	1	5	0.3		0.5	3	0.5	7	0.2	5		25	4	2						3	0.2				10	8	2			5	8	5			55	35	5									30								
Lepidosperma laterale									1				1														0.2																													
Leptospermum polygalifolium																0.2	1		0.2					25				2																												
Leptospermum trinervium																		1.5	0.1				4																																	
Leucopogon ericoides																					0.5																																			
Leucopogon juniperinus														0.4	1																																									
Leucopogon lanceolatus																							1																																	
*Ligustrum sinense***																																		2																						
*Lolium sp.**																																													20											

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588					PCT 1646						PCT 1649		PCT 1598		PCT 1716	PCT 1717					PCT 1724		PCT 1727					PCT 1736							PCT 1742		PCT 1071			PCT 1746		PCT 1747		
	Zone 1					Zone 2		Zone 3				Zone 4			Zone 5		Zone 6			Zone 7			Zone 8		Zone 9		Zone 10	Zone 11		Zone 12			Zone 13		Zone 14					Zone 15				Zone 16			Zone 17		Zone 18			Zone 19		Zone 20		Zone 21
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Lomandra filiformis subsp. coriacea						0.1	0.5																																																	
Lomandra filiformis subsp. filiformis	1	0.2		0.5									0.2				1	0.1																																						
Lomandra glauca																	0.5				0.1																																			
Lomandra longifolia			0.1		1			0.5	1				5							0.3	0.3	0.5			0.2		0.1	3																												
Lomandra multiflora													5		0.1								0.1																																	
Lomandra multiflora subsp. multiflora		0.1																																																						
Lomandra sp.								0.5						0.1								0.5																																		
Ludwigia peploides subsp. montevidensis																																																	5							
Macrozamia communis																		0.5	5	0.5																																				
Marsilea hirsuta																																									0.1															
*Medicago polymorpha**																																													0.1											
*Megathyrsus maximus***																																5	10																							
Melaleuca decora			25																									20																												
Melaleuca linariifolia	5								2																		5		5																											
Melaleuca nodosa	60		30	50					1				3			2								30			30	20																												
Melaleuca quinquenervia																									25	25				20	30			35														5								
Melaleuca styphelioides																																	0.5																							
Melichrus procumbens																		0.1																																						
*Melinis repens**									1			0.1									1		0.5																																	
Microlaena stipoides								5		5	10	7			1	2						5											1																							
Microlaena stipoides var. stipoides		1				2							1														0.1	5																												
Monotoca elliptica																	5	0.2	0.1	60																																				
Myrsine howittiana	0.1																																																							
Myrsine variabilis			15										0.5																																											
Notelaea longifolia	1	5	0.8										1	0.4	3																																									
*Ochna serrulata***		0.2										0.1																					0.1																							
*Olea europaea***																																			0.1																					
Opercularia diphylla									0.1						0.1	0.2																																								

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588				PCT 1646							PCT 1649		PCT 1598		PCT 1716	PCT 1717					PCT 1724		PCT 1727					PCT 1736								PCT 1742	PCT 1071			PCT 1746		PCT 1747		
	Zone 1				Zone 2			Zone 3				Zone 4			Zone 5	Zone 6				Zone 7			Zone 8		Zone 9		Zone 10	Zone 11		Zone 12			Zone 13		**Zone 14**					**Zone 15**				**Zone 16**				Zone 17	Zone 18			Zone 19		Zone 20		Zone 21
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Oplismenus aemulus							0.5																				10	15				1	10	20																						
Oplismenus imbecillis																												4																												
Oxalis perennans		0.1				0.1			0.1					0.1	0.1	0.1							0.1					0.1					0.1																							
Ozothamnus diosmifolius																						0.2																																		
Pandorea pandorana	0.1	0.1		0.1													0.1		0.1	0.2	0.1							0.5																												
*Panicum maximum var. maximum**																											0.2																													
*Panicum maximum var. trichoglume**																																					5																			
Panicum simile						1							0.1			0.1										2																														
Parsonsia straminea								0.2														0.2		0.1	5		0.5	2	5	0.1		0.1		0.5			2											0.1		1	2					
Paspalidium distans									1							0.5				0.1																																				
*Paspalum dilatatum***									5	10	25					1									0.3										0.5			0.1		10		25	10	25	5	1			0.1							
Paspalum distichum																																														0.5										
*Passiflora edulis**			0.1		0.1																																																			
Pellaea falcata									0.1																			0.1									0.5																			
*Pennisetum clandestinum***												25																								40										20			0.1							80
Persicaria decipiens																													5								0.2												0.1							
Persicaria hydropiper																																				25				10	0.1	0.1	0.5				0.1									
Persicaria lapathifolia																																									0.1			5												
Persicaria strigosa																																																0.1								
Persoonia lanceolata					0.3																0.5																																			
Persoonia levis																		0.5	0.2																																					
Persoonia linearis																		0.1	0.2	0.1						0.5																														
Phragmites australis																																								20										90	70					
*Phyla nodiflora***																																				0.1				20	0.5				10	2	1									20
Phyllanthus hirtellus													1																																											
Pimelea linifolia subsp. linifolia																			0.1																																					
*Pinus radiata***										5													20								20		0.2															65								
Pittosporum revolutum				5																																																				
Pittosporum undulatum					10			1												1		1												1																						
*Plantago lanceolata**										0.1	0.1																				0.2		0.5		0.1							0.1					0.1									0.1

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588					PCT 1646						PCT 1649		PCT 1598		PCT 1716		PCT 1717					PCT 1724	PCT 1727					PCT 1736								PCT 1742	PCT 1071			PCT 1746		PCT 1747		
	Zone 1				Zone 2			Zone 3				Zone 4			Zone 5		Zone 6			Zone 7			Zone 8		Zone 9		Zone 10		Zone 11		Zone 12			Zone 13	**Zone 14**					**Zone 15**				**Zone 16**				Zone 17	Zone 18			Zone 19		Zone 20		Zone 21
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Platycerium bifurcatum																																		0.1					0.2																	
Poa sp.													1																																											
Polygonum aviculare																																			0.1						0.1			0.1		0.5	0.1						0.1			0.2
Polymeria calycina		0.1							0.1																																															
*Polypogon monspeliensis**																																																				2				0.5
Pomax umbellata													0.5				1			0.3	0.2		0.1	1																																
Poranthera microphylla									0.5							0.1																																								
Pratia purpurascens	0.1	0.5		1		0.1		0.1	0.1	0.1			0.5	0.1	1	0.2						0.1	0.1					0.1				0.5																			0.1					
Pseuderanthemum variabile	0.1					0.1								0.1													0.1																													
Pseudoraphis paradoxa																								5																																
Pteridium esculentum																	15	7	25	25	1		0.5							20																		4								
Pterostylis longifolia													0.1																																											
Pterostylis sp.		0.5											0.1																																											
Pultenaea spinosa	2								2				0.5		0.2	0.5																																								
Pultenaea sp.																					0.3																																			
Pultenaea villosa									0.1																																															
Ranunculus inundatus																																																	0.2							
Rhagodia candolleana																																																					0.1			
Richardia brasiliensis									0.1																						1																									
Ricinocarpos pinifolius																	0.5		0.1																																					
*Ricinus communis***																																								0.1																
*Rosa rubiginosa***																																																								0.5
*Rubus fruticosus agg.***										8	20																																					10								
*Rumex conglomeratus**																																									0.1				0.1				0.1							
Rytidosperma pallidum				5	40										1																																									
Rytidosperma racemosum			0.1																								0.1																													
Sarcocornia quinqueflora																																																				1				
Schoenus ericetorum																					0.1																																			
*Senecio madagascariensis***									0.1		0.1																								0.1						0.1		0.1			0.1	0.1						0.1			0.2

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588				PCT 1646							PCT 1649		PCT 1598		PCT 1716		PCT 1717				PCT 1724		PCT 1727					PCT 1736							PCT 1742		PCT 1071			PCT 1746		PCT 1747		
	Zone 1				Zone 2			Zone 3				Zone 4			Zone 5	Zone 6				Zone 7			Zone 8		Zone 9		Zone 10		Zone 11	Zone 12			Zone 13		Zone 14					Zone 15				Zone 16			Zone 17		Zone 18			Zone 19		Zone 20		Zone 21
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
Senna pendula**			0.1																								0.5	5									1																			
Setaria parviflora*									5		2	2				10									0.1						5	1	5																							
Sida rhombifolia *							1			0.1		0.3																																												
Solanum nigrum*							0.1																									1	0.1		0.1																1					
Solanum prinophyllum																0.1																																								
Solenogyne bellioides															0.2																																									
Sonchus oleraceus*																0.1									0.1										0.1												0.1									
Sporobolus africanus*																																0.1	0.1																							
Sporobolus virginicus																																																					50		2	
Sporobolus virginicus var. minor																																																				50		0.1		
Stenotaphrum secundatum**																																			25				70								60					20				
Stephania japonica																																		0.2																						
Stylidium graminifolium						0.1																																																		
Suaeda australis																																																						0.2	0.5	
Syncarpia glomulifera																											0.2	10																												
Tagetes minuta*																																	0.1																							
Tetragonia tetragonioides																																																						0.2		
Tetratheca thymifolia																		0.2																																						
Thelymitra sp.																				0.1																																				
Themeda triandra	10	10		1		2		10	0.5					25	20	0.5						10																																		
Trachymene incisa																					0.1																																			
Trachymene incisa subsp. incisa																			0.1																																					
Tradescantia fluminensis **																																			0.1																					
Tricoryne elatior																										0.1																														
Trifolium repens*																															0.1					0.1					0.1	0.1	0.1	0.1		0.1	0.1									0.2
Triglochin microtuberosa																													0.1																											
Triglochin striata																																																					0.1			
Typha orientalis																																																	60							
Verbena bonariensis *							0.5			0.1	0.1	0.1																			1	0.2	1		0.1	0.1				0.1		0.1	1													

Species *Exotic **High-threat exotic	PCT 1590											PCT 1588				PCT 1646								PCT 1649	PCT 1598		PCT 1716		PCT 1717					PCT 1724	PCT 1727					PCT 1736								PCT 1742	PCT 1071			PCT 1746		PCT 1747		
	Zone 1				Zone 2			Zone 3				Zone 4			Zone 5		Zone 6			Zone 7			Zone 8		Zone 9		Zone 10		Zone 11		Zone 12			Zone 13		**Zone 14**					**Zone 15**				**Zone 16**				Zone 17	Zone 18			Zone 19		Zone 20		Zone 21
	Plot 2	Plot 4	Plot 6	Plot 17	Plot 40	Plot 1	Plot 53	Plot 58	Plot 54	Plot 64	Plot 65	Plot 66	Plot 3	Plot 42	Plot 70	Plot 55	Plot 21	Plot 27	Plot 34	Plot 35	Plot 59	Plot 60	Plot 61	Plot 28	Plot 15	Plot 20	Plot 5	Plot 38	Plot 36	Plot 48	Plot 29	Plot 62	Plot 63	Plot 49	Plot 13	Plot 22	Plot 43	Plot 45	Plot 46	Plot 0	Plot 7	Plot 23	Plot 33	Plot 8	Plot 9	Plot 10	Plot 26	Plot 30	Plot 11	Plot 12	Plot 44	Plot 24	Plot 57	Plot 14	Plot 56	Plot 25
*Verbena rigida**												0.2																																												
Vernonia cinerea															0.1																																									
Vernonia cinerea var. cinerea	0.1	0.5																									0.1																													
Xanthorrhoea fulva																		0.2	0.2	2																																				
Xylomelum pyriforme																		1																																						

Appendix B. Threatened species likelihood of occurrence assessment

Table B-1 Likelihood of occurrence criteria

Likelihood	Criteria
Recorded	The species was observed in the construction footprint during the current survey
High	It is highly likely that a species inhabits the construction footprint 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 construction footprint. Also includes species known or likely to visit the construction footprint during regular seasonal movements or migration.
Moderate	Potential habitat is present in the construction footprint. Species unlikely to maintain sedentary populations, however, may seasonally use resources within the construction footprint 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 construction footprint, 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 construction footprint and has not been recorded recently in the locality (10km). It may be an occasional visitor, but habitat similar to the construction footprint is widely distributed in the local area, meaning that the species is not dependent (i.e. for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the construction footprint or the species are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
Unlikely	Suitable habitat is absent from the construction footprint.

Table B-2 Likelihood of occurrence for EPBC Act listed threatened flora species

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Acacia bynoeana	Bynoe's Wattles	V	Found in central eastern NSW, from the Hunter District south to the Southern Highlands and west to the Blue Mountains. It has recently been found in the Colymea and Parma Creek areas west of Nowra. Occurs in heath or dry sclerophyll forest on sandy soils. Seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches. Associated overstorey species include Red Bloodwood (*Corymbia gummifera*), Scribbly Gum (*Eucalyptus haemastoma*), Drooping Red Gum (*E. parramattensis*), Old Man Banksia (*Banksia serrata*) and Small-leaved Apple (*Angophora bakeri*).	PMST	Low
Angophora inopina	Charmhaven Apple	V	Endemic to the Central Coast region of NSW. The known northern limit is near Karuah where a disjunct population occurs; to the south populations extend from Toronto to Charmhaven with the main population occurring between Charmhaven and Morisset. There is an unconfirmed record of the species near Bulahdelah. About 1250 hectares of occupied habitat has been mapped in the Wyong–southern Lake Macquarie area. This species is a member of the *A. bakeri* complex, which also includes *A. crassifolia, A. paludosa* and *A. exul*. It is most similar to *A. crassifolia* from which it is distinguished by the broader leaves with shorter petioles. None of these related species are known from the same area as A. inopina, although A. bakeri does occur sporadically in the ranges to the west, and near Kurri Kurri. Occurs most frequently in four main vegetation communities: (i) *Eucalyptus haemastoma–Corymbia gummifera–Angophora inopina* woodland/forest; (ii) *Hakea teretifolia*–Banksia oblongifolia wet heath; (iii) *Eucalyptus resinifera–Melaleuca sieberi–Angophora inopina* sedge woodland; (iv) *Eucalyptus capitellata–Corymbia gummifera–Angophora inopina* woodland/forest.	PMST	Unlikely
Arthraxon hispidus	Hairy-joint Grass	V	Occurs over a wide area in south-east Queensland, and on the northern tablelands and north coast of NSW but is never common. Also found from Japan to central Eurasia. Moisture and shade-loving grass, found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps.	PMST	Low
Asperula asthenes	Trailing Woodruff	V	This small herb occurs only in NSW. It is found in scattered locations from Bulahdelah north to near Kempsey, with several records from the Port Stephens/Wallis Lakes area. Occurs in damp sites, often along river banks.	1 – Atlas PMST	Moderate

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Asterolasia elegans		E	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby local government areas. Also likely to occur in the western part of Gosford local government area. Known from only seven populations, only one of which is wholly within a conservation reserve. Occurs on Hawkesbury sandstone. Found in sheltered forests on mid- to lower slopes and valleys, e.g. in or next to gullies which support sheltered forest. The canopy at known sites includes Turpentine (*Syncarpia glomulifera* subsp. *glomulifera*), Smooth-barked Apple (*Angophora costata*), Sydney Peppermint (*Eucalyptus piperita*), Forest Oak (*Allocasuarina torulosa*) and Christmas Bush (*Ceratopetalum gummiferum*).	PMST	Unlikely
Caladenia tessellata	Thick-lipped Spider-orchid	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	Low
Commersonia prostrata	Dwarf Kerrawang	E	Dwarf Kerrawang occurs on the Southern Highlands and Southern Tablelands (one plant at Penrose State Forest, one plant at Tallong, a small population near the Corang and about 2000 plants at Rowes Lagoon), a larger population in the Thirlmere Lakes area (particularly among the dying reeds at the edge of the water), and on the North Coast (less than 100 plants at the Tomago Sandbeds north of Newcastle). It is also found in Victoria. Occurs on sandy, sometimes peaty soils in a wide variety of habitats: Snow Gum (*Eucalyptus pauciflora*) Woodland and Ephemeral Wetland floor at Rowes Lagoon; Blue leaved Stringybark (*E. agglomerata*) Open Forest at Tallong; and in Brittle Gum (*E. mannifera*) Low Open Woodland at Penrose; Scribbly Gum (*E. haemostoma*)/ Swamp Mahogany (*E. robusta*) Ecotonal Forest at Tomago. Associated native species may include Imperata cylindrica, Empodisma minus and Leptospermum continentale. Appears to respond positively to some forms of disturbance (e.g. some Victorian records are from gravel road surfaces and the Tomago population is on an area previously subject to sandmining), however, there are conflicting reports about the response of the species to fire.	12 – Atlas PMST	Moderate

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Cryptostylis hunteriana	Leafless Tongue-orchid	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. The larger populations typically occur in woodland dominated by Scribbly Gum (*Eucalyptus sclerophylla*), Silvertop Ash (*E. sieberi*), Red Bloodwood (*Corymbia gummifera*) and Black Sheoak (*Allocasuarina littoralis*); appears to prefer open areas in the understorey of this community and is often found in association with the Large Tongue Orchid (*C. subulata*) and the Tartan Tongue Orchid (*C. erecta*).	PMST	Low
Cynanchum elegans	White-flowered Wax Plant	E	Occurs on the edge of dry rainforest vegetation. Other associated vegetation types include littoral rainforest; Coastal Tea-tree (*Leptospermum laevigatum*) – Coastal Banksia (*Banksia integrifolia* subsp. *integrifolia*) coastal scrub; Forest Red Gum (*Eucalyptus tereticornis*) aligned open forest and woodland; Spotted Gum (*Corymbia maculata*) aligned open forest and woodland; and Bracelet Honeymyrtle (*Melaleuca armillaris*) scrub to open scrub.	3 – Atlas	Moderate
Dichanthium setosum	Bluegrass	V	Dichanthium setosum has been reported from mid-coastal to inland NSW and Queensland. Dichanthium setosum occurs on the New England Tablelands, North West Slopes and Plains and the Central Western Slopes of NSW, extending west to Narrabri. Dichanthium setosum is associated with heavy basaltic black soils and red-brown loams with clay subsoil.	PMST	Low
Diuris praecox	Rough Doubletail	V	Known from between Bateau Bay and Smiths Lake. Grows on hills and slopes of near-coastal districts in open forests which have a grassy to fairly dense understorey. Exists as subterranean tubers most of the year. It produces leaves and flowering stems in winter.	PMST	Moderate
Eucalyptus camfieldii	Camfield's Stringybark	V	Restricted distribution in a narrow band with the most northerly records in the Raymond Terrace area south to Waterfall. Poor coastal country in shallow sandy soils overlying Hawkesbury sandstone. Coastal heath mostly on exposed sandy ridges. Occurs mostly in small scattered stands near the boundary of tall coastal heaths and low open woodland of the slightly more fertile inland areas. Associated species frequently include stunted species of *E. oblonga* Narrow-leaved Stringybark, *E. capitellata* Brown Stringybark and *E. haemastoma* Scribbly Gum.	2269 – Atlas PMST	Moderate
Eucalyptus glaucina	Slaty Red Gum	V	The Slaty Red Gum is only found on the north coast of NSW in two separate districts. It is found near Casino where it is locally common and further south from Taree to Broke and west of Maitland.	PMST	Low

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Eucalyptus parramattensis subsp. decadens	Drooping Red Gum	V	There are two separate meta-populations of *E. parramattensis* subsp. *decadens*. The Kurri Kurri meta-population is bordered by Cessnock—Kurri Kurri in the north and Mulbring—Aberdare in the south. Large aggregations of the subspecies are located in the Tomalpin area. The Tomago Sandbeds meta-population is bounded by Salt Ash and Tanilba Bay in the north and Williamtown and Tomago in the south. Generally occupies deep, low-nutrient sands, often those subject to periodic inundation or where water tables are relatively high. It occurs in dry sclerophyll woodland with dry heath understorey. It also occurs as an emergent in dry or wet heathland. Often where this species occurs, it is a community dominant. In the Kurri Kurri area, *E. parramattensis* subsp. *decadens* is a characteristic species of 'Kurri Sand Swamp Woodland in the Sydney Basin Bioregion', an endangered ecological community under the TSC Act. In the Tomago Sandbeds area, the species is usually associated with the 'Tomago Swamp Woodland' as defined by NSW NPWS (2000). Very little is known about the biology or ecology of this species. Flowers from November to January. Propagation mechanisms are currently poorly known. Seed dispersal is likely to be affected by wind and animals.	1149 – Atlas PMST	High – Confirmed
Euphrasia arguta		CE	Historically, *Euphrasia arguta* has only been recorded from relatively few places within an area extending from Sydney to Bathurst and north to Walcha. Was rediscovered in the Nundle area of the NSW north western slopes and tablelands in 2008. Historic records of the species noted the following habitats: 'in the open forest country around Bathurst in sub humid places', 'on the grassy country near Bathurst', and 'in meadows near rivers'. Plants from the Nundle area have been reported from eucalypt forest with a mixed grass and shrub understorey; here, plants were most dense in an open disturbed area and along the roadside, indicating the species had regenerated following disturbance.	1 – Atlas PMST	Unlikely
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	V	Sporadically distributed throughout the Sydney Basin with the main occurrence centred around Picton, Appin and Bargo. Separate populations are also known further north from Putty to Wyong and Lake Macquarie on the Central Coast, and Cessnock and Kurri Kurri in the Lower Hunter. Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	42 – OEH PMST	High – Confirmed

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Grevillea shiressii		V	Known from two populations near Gosford, on tributaries of the lower Hawkesbury River north of Sydney (Mooney Creek and Mullet Creek). Both populations occur within the Gosford Local Government Area. There is also a naturalised population at Newcastle. Grows along creek banks in wet sclerophyll forest with a moist understorey in alluvial sandy or loamy soils. Flowers mainly late winter to Spring (July-December), with seed released at maturity in October. Flowers are bird pollinated and seeds are dispersed by ants. A fire sensitive obligate seeder that is highly susceptible to local extinction due to frequent fire, however, fire is likely to be relatively infrequent in the habitat of *G. shiressii*. Seed germination does occur in the absence of fire; however some physical disturbance is likely to promote seed germination.	PMST	Low
Melaleuca biconvexa	Biconvex Paperbark	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.	1 – Atlas PMST	Low
Persicaria elatior	Tall Knotweed	V	Tall Knotweed has been recorded in south-eastern NSW (Mt Dromedary (an old record), Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui, and Picton Lakes. In northern NSW it is known from Raymond Terrace (near Newcastle) and the Grafton area (Cherry Tree and Gibberagee State Forests). This species normally grows in damp places, especially beside streams and lakes. Occasionally in swamp forest or associated with disturbance.	3 – Atlas PMST	High, recorded
Phaius australis	Southern Swamp Orchid	E	Occurs in Queensland and north-east NSW as far south as Coffs Harbour. Historically, it extended farther south, to Port Macquarie. Swampy grassland or swampy forest including rainforest, eucalypt or paperbark forest, mostly in coastal areas.	PMST	Low
Pterostylis gibbosa	Illawarra Greenhood	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 Hunter region, the species grows in open woodland dominated by Narrow-leaved Ironbark (*Eucalyptus crebra*), Forest Red Gum (*Eucalyptus tereticornis*) and Black Cypress Pine (*Callitris endlicheri*).	PMST	Low

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Rhizanthella slateri	Eastern Australian Underground Orchid	E	Occurs from south-east Queensland to south-east NSW. In NSW, currently known from fewer than 10 locations, including near Bulahdelah, the Watagan Mountains, the Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra. Habitat requirements are poorly understood and no particular vegetation type has been associated with the species, although it is known to occur in sclerophyll forest.	PMST	Moderate
Rutidosis heterogama	Heath Wrinklewort	V	Recorded from near Cessnock to Kurri Kurri with an outlying occurrence at Howes Valley. On the Central Coast it is located north from Wyong to Newcastle. There are north coast populations between Wooli and Evans Head in Yuraygir and Bundjalung National Parks. It also occurs on the New England Tablelands from Torrington and Ashford south to Wandsworth south-west of Glen Innes. Grows in heath on sandy soils and moist areas in open forest and has been recorded along disturbed roadsides.	21 – Atlas PMST	Moderate
Syzygium paniculatum	Magenta Lilly Pilly	V	The Magenta Lilly Pilly is found only in NSW, in a narrow, linear coastal strip from Upper Lansdowne to Conjola State Forest. 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.	3 – Atlas PMST	Low
Tetratheca juncea	Black-eyed Susan	V	Confined to the northern portion of the Sydney Basin bioregion and the southern portion of the North Coast bioregion in the LGAs of Wyong, Lake Macquarie, Newcastle, Port Stephens Council, Great Lakes and Cessnock. It is usually found in low open forest/woodland with a mixed shrub understorey and grassy groundcover. However, it has also been recorded in heathland and moist forest. The majority of populations occur on low nutrient soils associated with the Awaba Soil Landscape. While the species has a preference for cooler southerly aspects, it has been found on slopes with a variety of aspects. It generally prefers well-drained sites and occurs on ridges, although it has also been found on upper slopes, mid-slopes and occasionally in gullies.	58 – Atlas PMST	Unlikely

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Thesium australe	Austral Toadflax	V	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. Occurs in grassland on coastal headlands or grassland and grassy woodland away from the coast. Often found in association with Kangaroo Grass (*Themeda australis*).	PMST	Low

Key: V = vulnerable, E = endangered, EP = endangered population, CE = critically endangered,

* Distribution and habitat requirement information adapted from:

- Australian Government Department of the Environment http://www.environment.gov.au/biodiversity/threatened/index.html
- NSW Office of Environment and Heritage http://www.environment.nsw.gov.au/threatenedspecies/
- Department of Primary Industries – Threatened Fish and Marine Vegetation http://pas.dpi.nsw.gov.au/Species/All_Species.aspx

+ Data source includes

- Number of records from the NSW Office of Environment and Heritage Wildlife Atlas record data (Accessed November 2012); and
- Identified from the PMST Australian Government Department of Sustainability, Environment, Water, Populations and Community http://www.environment.gov.au/epbc/pmst/index.html

Table B-3 Likelihood of occurrence for EPBC Act listed threatened fauna species

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Birds					
Anthochaera phrygia	Regent Honeyeater	CE	Temperate woodlands and open forests of the inland slopes of south-east Australia. The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters usually nest in horizontal branches or forks in tall mature eucalypts and Sheoaks.	5 – Atlas PMST	Moderate
Botaurus poiciloptilus	Australasian Bittern	E	Occurs from south-east Queensland to south-east South Australia, Tasmania and the south-west of Western Australia. Occurs in terrestrial freshwater wetlands and, rarely, estuarine habitats.	29 – Atlas PMST	Moderate
Calidris canutus	Red Knot	E	Common in all the main suitable habitats around the coast of Australia. Mainly inhabit intertidal mudflats, sand flats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs.	124 – Atlas PMST	Low
Calidris ferruginea	Curlew Sandpiper	CE	The breeding range of the Curlew Sandpiper is mainly restricted to the Arctic of northern Siberia, including Yamal Peninsula east to Kolyuchiskaya Gulf, Chokotka Peninisula, and also New Siberian Island. Curlew Sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in salt work and sewage farms.	907 – Atlas PMST	Low
Calidris tenuirostris	Great Knot	CE, M	The Great Knot has been recorded around the entirety of the Australian coast, with a few scattered records inland. The species typically prefers sheltered coastal habitats, with large intertidal mudflats or sandflats. This includes inlets, bays, harbours, estuaries and lagoons.	27 – Atlas PMST	Unlikely
Charadrius leschenaultii	Greater Sand Plover	V, M	In Australia, the Greater Sand Plover occurs in coastal areas in all states, though the greatest numbers occur in northern Australia, especially the north-west. In the non-breeding grounds in Australasia, the species is almost entirely coastal, inhabiting littoral and estuarine habitats.	5 – Atlas PMST	Unlikely
Charadrius mongolus	Lesser Sand Plover	E, M	Within Australia, the Lesser Sand-Plover is widespread in coastal regions and has been recorded in all states. In non-breeding grounds in Australia, this species usually occurs in coastal littoral and estuarine environments.	28 – Atlas PMST	Unlikely

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Diomedea epomophora	Southern Royal Albatross	V, M	During the non-breeding season, the Southern Royal Albatross has a wide and possibly circumpolar distribution, ranging north to about 35°S. The Southern Royal Albatross is moderately common throughout the year in offshore waters of southern Australia, mostly off south-eastern NSW, Victoria and Tasmania. Off South Australia, they are mostly seen May to September. It breeds on Campbell, Adams, Enderby and Auckland Islands, south of New Zealand. Nests on flat or gently sloping ground on slopes, ridges, gullies and plateaux of large islands, and on the summits of islets. Depressions, gullies, lee slopes and vegetation provide shelter for its nests, but exposed sites are also needed nearby so that the Southern Royal Albatross can take off and land. Its nests are placed among vegetation that is sparse enough for easy access.	PMST	Unlikely
Diomedea epomophora sanfordi	Northern Royal Albatross	E, M	The Northern Royal Albatross ranges widely over the Southern Ocean, with individuals seen in Australian waters off south-eastern Australia. It breeds on Chatham Island and Tiara Head on the South Island of New Zealand. Its habitat includes subantarctic, subtropical, and occasionally Antarctic waters. The Northern Royal Albatross nests on flat or gently sloping ground, on slopes, ridges, gullies and plateaux of large islands, and on the summits of islets. Depressions, gullies, lee slopes and vegetation provide shelter for its nests, but exposed sites are also needed nearby so that the Southern Royal Albatross can take off and land. Its nests are placed among vegetation that are open enough for adults to easily walk through.	PMST	Unlikely
Diomedea exulans (sensu lato)	Wandering Albatross	V,M	The Wandering Albatross breeds on Macquarie Island. Macquarie Island lies in the southwest Pacific Ocean, about half-way between New Zealand and Antarctica. A single breeding pair has also been recorded on Heard Island. The Territory of Heard Island and McDonald Islands are an Australian external territory and volcanic group of barren Antarctic islands, about two-thirds of the way from Madagascar to Antarctica. It feeds in Australian portions of the Southern Ocean. On breeding islands, the Wandering Albatross nests on coastal or inland ridges, slopes, plateaux and plains, often on marshy ground. Nests of the Wandering Albatross are sited on moss terraces, in dense tussocks, and often in loose aggregations on the west (windward) side of islands. It prefers open or patchy vegetation (tussocks, ferns or shrubs), and it requires nesting areas that are near exposed ridges or hillocks so that it can take off.	PMST	Unlikely

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Diomedea exulans antipodensis	Antipodean Albatross	V, M	The Antipodean Albatross is endemic to New Zealand, however forages widely in open water in the south-west Pacific Ocean, Southern Ocean and the Tasman Sea, notably off the coast of NSW. It breeds on the New Zealand islands of Antipodes Island, Campbell Island, Pitt Island and the Auckland Islands. This subspecies nests in open patchy vegetation, such as among tussock grassland or shrubs on ridges, slopes and plateaus. On Antipodes Island, they nest in relatively uniform densities, but avoid areas of tall vegetation on steep coastal slopes, or amongst the tall ferns on poorly drained parts of the peaks near the island's centre (Walker & Elliott 2005).	PMST	Unlikely
Diomedea exulans gibsoni	Gibson's Albatross	V, M	In Australian territory, Gibson's Albatross has been recorded foraging between Coffs Harbour, NSW, and Wilson's Promontory, Victoria. Gibson's Albatrosses are rarely observed in the Pacific Ocean or Indian Ocean. The only Australian record of this species is from a recapture off Wollongong, NSW, in September 1997. Gibson's Albatross breeds on Adams Island and Auckland Island, New Zealand. There are no breeding colonies of Gibson's Albatross in Australian territory. This albatross visits Australian waters while foraging and during the non-breeding season.	PMST	Unlikely
Erythrotriorchis radiatus	Red Goshawk	V	This unique Australian endemic raptor is distributed sparsely through northern and eastern Australia, from the western Kimberley Division of northern Western Australia to north-eastern Queensland and south to far north-eastern NSW, and with scattered records in central Australia. The species is very rare in NSW, extending south to about 30°S, with most records north of this, in the Clarence River Catchment, and a few around the lower Richmond and Tweed Rivers. Formerly, it was at least occasionally reported as far south as Port Stephens. Red Goshawks inhabit open woodland and forest, preferring a mosaic of vegetation types, a large population of birds as a source of food, and permanent water, and are often found in riparian habitats along or near watercourses or wetlands. In NSW, preferred habitats include mixed subtropical rainforest, *Melaleuca* swamp forest and riparian *Eucalyptus* forest of coastal rivers.	PMST	Low

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Grantiella picta	Painted Honeyeater	V	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution. Inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. A specialist feeder on the fruits of mistletoes growing on woodland eucalypts and wattles. Prefers mistletoes of the genus *Amyema*.	PMST	Low
Hirundapus caudacutus	White-throated Needletail	V, M	Widespread in eastern and south-eastern Australia. Almost exclusively aerial, from heights of less than 1m up to more than 1000m above the ground. They also commonly occur over heathland but less often over treeless areas, such as grassland or swamps.	18 – Atlas PMST	Moderate
Lathamus discolor	Swift Parrot	E	On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as Swamp Mahogany (*Eucalyptus robusta*), Spotted Gum (*Corymbia maculata*), Red Ironbark (*E. sideroxylon*), and White Box (*E. albens*).	19 – Atlas PMST	Moderate
Limicola falcinellus	Broad-billed Sandpiper	M	The Broad-billed Sandpiper is a regular visitor in small numbers to NSW, in coastal areas, from Ballina, south to Shoalhaven Heads. The Broad-billed Sandpiper occurs in sheltered parts of the coast, favouring estuarine mudflats but also occasionally occur on saltmarshes, shallow freshwater lagoons, saltwork and sewage farms, and in areas with large soft intertidal mudflats, which may have shell or sandbanks nearby.	14 – Atlas PMST	Unlikely
Limosa lapponica baueri	Bar-tailed godwit (western Alaskan)	V, M	The bar-tailed godwit (both subspecies combined) has been recorded in the coastal areas of all Australian states. During the non-breeding period, the distribution of bar-tailed godwit (western Alaskan) is predominately New Zealand, northern and eastern Australia. The migratory bar-tailed godwit (western Alaskan) does not breed in Australia. The bar-tailed godwit (western Alaskan) occurs mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays.	PMST	Low
Limosa lapponica menzbieri	Bar-tailed godwit (northern Siberian)	CE, M	The bar-tailed godwit (both subspecies combined) has been recorded in the coastal areas of all Australian states. During the non-breeding period, the distribution of L. l. menzbieri is predominantly in the north and north-west of Western Australia and in south-eastern Asia. The migratory bar-tailed godwit (northern Siberian) does not breed in Australia. The bar-tailed godwit (northern Siberian) occurs mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays.	PMST	Low

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Limosa	Black-tailed Godwit	M	The Black-tailed Godwit is found in all states and territories of Australia; however, it prefers coastal regions and the largest populations are found on the north coast between Darwin and Weipa. The species is commonly found in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats, or spits and banks of mud, sand or shell-grit; occasionally recorded on rocky coasts or coral islets.	PMST	Unlikely
Macronectes giganteus	Southern Giant-petrel	E, M	The Southern Giant Petrel has a circumpolar pelagic range from Antarctica to about 20° S and is a common visitor off the coast of NSW. Over summer, the species nests in small colonies amongst open vegetation on Antarctic and subantarctic islands, including Macquarie and Heard Islands and in Australian Antarctic territory.	PMST	Unlikely
Macronectes halli	Northern Giant-petrel	V, M	The Northern Giant-Petrel has a circumpolar pelagic distribution, usually between 40-64ºS in open oceans. Their range extends into subtropical waters (to 28ºS) in winter and early spring, and they are a common visitor in NSW waters, predominantly along the south-east coast during winter and autumn. Breeding in Australian territory is limited to Macquarie Island and occurs during spring and summer. Adults usually remain near the breeding colonies throughout the year (though some do travel widely) while immature birds make long and poorly known circumpolar and trans-oceanic movements. Hence most birds recorded in NSW coastal waters are immature birds. Northern Giant-Petrels seldom breed in colonies but rather as dispersed pairs, often amidst tussocks in dense vegetation and areas of broken terrain.	PMST	Unlikely
Numenius madagascariensis	Eastern Curlew	CE, M	Within Australia, the Eastern Curlew has a primarily coastal distribution. The species is found in all states, particularly the north, east, and south-east regions including Tasmania. The Eastern Curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sand flats, often with beds of seagrass.	94 – Atlas PMST	Low
Pachyptila turtur subantarctica	Fairy Prion (southern)	V	Fairy Prions (including other subspecies) are often beachcast on the south-eastern coast of Australia and are commonly seen offshore over the continental shelf and over pelagic waters. The southern subspecies of the Fairy Prion is a marine bird, found mostly in temperate and subantarctic seas. On Macquarie Island and adjacent islets, the burrows of Fairy Prions are usually in crevices, in hollows beneath cushions of Colobanthus muscoides or in burrows in peaty soil held together by a thick cover of Cotula plumosa.	PMST	Low

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Pandion cristatus	Eastern Osprey	M	The breeding range of the Eastern Osprey extends around the northern coast of Australia (including many offshore islands) from Albany in Western Australia to Lake Macquarie in NSW; with a second isolated breeding population on the coast of South Australia, extending from Head of Bight east to Cape Spencer and Kangaroo Island. Eastern Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands.	18 – Atlas PMST	Moderate
Rostratula australis	Australian Painted Snipe	E, M	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. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	11 – Atlas PMST	Moderate
Sternula albifrons	Little Tern	M	The Australian breeding population can be divided into two major subpopulations: (1) a northern subpopulation that breeds across northern Australia; and (2) an eastern subpopulation that breeds on the eastern and south-eastern coast of the mainland. In Australia, Little Terns inhabit sheltered coastal environments, including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets, especially those with exposed sandbanks or sand-spits, and also on exposed ocean beaches.	20 – Atlas PMST	Unlikely
Sternula nereis	Australian Fairy Tern	V	Within Australia, the Fairy Tern occurs along the coasts of Victoria, Tasmania, South Australia and Western Australia; occurring as far north as the Dampier Archipelago near Karratha. The subspecies has been known from New South Wales (NSW) in the past, but it is unknown if it persists there. The Fairy Tern (Australian) nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. The subspecies has been found in embayments of a variety of habitats including offshore, estuarine or lacustrine (lake) islands, wetlands and mainland coastline. The bird roosts on beaches at night.	PMST	
Thalassarche bulleri	Buller's Albatross	V, M	Buller's Albatross breed in New Zealand (Snares, Solander and Chatham Islands), but are regular visitors to Australian waters. They are frequently seen off the coast from Coffs Harbour, south to Tasmania and west to Eyre Peninsula. In Australia, Buller's Albatross are seen over inshore, offshore and pelagic waters. They appear to congregate over currents where water temperature exceeds 16 °C.	PMST	Unlikely

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Thalassarche bulleri platei	Northern Buller's Albatross	V, M	The Pacific Albatross is a non-breeding visitor to Australian waters. Foraging birds are mostly limited to the Pacific Ocean and the Tasman Sea, although birds do reach the east coast of the Australian mainland. The Pacific Albatross is a marine, pelagic species. It occurs in subtropical and subantarctic waters of the South Pacific Ocean.	PMST	Unlikely
Thalassarche cauta	Shy Albatross	V	This species is circumpolar in distribution, occurring widely in the southern oceans. Islands off Australia and New Zealand provide breeding habitat. In Australian waters, the Shy Albatross occurs along the east coast from Stradbroke Island in Queensland along the entire south coast of the continent to Carnarvon in Western Australia. Although uncommon north of Sydney, the species is commonly recorded off southeast NSW, particularly between July and November, and has been recorded in Ben Boyd National Park. This pelagic or ocean-going species inhabits subantarctic and subtropical marine waters, spending the majority of its time at sea. Occasionally the species occurs in continental shelf waters, in bays and harbours. Known breeding locations include Albatross Island off Tasmania, Auckland Island, Bounty Island and The Snares, off New Zealand, where nesting colonies of 6-500 nests occur and may contain other species such as the Australian Gannet. Located on sheltered sides of islands, on cliffs and ledges, in crevices and slopes, nests are used annually and consist of a mound of mud, bones, plant matter and rocks.	PMST	Unlikely
Thalassarche cauta eremita	Chatham Albatross	E, M	Breeding for the Chatham Albatross is restricted to Pyramid Rock, Chatham Islands, off the coast of New Zealand. The principal foraging range for this species is in coastal waters off eastern and southern New Zealand, and Tasmania.	PMST	Unlikely
Thalassarche cauta salvini	Salvin's Albatross	V, M	Salvin's Albatross breeds on Bounty, Snares and Chatham Islands, south of New Zealand, as well as on Crozet Island in the Indian Ocean. The species forages over most of the southern Pacific Ocean, where it is particularly common in the Humboldt Current, off South America. There are small numbers in the Indian Ocean and sometimes in the South Atlantic Ocean. During the non-breeding season, the species occurs over continental shelves around continents. It occurs both inshore and offshore and enters harbours and bays (Jehl 1973). Salvin's Albatross is scarce in pelagic waters.	PMST	Unlikely
Thalassarche cauta steadi	White-capped Albatross	V, M	Breeding colonies occur on islands south of New Zealand. The White-capped Albatross is a marine species and occurs in subantarctic and subtropical waters. The White-capped Albatross is probably common off the coast of south-east Australia throughout the year.	PMST	Unlikely

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Thalassarche melanophris	Black-browed Albatross	M, V	The Black-browed Albatross has a circumpolar range over the southern oceans, and are seen off the southern Australian coast mainly during winter. This species migrates to waters off the continental shelf from about May to November and is regularly recorded off the NSW coast during this period. The species has also been recorded in Botany Bay National Park Inhabits Antarctic, subantarctic, subtropical marine and coastal waters over upwellings and boundaries of currents. Can tolerate water temperatures between 0ºC and 24ºC. Spends most of its time at sea, breeding on small isolated islands.	PMST	Unlikely
Thalassarche melanophris impavida	Campbell Albatross	V, M	The Campbell Albatross is a non-breeding visitor to Australian waters. Non-breeding birds are most commonly seen foraging over the oceanic continental slopes off Tasmania, Victoria and New South Wales. They breed only on sub-Antarctic Campbell Island (New Zealand), south of New Zealand. After breeding, birds move north and may enter Australia's temperate shelf waters.	PMST	Unlikely
Thinornis cucullatus	Hooded Plover (eastern)	V, M	The Hooded Plover is endemic to southern Australia and is nowadays found mainly along the coast from south of Jervis Bay, NSW, south through Victoria and Tasmania to the western side of the Eyre Peninsula (South Australia). In south-eastern Australia Hooded Plovers prefer sandy ocean beaches, especially those that are broad and flat, with a wide wave-wash zone for feeding, much beach cast seaweed, and backed by sparsely vegetated sand-dunes for shelter and nesting. Occasionally Hooded Plovers are found on tidal bays and estuaries, rock platforms and rocky or sand-covered reefs near sandy beaches, and small beaches in lines of cliffs. They regularly use near-coastal saline and freshwater lakes and lagoons, often with saltmarsh.	PMST	Unlikely
Xenus cinereus	Terek Sandpiper	M	In Australia, the Terek Sandpiper has a primarily coastal distribution, with occasional records inland. The Terek Sandpiper mostly forages in the open, on soft wet intertidal mudflats or in sheltered estuaries, embayments, harbours or lagoons.	232 – Atlas PMST	Unlikely

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Mammals					
Chalinolobus dwyeri	Large-eared Pied Bat	V	Forages over a broad range of open forest and woodland habitats, this species is a cave roosting bat which favours sandstone escarpment habitats for roosting, in the form of shallow overhangs, crevices and caves.	14 – Atlas PMST	Low
Dasyurus maculatus	Spotted-tailed Quoll	E	Wet and dry sclerophyll forests and rainforests, and adjacent open agricultural areas. Generally associated with large expansive areas of habitat to sustain territory size. Requires hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites.	14 – Atlas PMST	Moderate
Petauroides Volans	Greater Glider	V	The Greater Glider occurs in eucalypt forests and woodlands along the east coast of Australia from north east Queensland to the Central Highlands of Victoria. This species feeds exclusively on eucalypt leaves, buds, flowers and mistletoe. Shelter during the day in tree hollows and will use up to 18 hollows in their home range. Occupy a relatively small home range with an average size of one to three hectares.	PMST	Low
Petrogale penicillata	Brush-tailed Rock-wallaby	V	Range extends from south-east Queensland to the Grampians in western Victoria, roughly following the line of the Great Dividing Range. Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges, often facing north. Browse on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	PMST	Unlikely
Phascolarctos cinereus	Koala	V	In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. Inhabit eucalypt woodlands and forests. Feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species.	2231 – Atlas PMST	Moderate
Potorous tridactylus	Long-nosed Potoroo	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. 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. The fruit-bodies of hypogenous (underground-fruiting) fungi are a large component of the diet of the Long-nosed Potoroo. They also eat roots, tubers, insects and their larvae and other soft-bodied animals in the soil.	1 – OEH PMST	Low

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Pseudomys novaehollandiae	New Holland mouse	V	Distribution is fragmented across all eastern states of Australia, where it inhabits open heath lands, open woodlands with heath understorey and vegetated sand dunes.	42 – Atlas PMST	Moderate
Pteropus poliocephalus	Grey-headed Flying-fox	V	Generally found within 200 kilometres of the eastern coast of Australia, from Rockhampton in Queensland to Adelaide in South Australia. In times of natural resource shortages, they may be found in unusual locations. Occur 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 kilometres of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Individual camps may have tens of thousands of animals and are used for mating, and for giving birth and rearing young.	402 – Atlas PMST	High
Reptiles					
Caretta	Loggerhead Turtle	E, M	Loggerhead Turtles are found in tropical and temperate waters off the Australian coast. In NSW they are seen as far south as Jervis Bay and have been recorded nesting on the NSW north coast and feeding around Sydney. Loggerhead Turtles are ocean-dwellers, foraging in deeper water for fish, jellyfish and bottom-dwelling animals. The female comes ashore to lay her eggs in a hole dug on the beach in tropical regions during the warmer months.	PMST	Unlikely
Chelonia mydas	Green Turtle	V, M	Widely distributed in tropical and sub-tropical seas. Usually found in tropical waters around Australia but also occurs in coastal waters of NSW, where it is generally seen on the north or central coast, with occasional records from the south coast. Ocean-dwelling species spending most of its life at sea. Carnivorous when young but as adults they feed only on marine plant material.	PMST	Unlikely
Dermochelys coriacea	Leatherback Turtle	E, M	Throughout the world's tropical and temperate seas and in all coastal waters of Australia. Most sightings are in temperate waters. Occurs in inshore and offshore marine waters. Rarely breeds in Australia, with the nearest regular nesting sites being the Solomon Islands and Malayan Archipelago. Occasional breeding records from NSW coast, including between Ballina and Lennox Head in northern NSW.	PMST	Unlikely
Eretmochelys imbricata	Hawksbill Turtle	V, M	Major nesting of Hawksbill Turtles in Australia occurs at Varanus Island and Rosemary Island in Western Australia, and in the northern Great Barrier Reef and Torres Strait, Queensland. Hawksbill Turtles spend their first five to ten years drifting on ocean currents.	PMST	Unlikely

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Natator depressus	Flatback Turtle	V, M	The Flatback Turtle is found only in the tropical waters of northern Australia, Papua New Guinea and Irian Jaya and is one of only two species of sea turtle without a global distribution. Post-hatchling and juvenile Flatback Turtles do not have the wide dispersal phase in the oceanic environment like other sea turtles. Adults inhabit soft bottom habitat over the continental shelf of northern Australia, extending into Papua New Guinea and Irian Jaya although the extent of their range is not fully known.	PMST	Unlikely
Amphibians					
Heleioporus australiacus	Giant Burrowing Frog	V	The Giant Burrowing Frog is distributed in south eastern NSW and Victoria and appears to exist as two distinct populations: a northern population largely confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla, and a southern population occurring from north of Narooma through to Walhalla, Victoria. Found in heath, woodland and open dry sclerophyll forest on a variety of soil types except those that are clay based. Spends more than 95% of its time in non-breeding habitat in areas up to 300m from breeding sites. Whilst in non-breeding habitat it burrows below the soil surface or in the leaf litter. Individual frogs occupy a series of burrow sites, some of which are used repeatedly. The home ranges of both sexes appear to be non-overlapping suggesting exclusivity of non-breeding habitat. Home ranges are about 0.04 hectares in size.	PMST	Low
Litoria aurea	Green and Golden Bell Frog	V	Since 1990 there have been about 50 recorded locations in NSW, most of which are small, coastal, or near coastal populations. These locations occur over the species' former range; however they are widely separated and isolated. Large populations in NSW are located around the metropolitan areas of Sydney, Shoalhaven and mid north coast (one an island population). There is only one known population on the NSW Southern Tablelands. Ephemeral and permanent freshwater wetlands, ponds, dams with an open aspect and fringed by *Typha* and other aquatics, free from predatory fish.	8650 – Atlas PMST	Moderate
Litoria littlejohni	Littlejohn's Tree Frog	V	Distribution includes the plateaus and eastern slopes of the Great Dividing Range from Watagan State Forest (90 kilometres north of Sydney) south to Buchan in Victoria. This species breeds in the upper reaches of permanent streams and in perched swamps. Non-breeding habitat is heath based forests and woodlands where it shelters under leaf litter and low vegetation, and hunts for invertebrate prey either in shrubs or on the ground.	PMST	Unlikely

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Mixophyes balbus	Stuttering Frog	E	Occur along the east coast of Australia from southern Queensland to north-eastern Victoria. Found in rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range. Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor.	PMST	Unlikely
Mixophyes iteratus	Giant Barred Frog	E	Forages and lives amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 metres. They breed around shallow, flowing rocky streams from late spring to summer.	PMST	Unlikely
Fish					
Epinephelus daemelii	Black Cod	V	In Australia, the distribution of black cod ranges from southern Queensland through NSW to northern Victoria. However, records from Queensland and Victoria are rare, and the NSW coastline forms the species' main range, both in Australia and internationally. The use of estuaries may be an important part of the ecology of juvenile black cod in NSW waters.	PMST	Unlikely
Pristis zijsron	Green Sawfish	V	Previously in NSW, the species was regularly found in the shallow waters at the mouth of the Tweed, Clarence and Richmond Rivers, however the last recorded museum specimen from NSW was captured in 1972. The last specimen from the Sydney region was captured in 1926. With the Green Sawfish no longer found in NSW waters, or southern Queensland waters, the species appears to have experienced a contraction of range of around 30% in Australian waters.	Not recorded	Unlikely

Species name	Common name	Status EPBC Act	Distribution and habitat	No. records in locality	Likelihood of occurrence
Insects					
Synemon plana	Golden Sun Moth	CE	The Golden Sun Moth's NSW populations are found in the area between Queanbeyan, Gunning, Young and Tumut. The species' historical distribution extended from Bathurst (central NSW) through the NSW Southern Tablelands, through to central and western Victoria, to Bordertown in eastern South Australia. Occurs in Natural Temperate Grasslands and grassy Box-Gum Woodlands in which groundlayer is dominated by wallaby grasses *Austrodanthonia* sp. Grasslands dominated by wallaby grasses are typically low and open - the bare ground between the tussocks is thought to be an important microhabitat feature for the Golden Sun Moth, as it is typically these areas on which the females are observed displaying to attract males. Habitat may contain several wallaby grass species, which are typically associated with other grasses particularly spear-grasses *Austrostipa* sp. or Kangaroo Grass *Themeda australis*.	PMST	Unlikely

Appendix C. Biodiversity credit report

Biodiversity credit report

This report identifies the number and type of biodiversity credits required for a major project.

Date of report: 23/09/2020 Time: 8:12:27AM Calculator version: v4.0

Major Project details

Proposal ID:	179/2020/5065MP
Proposal name:	M12RT 2020
Proposal address:	Pacific Highway M12RT Newcastle NSW 2300
Proponent name:	Transport for NSW
Proponent address:	Newcastle NSW 2201
Proponent phone:	
Assessor name:	Chris Thomson
Assessor address:	12 Stewart Ave, Newcastle West NSW 2302
Assessor phone:	02 4979 2626
Assessor accreditation:	179

Summary of ecosystem credits required

Plant Community type	Area (ha)	Credits created
Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast	10.49	469.48
Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast	1.61	75.34
Forest Red Gum grassy open forest on floodplains of the lower Hunter	0.45	27.13
Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast	7.60	429.00
Grey Mangrove low closed forest	2.27	133.00
Jointed Twig-rush sedgeland	1.45	99.22
Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion	7.71	325.88
Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast	1.82	103.38
Saltmarsh Estuarine Complex	1.26	54.94
Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast	28.59	1,421.00
Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands	1.36	71.80
Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest	41.88	2,327.24
Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast	8.76	423.09
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter	59.04	2,304.44
Total	174.29	8,265

Credit profiles

1. Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast, (HU802)

Number of ecosystem credits created	429
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast, (HU802) Melaleuca decora low forest of the central Hunter Valley, Sydney Basin Bioregion, (HU564) Slaty Red Gum grassy woodland on hinterland foothills of the southern North Coast, (HU619) Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast, (HU803) Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest, (HU804) Red Ironbark - Spotted Gum - Prickly-leaved Paperbark shrubby open forest of the Lower Hunter, (HU807) Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter, (HU814) Spotted Gum - Narrow-leaved Ironbark-Red Ironbark shrub - grass open forest of the central and lower Hunter, (HU815) Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter, (HU816) Grey Box - Grey Gum - Rough-barked Apple - Blakely's Red Gum grassy open forest of the central Hunter, (HU822)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

2. Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest, (HU804)

Number of ecosystem credits created	2,327
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest, (HU804) Melaleuca decora low forest of the central Hunter Valley, Sydney Basin Bioregion, (HU564) Slaty Red Gum grassy woodland on hinterland foothills of the southern North Coast, (HU619) Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast, (HU802) Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast, (HU803) Spotted Gum - Red Ironbark - Grey Gum shrub - grass open forest of the Lower Hunter, (HU806) Red Ironbark - Spotted Gum - Prickly-leaved Paperbark shrubby open forest of the Lower Hunter, (HU807) Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter, (HU814) Spotted Gum - Narrow-leaved Ironbark-Red Ironbark shrub - grass open forest of the central and lower Hunter, (HU815) Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter, (HU816) Grey Box - Grey Gum - Rough-barked Apple - Blakely's Red Gum grassy open forest of the central Hunter, (HU822)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

3. Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central andLower North Coast, (HU860)

Number of ecosystem credits created	1,421
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast, (HU860) Smooth-barked Apple - White Stringybark - Red Mahogany - Melaleuca sieberi shrubby open forest on lowlands of the lower North Coast, (HU832) Scribbly gum - Wallum Banksia - Prickly-leaved Paperbark heathy coastal woodland on coastal lowlands, (HU851) Smooth-barked Apple - Blackbutt heathy open forest of the Tomaree Peninsula, (HU862)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

4. Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion, (HU673)

Number of ecosystem credits created	326
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion, (HU673) Cladium procerum coastal freshwater wetland, (HU949) Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter, (HU950)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

5. Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter, (HU950)

Number of ecosystem credits created	2,304
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter, (HU950) Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion, (HU673) Cladium procerum coastal freshwater wetland, (HU949)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

6. Jointed Twig-rush sedgeland, (HU956)

Number of ecosystem credits created	99
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Jointed Twig-rush sedgeland, (HU956) Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion, (HU533) Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion, (HU673) Cladium procerum coastal freshwater wetland, (HU949) Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter, (HU950) Typha rushland, (HU951) Tall Spike Rush freshwater wetland, (HU954) Lepironia articulata sedgeland, (HU955)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

7. Forest Red Gum grassy open forest on floodplains of the lower Hunter, (HU812)

Number of ecosystem credits created 27

IBRA sub-region Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Forest Red Gum grassy open forest on floodplains of the lower Hunter, (HU812) Coastal floodplain sedgelands, rushlands, and forblands of the North Coast, (HU532) Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion, (HU635) Parramatta red gum - Fern-leaved banksia - Melaleuca sieberi swamp woodland of the Tomaree Peninsula, (HU865) Prickly-leaved Paperbark - Flax-leaved Paperbark swamp forest on poorly drained soils of the Central Coast, (HU929) Cabbage Gum - Forest Red Gum - Flax-leaved Paperbark Floodplain Forest of the Central Coast, (HU934) Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU941) Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU942) Grey Gum - Red Gum - Paperbark shrubby open forest on coastal lowlands of the Northern Sydney Basin and Lower North Coast, (HU963)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

8. Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodlandof coastal lowlands, (HU863)

Number of ecosystem credits created 72

IBRA sub-region Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands, (HU863) Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion, (HU633) Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast, (HU930) Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast, (HU931) Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast, (HU932) Paperbarks - Woollybutt swamp forest on coastal lowlands of the Central Coast, (HU933) Melaleuca biconvexa - Swamp Mahogany - Cabbage Palm swamp forest of the Central Coast, (HU937) Flax-leaved Paperbark - Tall Sedge shrubland of the Sydney Basin, (HU940) Swamp paperbark - Baumea juncea swamp shrubland on coastal lowlands of the Central Coast and Lower North Coast, (HU944) Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley, (HU945)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

9. Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast,(HU930)

Number of ecosystem credits created	103
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast, (HU930) Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion, (HU633) Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast, (HU931) Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast, (HU932) Paperbarks - Woollybutt swamp forest on coastal lowlands of the Central Coast, (HU933) Melaleuca biconvexa - Swamp Mahogany - Cabbage Palm swamp forest of the Central Coast, (HU937) Swamp paperbark - Baumea juncea swamp shrubland on coastal lowlands of the Central Coast and Lower North Coast, (HU944) Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley, (HU945)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

10. Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast, (HU931)

Number of ecosystem credits created	469
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast, (HU931) Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion, (HU633) Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast, (HU930) Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast, (HU932) Melaleuca biconvexa - Swamp Mahogany - Cabbage Palm swamp forest of the Central Coast, (HU937) Swamp paperbark - Baumea juncea swamp shrubland on coastal lowlands of the Central Coast and Lower North Coast, (HU944) Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley, (HU945)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

11. Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU938)

Number of ecosystem credits created	75
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU938) Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion, (HU633) Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands, (HU863) Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast, (HU930) Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast, (HU931) Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast, (HU932) Paperbarks - Woollybutt swamp forest on coastal lowlands of the Central Coast, (HU933) Swamp Mahogany - Paperbarks - Harsh Ground Fern swamp forest of the Central Coast, (HU936) Melaleuca biconvexa - Swamp Mahogany - Cabbage Palm swamp forest of the Central Coast, (HU937) Swamp Mahogany - Broad-leaved Paperbark - Swamp Water Fern - Plume Rush swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU939) Flax-leaved Paperbark - Tall Sedge shrubland of the Sydney Basin, (HU940) Swamp paperbark - Baumea juncea swamp shrubland on coastal lowlands of the Central Coast and Lower North Coast, (HU944) Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley, (HU945)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

12. Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU941)

Number of ecosystem credits created	423
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU941) Coastal floodplain sedgelands, rushlands, and forblands of the North Coast, (HU532) Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion, (HU635) Parramatta red gum - Fern-leaved banksia - Melaleuca sieberi swamp woodland of the Tomaree Peninsula, (HU865) Cabbage Gum - Forest Red Gum - Flax-leaved Paperbark Floodplain Forest of the Central Coast, (HU934) Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU942)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

13. Saltmarsh Estuarine Complex, (HU960)

Number of ecosystem credits created	55
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Saltmarsh Estuarine Complex, (HU960) Saltmarsh in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion, (HU606)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

14. Grey Mangrove low closed forest, (HU961)

Number of ecosystem credits created	133
IBRA sub-region	Hunter

Offset options - Plant Community types	Offset options - IBRA sub-regions
Grey Mangrove low closed forest, (HU961) Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion, (HU563)	Hunter and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

Summary of species credits required

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Australasian Bittern	Botaurus poiciloptilus	43.64	567
Black Bittern	Ixobrychus flavicollis	61.95	805
Eucalyptus parramattensis subsp. decadens	Eucalyptus parramattensis subsp. decadens	34.00	476
Koala	Phascolarctos cinereus	51.12	1,329
Netted Bottle Brush	Callistemon linearifolius	157.00	2,198
Tall Knotweed	Persicaria elatior	3.00	39
Wallum Froglet	Crinia tinnula	2.68	35
Sand Doubletail	Diuris arenaria	161.00	12,397

Appendix D. Assessment of significance (EPBC Act)

The assessment of Matters of National Environmental Significance has considered that a referral for this project has already been assessed by the Department of Agriculture, Water and Environment (EPBC 2018/8288, SSI15_7319) which had determined that significant impacts were likely for some MNES but not others.

In providing comment on the current SEARs, the Department has indicated that for those species assessed as not having a significant impact, (i.e. Earps Gum (*Eucalyptus parramattensis subsp decadens*), Small-flower Grevillea (*Grevillea parviflora subsp parviflora*), Tall Knotweed (*Persicaria elatior*), Australian Bittern (*Botaurus poicilioptilus*), Australian Painted Snipe (*Rostratula australis*), and Green and Golden Bell Frog (*Litoria aurea*) that 'if the assessment process identifies any new or increased impacts on these species compared to the impacts in the referral, such impacts must be addressed in the EIS'.

In addressing this comment, the BAR has provided discussion and assessment on increased impacts to these species as outlined in the following, and additionally has provided the Assessment of Significance for species previously assessed as significantly impact, although note that these species (Koala (*Phascolarctos cinereus*), Regent Honeyeater (*Anthochaera phrygia*), Swift Parrot (*Lathamus discolor*) and Grey-headed Flying-fox (*Pteropus poliocephalus*) have already been assessed as significantly impacted by DAWE.

Following submission of the referral, further targeted survey was conducted to determine the presence of Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland endangered ecological community which was provisionally presented in the referral as present. These surveys have subsequently confirmed the absence of this community, and hence there will be no significant impact, and an Assessment of Significance is not required.

The project has developed further since the referral of the project to the Commonwealth in 2018, resulting in a refined design and construction footprint that warranted further survey and assessment for impacts on biodiversity. In addition to the impacts assessed in the referral, the assessment process has identified one new impacted species (*Persicaria elatior*) and five increased impacts on threatened species compared to the impacts described in the referral, as follows:

- *Persicaria elatior* (vulnerable species) – three individuals of this species were identified during supplementary surveys post referral. All occur within the construction footprint and will be directly impacted
- Impacts on the identified *Eucalyptus parramattensis* subsp*. decadens* (vulnerable species) has increased from 16 individuals identified in the referral to 34 individuals with final design
- Impacts on Australasian Bittern habitat has increased from about five hectares of wetland habitat at Windeyers Creek' to up to around 43.6 hectares of associated PCTs that may provide suitable habitat
- Impacts on Australian Painted Snipe has increased from 33 hectares identified in the referral to up to around 43.6 hectares of associated PCTs that may provide suitable habitat
- Impacts on Spotted-tailed Quoll has increased from 45 hectares identified in the referral to up to around 47 hectares of associated PCTs that may provide suitable habitat
- Impacts on New Holland Mouse has increased from 20.4 hectares identified in the referral to 28.6 hectares of associated PCTs that may provide suitable habitat

Assessments of Significance addressing the MNES Significant impact guidelines 1.1 (DoE, 2013) are presented herein. In accordance with the MNES Significant impact guidelines 1.1 (DoE, 2013), the term "proposed action" refers to the project. The assessments concluded that a significant impact is not likely for any of the species assessed.

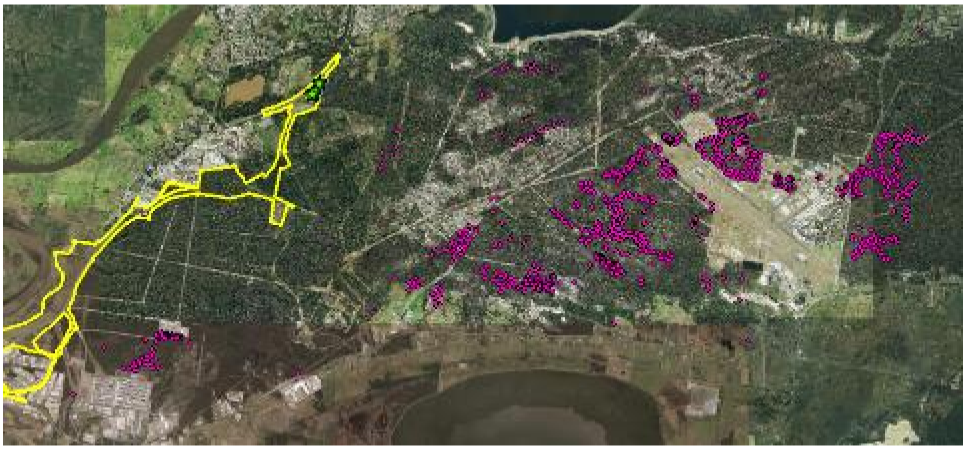
For completeness, the Assessments of Signifiicance for Small-flowered Grevillea (Grevillea parviflora subsp. parviflora) and Green and Golden Bell Frog (Litoria aurea) have also been included in **Appendix D** despite not having an increased or changed impact since the original referral.

Eucalyptus parramattensis subsp. *decadens*

Dropping Red Gum or Earp's Gum (*Eucalyptus parramattensis* subsp. *decadens*) is listed as vulnerable under the EPBC Act. A small isolated stand of trees was identified at the northern end of the construction footprint on the eastern side of the existing Pacific Highway, in proximity to the proposed connection of the upgrade with the existing highway. A total of 34 trees were mapped in this location and a targeted survey of a two-kilometre radius confirmed the extent of the population was restricted to this small area about five hectares on the edge of a large fragment of Swamp Sclerophyll and Open forest (refer **Photograph D-1**) which continues to the east and north. The habitat is largely contiguous to the east towards Williamtown and is therefore connected to the large Tomago Sandbeds sub-population of *E. parramattensis* subsp. *decadens* (refer **Photograph D-2**).

The habitat next to the Pacific Highway is not typical of the species, which prefers deep low nutrient soils. Rather the habitat in the construction footprint at this location is heavy clay soil. It is unknown whether these have been planted as part of the Raymond Terrace bypass upgrade and the site where they are located was apparently a construction compound.

Photograph D-1: Location of 34 *E. parramattensis* subsp. *decadens* in the construction footprint



Photograph D-2: Distribution of the Tomago Sandbeds sub-population of *E. parramattensis* subsp. *decadens*

The current design of an off-ramp at this location would directly impact on all 34 individuals. However, this is based on a worst-case footprint and some individuals may remain following detailed design. This population occurs in an area of habitat that has been substantially modified and disturbed and is located on a portion of land that was a previously used for the compound site for the construction of the Raymond Terrace bypass in the 1980's. it cannot be confirmed if they were included in site restoration planting, however all individuals are of a similar age.

The definition of an important population as provided in the Matters of National Environmental Significance Significant Impact Guidelines 1.1 (DoE 2013) is a "… a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- Key source populations either for breeding or dispersal
- Populations that are necessary for maintaining genetic diversity, and/or
- Populations that are near the limit of the species range".

The sub-population of *Eucalyptus parramattensis* subsp. *decadens* within the construction footprint is unlikely to be a key source population for breeding or dispersal as it is very small and isolated. There are two large populations of Earp's gum (NSW OEH, 2012). The Kurri Kurri population is bordered by Cessnock/Kurri Kurri in the north and Mulbring—Abedare in the south (NSW OEH, 2012). Large aggregations of the subspecies are also located in the Tomalpin area (NSW OEH, 2012).

The second Tomago Sandbeds population is bounded by Salt Ash and Tanilba Bay in the north and Williamtown and Tomago in the south, refer to plate above (NSW OEH, 2012). The plants within the construction footprint are part of the Tomago Sandbeds sub-population and may be outliers on the western extent of this large population as there is no further habitat available to the west of north at this location.

The Tomago Sandbeds population is an important population and the stand of trees in the construction footprint is a very small component of the large Tomago Sandbeds sub-population of this species.

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

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

The action would totally remove the small isolated stand of trees located in the road corridor. All of the 34 trees confirmed in this location would need to be removed, however this is based on a worst-case footprint and some individuals may remain following detailed design. This stand of trees is part of the larger Tomago Sandbeds sub-population. It is noted that almost all of the Tomago Sandbeds population is on private land and so the long-term future is uncertain. However, given the very large size and distribution of the Tomago Sandbeds population, the loss of the trees from this project is unlikely to lead to a long-term decrease in the size of this important population.

2. reduce the area of occupancy of an important population

The 34 *Eucalyptus parramattensis* subsp. *decadens* plants which would be removed are at the western edge of the range for the Tomago Sandbeds population (refer to plate above). The removal of these plants and associated habitat would reduce the area of occupancy of an important population. No further trees were located in targeted searches on the western side of the highway in this location, however, additional *Eucalyptus parramattensis* subsp. *decadens* plants are likely to occur to the east of the construction footprint as the habitat is contiguous through to Williamtown and Salt Ash where large numbers are known to occur. Bell (2006) has reported a widespread population bounded by Salt Ash and Tanilba Bay in the north and Williamtown and Tomago in the south.

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

The existing Tomago Sandbeds population extends from Salt Ash, through Williamtown and Tomago to Grahamstown Dam (Bell 2006). Importantly, the action would not result in the breaking apart of large blocks of high-quality habitat for *Eucalyptus parramattensis* subsp. *decadens* and would not fragment a continuous population. The Tomago Sandbeds population is currently located across a large landscape of roads, power easements and cleared tracks. The small stand of tree identified would be removed by the off-ramp, however this would not fragment the larger population into two or more discreet and isolated populations.

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

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

Critical habitats for *Eucalyptus parramattensis* subsp. *decadens* in the locality include the low nutrient soils on land owned by Hunter Water Corporation as part of the Tomago Sandbeds as well as Tilligerry Nature Reserve and buffer lands surrounding the Williamtown/Newcastle airport. Populations on private property are also likely to be important for the survival of this species but no specific areas of critical habitat have been identified.

The area of habitat to be impacted by the action is directly next to the existing Pacific Highway close to road reserve. The stand is small and the habitat is unsuitable for any management actions to preserve the species. In the context of the existing large Tomago Sandbeds population and areas of habitat that are clearly more critical to the survival of this species, the habitat to be affected is not considered critical.

5. disrupt the breeding cycle of an important population

The action would disrupt the breeding cycle of the *Eucalyptus parramattensis* subsp. *decadens* population in this location as the majority of the trees identified would be removed or indirectly impacted. The breeding cycle of the overall core Tomago Sandbeds population would continue.

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 action would result in a very small decrease in the availability of habitat for *Eucalyptus parramattensis* subsp. *decadens* of about 5 hectares. This habitat loss represents a very small fraction of the known and available habitat for the core population which extends from Tomago to Salt Ash and Grahamstown dam. Removal of the 5 hectares of habitat within the construction footprint is unlikely to be so detrimental as to cause this species to decline.

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

The potential for weed invasion is considered possible with a project 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 as outlined in RTA (2011). The small isolated fragment of vegetation is currently experiencing weed invasion, particularly invasive grasses and shrubs such as a Lantana; this is likely to continue along the edge of the new road.

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

There are no diseases that are known to affect *Eucalyptus parramattensis* subsp. *decadens*. Furthermore, the project 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.

There is no recovery plan for *Eucalyptus parramattensis* subsp. *decadens*. However, the EES Group have identified three priority actions to help recover this species as follows:

- Prevent frequent fires from impacting on the populations
- Habitat rehabilitation through wed removal
- Protect known habitat from clearing, fragmentation, disturbance and modifications to drainage patterns

The action would remove an area of known habitat and is inconsistent with the priority actions identified for this species. However, the recovery of this species is not dependent on the small stand of individuals to be removed by the action.

Conclusion

Thirty-four *Eucalyptus parramattensis* subsp. *decadens* trees from an isolated stand (part of the larger core population on the Tomago Sandbeds) situated in disturbed roadside vegetation would be removed by the action. This is a very small stand and only a small reduction in extent of suitable habitat would occur from the action. The local occurrence of this species would persist after the action is built as the larger population on the Tomago Sandbeds would not be disturbed.

Given the conservation status of this species (vulnerable) and the low magnitude of the impact, an overall conclusion has been made that the action is unlikely to result in a significant impact to *Eucalyptus parramattensis* subsp. *decadens*.

A significant impact is not predicted for the following reasons:

- The larger core population, to which the impacted trees belong, would still exist over the larger area from Tomago to Salt Ash within the Tomago Sandbeds. There is also potential for additional *Eucalyptus parramattensis* subsp. *decadens* to be present on private property further to the west of the construction footprint. Overall, the removal of 34 plants form the western edge of the larger core population would not lead to a long-term decrease in the size of the important population
- The area of habitat to be impacted by the action is directly next to the existing Pacific Highway close to the road reserve. In the context of the existing large population and areas of habitat that are clearly more critical to the survival of this species, the habitat to be affected is not considered critical
- While the action would disrupt the breeding cycle of the *Eucalyptus parramattensis* subsp. *decadens* in the construction footprint, the breeding cycle of the overall core population would continue.

Given the context and intensity of the potential impact and the impact magnitude, a significant impact to *Eucalyptus parramattensis* subsp. *decadens* is considered unlikely.

Persicaria elatior

Tall Knotweed (*Persicaria elatior*) is listed as vulnerable under the EPBC Act. Three individuals were recorded from the edge of a drainage line in the floodplain on the south side of the Hunter River in 2018. A sample was verified by the Royal Botanic Garden Sydney on 11 July 2018.

These plants were recorded in March 2018 following months of below average rainfall. The drainage line presents more suitable habitat for this species. There is potential for more individuals to show up following suitable rainfall, however the land has a long history of grazing and suppression of regrowth. All three plants would be directly impacted by the project removing this small isolated population.

Photograph D-3: Grazed floodplain where *Persicaria elatior* was identified

Photograph D-4: One of the three *Persicaria elatior* individuals

Photograph D-5: The location of the three *Persicaria elatior* individuals on the floodplain

The definition of an important population as provided in the Matters of National Environmental Significance Significant Impact Guidelines 1.1 (DoE 2013) is a "… a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- Key source populations either for breeding or dispersal
- Populations that are necessary for maintaining genetic diversity, and/or
- Populations that are near the limit of the species range".

There is no population information for *Persicaria elatior*, however the SPRAT profile recognised Raymond Terrace as a general location in NE NSW where it has been collected. Records of this species in the locality include a cluster of plants in pasture around Grahamstown drain seven kilometres to the NE and a single record from partly cleared sandy swamp forest between Heatherbrae and Williamtown, around 8.5 kilometres east. Documented habitat for *Persicaria elatior* includes sandy, alluvial soil in swampy areas and riparian herb lands along watercourses and lake edges. This describes the likely habitat in sandy swamp forest between Heatherbrae and Williamtown. The extent of the local population likely includes large areas of swamp forest throughout the Tomago Sandbeds. It is possible that the floodplain contains a seedbank which represents a local sub-population that has dispersed onto the site through wetlands to the east. Any populations of *Persicaria elatior* are likely to be necessary for maintaining the genetic diversity. Based on this information the subject population is considered to be part of an 'important population'.

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

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

Only three individuals were identified in the construction footprint in 2018. These plants could not be found in 2020. However, this species is short-lived, surviving for up to two years. Following rain, it germinates readily from seed on bare ground. Knotweed grows rapidly, flowers and sets seed within six months of germinating (Leiper 2008). Given this, it is likely there is an important population in the seed bank on the floodplain. The size of the population is unknown. Considering the location of the plants on the bank of the shallow drainage line, it is possible that there is seed distributed all around this immediate vicinity.

The project would result in direct impact to these three plants and all of the suitable habitat within the immediate vicinity of the location where the plants were observed. It is possible that the entire sub-population would be cleared by the project. However, it is also possible that this species is more widespread on the floodplain than is known.

The quality of the habitat for this species in this location is poor, mainly due to the presence of grazing. Cattle may eat new shoots following suitable rain. The habitat does not perfectly match habitat characteristics documented for this species (apart from the disturbed areas), therefore it is likely that these individuals have dispersed from nearby swamp forest and wetlands to the east.

Given the plants likely represent a sub-population of a local population, the removal of at least three plants is unlikely to lead to a long-term decrease in the size of the important population.

2. reduce the area of occupancy of an important population

The road alignment would permanently remove most of the occurrence of potential habitat on the floodplain. In this respect, the project would reduce the area of occupancy of an important population.

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

The actual extent of the important population is not known, however based on the extent of records in the region and the known habitat requirements of this species (sand substrate), the individuals on the site may be part of the western extent part of the important population, having dispersed out of swamp habitat to the east. The project would slightly widen the gap between the swamp habitats to the east and the floodplain habitats, however the pasture habitat where these plants were identified is not considered to be high-quality habitat for *Persicaria elatior.* Habitats immediately west of this location are likely to saline.

Given this, the project is unlikely to result in fragmenting the important population into two or more populations, with the main occurrence of the *Persicaria elatior* population in swamp habitat retained.

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

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The SPRAT profile for *Persicaria elatior* states that it grows in damp places, including:

- Coastal with swampy areas
- Along watercourses, streams and lakes
- Swamp forest
- Disturbed areas.

Associated species include *Melaleuca linearifolia*, *M. quinquenervia*, *Lophostemon suaveolens*, *Casuarina glauca*, *Corymbia maculata*, *Pseudognaphalium luteoalbum* and *Polygonum hydropiper*.

The quality of the habitat for this species in this location is poor, mainly due to the presence of grazing. Cattle may eat new shoots following suitable rain. The habitat does not perfectly match habitat characteristics documented for this species (apart from the disturbed areas), therefore it is likely that these individuals have dispersed from nearby swamp forest and wetlands to the east. Given this, the habitat that would be impacted by the project is not considered likely to be habitat critical to the survival of the species.

5. disrupt the breeding cycle of an important population

The action is unlikely to disrupt the breeding cycle of the important population. There is no data available on pollination, however other *Persicaria* species are insect pollinated. Seed is likely dispersed by flooding. The action would result in the removal of at least three plants, which would disrupt the sub-population on the floodplain, however, is unlikely to disrupt the important population itself. The breeding cycle of the overall core population is likely to continue.

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 action would result in the removal of at least three plants and a large area of low condition floodplain habitat on the southern bank of the Hunter River. The remaining floodplain habitat is already highly disturbed and unlikely to be substantially indirectly impacted by the project. As discussed, these individuals likely dispersed to this location from better quality habitat where the important population retinas a stronghold. Based on described habitat characteristics, this is likely to be to the east around Tomago Sandbeds. Therefore, the removal of this floodplain pasture habitat is unlikely to cause this species to decline.

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

The potential for weed invasion is considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The floodplain pasture is already dominated by exotic pasture species and unlikely to be substantially indirectly impacted by the project. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

8. introduce disease that may cause the species to decline

There are no diseases that are known to affect *Persicaria elatior*. Furthermore, the project 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.

There is no recovery plan for *Persicaria elatior*. However, the EES Group have identified six priority actions to help recover this species as follows:

- Identification of priority locations, assessment of threats and implementation of recovery actions.
- Provision of information to landholders to assist identification
- Ensuring that adequate surveys occur in suitable habitat proposed for development or clearing
- Alerting road and track maintenance staff (in Sydney Water and NSW Forests) to reduce damage to populations
- Protecting wetland habitat containing (or likely to contain) this species.

The action is inconsistent with the priority actions identified for this species as it would remove plants and suitable habitat. However, the recovery of this species is not likely to be dependent on the individuals or the habitat to be removed by the action.

Conclusion

The summary of direct impact involves removal of three *Persicaria elatior* plants and likely most of the area occupied by this species in the floodplain pasture.

There is little information available to assist in the assessment of impact on this species. Based on the documented habitat characteristics provided in the SPRAT profile, the floodplain where this species was located in 2018 is unlikely to represent the full extent of the local population. Local records are uncommon; however, this species is a fast growing and short-lived species. The presence of records around the Tomago Sandbeds is likely to be an indication of the presence of the local important population. Assuming this, the individuals that would be impacted by the project are likely to have dispersed to this location during a flood.

This impact is unlikely to be significant with the assumption that a local viable population is present within the sandy swamp habitats east of the project. However, if the floodplain is an isolated occurrence of *Persicaria elatior* then the project would potentially remove all individuals. Further widespread surveys of the locality following suitable rain would be required to determine the full extent of the impact on a *Persicaria elatior* population.

Grevillea parviflora subsp parviflora

Small-flower Grevillea (*Grevillea parviflora subsp parviflora*) is listed as vulnerable under the EPBC Act. A population was identified in a small isolated remnant patch of Spotted Gum-Ironbark open forest (about 4.3 hectares) situated between a cleared power easement and industrial land at Tomago. The population is located on the edge of the cleared power easement where it appears to be restricted to disturbed edge habitat, which is typical of this species and no individuals were identified within the interior core areas of the remnant.

The population was estimated to consist of about 200 individuals and the location was originally directly impacted by the initial project design of a new link road at Tomago which was presented in the referral. The plants that remained outside of the construction footprint were to be effectively isolated between the easement and the new road corridor. As a result, (post-referral) the link road was redirected to the west and designed to avoid the population, and subsequently there will be no loss of plants under the revised project design.

The definition of an important population as provided in the Matters of National Environmental Significance Significant Impact Guidelines 1.1 (DoE, 2013) is a "… a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- Key source populations either for breeding or dispersal
- Populations that are necessary for maintaining genetic diversity, and/or
- Populations that are near the limit of the species range".

In addition to this information the Environmental Impact Assessment Guidelines for Grevillea parviflora subsp parviflora (NPWS 2002) identifies sites of significance for this species as those that meet the following criteria:

- Any population greater than 50 plants (the population identified is estimated at about 200 plants, with all plants being avoided from the revised project design)
- An area of intact habitat away from disturbance (the subject population is in an isolated fragment located between a cleared easement and an industrial estate)
- Population with varied age structure including active recruitment of seedlings (this is evident for the subject population).

Based on this information the subject population is considered an 'important population'.

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 revised road alignment to the west of the existing population results in no net loss in the size of the population. The species was observed to be self-reproducing as evidenced by the age range of individuals and recruitment of plants was restricted to a small area around the parent plants, which is typical of the species limited dispersal ability. It is unlikely that the project will reduce the reproductive success of the population. The population has remained stable in this location, despite is current isolation, and the project will not cause the isolation of the population but will increase the degree of isolation to other remnants nearby. There is however sufficient space for the species to expand from its current location over the long-term.

In its current location, the threats to the population are continued degradation of this small remnant through edge effects and weeds, and the threat of fire. The population appears to be resilient to edge effects and is growing in the edge habitat rather than the interior of the patch. This would suggest that the newly created edge along the road may also provide favourable habitat.

As none of the known plants in this small outlier population will be removed by the proposed action, the local sub-population will not become extinct as a result of the proposed action and the proposed action is unlikely to lead to a long-term decrease in the size of the important population.

2. reduce the area of occupancy of an important population

The revised road alignment to the west of the existing population results in no net loss in the size of the population and the area of occupancy of the important population.

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

The action will not result in fragmenting an important population into two or more populations. This population currently exists in a small fragmented remnant (about 4.3 hectares). The proposed action for the revised project has been removed from the previous design that was previously assessed in the referral, and now will not result in any increased fragmentation for this population.

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

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The area of habitat to be impacted by the proposed action is located along the edges of the existing Tomago Road and a cleared power easement. The sub-population is small, and the isolated and disturbed habitat is unsuitable for any long-term management actions to preserve *Grevillea parviflora subsp parviflora*. In the context of existing larger populations and areas of habitat that are clearly more critical to the survival of this species, the habitat to be affected is not considered critical.

5. disrupt the breeding cycle of an important population

The action will not disrupt the breeding cycle of the *Grevillea parviflora* population as the existing mature plants will remain in situ and the soil seedbank from the sub-population within the construction footprint will not need to be removed. The breeding cycle of the overall core population will continue.

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 revised project design from that assessed in the referral has now avoided any decrease in the remnant patch of habitat where this species was identified along the power easement. The availability of habitat for this species will therefore remain in-situ at this site and the population is not currently occupying any habitat where the road infrastructure will be positioned.

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

The potential for weed invasion is considered possible with a proposed action 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 CEMP and during operation of the highway using best practice methods as outlined in Biodiversity Guidelines (RTA, 2011). The revised project design will be restricted to the edges of Tomago Road, and will not require any specific weed management actions adjoining this population.

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

There are no diseases that are known to affect *Grevillea parviflora*. Furthermore, the mitigation strategy and environmental management procedures for the proposed action 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.**

There is no recovery plan for *Grevillea parviflora subsp parviflora*. However, the OEH have identified eight priority actions to help recover this species as follows:

- Ensure that personnel planning and undertaking road maintenance are able to identify the species and are aware of its habitat
- Reinstate an appropriate fire regime (either restrict fire or undertake ecological burns as required)
- Ensure that this species is considered in all planning matters on land that contains or may contain populations
- Mark and fence off sites during development/road maintenance activities
- Undertake weed control using methods that will not impact on populations of *Grevillea parviflora subsp. parviflora* (avoid spraying in the vicinity of the plants and either hand pull weeds or cut and paint them)
- Ensure these populations and this habitat is protected
- Mark known sites and potential habitat onto maps used for planning maintenance work
- Conduct searches in potential habitat for new population.

Specific management actions are not required for this species, as the project will not directly, or indirectly impact on the identified population.

Conclusion

The changed road alignment to the west of the population results in no net loss in the size of the population and no direct impacts to the patch of habitat that was previously assessed in the referral. For this species, the impact has been avoided and there are direct or indirect impacts expected.

Given the context and intensity of the potential impact and the impact magnitude, a significant impact to *Grevillea parviflora subsp parviflora* is considered unlikely.

Australasian Bittern (*Botaurus poiciloptilus*)

The Australasian Bittern is considered likely to occur based on the presence of suitable habitat.

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 would:

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

Potential habitat for this species in the construction footprint includes associated PCTs 1071, 1736, 1742 and 1746. Only good condition examples of these PCTs have been included as potential habitat. The best quality habitat is located in the deep vegetated wetland on Windeyers Creek. There is only one record of this species from about 1999 and it is limited to this location, however there are anecdotal sightings of this species around the Hunter wetlands National Park.

The proposed action may directly or indirectly affect the life cycle of a local population by displacing or disturbing individuals or established pairs. This may include nesting, foraging or roosting life cycle activities. However potential habitats for the species are widespread throughout the lower Hunter Valley and region including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands. Although there are a few records of the Australasian Bittern in the region and these are patchily distributed across the region, this may be a result of the secretive behaviour of the species in addition to low density.

Indirect impacts associated with edge effects, light and noise these would be localised in relation to home range and territory. The number of pairs potentially affected is not known. There is expected to be several pairs in the floodplain areas of the Hunter River. The proposed action is not expected to lead to a long-term decrease in the size of the Australasian Bittern population within the construction footprint.

2. reduce the area of occupancy of a species

The Australasian Bittern favours permanent freshwater wetlands and riparian vegetation with tall, dense vegetation, particularly bulrushes (*Typha* sp.) and spikerushes (*Eleocharis* sp.). As the proposed action traverses a portion of the floodplain of the Hunter River in addition to Windeyers Creek, these habitat types are common and widespread across the major floodplains of the locality. The proposed action would result in direct impacts to PCTs 1071, 1736, 1742 and 1746 which represents the potential habitat for the species in the construction footprint, with the highest quality areas around Windeyers Creek.

The proposed action would result in the reduction of suitable habitat by 43.64 hectares and if present this may potentially reduce the occupancy of the species. However much of this habitat is likely too disturbed to be occupied by this species.

3. fragment an existing population into two or more populations

The proposed action has potential to isolate remnant wetland habitat either side of the bridge at Windeyers Creek. This area of habitat is likely only large enough to support a single pair and would not fragment a population of Australasian Bittern, although may reduce the suitability of the habitat. Potential for movements under and over the highway would exist.

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

The proposed action would result in direct impacts to about 43.64 hectares of associated habitat across the construction footprint, with around five hectares of high-quality habitat at Windeyers Creek, which may be considered critical to the survival of the species. The species was confirmed at this location in 1999, although there are no recent records, which would indicate that the habitat is critical to the survival of an individual or established pairs. This impact is likely to affect life cycle activities for localised populations. However, the distribution and abundance of populations over this scale is not known.

There are widespread potential habitats in the Hunter Wetlands National Park and Hexham Swamp Nature Reserve and contiguous wetland habitats (coastal wetlands) in the locality. It is assumed that these habitats also contribute to the long-term maintenance of the species including maintaining genetic diversity and the long-term evolutionary development of the species.

5. disrupt the breeding cycle of a population

On the basis that the construction stage would extend over two to three years, there is potential for the activity to disrupt the breeding cycle of at least one breeding pair. The scale of this disturbance, however, would not impact on a regional population which may extend to the considerably large wetlands of the Hunter Wetland National Park and Hexham Swamp Nature Reserve.

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 proposed action would result in direct impacts to about 43.64 hectares of associated habitat across the construction footprint, with around five hectares of high-quality habitat at Windeyers Creek, which may be considered suitable for this species. While the distribution and abundance of populations over this scale is not known there are large areas of suitable habitat in the Hunter Wetlands National Park, Kooragang Nature Reserve and Hexham Swamp Nature Reserve in addition to numerous non-listed wetlands in the region. It is assumed that these habitats also contribute to the long-term maintenance of the species and recruitment into other habitats.

7. **result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat**

The potential for weed invasion has been considered possible with a proposed action of this nature and appropriate controls have been provided during the construction and operation of the road to reduce this threat as it may have long term implications for the habitat of threatened species. The management of invasive species would be managed under the CEMP and during operation of the highway.

8. **introduce disease that may cause the species to decline**

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 of the species. 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 mitigation strategy and environmental management procedures for the proposed action 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 proposed action would not conflict with the recovery of this species. The route for the proposed action has been selected on the basis of avoiding high quality wetland habitats for threatened fauna, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the construction footprint.

Conclusion

The proposed action may result in a reduction of 43.64 hectares of suitable associated habitat for this species and may impact on future use of Windeyers Creek wetland as breeding habitat for a single pair. The proposed action is unlikely to reduce the local or regional population size of the Australasian Bittern. The proposed action would not interfere with the recovery of the Australasian Bittern. After consideration of the factors above, an overall conclusion has been made that the proposed action is unlikely to result in a significant impact to the Australasian Bittern.

Australian Painted Snipe (*Rostratula australis*)

The Australian Painted Snipe is considered likely to occur based on the presence of suitable habitat.

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 would:

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

The Australian Painted Snipe is widespread across Australia with most observations recorded in the Riverina, Sydney Basin and southeast Queensland regions. There are many records in 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 Valley and Lower Hunter Valley (OEH 2013).

There are few records of the Australian Painted Snipe in the locality, but the species may occasionally visit wetlands and floodplains associated with the Hexham Swamp and Hunter River floodplain in areas affected by the proposed action. There are about 43.64 hectares of potential wetland habitat surrounding the construction footprint that may be impacted and include areas grazed with limited and disturbed aquatic vegetation. These habitats would not support an ecologically significant proportion of the Australian Painted Snipe population, however, may be visited occasionally. The habitat adjoins large areas of contiguous wetland within the coastal wetland and Hexham Swamp Nature Reserve that may also be used by the species. The small area of disturbance along the edge of the wetland habitat would not lead to a long-term decrease in the size of the Painted Snipe population.

2. reduce the area of occupancy of a species

The Australian Painted Snipe prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Australian Painted Snipe occupation in suitable habitat has not been recorded in the construction footprint. A review of potential habitat available to this species, suggests that habitat is widespread throughout the survey area including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands. Of the potential wetland habitat next to the construction footprint and impacted by the proposed action, this represents a very small percentage of the habitat available to the Hunter Estuary Ramsar wetland, Kooragang Nature Reserve and Hexham Swamp Nature Reserve which are all within two to three kilometres of the construction footprint.

Potential indirect impacts resulting from the proposed action of relevance to this species include alterations to habitat attributes through changes in hydrological and nutrient regimes within habitats downstream of the construction footprint. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. Management measures to be implemented during construction and the implementation of specific design features are likely to minimise these indirect impacts. These would include measures to ensure that vegetation clearing is confined strictly to the construction footprint and surrounding vegetation and measures to control soil and water runoff from construction areas.

Impacts on water quality could occur due to erosion and sedimentation. Disturbance of acid sulphate soils is also possible and creates the potential for oxidation of these soils and subsequent generation of acidic run-off. These have the potential to indirectly impact potential habitat for this species downstream of the proposed action. Management measures to be implemented during construction and would include the preparation of a comprehensive soil and water management plan and an acid sulphate soils management sub-plan as part of the CEMP. This would include a contingency plan to deal with the unexpected discovery of actual or potential acid sulphate soils, a water quality monitoring program and measures to manage acid sulphate soil impacts.

There would be limited impacts to potential habitat which would be ameliorated through the implementation of management measures, the proposed action is unlikely to reduce the area of occupancy of the Australian Painted Snipe.

3. fragment an existing population into two or more populations

The proposed action would increase the fragmentation of habitat in the landscape by impacting on contiguous forest and grassy wetland areas. The species may use the habitats of the construction footprint for foraging or breeding, or as a temporary stopover when migrating between other areas of higher quality habitat. However, there is no evidence that the construction footprint supports an important population of this species. Furthermore, the species is migratory and travels long distances between isolated wetlands.

Given the mobility of the species and presence of suitable protected habitat for this species throughout the locality and region, it is unlikely that the proposed action would fragment an existing population into two or more populations.

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

Habitat important to the breeding of this species is specific: shallow wetlands near areas of bare, wet mud and upper and canopy cover. The species forages in temporary and permanent lakes, swamps, clay pans, inundated/waterlogged grasslands or saltmarsh, dams, rice crops, sewage dams and bore drains (DSEWPaC, 2012).

The proposed action would result in direct impacts to about 43.64 hectares of potential grassland / marshy wetland habitat and potential indirect impacts to associate floodplains of the Hunter River. This impact is unlikely to affect life cycle activities of Australian Painted Snipe populations potentially occurring in the area. The distribution and abundance of populations over this scale is not known.

The habitats within the construction footprint are not known to provide long-term maintenance of the species. While the presence of potential habitat for this species has been identified in the construction footprint and would be impacted to a small degree as discussed previously, this habitat is not considered critical to the survival of the species in Australia.

5. disrupt the breeding cycle of a population

The Australian Painted Snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains (Marchant & Higgins, 1993). It may breed in response to wetland conditions rather than during a particular season and has been recorded breeding in all months in Australia.

The Australian Painted Snipe could potentially use the wetlands of the Hunter River floodplains around Tarro as foraging habitat, however the areas next to the proposed action are grazed and degraded, with minimal vegetation cover and are therefore of very limited potential as breeding habitat.

Higher condition habitats are located well away from the construction footprint of the proposed action within coastal wetland and Hexham Swamp Nature Reserve. It may use the habitats within the proposed action footprint as a temporary stopover when migrating between other areas of higher quality habitat.

While construction of the proposed action would extend over two to three years, it is unlikely that this activity would disrupt the breeding cycle of the Australian population. Measures to minimise impacts on waterways during construction are to be implemented as part of the CEMP, which would serve to mitigate potential impacts to the breeding cycle of the population.

Given the absence of any evidence of a population within the construction footprint and the small area of impact on low condition wetland habitat, the proposed action is unlikely to disrupt the breeding cycle of a population of the Painted Snipe.

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

There are few records of the Australian Painted Snipe in the locality, but the species may occasionally visit wetlands and floodplains associated with the Hunter River, and has been recorded in Kooragang Nature

Reserve, which is about two to three kilometres south of the construction footprint. This species is migratory and travels long distances between isolated wetlands. The proposed action would not isolate any areas of habitat for the species.

The quality of potential wetland habitats within the construction footprint are generally in low to moderate condition as a result of a long-history of cattle grazing. The proposed action would include the removal of 43.64 hectares of low condition freshwater wetland habitat in the form of ephemeral marshy and grassed habitat, comprising a very small percentage of the habitat available in the wider Hexham and Kooragang area.

Potential indirect impacts such as the alteration of the floristic composition and vegetation structure and water quality of adjacent wetland habitats through sediment, pollution, acidic run-off and weeds would be managed through management measures implemented via the CEMP.

Based on the above considerations, the proposed action is considered 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 critically endangered or endangered species' habitat

Given the nature and extent of the proposed action, weed invasion is considered possible. Weed invasion may have long term implications for the potential wetland habitat of the Australian Painted Snipe. Accordingly, although the potential Australian Painted Snipe habitats within the construction footprint are not known to provide long-term maintenance of the species, management of invasive species would be required during the construction and operation of the road, under the guidance of the CEMP, to reduce this threat. It is therefore unlikely that the proposed action would result in the establishment of invasive species in the Australian Painted Snipe's habitat that would be harmful to the species.

8. introduce disease that may cause the species to decline

Phytophthora cinnamomi (Root Rot Fungus) and Myrtle Rust infection of native plants has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the proposed action has the potential to transmit the fungus to remaining vegetation in wetland remnants of potential habitat for the Australian Painted Snipe. This in turn could result in dieback of this potential habitat, with impacts for the Australian Painted Snipe.

Phytophthora is not a threat to plant communities on the NSW North Coast as cases of *Phytophthora* dieback are rarely reported from this region (Benwell, 2013). *Phytophthora cinnamomi* has been isolated from rainforest in eastern Australian soils where it appears to be indigenous and the local flora adapted to its presence in the soil. Myrtle Rust in unlikely to affect Australian Painted Snipe habitat as it affects plants in the plant family Myrtaceae. To minimise the chance of introducing new plant pathogens, however, machinery would be washed down before moving from area to area and personnel excluded from walking through habitat areas unless necessary.

In conclusion, the proposed action has potential to introduce disease that may cause the species to decline and proven management measures for prevention of the introduction and spread of disease would therefore be implemented during construction.

9. interfere substantially with the recovery of the species.

There is no recovery plan for the Australian Painted Snipe in Australia. A number of recovery actions have been identified by Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012). Important to this species' recovery is the identification and protection of any habitat used by the species in the last 10 years.

The proposed action would not conflict with the recovery of this species as the habitat to be removed is not considered to comprise principal breeding wetlands or critical habitat given it is of small extent on a local and regional basis and is degraded and modified.

Conclusion

The proposed action may have minor impacts to the potential habitat of this wide-ranging species. General management measures such as the control of weeds, limiting impacts on hydrology and water quality and controlling the introduction and spread of disease, would be implemented to minimise disturbance to any remaining habitats. In conclusion the Assessment of Significance has found that it would be unlikely that the proposed action would have a significant impact on the Australian Painted Snipe.

Regent Honeyeater (*Anthochaera phrygia*)

The Regent Honeyeater (*Anthochaera phrygia*) is considered likely to occur based on the presence of suitable habitat and known winter-flowering food resources.

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

In 2011, the Regent Honeyeater's population was estimated with medium reliability at between 350 and400 mature birds. The majority of these birds exist in the Bundarra-Barraba area and the Capertee Valley in NSW, and north- eastern Victoria. Mapped areas of important habitat also occur in the Cessnock-Kurri Kurri area. The impacts to around 81 hectares of potential foraging habitat in the construction footprint are considered unlikely to lead to a long-term decrease in the size of the Regent Honeyeater population as the proposed action will not impact on the critical remaining strongholds of the species or an area of known important habitat for breeding or foraging.

2. reduce the area of occupancy of the species

The Regent Honeyeater is endemic to south-east Australia, where it is widespread but with an extremely patchy distribution. The Regent Honeyeater's area of occupancy is estimated at 300 square kilometres but in NSW, the Regent Honeyeater has an area of occupancy of less than 200 square kilometres. This species is noted as being largely absent around Sydney.

The proposed action will not reduce the current area of occupancy for the Regent Honeyeater as there will be no impact to important mapped habitat areas.

3. fragment an existing population into two or more populations

Importantly, the proposed action will not result in fragmentation of habitat for the Regent Honeyeater. This species is highly mobile and capable of long-distance flight. However, movements between breeding populations are not frequent and most birds appear to remain in the breeding areas of Bundarra-Barraba area and the Capertee Valley in NSW, and north-eastern Victoria.

The proposed action is considered unlikely to fragment the existing population as movement corridors between the three main populations will still remain after the road has been built.

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

Key habitats for this species include key breeding areas such as the Chiltern section of Chiltern-Mt Pilot National Park (NP), north-east Victoria; Capertee Valley, central east NSW; and the Bundarra-Barraba region, northern NSW. Other breeding areas include the Wangaratta-Mansfield region, Victoria; Warrumbungle NP, Pilliga forests and Mudgee-Wollar region, central north NSW; Hunter Valley (Cessnock-Kurri Kurri area) and Clarence Valley, east NSW; and south-east Queensland.

The construction footprint is not situated in a key breeding area for the Regent Honeyeater. The habitat within the construction footprint is considered to be secondary habitat for the Regent Honeyeater as this species is not regularly recorded in the area and the area is not known as critical habitat.

5. disrupt the breeding cycle of a population

The key breeding areas for the Regent Honeyeater are the Chiltern section of Chiltern-Mt Pilot National Park (NP), north-east Victoria; Capertee Valley, central east NSW; and the Bundarra-Barraba region, northern NSW. Other breeding areas include the Wangaratta-Mansfield region, Victoria; Warrumbungle NP, Pilliga forests and Mudgee-Wollar region, central north NSW; Hunter Valley and Clarence Valley, east NSW; and south-east Queensland.

The proposed action will not impact on breeding habitat for this species. Additionally, important winter foraging grounds and areas of important habitat 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

Potential foraging habitat for this species will be reduced by about 81 hectares. The species is an occasional visitor to the region and may utilise trees in the construction footprint for foraging intermittently when no other suitable resources are available. The proposed 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.

The habitat to be impacted has not been identified as important habitat in a habitat model developed by Birdlife Australia (2013) for the lower Hunter region.

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 habitat for the Regent Honeyeater are weeds. Noisy Miners are abundant in the habitat which may make the habitat less suitable for the Regent Honeyeater due to competitive exclusion. The proposed 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 CEMP 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 of the species. 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 mitigation strategy and environmental management procedures for the proposed action 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 Regent Honeyeater Recovery Plan 1999-2003 (Department of Natural Resources and Environment, 1999) outlines recovery actions for the species. These include:

- Project management: Continue to manage the Recovery Team and full-time Coordinator; increase the contribution of the NSW Government to program management; encourage greater input from the Queensland and ACT wildlife agencies; encourage and direct the contributions of Operations Groups centred on regions containing key habitat; increase the effectiveness of collaboration with the Swift Parrot Recovery Team

- Habitat management: Rehabilitation and revegetation are best achieved by facilitating community ownership and participation in these activities. Expand the composition, influence and resources of Operations Groups in the four key regions so that they are able to implement regional works plans; prepare regional guidelines for management of Regent Honeyeater habitat, ensure that regional ecosystem management plans take account of the guidelines and promote them to landholders and agency staff. Obtain agreements to undertake cooperative work with landholders to alleviate threats. Prepare bids for funding from Bushcare to allow operations groups to shoulder their increased responsibilities. Where shown to be necessary, active management of populations of predators and competitors should be carried out
- Population monitoring: Initiate a population monitoring program at the three main breeding areas; take full advantage of the existing sightings database and the Birds Australia Bird Atlas Project to elucidate distribution patterns and the magnitude of the range reduction over recent decades
- Ecological research: Initiate innovative research into movement patterns, particularly post breeding, and the degree of isolation between breeding populations; investigate the impact of Noisy Miners on population stability and undertake a comparison of resource utilisation between northern NSW and Victoria
- Community education and participation: Conduct a public education program about the species and its requirements, aimed particularly at developing habitat management partnerships with landowners within the range of the species; establish an educational Regent Honeyeater exhibit at Taronga Zoo. Produce a semi-annual newsletter
- Captive management: Maintain a viable captive population, spread across at least three ARAZPA institutions, to act as insurance against the demise of the wild population; conduct trials of hard-release techniques; complete the captive husbandry manual and a guide to aging and sexing Regent Honeyeaters.

The recovery actions listed above to help recover the Regent Honeyeater are largely not applicable to the proposed action. The proposed action will not interfere with the recovery of the Regent Honeyeater.

Conclusion

The proposed action would result in a small reduction in the extent of potential non-breeding foraging habitat for this species. However, impacts are predicted to be minimal as this species is unlikely to use the construction footprint consistently. The proposed action is unlikely to reduce the population size of the Regent Honeyeater or decrease the reproductive success of this species. The proposed action would not interfere with and key breeding sites or foraging areas and will not interfere with the recovery of the Regent Honeyeater. After consideration of the factors above, an overall conclusion has been made that the proposed action is unlikely to result in a significant impact to the Regent Honeyeater.

Swift Parrot (*Lathamus discolor*)

The Swift Parrot (*Lathamus discolor*) is considered likely to occur based on the presence of suitable winter foraging habitat.

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 construction footprint contains some potential foraging habitat for the Swift Parrot. While the habitat in the construction footprint is not optimal, the loss of potential feed trees would directly affect the species opportunity to feed in the area. However, the construction footprint is not considered a critical area for the Swift Parrot. The Swift Parrot may utilise trees in the construction footprint 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 proposed action would remove about 82 hectares of potential foraging habitat.

The Swift Parrot does not breed in the construction footprint and the extent of habitat remaining in the construction footprint would provide sufficient resources to sustain future visitation, such that the proposed action is unlikely to lead to a long-term decrease in the size of the Australian population. A report and model on the distribution of important habitat in the lower Hunter region has not identified this area as important habitat (Birdlife Australia 2013).

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 construction footprint for foraging intermittently when no other suitable resources are available.

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

3. fragment an existing population into two or more populations

Importantly, the proposed action will not result in fragmentation of habitat for 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 proposed 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 (*Eucalyptus robusta*), Red Bloodwood (*Eucalyptus gummifera*) and Forest Red Gum (*Eucalyptus tereticornis*) forests. The construction footprint supports stands of each of these tree species, hence why suitable habitat for this species is considered to be present. The habitat within the construction footprint is considered to be secondary habitat for the Swift Parrot as this species is not regularly recorded from the construction footprint and it 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 proposed action would 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 81 hectares. As a long distant migratory species, 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 construction footprint for foraging intermittently when no other suitable resources are available. The proposed 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. Noisy Miners are abundant in the habitat which may make the habitat less suitable for the Swift Parrot due to competitive exclusion. The proposed 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 CEMP 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 of the species. 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 mitigation strategy and environmental management procedures for the proposed action 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) identifies the following actions for recovery of this species:

- Identify the extent and quality of habitat
- Manage and protect Swift Parrot habitat at the landscape scale
- Monitor and manage the impact of collisions, competition and disease
- Monitor population and habitat.

The recovery actions listed above to help recover the Swift Parrot are largely not applicable to the proposed action. The proposed action will not interfere with the recovery of the Swift Parrot (*Lathamus discolor*).

Conclusion

The proposed action would result in a small reduction in extent of foraging habitat. The proposed action is unlikely to reduce the population size of the Swift Parrot or decrease the reproductive success of this species. The proposed action would not interfere with the recovery of the Swift Parrot. After consideration of the factors above, an overall conclusion has been made that the proposed action is unlikely to result in a significant impact to the Swift Parrot.

Spotted-tailed Quoll (*Dasyurus maculatus*)

The Spotted-tailed Quoll is considered moderately likely to occur based on the presence of large expanse of forested habitat extended from Tomago and Heatherbrae to the east to Williamtown, Salt Ash and Lemon Tree Passage. There are records of the species from the Tomago Sandbeds which are contiguous with the forest at the northern of the proposed action. The species has a much lower chance of occurring at the western end of the proposed action at Black Hill due to the degree of disturbance, human activity and smaller fragmented nature of the forest habitat at this location.

Up to 50 hectares of forest habitat would be cleared along the western edge of this large expanse that could potentially be used by this species. The highway upgrade is not expected to create a significant barrier for this species due to absence of large expanses of habitat to the north of the existing highway or the new upgrade.

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 would:

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

The Spotted-tailed Quoll is considered likely to occur based on the presence of large expanse of forested habitat extended from Tomago and Heatherbrae to the east to Williamtown, Salt Ash and Lemon Tree Passage continuing through to Anna Bay and Nelson Bay. The area of potential habitat for a local population is very extensive and the area impacted by the proposed action is relatively small and occurs on the western edge of this large expanse. The extent of habitat remaining in the locality would provide sufficient resources to sustain this species, such that the proposed action is unlikely to lead to a long-term decrease in the size of the population.

2. reduce the area of occupancy of a species

Radio-tracking studies (Claridge et al., 2005) of the Spotted-tailed Quoll in Kosciuszko NP in 2002 resulted in home range estimates of between 620 and 2,560 hectares for males, and between 90 and 650 hectares for females. It is evident that this species occupies very large areas of habitat. The proposed action would contribute to the loss of habitat for this species from the wider locality, however given the location of this habitat along the edge of a considerably larger core area of habitat it is not likely that the area of occupancy would be reduced.

3. fragment an existing population into two or more populations

Importantly, the proposed action would not result in fragmentation of habitat for the Spotted-tailed Quoll. The highway upgrade is not expected to create a significant barrier for this species due to absence of large expanses of habitat to the north of the existing highway or the proposed action.

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

The Spotted-tailed Quoll prefers mature wet forest habitat (Belcher, 2000; Green & Scarborough, 1990; Watt, 1993), especially in areas with rainfall 600 millimetres per year (Edgar & Belcher, 2008; Mansergh, 1984). Unlogged forest or forest that has been less disturbed by timber harvesting is also preferable (Catling et al. 1998, 2000). The habitats over the Tomago Sandbeds have been affected by sand mining and timber harvesting, however in general and due to the low fertility soils, these forests have minimal disturbance suggesting that they may be critical for the survival of this species in the region. Up to 47 hectares of forest habitat would be cleared along the western edge of this large expanse that could potentially be used by this species.

5. disrupt the breeding cycle of a population

The species is unlikely to be directly dependent on the edge habitat for breeding. The large expanses of core habitat provide sufficient opportunities for breeding pairs, and the proposed action is not expected to disrupt breeding cycles of established territories.

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 proposed action would have an impact on up to 50 hectares of habitat along the western edge of a large expanse of similar and better-quality habitat extending to the east. The area of disturbance in the construction footprint represents a small proportion of the potential habitat available in the locality for this species. This species is expected to continue using the remaining habitats in the construction footprint and the proposed 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 critically endangered or endangered species' habitat

The potential for weed invasion was considered possible with a proposed action 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 CEMP and during operation of the proposed action using best practice methods.

8. introduce disease that may cause the species to decline

There are no known disease issues affecting this species in relation to the proposed action.

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 for the proposed action has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the proposed action. 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.

9. interfere substantially with the recovery of the species.

There is no recovery plan for this species, important management actions would aim to address threats to the species such as predation and loss of habitat. The proposed action would remove an area of potential habitat although is not expected to directly increase the threat of predation.

Conclusion

The proposed action would result in the relatively small reduction of potential habitat for the Spotted-tailed Quoll from the large expanse of available habitat for this species in the locality. The proposed action is unlikely to reduce the population size of this species or decrease its reproductive success. The proposed action is unlikely to result in a significant impact to the Spotted-tailed Quoll.

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

The Grey-headed Flying-fox (*Pteropus poliocephalus*) was identified in the survey area during the surveys. All forest and woodland habitat in the survey area is considered foraging habitat critical to the survival of the species. The Grey-headed Flying-fox exists as a single interconnected population in Australia. As such, it is considered an important population.

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 survey area or construction footprint and the proposed action will not impact on any known permanent roosting, breeding / maternity site. Therefore, it is likely that the impacts of construction and operation of the proposed action would be confined to loss of foraging resources 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 proposed action would directly remove up to 85 hectares of potential foraging habitat. 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 proposed action and the five nationally important roost camps within a 50 kilometres radius (Raymond Terrace two kilometres from the proposed action, Carrington Mangroves 10 kilometres from the proposed action, Blackbutt Reserve 12 kilometres from the proposed action, Glen William 28 kilometres from the proposed action and Cessnock 34 kilometres from the proposed action). 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 proposed action 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 proposed action. No impact to area of occupancy is expected.

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 proposed action 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.

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 survey area, or the construction footprint and the construction footprint does not provide critical roosting habitat. However, there are five nationally important roost camps within a 50 kilometre radius of the study area (Raymond Terrace – two kilometres from the proposed action, Carrington Mangroves – 10 kilometres from the proposed action, Blackbutt Reserve – 12 kilometres from the proposed action, Glen William – 28 kilometres from the proposed action and Cessnock – 34 kilometres from the proposed action). 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 greater than 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 (September to 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 construction footprint would constitute critical foraging habitat. However, the affected area of critical foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the camp sites described. Given the relative widespread nature of similar vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the proposed action 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 proposed action would not directly impact on a known roost camp breeding or maternity site.

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 within the survey area. Further, there would be a relatively minor impact on critical foraging habitat as a result of the proposed action. This impact is not expected 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 proposed 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 proposed action of this nature and appropriate controls are required during construction and operation to reduce this threat. The management of invasive species would be managed under the CEMP 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 this species in relation to the proposed action. The proposed 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*) 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 proposed action and accordingly the proposed action is not expected to interfere substantially with the recovery of the species.

Conclusion

The Grey-headed Flying-fox will experience a small reduction in extent of suitable foraging habitat from the proposed action. No breeding camps or other important habitat will be impacted. The proposed action is unlikely to reduce the population size of the Grey-headed Flying-fox or decrease the reproductive success of this species. The proposed 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 proposed action is unlikely to result in a significant impact to the Grey-headed Flying-fox.

Koala (*Phascolarctos cinereus*)

It is recognised that the northern part of the proposed action occurs in Port Stephens Council LGA which is noted for one of the largest coastal populations of Koala in eastern Australia. The proposed action has been designed to avoid and minimise the loss of mature forest by passing as close to the existing Pacific Highway from Tomago to Heatherbrae where possible, and by flanking the edge of forest in this location. It is evident that the construction footprint is on the furthest western extent of the large expanse of habitat from Tomago through to Tilligerry, Williamtown and Grahamstown Dam that is available to Koalas.

There are about 2000 Koala records within a 10 kilometre radius of the proposed action. The majority of these records are located on the northern side of the Hunter River in the Port Stephens Council LGA and associated with the large contiguous forests to the east of the existing Pacific Highway at Heatherbrae through to Tomago Road and also to the north of Raymond Terrace surrounding Grahamstown Dam.

While scattered Koala records show that the Port Stephens Koala population does extend across the northern part of the proposed action either side of Masonite Road, it is evident that this proposed action would have minimal impact to the population in terms of absolute habitat loss, and minimal impact to movements of the species. There would be direct impacts through clearing of around 51 hectares of habitat containing koala food tree species, along the road corridor which includes indirect loss though fragmentation.

Targeted surveys for Koala involved daytime searches, spotlighting and call playback at each mammal trap site in addition to scat searches across the survey area. No evidence of Koalas was recorded however, the survey area occurs along the edge of very large expanse of habitat extending to the east which is known Koala habitat. Koala activity could be expected to be less in the edge habitat given the size of the core area, so this result is not unusual, and would suggest infrequent habitat use in the construction footprint, despite the presence of potential habitat.

Three primary feed tree species were identified within the survey area: Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*Eucalyptus tereticornis*) and Drooping Red Gum (*Eucalyptus parramattensis subsp decadens*). Two secondary Koala feed tree species were also identified: Grey Gum (*Eucalyptus punctata*) and Red Mahogany (*Eucalyptus resinfera*).

The impact to potential Koala habitat has been minimised by situating the proposed action as close as possible to the existing highway between Tomago Road and Masonite Road where the area of potential Koala habitat predominantly occurs. The results of modelling Koala habitat by DoEE are shown in relevance to the northern section of the project in Figure D-1 below, as reported in Eco Logical Australia (2013). The proposed action will indirectly impact (fragment) two areas identified as very high-quality habitat (shown in dark purple and identified for this assessment as Site A and Site B) by fragmented from currently connected areas.

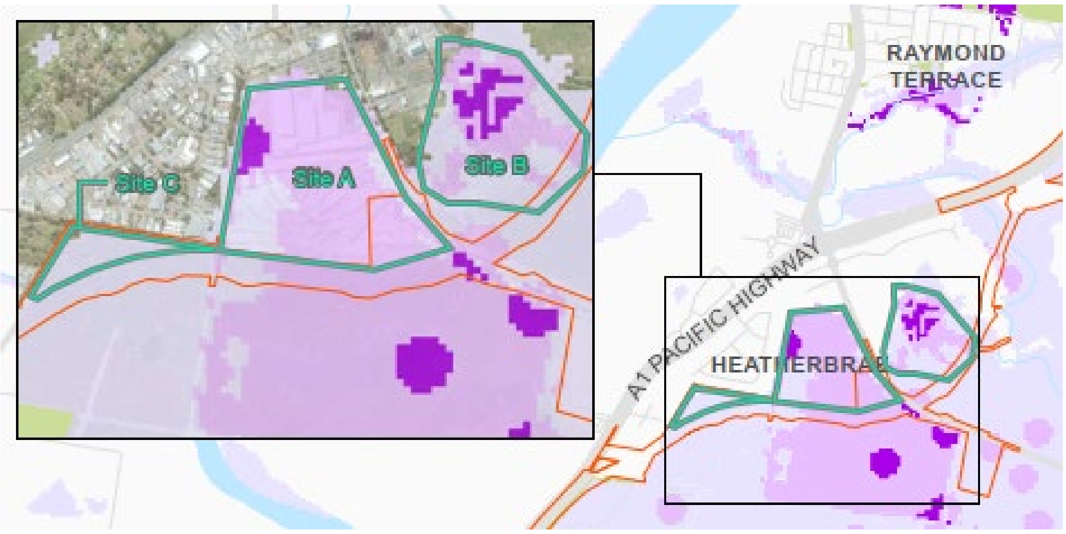


Figure D-1. Regional koala habitat modelling data (EcoLogical 2013) of relevance to the northern extent of the study area near Masonite Road

Scat searches were conducted for this assessment on Site B and did not find any evidence of Koala activity but did confirm the presence of scattered Forest Red Gum (*Eucalyptus tereticornis*), which is a primary feed tree species. Most of the impact to Site A and Site B would involve the fragmentation / isolation of these two habitat patches. However, as part of a separate approved development application, Site A was cleared in 2014 and therefore would not be fragmented. All vegetation north of the proposed action has now been removed by an approved development. Additionally, Site B is the subject of an approved subdivision development application and is expected to be cleared in the future. If clearing occurs before the proposed action commences construction, the proposed action will no longer fragment vegetation in this area. Therefore, for the purpose of this assessment, both Site A and Site B have been excluded from Koala habitat impact calculations. The only fragmentation and isolation of koala habitat would occur at Site C. This patch of vegetation is bordered to the north and west by the industrial area and would be isolated from the large expanse of habitat continuing east from the construction footprint. This vegetation is modelled and shown in Figure D-1 as moderate and low-quality habitat for the Koala. Given the small area of this patch and the surrounding roads and development, the need to provide connectivity was reviewed and considered unnecessary for the survival of the local population. This is particularly the case given the large expanses of habitat to the south. Mitigation is proposed at this location in the form of an exclusion fence to prevent Koalas from accessing the road corridor of the proposed action (see **Section 9.1** and **Figure 9-1**).

A series of connectivity workshops were held to assess the barrier effect of the upgrade to the Koala and identify opportunities for mitigation. There is one current opportunity for Koalas to cross the existing Pacific Highway to the immediate north of the proposed action under the existing Grahamstown Drain bridge. The bridge is about 200 metres long and provides connectivity between patches of Koala habitat on both sides of the Pacific Highway. It is unknown if this crossing point is in use, however there are numerous Koala records on both sides of the Pacific Highway, and the large structure is well positioned in the landscape. Consideration was given to the need for additional underpasses to connect Koala habitat.

The proposed action would isolate one small area of habitat at Heatherbrae for the Koala. This small area of habitat is around seven hectares in size and would be surrounded on all sides by development and roads. As such the value of the habitat for Koalas is limited and the need for connectivity was not considered productive for the local population. This is reinforced by the large expanse of Koala habitat that would remain on the eastern side of the proposed action and Pacific Highway through the Tomago Sandbeds. As the proposed activity would not sever an important link for Koalas or isolate important Koala habitat, specific connectivity measures were not required.

Habitat for the Koala is widespread to the east and south of the existing Pacific Highway near the proposed action. The existing Pacific Highway presents a significant barrier for potential northern movements and dispersal by Koala. The proposed action is not predicted to sever any important link for Koalas in the landscape.

In order to make an assessment of whether the impacts of the proposed action would be likely to have a significant impact on the Koala, the background review and field survey data has been used to assess the sensitivity, value and quality of the Koala habitat in the impact area. These attributes have been assessed using the Koala habitat tool (DoE 2014) to determine whether habitat critical to the survival of the species is present. According to the guidelines, impact areas that score five or more using the habitat assessment tool for the Koala contain habitat critical to the survival of the Koala (DoE 2014). The outcomes of the Koala habitat assessment tool indicate that the habitat in the impact area scores six, and therefore contains habitat critical to the survival of the Koala. However, given the location of the proposed action, the findings from the background review, spatial review and field surveys, and the outcomes of the Assessment of Significance, the proposed action is not expected to significantly impact on the Koala.

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

The project would directly impact around 51 hectares of potential koala habitat. This is based on the loss of modelled koala habitat provided by the Lower Hunter Koala Study (Eco Logical Australia, 2013) and the results of the targeted surveys considered for this assessment, as well as areas of land that have been cleared since the model was prepared.

With regards to possible isolation of habitat, there are two areas of very high habitat value shown on the Lower Hunter Koala map to the east and west of Masonite Road that would be intersected by the proposed action. The area to the west of Masonite Road was cleared in 2014 for an approved development application (an industrial subdivision). The land to the east of Masonite Road was ground-truthed during surveys for the proposed action and found to comprise predominantly planted pine trees, with a very low density of scattered Forest Red Gum and very high weed abundance. This land is also the subject of an approved subdivision development application and is likely to be cleared in the future. If the clearing occurs before the proposed action is built, the proposed action will no longer fragment vegetation in this area. The remainder of the proposed action is positioned along the edge of the forest habitat with cleared land to the north. There are no Koala records at the western end of the proposed action near the M1 Pacific Motorway, and the proposed action would not remove potential habitat in this location.

The construction footprint is located on the western extent of the Tomago Sandbeds. Koala populations reportedly extend from Tomago through to the eastern end of the LGA, including Anna Bay, Nelson Bay, Tilligerry and Lemon Tree Passage. This is a known important population. The small area of habitat loss along the edge of the existing Pacific Highway between Tomago and Heatherbrae is unlikely to result in a long-term decrease in the size of this important population. The proposed action has been positioned to avoid important habitat and it is evident that no significant movement corridors or isolation of habitat would occur.

2. reduce the area of occupancy of an important population

The proposed action will directly remove about 51 hectares of vegetation that is modelled as habitat for the Koala population and potentially isolate an additional small area of disturbed habitat (5.3 hectares) mapped as moderate quality habitat (Site C). Sites A and B are not considered in this assessment as they are already cleared (A) or approved for clearing (B). Scat searches conducted along the alignment of the proposed action and specifically within the to-be-isolated fragments did not find any evidence of Koala activity within the areas identified as high and very high-quality Koala habitat. It is considered unlikely that this small loss would reduce the area of occupancy for the Koala. This is based on significantly large areas of very high and high-quality habitat that have been modelled to occur to the east and north of the construction footprint (Eco Logical Australia, 2013), throughout the range of the Port Stephens Koala population.

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

The existing Pacific Highway represents a major barrier to north-south Koala movements from the crossing of the Hunter River north to Grahamstown Dam. The proposed action has been designed to minimise impacts to vegetation contained on Hunter Water Corporation land, through placement of the road design on the edge of the large expanse of vegetation and located as close to the existing Pacific Highway as possible. The proposed action would further isolate one small patch of habitat and isolate a new patch of moderate value habitat (Site C). Site A is already cleared, and Site B is the subject of an approved subdivision development application. Therefore, these two sites were not included in this assessment.

Given the small area of this patch (Site C) and the surrounding roads and development, the need to provide connectivity was reviewed and considered unnecessary for the survival of the local population. This is particularly the case given the large expanses of habitat to the south. Mitigation is proposed at this location (Site C) and adjacent to other identified potential habitats in the form of an exclusion fence to prevent Koalas from accessing the road corridor.

The proposed action is not expected to fragment an important population of this species.

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

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The proposed action would directly impact to up to 51 hectares of potential habitat according to the modelling presented in Eco Logical Australia (2013) and additional 5.3 hectares would be isolated. No evidence of Koala activity was confirmed along the corridor for a survey of eight spotlight sites and 62 scat search plots.

As such, the proposed action is unlikely to impact habitat critical to the survival of the species.

5. disrupt the breeding cycle of an important population

If individual Koalas are using the edge habitat along the existing highway there is potential to disrupt the breeding cycle of a small number of animals. This impact would be minor relatively to the greater extent of the Port Stephens Koala population.

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 action would have an impact of up to 51 hectares of potential Koala habitat and contribute to the fragmentation of potential habitat in the landscape, which includes the fragmentation of a further 5.3 hectares. The decrease is minor relative to the extent of core Koala habitat throughout the Port Stephens Council LGA as identified in the Comprehensive Koala Plan of Management (Port Stephens Council and Australian Koala Foundation, 2002). It is unlikely that the proposed action would directly lead to the decline of the species in the locality.

Management measures such as connectivity and fencing to minimise road kills to Koalas would be implemented as part of the EIS. These measures would be identified to address significant threats to Koala populations in Port Stephens.

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

The potential for weed invasion was considered possible with an action of this nature and appropriate controls are required during construction and operation to reduce this threat. The management of invasive species would be managed under the CEMP and during operation using best practice methods.

8. introduce disease that may cause the species to decline

The proposed action will not be directly responsible for introducing disease known to affect Koala populations, such as Chlamydia.

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 for the proposed action has the potential to transmit the fungus to remaining native vegetation remnants of the species. 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.

9. interfere substantially with the recovery of the species

The National Recovery Plan for the Koala (DECC, 2008) identifies the following objectives for recovery of this species:

- To conserve Koalas in their existing habitat
- To rehabilitate and restore Koala habitat and populations
- To develop a better understanding of the conservation biology of Koalas
- To ensure that the community has access to factual information about the distribution, conservation and management of Koalas at a national, state and local scale
- To manage captive, sick or injured Koalas and orphaned wild Koalas to ensure consistent and high standards of care
- To manage over browsing to prevent both Koala starvation and ecosystem damage in discrete patches of habitat
- To coordinate, promote the implementation and monitoring the effectiveness of the NSW Koala Recovery Plan across NSW.

The proposed action will not interfere with any of the objectives identified in the National Recovery Plan.

Conclusion

It is recognised that the northern part of the proposed action occurs in Port Stephens Council LGA which is noted as being the location of one of the largest coastal populations of Koala in eastern Australia. Large expanses of known and potential koala habitat occur to the east of the Pacific Highway. The proposed action has been designed to avoid and minimise the loss of mature forest by running as close as possible to the existing Pacific Highway from Tomago to Heatherbrae and also by flanking the edge of the forest in this location.

Scattered Koala records show that the Port Stephens Koala population does extend across the northern part of the construction footprint on both sides of Masonite Road. It is evident, however, that the proposed action would have a minimal impact to the population in terms of absolute habitat loss and impacts to movements of the species. Clearing as part of other developments in the area are also likely to reduce the likelihood of the proposed action causing fragmentation. There are current opportunities for Koalas to cross the existing Pacific Highway to the immediate north of the proposed action and the construction footprint does not isolate a significant area of habitat or disrupt apparent important landscape links for this species. Fauna connectivity and management measures have been prepared as part of the BAR (see **Chapter 9**) for the proposed action, which identifies additional measures to ensure that Koalas do not enter the road corridor and that suitable connectivity is provided where movement opportunities may occur.

Given the position of the proposed action, the findings from the background review, spatial review and field surveys, and the outcomes of the Assessment of Significance, the proposed action is not expected to significantly impact on the Koala.

New Holland Mouse (*Pseudomys novaehollandiae*)

The New Holland Mouse was not identified during surveys for this assessment however is considered moderately likely to occur within the construction footprint based on the presence of suitable habitat. The species favours open forest habitats on sandy soils which are consistent with the Smooth-barked Apple-Blackbutt Forest (PCT 1646) next to and between the Hunter Region Botanic Gardens and Masonite Road at Heatherbrae. The proposed action would impact on about 28.6 hectares of this habitat type and also fragment a small area of about five hectares that is connected to the large expanse of habitat continuing east from the construction footprint. The area of potential habitat for this species is very widespread to the east continuing to the Tomago Sandbeds through to Salt Ash and any population residing in the edge habitat affected by the proposed action would not be considered an important population.

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

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

It is considered unlikely that an important population occurs in the construction footprint. The proposed action would remove up to 28.6 hectares of forest/woodland vegetation that would likely form part of the potential habitat for the New Holland Mouse. This is associated with the Smooth-barked Apple-Blackbutt open forest (PCT 1646) occurring from Tomago to Heatherbrae on the eastern side of the existing Pacific Highway. The preferred habitat type for this species is reliant on soil type, with a preference for deep siliceous podsols, sandy clay, and loamy sands. This habitat type is very extensive to the east of the proposed action through to Salt Ash, Lemon Tree Passage and Anna Bay.

The proposed action has been designed to minimise vegetation loss by placing the route on the edge of the forested habitat owned by Hunter Water Corporation between the Botanic Gardens and Heatherbrae. This design would remove a relatively small area of the extensive forested habitat in this location which extends to the east and would not sever any major movement corridors for fauna.

The size of local population is not known, although expected to not to be considerably large considering the area of habitat available. Impacts to these habitats would impact on the potential breeding, shelter and foraging habitat, however any potential overall reductions to the abundance of habitat is likely to be relatively minimal, considering the widespread nature of these habitats in the locality.

Considering the position of the proposed action and the abundance of suitable foraging habitat in the locality, the proposed action is considered unlikely to lead to a long-term decrease in the size of an important population of this species.

2. reduce the area of occupancy of an important population

The proposed action would remove about 28.6 hectares of potential habitat for the New Holland Mouse. The preferred habitat type for this species is deep siliceous podsols, sandy clay, and loamy sands. This habitat type is very extensive to the east of the construction footprint through to Salt Ash, Lemon Tree Passage and Anna Bay in the wider Port Stephens Council LGA. As such, the New Holland Mouse can be expected to remain in the locality after completion of the proposed action. The proposed action is therefore considered unlikely to reduce the area of occupancy of an important population of this species. The area of occupancy for this species would remain at about 420 square kilometres.

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

The proposed action has been designed to minimise vegetation loss by placing the route on the edge of the forested habitat owned by Hunter Water Corporation between the Botanic Gardens and Heatherbrae. This design would remove a relatively small area of the extensive forested habitat in this location which extends to the east and would not sever any major movement corridors for fauna.

The proposed action is not expected to fragment an important population of this species.

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

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The disturbance associated with the construction footprint represents a very small fraction of the potential habitat for the New Holland Mouse, although the species was not identified from a targeted survey but may occur within the survey area. As such, the proposed action is unlikely to impact habitat critical to the survival of the species.

5. disrupt the breeding cycle of an important population

The removal of potential habitat has potential to disrupt the breeding cycle of a small portion of the overall population, if this species occurs in the locality. This would represent a temporary short-term impact on a very small proportion of the population.

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 proposed action would have an impact of up to 28.6 hectares of habitat along the western edge of a large expanse of similar and better-quality habitat extending to the east. This area of disturbance represents a small proportion of the potential habitat available in the locality for this species. This species is expected to continue using the remaining habitats in the construction footprint and the proposed 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 vulnerable species becoming established in the vulnerable species' habitat

The potential for weed invasion was considered possible with a proposed action of this nature and appropriate controls are required during construction and operation to reduce this threat. The management of invasive species would be managed under the CEMP and during operation using best practice methods.

8. introduce disease that may cause the species to decline

There are no known disease issues affecting this species in relation to the proposed action.

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 for the proposed action has the potential to transmit the fungus to remaining native vegetation remnants of the species. 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.

9. interfere substantially with the recovery of the species.

There is no recovery plan for this species, important management actions would aim to address threats to the species such as predation and loss of habitat. The proposed action would remove and area of potential habitat although is not expected to directly increase the threat of predation.

Conclusion

The proposed action would result in the relatively small reduction of potential habitat for the New Holland Mouse from the large expanse of available habitat for this species in the locality. The proposed action is unlikely to reduce the population size of this species or decrease its reproductive success. The proposed action is unlikely to result in a significant impact to the New Holland Mouse.

Green and Golden Bell Frog (*Litoria aurea*)

The Green and Golden Bell Frog (*Litoria aurea*) is considered moderately likely to occur within the construction footprint based on the presence of suitable wetland habitat and the proximity of known habitats in Hunter Wetlands National Park two to three kilometres to the south. However, the species was not detected from 17 different sites (survey effort was 13 nights and 2 days) between 2016 and 2018 during optimum seasonal and weather conditions. This occurred whilst the species was detected calling at nearby reference sites during the same period suggesting that the species does not occur in the construction footprint or that an important population does not occur in the proposed action.

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

It is considered unlikely that an important population occurs in the construction footprint, this conclusion is based on extensive targeted surveys in the study area conducted during optimum survey conditions. The proposed action will involve direct clearing and disturbance to a number of ephemeral and permanent wetlands and dams that provide potential habitat for this species. This includes about 59 hectares of grassy meadow habitat with shallow seasonally inundated freshwater wetlands, and 7.7 hectares of *Typha* rushland. This grassy meadow wetland habitat is very widespread in the Tarro to Hexham area and impacts to this habitat are very minimal and limited to the edge of the large coastal wetland in this location. The impact to potential habitat is considered minor and would not lead to a long-term decrease in the size of an important population.

2. reduce the area of occupancy of an important population

It is considered unlikely that an important population occurs in the construction footprint. Further to this the species was not confirmed in the construction footprint and may not occur, despite the presence of suitable habitat. The proposed action would reduce the area of potential habitat for the species in the region but not the occupancy of an important population.

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

It is considered unlikely that an important population occurs in the construction footprint. There is a high degree of habitat fragmentation across the construction footprint, and if populations do occur, these would likely already be fragmented. There are no areas of wetland that will be fragmented, as the road skirts along the edge of the wetland or crosses using a bridge that would allow movements of frogs. The proposed action is not expected to fragment an important population of this species.

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

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal

- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The proposed action would impact about 59 hectares of grassy meadow habitat with shallow seasonally inundated wetlands, and 7.7 hectares of Typha rushland. A population was not confirmed through systematic sampling of these habitats and they are not considered critical to the survival of the species in the locality.

5. disrupt the breeding cycle of an important population

It is considered unlikely that an important population occurs in the construction footprint. The proposed action would not directly impact on a known breeding site and such as unlikely to disrupt the breeding cycle of 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

The proposed action will involve direct clearing and disturbance to a number of ephemeral and permanent wetlands and dams that provide potential habitat for this species. This includes about 59 hectares of grassy meadow habitat with shallow seasonally inundated wetlands, and 7.7 hectares of Typha rushland. This grassy meadow wetland habitat is very widespread in the Tarro to Hexham area and impacts to this habitat are very minimal and limited to the edge of the large coastal wetland in this location. The impact to potential habitat is considered minor and would not decrease the availability of habitat to the extent that the species is likely to decline. Further to this, the area of potential habitat to be disturbed is grazed and disturbed and of low quality.

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

The potential for weed invasion was considered possible with a proposed action of this nature and appropriate controls are required during construction and operation to reduce this threat. The management of invasive species would be managed under the CEMP and during operation using best practice methods.

8. introduce disease that may cause the species to decline

The presence and spread of the Chytrid Fungus is recognised as a Key Threatening Process in Australia and is widely regarded as playing an important role in the decline of the GGBF in Australia. Chytrid Fungus is already widespread in NSW; however, some populations of this species are free from or resistant to it (Commonwealth of Australia 2009). It has been suggested that such populations are located in areas inhospitable to the growth of the disease, such as fluctuating levels of salinity (Commonwealth of Australia 2009). Specific hygiene protocols to minimise the risk of the spread of Chytrid Fungus are detailed in the GGBFMP and Guide 7: Pathogen Management of the Roads and Maritime Biodiversity Guidelines (RTA 2011). Measures include, clothing and equipment wash down procedures and the sourcing of suitable materials that are not likely to be contaminated with the Chytrid Fungus.

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 for the proposed action has the potential to transmit the fungus to remaining native vegetation remnants of the species. 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.

9. interfere substantially with the recovery of the species

The Draft Recovery Plan: Green and Golden Bell Frog (DEC, 2005) identifies the following objectives for recovery of this species:

- Identify key populations for protection
- Implement conservation and management strategies for key populations
- Research the species to augment biological and ecological data to enable conservation management.

The proposed action will not interfere with any of the objectives identified in the draft National Recovery Plan for the Green and Golden Bell Frog.

Conclusion

The Green and Golden Bell Frog will experience a small reduction in extent of potential habitat, including about 49 hectares of grassy meadow habitat with shallow seasonally inundated wetlands, and 7.7 hectares of Typha rushland. However, the construction footprint does not contain a known population and the proposed action is unlikely to reduce the population size of this species or decrease its reproductive success. The proposed action is unlikely to result in a significant impact to the Green and Golden Bell Frog.

Appendix E. Matters for further consideration (impacts on threatened species)

Table E-1 Summary of potential impacts to Regent Honeyeater

Matters for Consideration	Regent Honeyeater (Critically Endangered TSC Act an EPBC Act)
a) the size of the local population directly and indirectly impacted by the development	a) The Regent Honeyeater is listed as critically endangered under the TSC Act. The species was not confirmed from surveys in the construction footprint, although may occur on occasion based on the presence of suitable habitats and the fact that a portion of the population is known to regularly visit the lower Hunter Valley, particularly the large areas of dry sclerophyll shrub/grass forest in the Cessnock and Kurri Kurri area to the west of the project site. The species has also been recorded at the Hunter Region Botanic Gardens within <1km from the construction footprint as recent as 2018.
(b) the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to: *(i) an estimate of the change in habitat available to the local population as a result of the proposed development* *(ii) the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and* *(iii) modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.* *Atlas records or other documented, quantifiable means must be used by the assessor to estimate what percentage of the species' population and habitat is likely to be lost in the long term within the IBRA subregion due to the direct and indirect impacts of the development* *(c) the likely impact on the ecology of the local population. At a minimum, address the following:* *(i) for fauna:*	b) i) The DoE commissioned a report to identify the distribution of important habitat for the Regent Honeyeater in the lower Hunter Valley (Birdlife Australia 2013). Further to this, as the Regent Honeyeater is a dual credit species, the habitat constraint information listed in the TBDC for this species refers to mapped areas of important habitat (land that is considered important to support critical life stages of the species, including breeding areas or known locations for over-wintering for migratory species). Significantly large areas have been mapped in the lower Hunter from Bishops Bridge in the north to Watagans National Park in the south and west to Millfield and Paxton and east to Richmond Vale. (ii) The forested habitats in the construction footprint are not included in the important area maps for this species and have been identified as low value for the Regent Honeyeater according to Birdlife Australia (2013). The project is expected to remove around 81 hectares of dry sclerophyll forest and swamp sclerophyll forest that may be used infrequently by the species, although the habitat value and impact from loss of habitat is considered low. (iii) The project would remove around 68 hectares of dry sclerophyll forest containing communities (PCTs 1590 and 1646) known to utilised by this species, such as the Lower Hunter Spotted Gum / Ironbark open forest and woodland, and around 13 hectares of lowland forests (PCTs 1649, 1717 and 1724) containing important winter flowering eucalypt species Forest Red Gum and Swamp Mahogany. Habitat within the construction footprint may be used by a small number of individuals for foraging and refuge but have not been identified as important areas for breeding. c) The removal of the forested habitats as described above, would contribute to the cumulative loss of habitat for this species in eastern Australia. The loss of habitat in the context of the construction footprint, relates to the infrequent occurrence of individuals, possibly annually, for foraging life cycle activities. Regent Honeyeater are known to visit the low Hunter on regular basis, and large areas are mapped as important for the species (refer to discussion above). However, the forests in construction footprint, which occur east of the M1 Pacific Motorway, are not mapped, suggesting that these habitats to be removed, as a minimum may provide marginal habitat that is used occasionally however are not important habitats for breeding or seasonal movements d) the Regent Honeyeater is not a sedentary species in the construction footprint and is considered a transient visitor to the region capable of traversing large areas of fragmented habitat during nomadic movements. The project would not isolate individuals or habitat for this mobile species. e) The Regent Honeyeater exists as a single large population estimated at between 800 to 2000 birds. There is no local population, rather local important habitat that is visited by a portion of the overall population. The area of important habitat

Matters for Consideration	Regent Honeyeater (Critically Endangered TSC Act an EPBC Act)
– breeding *– foraging* *– roosting, and* *– dispersal or movement pathways* *(d) a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development* *(e) the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range* *(f) the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population* *(g) the measure/s proposed to contribute to the recovery of the species in the IBRA subregion*	however is considered critical to the survival of the population. These areas do not include the forested habitats in the construction footprint. f) The removal of the forested habitats as described above, would contribute to the cumulative loss of habitat for this species in eastern Australia and thus any removal of habitat known to be used by a critically endangered species is considered to contribute as a threat to the long-term survival of the species. However, the forests in construction footprint, which occur east of the M1 Pacific Motorway, are not mapped as important habitat, suggesting that these habitats to be removed, as a minimum may provide marginal habitat that is used occasional however are not important habitats for breeding or seasonal movements. On this basis, the removal would not be considered to directly lead to a decrease in the viability of the local population. g) The project would remove PCTs / habitats that contain plant species and characteristics know to be important for Regent Honeyeater. Any residual impacts associated with this habitat loss will be offset in accordance with the FBA.

Table E-2 Summary of potential impacts to Mahony's Toadlet

Matters for Consideration	Mahony's Toadlet (Endangered BC Act – not listed under the TSC Act)
a) the size of the local population directly and indirectly impacted by the development	a) *Uperoleia mahonyi* is endemic to the mid-north coast of New South Wales (NSW) and is found between Kangy Angy and Seal Rocks. The species was not confirmed from the site surveys, although suitable habitat is present, and a population is assumed present on a precautionary basis. This is because the species was listed under the BC Act during the assessment phase for this BAR. Suitable habitat occurs and other associated frog species in the area between Hunter Botanic Garden entry across Masonite Road, to Windeyers Creek (only area of the project with sandy soils). If a local population exists, the size of this population is not known. Around 3.2 hectares of potential habitat has been mapped in this assessment, based on the known habitat types described for this species in the scientific determination. Similar type habitats are widespread and very large, particularly in Hunter Water Corporation owned lands in Heatherbrae and to the east of Raymond Terrace within the Tomago Sandbeds region. If indeed a population occurs in the construction footprint, it is reasonable to consider this would be a minor proportion of the broader local population.
(b) the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to: *(i) an estimate of the change in habitat available to the local population as a result of the proposed development* *(ii) the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and* *(iii) modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.* *Atlas records or other documented, quantifiable means must be used by the assessor to estimate what percentage of the species' population and habitat is likely to be lost in the long term within the IBRA subregion due to the direct and indirect impacts of the development*	b) i) Mahony's Toadlet has been recorded almost exclusively on a substrate of leached (highly nutrient impoverished) white sand and is commonly associated with acid paperbark swamps. Vegetation communities in which *U. mahonyi* has been found include wallum heath, swamp mahogany-paperbark swamp forest, heath shrubland and Sydney red gum woodland. Aquatic vegetation at breeding sites includes sedges *Schoenoplectus* sp., *Baumea* sp., *Lepironia articulata*, and *Typha orientalis*. Suitable habitat for Mahony's Toadlet was identified for this assessment at several locations between the Hunter Region Botanic Gardens at Tomago and wallum habitats associated with Windeyers Creek in Heatherbrae. The Wallum Froglet (*Crinia tinnula*) was recorded from the construction footprint and is also an acid frog species with similar habitat as described for Mahony's Toadlet. The area of potential habitat for both species, included wetlands and drainage lines, and periodically flooded depressions on sandy soils. The Wallum Froglet was also recorded in pine plantations on sand that is periodically flooded and would have previously been occupied by Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646) (HU860). The project would directly impact around 3.2 hectares of habitat for this species, this is based on mapping suitable habitat and placing a 40-metre buffer around these species polygons. A further 73 hectares occurs in the landscape buffer for this project, that would not be impacted. c) i) Breeding habitat for Mahony's Toadlet appears to be similar to that for Tyler's Toadlet (*Uperoleia tyleri*), which occupies permanent or semi-permanent swamps and ponds of moderate size with no apparent flow of water. *Uperoleia tyleri* was recorded calling from a number of locations during targeted surveys conducted in the construction footprint. these areas where included in the Mahony's Toadlet species polygon, and the project would directly impact on around 3.2 hectares that could be considered suitable as breeding habitat for this species. d) The M12RT project would not result in excessive landscape scale habitat fragmentation, this is because there is already a high degree of fragmentation in the landscape associated with a long history of clearing floodplain forests, and development of an extensive road, rail and power network. Also, the construction footprint has been placed on the edge of forested land where possible and in this way avoids large-scale fragmentation. This is particularly the case from Tomago

Matters for Consideration	Mahony’s Toadlet (Endangered BC Act – not listed under the TSC Act)
(c) the likely impact on the ecology of the local population. At a minimum, address the following: *(i) for fauna:* *– breeding* *– foraging* *– roosting, and* *– dispersal or movement pathways* *(d) a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development* *(e) the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species’ range* *(f) the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population* *(g) the measure/s proposed to contribute to the recovery of the species in the IBRA subregion*	Road to Masonite Road (sandy soils substrates), where the project is located on the western edge of any potential areas of habitat. However, the project would result in small-scale localised fragmentation of habitat including habitat potentially used by this species. the most likely location would by norther of Masonite Road to and either side of Windeyers Creek. There is a large bridge proposed over Windeyers Creek (c. 300 metres) which would assist with mitigating the barrier effect of the highway in this location. e) Clulow et al. (2016) report this species occurring in eight locations on sand beds in the Port Stephens, Myall Lakes and northern Central Coast areas. Local sites include Tomago, Oyster Cove, Nelson Bay, and Fingal Bay. Population size is unknown, however, at waterbodies where they are recorded, the estimated abundance is in the hundreds. All populations that have been recorded in the Port Stephens area are east of the construction footprint, and if present in the study are, this would represent the most western extent of the population. This is directly related to the presence of sandy soils and the fact that the project largely traverses the alluvial floodplain. There are sandy soils present in the northern third of the project only, between Tomago Road, Masonite Road and Windeyers Creek, the western extent of this geology in the Port Stephens area. The nearest record to the construction footprint is around 3.5 kilometres east of Heatherbrae. This suggests that if present, there is unlikely to be any interaction with the Tomago and Oyster Cove populations, but rather the limit of the species range in the locality. f) *Uperoleia mahonyi* faces a range of threats including habitat loss, habitat degradation and disease. Historical and ongoing urban and agricultural development, which is widespread in coastal NSW, results in the loss and fragmentation of habitat and also degrades adjoining uncleared areas through changes in water flow regimes and water quality. Historical clearing for housing (and other purposes) around the city of Newcastle, smaller satellite towns (e.g. Port Stephens, Hawks Nest, Tea Gardens) and the development of the foreshores of Tuggerah Lakes and Lake Macquarie have resulted in the loss of 31–44% of the potential habitat for this species in these areas (OEH 2012, 2016). This project may remove up to 2.5 hectares of habitat that is considered potential for the species and at the western limit of its distribution in the region. However, given the location of the site on the edge of the Heatherbrae township and existing Pacific Highway, and the fact that much of the potential occurs in pine plantation, suggests that the potential habitat if present in the construction footprint would not be an area of core habitat for this species. g) According to the NSW scientific determination for this species a total of ~18,000 hectares of potentially suitable habitat occurs in reserves in coastal NSW. The project would remove PCTs / habitats that contain plant species and characteristics know to be important for Mahony’s Toadlet. Any residual impacts associated with this habitat loss will be offset in accordance with the FBA.

Table E-3 Summary of impacts to *Diuris arenaria* (Sand Doubletail)

Matters for Consideration	*Diuris arenaria* (Endangered TSC Act)
a) the size of the local population directly and indirectly impacted by the development	A large population of Diuris arenaria occurs in sandy forest and on cleared land and tracks from the industrial area near the Pacific Highway in Heatherbrae to land just north of Masonite Road, with the majority of plants occurring in a cleared lot west of Masonite Road that has received development approval for a separate project. The species has colonised this site after being disturbed and cleared of vegetation. The population was first identified late in the survey season in 2015, when only fruiting plants remained. Subsequent targeted surveys were conducted in September 2016 and again in September 2018. A population count is difficult, as plants are conspicuous (particularly in woodland) and not all plants produce flowers each year. The number of Diuris arenaria recorded in the surveys was 1443 (2016) and 329 (2018). Over the two survey years a total of 1772 plants were recorded in and around the construction footprint, however many of these (753) are located within land that has previously been approved for development. Taking the larger count from the survey years (2016), the project would directly impact an estimated 161 plants and fragment habitat occupied by the population.
(b) the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to: *(i) an estimate of the change in habitat available to the local population as a result of the proposed development* *(ii) the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and* *(iii) modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.* *Atlas records or other documented, quantifiable means must be used by the assessor to estimate what percentage of the species' population and habitat is likely to be lost in the long term within the IBRA subregion due to the direct and indirect impacts of the development*	The location of the subject population in relation to the project is shown below. There are also additional records originally provided by Hunter Water Corporation that are not available on Atlas, which show the species to the north and south of the construction footprint along the cleared easement. The cleared site shown in the image is land approved for industrial development under a separate approved DA and may be used as an ancillary area for the 12RT project. Since the clearing of the block west of Masonite Road, this species has spread rapidly across the disturbed land. Based on the current information up to 721 plants are known to be within the construction footprint. However, the cleared land where most of the population occurs has already been approved for development. Considering impact to these species is not required to be assessed as part of this assessment, the project would impact 161 plants (or around 10% of the local population) and fragment the remaining population into two sub-populations, assuming the plants growing along the powerline easement to the north survive.

Matters for Consideration	*Diuris arenaria* (Endangered TSC Act)
c) the likely impact on the ecology of the local population. At a minimum, address the following: *(i) for fauna:* *– breeding* *– foraging* *– roosting, and* *– dispersal or movement pathways* *(d) a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development* *(e) the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range* *(f) the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population* *(g) the measure/s proposed to contribute to the recovery of the species in the IBRA subregion*	 Mapped location of *Diuris arenaria* population in relation to the construction footprint (shown in yellow). Shows majority of population has colonised land cleared as part of separate DA approval, which would be used as ancillary area. Based on the location of recorded plants, this species exists within the construction footprint from the eastern edge of the Botanic Gardens to disturbed land east of Masonite Road, which includes about 63.65 hectares of potential habitat. The total area of potential habitat is likely to be less than this and be associated with cleared zones for fire breaks and service tracks with patches of damp stabilized sandy soil providing the microhabitat that *D. arenaria* particularly favours Similar microhabitats are very widespread outside the road footprint and associated with the large network of cleared trails and easements on Hunter Water Corporation land and throughout the Tomago Sandbeds. A targeted survey has not been conducted on Hunter Water Corporation land south of the construction footprint to date to confirm the size of the local population. As the species relies on wind-blown dispersal of seed it is unlikely that the constructed road would provide a substantial barrier to dispersal and recruitment of new plants into the locality. It is also unlikely that the mycorrhizal associations preferred by this species would be significantly affected by the construction and operation of the road The outcome of the surveys to date suggest that the relatively small potential loss of plants at this location (considering the likely widespread extent south of the project) is unlikely to significantly reduce the viability and genetic diversity of this species at the western extent of its range.

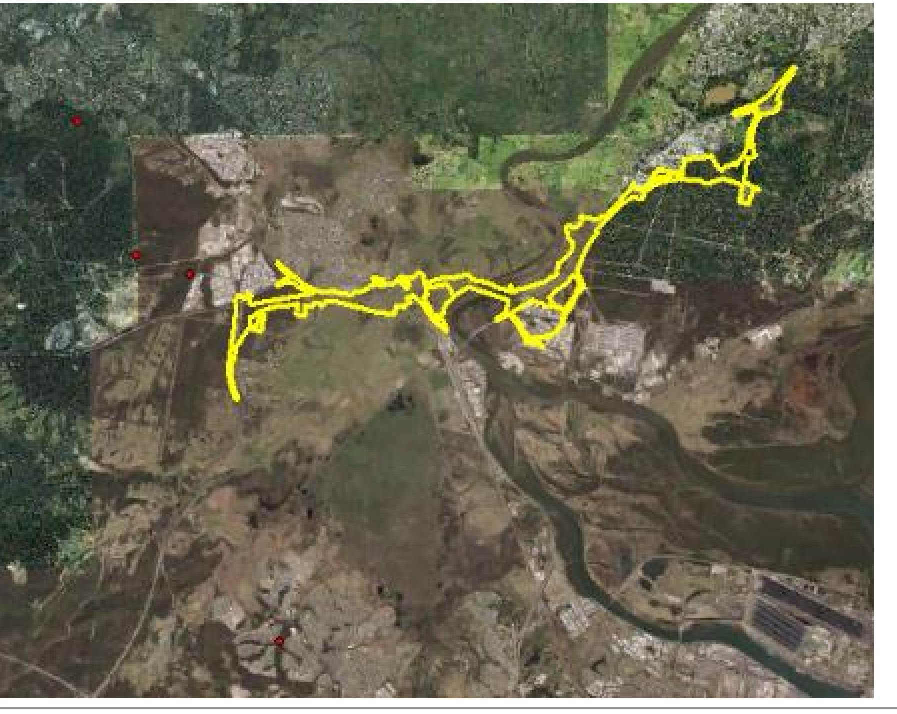
Table E-4 Summary of potential impacts to *Rhodamnia rubescens* (Scrub Turpentine)

Matters for Consideration	***Rhodamnia rubescens* (Critically Endangered TSC Act)**
a) the size of the local population directly and indirectly impacted by the development	a) *Rhodamnia rubescens* occurs in coastal districts north from Batemans Bay in New South Wales to areas inland of Bundaberg in Queensland. Populations of *R. rubescens* typically occur in coastal regions and occasionally extend inland onto escarpments up to 600 metres a.s.l. in areas with rainfall of 1000-1600 mm. Found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils. In the Newcastle area, records are located around Glenrock State Conservation Area, Blackbutt Nature Reserve, Wentworth Creek in Maryland, Blue Gum Creek in Seahampton, Long Gully in Black Hill and, the closest record to the construction footprint, from a now-cleared site near Scotch Dairy Creek in Thornton. *Rhodamnia rubescens* was not identified in the construction footprint. A small area of mesic wetland habitat around the Old Punt road and Pacific Highway intersection is considered the only suitable habitat. This species is unlikely to be directly or indirectly impacted by the development. 

Matters for Consideration	*Rhodamnia rubescens* (Critically Endangered TSC Act)
(b) the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to: *(i) an estimate of the change in habitat available to the local population as a result of the proposed development* *(ii) the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and* *(iii) modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.* *Atlas records or other documented, quantifiable means must be used by the assessor to estimate what percentage of the species' population and habitat is likely to be lost in the long term within the IBRA subregion due to the direct and indirect impacts of the development* *c) the likely impact on the ecology of the local population. At a minimum, address the following:* *(i) for fauna:* *– breeding* *– foraging* *– roosting, and* *– dispersal or movement pathways* *(d) a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development* *(e) the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other*	b) This species was not identified in the construction footprint. A small area of mesic wetland habitat around the Old Punt road and Pacific Highway intersection is considered the only suitable habitat. The project would remove 1.61 hectares of mesic wetland that may provide suitable habitat for the local *Rhodamnia rubescens* population, however there are no records near this habitat and this species is unlikely to be present. There is likely to be some indirect impacts (edge effects) on the remaining area of this habitat, such as weed and light invasion. No fragmentation or isolation would occur as this species has not been identified. As such, it is unlikely that the project would directly or indirectly impact *Rhodamnia rubescens.* c - g). There is no local population present and no perceived impacts from the project

Matters for Consideration	*Rhodamnia rubescens* (Critically Endangered TSC Act)
population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range *(f) the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population* *(g) the measure/s proposed to contribute to the recovery of the species in the IBRA subregion*	

Table E-5 Summary of potential impacts to *Rhodomyrtus psidioides* (Native guava)

Matters for Consideration	*Rhodomyrtus psidioides* (Critically Endangered TSC Act)
a) the size of the local population directly and indirectly impacted by the development	*Rhodomyrtus psidioides* occurs from Broken Bay, New South Wales, to Maryborough in Queensland. Populations are typically restricted to coastal and sub-coastal areas of low elevation however the species does occur up to c. 120 kilometres inland in the Hunter and Clarence River catchments and along the Border Ranges in NSW. Pioneer species found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest often near creeks and drainage lines. In the Newcastle area, only a few records exist scattered Wentworth Creek in Maryland to Four Mile Creek in Ashtonfield. To records close to the western end of the construction footprint in Donaldson Open cut mine are on Weakleys Flat Creek and from a now-cleared site near Scotch Dairy Creek. *Rhodomyrtus psidioides* was not identified in the construction footprint. A small area of mesic wetland habitat around the Old Punt road and Pacific Highway intersection is considered the only suitable habitat. This species is unlikely to be directly or indirectly impacted by the development. 

Matters for Consideration	*Rhodomyrtus psidioides* (Critically Endangered TSC Act)
(b) the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to: *(i) an estimate of the change in habitat available to the local population as a result of the proposed development* *(ii) the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and* *(iii) modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.* *Atlas records or other documented, quantifiable means must be used by the assessor to estimate what percentage of the species' population and habitat is likely to be lost in the long term within the IBRA subregion due to the direct and indirect impacts of the development* *c) the likely impact on the ecology of the local population. At a minimum, address the following:* *(i) for fauna:* *– breeding* *– foraging* *– roosting, and* *– dispersal or movement pathways* *(d) a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development* *(e) the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other*	b) This species was not identified in the construction footprint. A small area of mesic wetland habitat around the Old Punt road and Pacific Highway intersection is considered the only suitable habitat. The project would remove 1.61 hectares of mesic wetland that may provide suitable habitat for the local *Rhodomyrtus psidioides* population, however there are no records near this habitat and this species is unlikely to be present. There is likely to be some indirect impacts (edge effects) on the remaining area of this habitat, such as weed and light invasion. No fragmentation or isolation would occur as this species has not been identified. As such, it is unlikely that the project would directly or indirectly impact *Rhodomyrtus psidioides.* c - g). There is no local population present and no perceived impacts from the project

Matters for Consideration	*Rhodomyrtus psidioides* (Critically Endangered TSC Act)
population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range *(f) the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population* *(g) the measure/s proposed to contribute to the recovery of the species in the IBRA subregion*	

Table E-6 Summary of potential impacts to *Pterostylis chaetophora*

Matters for Consideration	***Pterostylis chaetophora* (vulnerable TSC Act)**
a) the size of the local population directly and indirectly impacted by the development	In NSW, *Pterostylis chaetophora* is currently known from 18 scattered locations in a relatively small area between Taree and Kurri Kurri, extending to the south-east towards Tea Gardens and west into the Upper Hunter, with additional records near Denman and Wingen. There are also isolated records from the Sydney region. The species occurs in two conservation reserves, Columbey National Park and Wingen Maid Nature Reserve. The closest records to the construction footprint are located around the northern end of Grahamstown Dam. These records may be part of a single population. *Pterostylis chaetophora* was not identified in the construction footprint despite targeted surveys of potential habitat. This species is unlikely to be directly or indirectly impacted by the development. 

Matters for Consideration	*Pterostylis chaetophora* (vulnerable TSC Act)
(b) the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to: *(i) an estimate of the change in habitat available to the local population as a result of the proposed development* *(ii) the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and* *(iii) modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.* *Atlas records or other documented, quantifiable means must be used by the assessor to estimate what percentage of the species' population and habitat is likely to be lost in the long term within the IBRA subregion due to the direct and indirect impacts of the development* *c) the likely impact on the ecology of the local population. At a minimum, address the following:* *(i) for fauna:* *– breeding* *– foraging* *– roosting, and* *– dispersal or movement pathways* *(d) a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development* *(e) the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range* *(f) the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population* *(g) the measure/s proposed to contribute to the recovery of the species in the IBRA subregion*	b) *Pterostylis chaetophora* was not identified in the construction footprint despite targeted surveys of potential habitat. This species is unlikely to be directly or indirectly impacted by the development. c - g). There is no local population present and no perceived impacts from the project

Appendix F. Detailed description of fauna survey methods, timing and weather conditions

Timing and weather conditions

Fauna surveys were conducted initially in 2015/2016 and then again in 2018. Surveys in 2015/2016 were carried out over 23 days in four different seasons between February 2015 and February 2016. An additional four days were spent conducting koala scat searches. Surveys in 2018 were carried out over 16 days between February 2018 and October 2018, including several days conducting koala scat searches during vegetation plot surveys. Details of the field survey times, average temperature and daily rainfall conditions experienced during the surveys are provided in **Table F-1**. Climate records were taken from Williamtown Airport (Station 061078) (BOM, 2020).

Table F-1 Timing, weather and rainfall conditions for fauna surveys

Survey dates	Season / Survey period	Mean ambient air temperature (degrees Celsius)		Wind speed (km/h) and direction		Cloud cover	Moon phase	Rainfall each 24 hour period (mm)	Total rainfall 7 days preceding survey date
		Min	Max	9am	3pm				
2015									
6 Jan 2015	Amphibian / night	20	30	21 SE	26 SE	0 %	Full moon	0	0
8 Jan 2015	Amphibian / night	17.7	33.1	15 N	28 ENE	0 %	Waning gibbous	0	0
24 Feb 2015	Amphibian / day	19.6	27.9	8 ENE	30 SSE	0 %	First Quarter	11.8	11.8
26 Feb 2015	Amphibian / night	19.3	26.2	11 SW	15 SSE	100 %	First Quarter	0	11.8
2 Mar 2015	Amphibian / night	20.1	24.7	24 S	24 SE	10 %	Waxing gibbous	8.2	8.6
13 Aug 2015	Winter Bird	8.5	19.4	39 WNW	30 WNW	0 %	New moon	0	0
14 Aug 2015	Winter Bird	5.3	18.4	24 WNW	17 NW	0 %	New moon	0	0
23 Nov 2015	Mammal trapping	13.5	31.1	13 WNW	30 SSE	20 %	Waxing gibbous	0	0
24 Nov 2015	Mammal trapping Spring Bird Spotlight	15.5	25.3	15 ESE	28 ESE	50 %	Waxing gibbous	0	0
25 Nov 2015	Mammal trapping	13.8	32.5	11 NNW	22 E	80 %	Full moon	0	0
26 Nov 2015	Mammal trapping	20.3	41.6	11 NNW	43 WNW	80%	Full moon	0	0

Survey dates	Season / Survey period	Mean ambient air temperature (degrees Celsius)		Wind speed (km/h) and direction		Cloud cover	Moon phase	Rainfall each 24 hour period (mm)	Total rainfall 7 days preceding survey date
		Min	Max	9am	3pm				
27 Nov 2015	Mammal trapping	17.7	23.5	19 ENE	17 NE	90%	Waning gibbous	0	0
7 Dec 2015	Mammal trapping	13.7	27	11 SE	30 ESE	20 %	Waning crescent	0	0.6
8 Dec 2015	Mammal trapping Spotlight	19.3	32.2	9 N	17 ENE	50 %	Waning crescent	0	0.6
9 Dec 2015	Mammal trapping	21	33.9	11 NNE	15 N	20 %	Waning crescent	0.8	0.4
10 Dec 2015	Mammal trapping Spotlight	18.7	26.2	13 SSE	26 ESE	100 %	New moon	10.8	1.2
11 Dec 2015	Mammal trapping	17	38.6	13 NNW	39 NW	100 %	New moon	10	10.8
2016									
7 Jan 2016	Amphibian / night	16.2	22.6	24 WSW	33 SSW	100 %	Waning crescent	225	328.2
11 Jan 2016	Amphibian / night	17.3	35.9	13 NNW	11 NNW	0 %	Waxing crescent	0	328.2
12 Jan 2016	Amphibian / night	20.9	32.9	7 N	35 WNW	0 %	Waxing crescent	0	287.6
13 Jan 2016	Amphibian / night	22.4	29.6	9 WSW	20 SE	0 %	Waxing crescent	0	262.4
14 Jan 2016	Amphibian / night	21.9	40.1	13 N	24 NNW	0 %	Waxing crescent	0	37.4
15 Jan 2016	Migratory Bird	16.1	22	35 S	17 W	100 %	Waxing crescent	0	0
2018									
1 Mar 2018	Amphibian / day	18.5	26.5	24 SSW	33 SSE	100 %	Full moon	0	64.8
22 Mar 2018	Amphibian / night	18.9	23.4	22 ESE	28 SE	100 %	Waning crescent	143.8	21.8
23 Mar 2018	Amphibian / night	18.4	22.3	9 NE	13 NE	100 %	First quarter	128.4	143.8
24 Mar 2018	Amphibian / night	17.9	27.4	9 NNE	17 E	100 %	First quarter	15.4	150.2
25 Mar 2018	Amphibian / night	17.7	33.1	11 NW	31 NW	100 %	First quarter	9.2	159.2

Survey dates	Season / Survey period	Mean ambient air temperature (degrees Celsius)		Wind speed (km/h) and direction		Cloud cover	Moon phase	Rainfall each 24 hour period (mm)	Total rainfall 7 days preceding survey date
		Min	Max	9am	3pm				
7 June 2018	Winter Bird	7.7	20.2	0	19 NE	100 %	Last quarter	24.8	84.6
21 June 2018	Winter Bird	11.3	15.4	13 WNW	2 SW	100 %	First quarter	54	90.8
22 Oct 2018	Mammal trapping	16.0	23.4	13 S	26 ESE	20 %	Waxing gibbous	15.6	20.4
23 Oct 2018	Mammal trapping Spring Bird Spotlight	13.2	29.4	9 NW	15 E	20 %	Full moon	0	20.2
24 Oct 2018	Mammal trapping	16.9	21.8	28 SW	31 S	0 %	Full moon	0	18.8
25 Oct 2018	Mammal trapping Spotlight	15.7	22.1	9 SSW	15 SE	50 %	Full moon	0.2	18.8
26 Oct 2018	Mammal trapping	13.7	23.4	17 SSW	30 S	0 %	Waning gibbous	0.2	16
29 Oct 2018	Mammal trapping Spotlight	11.8	21.5	24 SE	26 ESE	10 %	Waning gibbous	0.2	0.4
30 Oct 2018	Mammal trapping Spring bird	10.8	28.8	20 N	9 N	10 %	Last quarter	0	0.4
31 Oct 2018	Mammal trapping	17.9	25.2	15 S	26 ESE	10 %	Last quarter	0	0.6
1 Nov 2018	Mammal trapping	19.0	31.5	4 WSW	11 ENE	0 %	Last quarter	0	0.4
2 Nov 2018	Mammal trapping	20.8	36.7	11 NNW	26 NW	0 %	Waning crescent	0	0.4

Stratification and site selection

Fauna surveys and habitat assessment were conducted at stratified sampling locations positioned along the length of the project alignment (within the construction footprint) and prioritising habitat likely to be directly and indirectly impacted by the project. The construction footprint was stratified initially by PCT and then by discrete habitats such as freshwater wetlands with dense emergent vegetation and higher condition riparian areas. Considering the large scale of the project, opportunistic surveys were conducted throughout much of the construction footprint where possible. The specific number and location of survey sites is described in the species-specific methods following and summarised in **Table 4-8**.

Amphibian surveys

Target species: Green and Golden Bell Frog (*Litoria aurea*), Green-thighed Frog (*Litoria brevipalmata*), Wallum Froglet (*Crinia tinnula*) and Mahony's Toadlet (*Uperoleia mahonyi*).

Although the Green and Golden Bell Frog is only currently known from the confines of Kooragang Island's wetland system, suitable habitat for this species is widespread throughout the construction footprint. Freshwater wetlands and wet meadows are a dominant habitat type on the floodplain and present numerous waterbodies (including some man-made farm dams) offering much of this species required habitat features. The presence of emergent and surrounding vegetation varies considerably between water bodies, from completely absent to a species rich wetland type environment with abundant emergent vegetation and surrounding tree canopy with grassy understorey. As much of the aquatic habitat in the construction footprint may provide potential habitat for the Green and Golden Bell Frog an initial habitat assessment was conducted to stratify the habitat available and target survey effort at sites where habitats appeared most suited to *Litoria aurea*. To identify this review of literature on the habitat requirements of the species was carried out, namely Pyke and White (1996). These authors document the criteria found most consistently at sites that support breeding and non-breeding populations, this included the following:

- Presence of emergent vegetation providing shelter sites
- Moderate to high level disturbance
- Aquatic plant species present (especially *Typha* sp.)
- Still or low flowing water
- Run-off urban / industrial / grazing or parkland
- Substrate sand, or rock
- Shallow water depth, less than 50 centimetres
- Nearby vegetation low, grassland, or shrubland or woodland
- Unshaded or partial shade
- Areas of grass nearby
- No visible signs of pollution
- *Crinia tinnula* or *Limnodynastes peronii* present
- Gambusia holbrooki absent.

Wallum Froglets are found in a wide range of habitats, usually associated with acidic swamps on coastal sand plains. They typically occur in sedgelands and wet heathlands with suitable habitats identified on the sandy soils near Heatherbrae and Tomago. They can also be found along drainage lines within other vegetation communities and disturbed areas, and occasionally in swamp sclerophyll forests. The species breeds in swamps with permanent water as well as shallow ephemeral pools and drainage ditches.

Similarly, Mahony's Toadlet has been recorded almost exclusively on a substrate of leached (highly nutrient impoverished) white sand and is commonly associated with acid paperbark swamps on the mid-north coast of NSW between Kangy Angy and Seal Rocks. Vegetation communities in which *U. mahonyi* has been found include wallum heath, swamp mahogany-paperbark swamp forest, heath shrubland and Sydney red gum woodland. Aquatic vegetation at breeding sites includes sedges *Schoenoplectus* sp., *Baumea* sp., *Lepironia articulata*, and *Typha orientalis*.

Suitable habitat for Wallum Froglet and Mahony's Toadlet was identified at several locations between the Hunter Region Botanic Gardens at Tomago and wallum habitats associated with Windeyers Creek in Heatherbrae.

Green-thighed Frogs occur in a range of habitats from rainforest and moist eucalypt forest to dry eucalypt forest and heath, typically in areas where surface water gathers after rain. It prefers wetter forests in the south of its range but extends into drier forests in northern NSW and southern Queensland. Suitable habitat was identified in damp areas surrounding Windeyers Creek and at an Glenrowan Creek at Black Hill next to Lenaghans Drive.

Surveys were carried out with regard to the significant impact guidelines for the Green and Golden Bell Frog (DECC, 2009) and the Commonwealth survey guidelines for threatened frogs (DEWHA, 2010a). The guidelines recommend an initial habitat assessment followed by at least four nights of surveys between September and March, during warm and windless weather conditions following rainfall.

A preliminary site walkover (habitat assessment) on 24 January 2015 was used to gain an understanding of potential amphibian habitat and select initial sites to survey before the end of the 2015 Green and Golden Bell Frog breeding season. Nocturnal surveys were conducted at two sites in summer 2015, including one farm dam (Site F2) and one large freshwater wetland (Site F12). Nocturnal surveys were also carried out within the construction footprint in January 2015 at Site F4.

Throughout 2015 a number of field surveys and assessments of mapping were used to develop an understanding of potential amphibian habitat across the construction footprint. This resulted in the selection of an initial twelve locations to survey for the Green and Golden Bell Frog, Green-thighed Frog and Wallum Froglet, which were visited in 2016. Surveys for the Green and Golden Bell Frog also included an investigation at a known reference site in Hunter Wetlands National Park (Ash Island) about three kilometres from the project. Two visits were made to the reference site at dusk for one hour at the beginning of each of the two survey weeks (26 January 2015 and 12 January 2016). Reference sites were also surveyed in March 2018. All surveys at reference locations confirmed male Green and Golden Bell Frog were calling and active.

Nocturnal surveys were then conducted at the remaining sites over five nights, between 7 January 2016 and 14 January 2016. Each site was searched by two ecologists at least once during the survey period with some higher quality areas searched on more than one occasion (example Windeyers Creek). Further surveys were carried out again in 2018, with the addition of five new survey sites for habitat assessment. Mahony's Toadlet (*Uperoleia mahonyi*) was listed after the 2016 surveys were completed, so it was also targeted in 2018. Not all sites were surveyed again in 2018 due to access restrictions and some ephemeral sites surveyed in 2016 were dry. The duration of each sampling event extended between 0.25 and 1 hour per site depending on the size of the site. The survey involved a spotlight search of the entire perimeter of the water body / channel (where possible) focusing on the upper water column and within emergent vegetation. Call playback for the three species (no recorded calls were available for *U. mahonyi*) was used at each site which involved playing calls through a 20W loudhailer for two to five minutes at each location. Smaller sites involved a single broadcast point, while larger sites (for example Site 12 and Site 4) and densely vegetated sites used multiple call sites whilst searching the perimeter of the site. Details of the survey effort are described in **Table F-2.**

Table F-2 Details of survey sites and sampling events for targeted frog surveys

Survey site	Survey day/night														Total duration (hours)	No. sampling events
	2016									2018						
	1	2	3	4	5	6	7	8	9	1	2	3	4	5		
1. Freshwater Creek off Lenaghans Drive, Black Hill					X			X			X				3.0	1
2. Freshwater ephemeral wetlands (flooded paddocks and drainage line) property off New England Highway			X			X					X				3.0	2
3. Freshwater ephemeral wetlands (flooded paddocks) access road to Aurizon land near Tarro interchange								X	X	Dry					2.0	3
4. Brackish wetlands on RZM site, access from drain located along river bank near proposed bridge	X	X								No Access					2.0	5

Survey site	Survey day/night														Total duration (hours)	No. sampling events
	2016									2018						
	1	2	3	4	5	6	7	8	9	1	2	3	4	5		
5. Constructed drain and wetlands between river and highway south of Old Punt Road intersection							X			Dry					1.0	4
6. Old Punt Road –freshwater wetlands on both corners of intersection						X		X				X			3.0	6
7. Northern creekline on Hunter Region Botanic Gardens property (Wallum acidic habitat)					X							X			2.0	7
8. Freshwater wetland next to Weathertex property on Hunter Water Corporation land					X								X		3.0	8
9. Ephemeral freshwater ponds (cleared Weathertex site)						X				Dry					2.0	9
10. Weathertex freshwater wetland / depression near site entrance						X							X		1.5	10
11. Ephemeral freshwater soaks in proximity to wetland – slightly acidic							X							X	1.25	11
12. Windeyers Creek / freshwater wetland				X		X							X	X	4.0	12
13. Artificial drainage/creek line between Hunter River and Hunter Region Botanic Gardens										X					0.5	13
14. Floodplain depression on drainage line between Hunter River and Pacific Highway north of Old Punt Road intersection										X					0.5	14
15. Freshwater wetland and forested swamp south of Hunter Region Botanic Gardens										X		X			1.5	15
16. Purgatory Creek										X					0.5	16
17. Floodplain depression in pasture on northern bank of Hunter River										X					0.5	17

Wetland birds

Target species: Australasian Bittern (*Botaurus poiciloptilus*), Australian Painted Snipe (*Rostratula australis*), Black Bittern (*Ixobrychus flavicollis*) and Black-necked Stork (*Ephippiorhynchus asiaticus*).

Most of these species are considered moderately likely to occur in the construction footprint due to the extensive amount of wetland habitat throughout the Hunter Estuary. All these species have greater than 10 records in the locality (Bitterns are notoriously cryptic so the presence of any record is notable) except for the Black Bittern which is only represented by one record. The Black-necked Stork potentially has the highest probability of occurring due to the presence of 157 records, with these are mostly associated with Hexham Swamp Nature Reserve to the south of the construction footprint.

These species were all targeted during diurnal bird surveys around water bodies, targeted waterbird surveys at two sites after heavy rainfall on 15 January 2016 and spotlighting and call playback over five nights by two ecologists using 50W spotlights and a 20W loudhailer. Nocturnal survey times varied between 0.5 to 2.0 hours depending on the size of the habitat and concentrated on densely vegetated dams and adjoining riparian habitats and were conducted following the targeted Green and Golden Bell Frog surveys in 2016 and again in 2018 at sites considered suitable for these species. In total 11 sites were surveyed for bitterns in 2016 consistent with frog sites (except for Site 4 which was surveyed before the project started) and a further 16 sites surveyed in 2018 (refer to Table 4-9). Call playback used a single point broadcast for five minutes duration at the start of the survey and then quiet searching and listening for individuals during the remainder of the survey.

Diurnal birds

Target species: Swift Parrot (*Lathamus discolor*), Regent Honeyeater (*Anthochaera phrygia*), Eastern Osprey (*Pandion haliaetus*) and White-bellied Sea-Eagle (*Haliaeetus leucogaster*)

A time-based bird survey was repeated at 10 sites within four hours of sunrise in winter 2015 (13 and 14 August 2015). Sites were selected based on dominant tree species, targeting areas with high abundances of winter flowering eucalypts such Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*Eucalyptus tereticornis*), Red Mahogany (*Eucalyptus resinifera*) and Spotted Gum (*Corymbia maculata*). This involved 20-minute surveys at each site by two ecologists. Surveys were generally area-based, however where this was not possible (for example along edge of waterbody) transect surveys were used. These 10 sites were surveyed again in spring/summer 2015, including an additional eight sites making a total of 18 sites across the construction footprint. These 18 sites were again repeated in spring/summer 2018. Spring survey sites were placed evenly across the different PCTs with the aim of documenting any threatened species. Treetops were also scanned during timed surveys (and opportunistically throughout all surveys) for Eastern Osprey and White-bellied Sea-Eagle nests.

All bird species heard or observed were recorded including those outside the habitat node (i.e. flying over the site). Birds were also recorded opportunistically during all other site visits and field surveys activities. Binoculars were carried in the field at all times to assist in identification.

Although owls were not required to be targeted during this assessment, call playback was used for the Powerful Owl (*Ninox strenua*) and Masked Owl (*Tyto novaehollandiae*) at the beginning of spotlighting at three locations (Black Hill, Tomago and Heatherbrae) in 2016 and again in 2018. Each site was surveyed for birds while waiting for an appropriate time to carry out call playback. A period of five minutes was spent listening and spotlighting for owls after call playback.

Flying mammals

Target species: Large Bent-winged Bat (*Miniopterus orianae oceanensis*), Little Bent-winged Bat (*Miniopterus australis*), Southern Myotis (*Myotis macropus*) and Grey-headed Flying Fox (*Pteropus poliocephalus*).

Standard two-bank 4.2 square metre harp traps were used to survey for microchiropteran bats at five woodland locations in summer (23 to 25 November 2015 and 8 to 10 December 2015). Traps were set for two nights in narrow fly-ways along tracks, forest edges and water bodies. Captured bats were collected early the following morning, identified and measured then soft-released at the capture point using a bat release box.

Two stationary ultrasonic bat call detectors (Anabat™ II, Titley Electronics) were used with a storage ZCAIM unit to record bat calls at five sites concurrently during the trapping period. The placement of call detectors considered the location of open water bodies, open areas along the edge of heavily vegetated areas and also natural flyways. Calls were recorded continuously between 1900 and 0500 hours on each occasion. Calls were identified to genus or species level where possible using computer frequency analysis software (i.e. Analook v.4.0).

All culverts that would be impacted during construction work were inspected in June 2020 where possible to inspect for the presence of roosting microbats.

The Grey-headed Flying-fox was targeted through spotlighting surveys conducted across the eight mammal trap sites over three nights in spring 2015 (24 November 2015, 8 and 10 December 2015) and spring 2018 (23, 25 and 29 October 2018). There are no known roosting camps within the construction footprint, however foraging habitat is widespread and would be impacted by the project.

Non-flying mammals

Target species: Koala (*Phascolarctos cinereus*), Squirrel Glider (*Petaurus norfolcensis*), Brush-tailed Phascogale (*Phascogale tapoatafa*), Eastern Pygmy-possum (*Cercartetus nanus*), Common Planigale (*Planigale maculata*) and Eastern Chestnut Mouse (*Pseudomys novaehollandiae*).

Live trapping was carried out for arboreal and ground-dwelling mammals over four nights between 24 and 27 October 2015 at sites 11, 12, 13 and 14, and four nights between 7 and 10 December 2015 at sites 15, 16, 17 and 18. These sites were resurveyed again from 22 to 26 October 2018 (sites 11, 12, 13 and 14) and 29 October to 2 November 2018 (sites 15, 16, 17 and 18).

At each site a transect of 10 Elliot-B style aluminium folding traps (15 x 16 x 45 centimetres) were positioned about 20 to 50 metres apart along a transect line, with transects being up to 300 metres in length, however this was subject to the size of the habitat. Traps were mounted on trees with a platform positioned three to four metres above the ground using a ladder. Tree traps were placed on the western side of the tree to ensure trapped animals did not overheat with the sunrise. Trees and foliage surrounding tree traps were sprayed with honey dissolved in water once the traps were installed, and again every morning after traps were checked to act as an attractant.

To survey for ground-dwelling mammals, a transect of 20 Elliot-A style folding aluminium folding traps (8 x 9 x 33 centimetres) were positioned about 20 to 50 metres apart along the same transect line, targeting areas of obvious fauna use. Placement also considered visibility from tracks and protection from weather. Each trap was baited with rolled oats, peanut butter and honey. Additionally, leaf litter was placed in each trap to offer some nesting material for trapped animals.

Pitfall traps were used at four mammal trap sites (i.e. 11, 13, 14, 16) sites were selected open forest with heathy understorey to target Common Planigale, Eastern Pygmy Possum and New Holland Mouse. At each site five pits were used (20 litre plastic buckets) with drift fencing. Leaf litter was placed in the bucket for shelter and trap left open for three nights. The total pit trap effort was 96 nights in 2016 and 96 nights in 2018.

All Elliot and pitfall traps were checked every morning within two hours of sunrise. Animals caught were identified and released immediately. Each trap site was active for four consecutive trap nights in November and December 2015, and again in October and November 2018. Trapping was not conducted in the open wetlands or disturbed and weed infested riparian habitat due to lack of suitable habitat for the target species.

In 2018, additional survey effort included the use of nest boxes targeting Eastern Pygmy Possum, which were deployed at three locations (two nest boxes per site) between the Pacific Highway and Masonite Road in Heatherbrae. Nest boxes were deployed in October 2018 and collected in late February 2019.

Motion-sensor cameras (Reconyx Hyperfire) were also deployed at various locations where mammal trapping surveys were carried out. Twenty individual cameras were deployed for 10 nights each, totalling 200 trap nights. Half of the cameras were installed around two metres up into trees and half were placed on the ground to target non-arboreal species. All cameras were pointed at a bait station, which was loaded with rolled oats, peanut butter and honey.

Koala scat searches were conducted at 61 sites stratified across the construction footprint using the Koala Rapid Assessment Method (KRAM) (Woosnam et al., 2012) to target koala and assess the quality of koala habitat. Surveys were initially carried out between November 2015 and March 2016 and then each site was revisited again in 2018 (resulting in search of 122 sites). Surveys involved sampling a radial plot randomly placed at the site and searching for scats, starting at a central tree and continuing until 20 trees were searched. Details of each tree species within the plot were recorded.

Spotlighting and call playback for arboreal mammals was conducted across eight sites over three nights in spring 2015 (24 November 2015, 8 and 10 December 2015) and three nights in spring 2018 (23, 25 and 29 October 2018). Spotlighting was both foot and vehicle-based and comprised of a general traverse of the site, utilising hand-held LED spotlights (LEDLenser X21R.2) and LED headtorches. Two ecologists conducted the surveys for a minimum period of 30 minutes per site, though where sites were linked by walking or driving surveys were up to three hours. Spotlighting was also conducted while moving between sites and all fauna heard or observed over the three-hour period were recorded.

Appendix G. Aquatic habitat assessment

The criteria by which the waterway class is derived are outlined in **Table G-1**

Table G-1 Classification criteria according to sensitivity of key fish habitat (source: DPI 2013)

Classification	Habitat characteristics
Type 1 – Highly Sensitive Key Fish Habitat	• Coastal Management SEPP Wetlands, wetland recognised under international agreements, or listed in the Directory of Important Wetlands of Australia • Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 metres in length, or native aquatic plants* • Any known or expected threatened species habitat or area of declared 'critical habitat' under the *Fisheries Management Act 1994* (FM Act) • Coastal saltmarsh greater than 5 m^2 in area • Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act
Type 2 – Moderately sensitive key fish habitat	• Aquatic habitat within 100 metres of a marine park, an aquatic reserve or intertidal protected area • Freshwater habitats other than those defined in Type 1* • Weir pools and dams up to full supply level where the weir or dam is across a natural waterway Mangroves • Coastal saltmarsh less than 5 m^2 in area • Marine macroalgae such as Ecklonia and Sargassum species • Estuarine and marine rocky reefs • Coastal lakes and lagoons that are permanently open or subject to artificial opening via agreed management arrangements (e.g. managed in line with an entrance management plan) • Aquatic habitat within 100 metres of a marine park, an aquatic reserve or intertidal protected area • Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna • Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in Type 1
Type 3 – Minimally sensitive key fish habitat may include:	• Unstable or vegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna • Coastal or freshwater habitats not included in Types 1 or 2* • Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation.

*Farm dams on first and second order streams, unmapped gullies and agricultural or urban drains are not considered key fish habitat (Source: DPI 2013)

Table G-2 Fish habitat classification criteria for watercourses

Classification	Characteristics of waterway type
Class 1 – Major fish habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.
Class 2 – Moderate fish habitat	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area. Type 1 and 2 habitats present.
Class 3 – Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (eg fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or other Class 1-3 fish habitats.
Class 4 – Unlikely fish habitat	Named or unnamed watercourse with intermittent flow during rain events only, little or no defined drainage channel, little or no free-standing water or pools after rain event (eg dry gullies or shallow floodplain depression with no permanent wetland aquatic flora).

Source: DPI 2013; Fairfull and Witheridge 2003

Table G-3 Location and results of the aquatic habitat assessments

Site / classification / description	Site photograph
M12RT 1 **"Glenrowan Creek" at crossing** Not KFH, Class 4 Glenrowan Creek is an ephemeral, first order stream which was mostly dry, with some residual puddles (less than 5 cm deep) at the time of inspection. The channel at this location is about 15 metres wide and appeared marshy with minimal bank definition. The substrate is a silty clay, and no evidence of active erosion was observed during site inspections. Some instream macrophytes were observed. The riparian corridor has been identified as freshwater wetlands (PCT 1736 at the site and PCT 1071 downstream). However, the riparian habitat is largely cleared for grazing. No woody debris was present. Threatened fish are not predicted to occur (DPI, 2016). However, SEPP listed wetlands are mapped about 500 metres downstream of the site. As the waterway is an ephemeral, first order, intermittent stream with no water or instream habitat features at the time of inspection and is disconnected from any major waterways including the Hunter River, it does not meet the minimum criteria of KFH (DPI, 2013). With respect to fish passage, it has been classified as "Class 4 - Unlikely fish habitat" (Fairfull and Witheridge, 2003) due to its ephemeral nature and a lack of connectivity to downstream.	 Glenrowan Creek at crossing looking upstream  Glenrowan Creek at crossing looking downstream

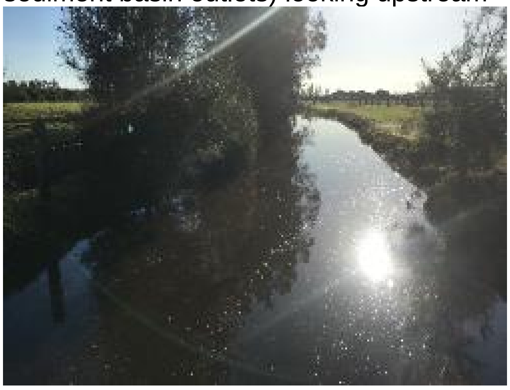
Site / classification / description	Site photograph
M12RT 2 **Purgatory Creek Crossing 1** <u>Not KFH, Class 4</u> Purgatory Creek headwaters is an ephemeral, first order stream and consists of sprawled marshy wetland with shallow residual pools and silty clay substrate. At the time of inspection, water levels were higher than usual and the waterway consisted of a pooled marshy wetland waterbody spanning about 10 metres. The creek had poor channel definition at this location and there was no evidence of active erosion or erosion potential. The dominant plant community type is Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736). There were some aquatic habitat features present in stream, including woody snags (less than one metre), overhanging vegetation, and some emergent and submerged macrophytes, although the quality of aquatic habitat at this site was sparse and poor and there were exotic grasses and several weed species established within the waterbody and downstream. The site and habitat features which are present are unlikely to support by benthic species due to a lack of connectivity to downstream. Further, the wetland area is also considered unlikely to be utilised by other aquatic organisms such as macroinvertebrates and dragonfly species due to the poor quality and minimal habitat available. Purgatory Creek has not been mapped as KFH (DPI, 2007) at this location, however it is mapped as Coastal Wetland under the Coastal Management SEPP. Despite being classified as a Coastal Wetland, this area is unlikely to be important wetland habitat for aquatic species, especially given better quality habitat is available nearby in Hexham Swamp Nature Reserve. As such, the site has been determined to be 'Not KFH' as it does not meet the minimum criteria for KFH (DPI, 2013). With respect to fish passage, it is classified "Class 4 – Unlikely fish habitat" (Fairfull and Witheridge, 2003) due to its ephemeral nature, as well as there being a lack of connectivity to Hunter River due to presence of several culverts and the floodgates at the downstream extent of the waterway.	 Purgatory Creek Crossing 1 looking upstream  Purgatory Creek Crossing 1 looking downstream
M12RT 2b **Purgatory Creek (west of Woodlands Close)** <u>Not KFH, Class 4</u> Purgatory Creek at this site is an ephemeral, second order stream, which forms a drainage depression through farm grazing land. The channel at this location is about 10 metres width, however, channel definition is minimal and there are a number of barriers (small culverts) which block flow and fish passage along the channel. The substrate is silty clay. Some submerged aquatic macrophytes (*Vallisneria* sp.) were present at the site, however there was minimal riparian vegetation and threatened fish are not predicted to occur (DPI, 2016). The plant community type has been identified as Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736). Purgatory Creek at this location is not mapped as KFH and does not meet the minimum criteria of KFH (DPI, 2013). As such, it has been classified as 'Not KFH'. With respect to fish passage, it is classified "Class 4 – Unlikely fish habitat" due to its ephemeral	 Purgatory Creek (west of Woodlands Close) looking downstream

Site / classification / description	Site photograph
nature and because there is no potential for aquatic species to migrate upstream to the site from the Hunter River due to the presence of floodgates and several culverts.	 Purgatory Creek (west of Woodlands Close) looking upstream
M12RT 2a **Purgatory Creek (at crossing/compound location)** <u>Not KFH, Class 3</u> Purgatory Creek at this site is a third order stream, which forms a narrow, artificially incised drainage channel through agricultural grazing land. The channel is about eight metres wide at this location. The channel appears to have been highly modified with culverts upstream and downstream of the site and floodgates located downstream at the Hunter River discharge point which artificially blocks tidal exchanges and fish passage. Minor active erosion was occurring at meanders and there is moderate potential for further erosion due to lack of riparian vegetation. The substrate consists of a silty clay sediment. Minimal aquatic habitat is present, with no woody snags and dried out aquatic macrophytes (*Typha orientalis*). However, a small area of mangroves was present on the left bank. While the riparian habitat is largely cleared, there are isolated patches of PCT Grey Mangrove low closed forest (1747) along Purgatory Creek. Threatened fish are not predicted to occur (DPI, 2016). Purgatory Creek has been mapped as KFH at this location, however because it have been artificially modified and is isolated from the Hunter River downstream due to the presence of floodgates and culverts, it does not meet the minimum criteria of KFH (DPI, 2013) therefore has been classified as 'Not KFH'. With respect to fish passage, it is classified "Class 3 - Minimal fish habitat" (Fairfull and Witheridge, 2003) as there is generally water present in the drainage line, however there is no potential for aquatic species to migrate upstream to the site from the Hunter River.	 M12RT 2a Purgatory Creek (at crossing/compound location) looking upstream  M12RT 2a Purgatory Creek (at crossing/compound location) looking downstream

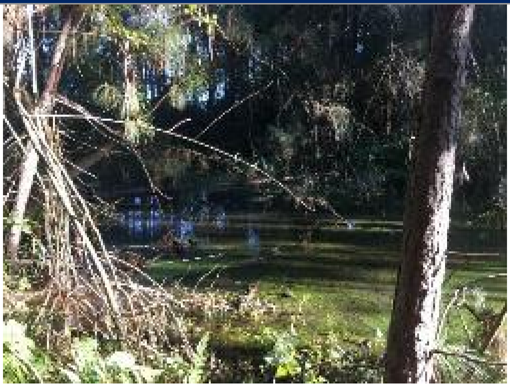
Site / classification / description	Site photograph
M12RT 2c **Purgatory Creek downstream** <u>Not KFH, Class 3</u> Purgatory Creek at this site is a third order stream, which forms a narrow, artificially incised drainage channel through agricultural grazing land. The channel is about 13 metres wide at this location. Flood gates are located downstream at the Hunter River discharge points which artificially blocks fish passage and tidal exchanges. Minor active erosion was occurring at meanders and there is moderate potential for further erosion due to a lack of riparian vegetation. The substrate consists of a sandy clay sediment. Minimal aquatic habitat is present at the site, with no woody snags and dried out aquatic macrophytes along the banks. Threatened fish are not predicted to occur (DPI, 2016). While the riparian habitat is largely cleared and consists of Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736), patches of PCT Grey Mangrove low closed forest (1747) still remain in some areas. While Purgatory Creek at this location is mapped as KFH, it has been artificially modified and is isolated from the Hunter River downstream due to the presence of floodgates, therefore does not meet the minimum criteria for KFH (DPI, 2013) and has been classified as 'Not KFH'. With respect to fish passage, it is classified "Class 3 - Minimal fish habitat" (Fairfull and Witheridge, 2003) as there is generally water present in the drainage line however there is no potential for aquatic species to migrate upstream to the site from the Hunter River due to the presence of floodgates downstream.	 Purgatory Creek downstream looking upstream  Purgatory Creek downstream looking downstream
M12RT 2d **Purgatory Creek downstream at junction with Hunter River** <u>KFH Type 1, Class 2</u> Purgatory Creek at this site is a third order waterway and estuarine system. The channel is about 12 metres wide at this location. Floodgates are located about 100 metres upstream of the site. Water level downstream of the floodgates is tidally influenced. At the time of inspection, water level was moderate and the tide was going out. Water appeared to be highly turbid. The channel was narrow, and appeared to have been artificially incised with clearly defined, steeply sloping banks. There was no evidence of active erosion along the banks but there was moderate potential for erosion. Some minor aquatic habitat was present at the site, including some instream macrophytes, as well as mangrove trees, roots and salt marsh along the embankment and in the intertidal zone. The mangroves and saltmarsh present in the intertidal zone may be utilised by marine/aquatic species for refuge and spawning. The riparian zone was sparsely vegetated with planted riparian vegetation only present within one metre of the waterway, the remaining area surrounding the site consisted of cleared grassland. No woody snags were present within the waterway. Threatened fish are not predicted to occur (DPI, 2016), however due to proximity and connection with the Hunter River, there is potential for Purple Spotted Gudgeon (*Mogurnda adspersa*) and Black Rock Cod (*Epinephelus daemelii*) to be found in this section of the creek, although this is highly unlikely.	 Purgatory Creek at junction with Hunter River looking upstream

Site / classification / description	Site photograph
Despite the modified state of the waterway, Purgatory Creek at this site has been classified "Type 1 – Highly sensitive key fish habitat" due the presence of mangroves and proximity to the Hunter River where threatened species are predicted to occur (DPI, 2013). With respect to fish passage, it is classified "Class 2 - Moderate fish habitat" (Fairfull and Witheridge, 2003) as it is directly connected to the Hunter River but does not present many high quality habitat features.	 Purgatory Creek at junction with Hunter River looking downstream
M12RT 3 **Hunter River at crossing** <u>KFH Type 1, Class 1</u> Hunter River at this site is a ninth order, major waterway and estuarine system with extensive mangrove forests on the east bank. The west bank consists of cleared agricultural grazing land and has been highly modified with bank revetment works including rock armouring and building levee. The water level was moderate at the time of inspection and the tide was going in. The channel at this location is about 250 metres wide and there was some evidence of active erosion on the west bank, with moderate potential for further erosion. Some aquatic habitat was present on the western bank such as mangroves, woody snags and gravel beds. This habitat has potential to form fish refuge and spawning areas. Threatened species Purple Spotted Gudgeon (*Mogurnda adspersa*) and Black Rock Cod (*Epinephelus daemelii*) have been mapped as having potential to occur in this section of the Hunter River (DPI, 2016; DPI, 2012). The monitoring location is located within areas of PCT Saltmarsh Estuarine Complex (1746) and Grey Mangrove low closed forest (1747) on the western river bank. Hunter River has been classified as "Type 1 - Highly sensitive key fish habitat" as it contains permanent fish refuge, and lots of aquatic habitat features including large woody snags, mangrove forests and overhanging or trailing vegetation (DPI, 2013). With respect to fish passage, it is classified "Class 1 - Major fish habitat" (Fairfull and Witheridge, 2003).	 Hunter River at crossing looking upstream  Hunter River at crossing looking downstream
M12RT 3a **Hunter River midstream** <u>KFH Type 1, Class 1</u> Hunter River at this site is a ninth order major waterway and estuarine system. The western bank is mostly cleared has been completely modified by rock armouring and a constructed levee along the length of the western bank. The site also has had additional imported and compacted fill deposited onto of the floodplain for a works compound that was used during construction of the Hexham Bridge downstream (can be seen in the photograph). Maitland Road is next to the site and about 700 metres west of the western riverbank. The water level was moderate at the time of inspection and the tide was going out. The channel at this location was about 140 metres wide and was well	 Hunter River midstream looking upstream

Site / classification / description	Site photograph
defined with steeply sloping rock armoured banks. There was no evidence of active erosion. Purple Spotted Gudgeon (*Mogurnda adspersa*) and Black Rock Cod (*Epinephelus daemelii*) have been mapped as having potential to occur in this section of the Hunter River (DPI, 2016; DPI, 2012). Hunter River has been classified as “Type 1 - Highly sensitive key fish habitat” as it is a major river system which contains permanent fish refuge, and important aquatic habitat (DPI, 2013). With respect to fish passage, it is classified “Class 1 - Major fish habitat” (Fairfull and Witheridge, 2003).	 Hunter River midstream looking downstream
M12RT 3b **Hunter River downstream** <u>KFH Type 1, Class 1</u> Hunter River is a ninth order major waterway and estuarine system with extensive mangrove forests on the eastern bank. The western bank consists of a boat ramp, main road and the existing Hexham Bridge structure. The water level was low at the time of inspection and the tide was going in. The channel was about 205 metres wide at this location and there was some evidence of active erosion and bank undercutting. There is moderate potential for further erosion. Habitat features on the western bank included some sparse mangroves and rock armouring which has some potential to form fish refuge and spawning areas, however the habitat is considered poor in comparison to nearby areas such as the mangrove forests which are located on the adjacent (eastern) bank. The vegetation on the western bank is highly modified from existing road infrastructure though may have historically been mangrove vegetation based on existing disturbed patches. Threatened species Purple Spotted Gudgeon (*Mogurnda adspersa*) and Black Rock Cod (*Epinephelus daemelii*) have been mapped as having potential to occur in this section of the Hunter River (DPI, 2016; DPI, 2012). Hunter River has been classified as a “Type 1 - highly sensitive key fish habitat”, as it is a major waterway which contains permanent fish refuge and estuarine habitat features (DPI, 2013). With respect to fish passage, it is classified “Class 1 – Major fish habitat” (Fairfull and Witheridge 2003).	 Hunter River downstream looking upstream  Hunter River downstream looking downstream
M12RT 4 **Hunter River Drain (upstream of Hunter River)** <u>Not KFH, Class 3</u> The Hunter River Drain is a second order drainage line, which forms a narrow channel (about four metres wide) through agricultural grazing land consisting of a silty substrate. The water is saline with some evidence of active erosion. There is moderate potential for further erosion. Minimal aquatic habitat was present, with no woody snags and sparse macrophytes occurring along banks. The surrounding riparian has been identified as PCT Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727). Threatened fish are not predicted to occur within the drainage line (DPI, 2016).	 Hunter River Drain (upstream of Hunter River) looking upstream

Site / classification / description	Site photograph
The drainage line is not mapped key fish habitat (DPI, 2007) however is within 50 metres of Coastal Management SEPP listed wetland (DPI, 2013). Despite being close to the Coastal Wetland area, the waterway is an agricultural drainage line that has poor water quality and does not discharge directly to the wetland due to the presence of floodgates. As such, the waterway does not meet minimum criteria of KFH and has been classified as 'Not KFH'. With respect to fish passage, it is classified "Class 3 - Minimal fish habitat" (Fairfull and Witheridge, 2003) as there is no potential for fish passage due to the presence of the floodgate downstream.	 Hunter River Drain (upstream of Hunter River) looking downstream
M12RT 5 **Unnamed tributary of Hunter River Drain (at sediment basin outlets)** <u>Not KFH, Class 4</u> The unnamed tributary of Hunter River Drain at this site is a second order, drainage line with an artificially formed channel through agricultural land. The drainage line is narrow and consists of a silty substrate. The channel was about eight metres wide at this location and there was no evidence of erosion at the time of inspection, although the channel is highly susceptible to changes in flow due to limited riparian zone and cleared surrounding lands. There is therefore a moderate potential for erosion to occur. Minimal aquatic habitat is present at this site, with no woody snags and sparse aquatic macrophytes along the banks. The surrounding riparian vegetation was not identified as part of this assessment, though is predominately a cleared landscape with scattered Swamp Oak. Threatened fish are not predicted to occur (DPI, 2016). As the waterway is a second order drainage line running through agricultural land and minimal aquatic habitat features present, it does not meet the minimum requirements for KFH (DPI, 2013). As such, it has been classified as 'Not KFH'. With respect to fish passage, it is classified "Class 4 - Unlikely fish habitat" (Fairfull and Witheridge 2003) due to multiple existing barriers to fish passage downstream (including culverts and the floodgate on Hunter River Drain).	 Unnamed tributary of Hunter River Drain (at sediment basin outlets) looking upstream  Unnamed tributary of Hunter River Drain (at sediment basin outlets) looking downstream
M12RT 6 **Windeyers Creek (east of Pacific Highway)** <u>Not KFH, Class 3</u> Windeyers Creek at this site is a second order stream with limited channel definition. At the time of inspection, the site exhibited residual, isolated pools and boggy, wetland habitat features. The creek is situated downstream of the Tomago Sandbeds. There was no evidence of active erosion at the time of inspection due to high water levels. A variety of aquatic habitat features were present, including emergent macrophytes, woody debris greater than 3 metres in length, overhanging and trailing vegetation. The vegetation has been identified as PCT Jointed Twig-rush sedgeland (1742),	 Windeyers Creek (east of Pacific Highway) looking upstream

Site / classification / description	Site photograph
boarded by pine plantation. Threatened fish are not likely to occur (DPI, 2016). Despite the waterway containing some aquatic habitat features, Windeyers Creek is not mapped as KFH (DPI, 2007) as it is classified as second order and is disconnected to the downstream major waterway. As such, it has been classified as 'Not KFH'. With respect to fish passage, it is classified as "Class 3 - Minimal fish habitat" (Fairfull and Witheridge, 2003) as there is permanent water present however there are multiple existing barriers to fish passage downstream including culverts and the floodgate on Windeyers Creek near the confluence with Hunter River.	 Windeyers Creek (east of Pacific Highway) looking downstream
M12RT 6a **Windeyers Creek (Upstream)** <u>Not KFH, Class 3</u> Windeyers Creek at this site is a second order stream with some channel definition. At the time of inspection, the channel spanned about 15 metres and the site exhibited high water levels in some areas surrounded by boggy, wetland habitat. There was no evidence of active erosion the time of inspection due to high water levels. The creek is situated on Tomago Sandbeds. A variety of aquatic habitat was present, including overhanging and trailing vegetation, instream macrophytes and woody debris. Minimal flow and a high level of organic matter was observed at the time of inspection. The waterway boarders pine plantation and native vegetation has been identified as PCT Jointed Twig-rush sedgeland (1742). Threatened fish are not likely to occur (DPI, 2016). Despite the waterway containing some aquatic habitat features, Windeyers Creek is not mapped as KFH (DPI, 2007) as it is classified as second order and is disconnected to the downstream major waterway. As such, it has been classified as 'Not KFH'. With respect to fish passage, it is classified as "Class 3 - Minimal fish habitat" (Fairfull and Witheridge, 2003) as there is permanent water present however there are multiple existing barriers to fish passage downstream including culverts and the floodgate on Windeyers Creek near the confluence with Hunter River.	 Windeyers Creek (Upstream) looking upstream  Windeyers Creek (Upstream) looking downstream
M12RT 6b **Downstream of Windeyers Creek and tributary of Windeyers Creek** <u>Not KFH, Class 3</u> Windeyers Creek at this site is a second order stream with good channel definition and moderately sloped banks on either side of the creek line. At the time of inspection, water levels were high, although the water quality appeared to be poor as it was stagnant and there was lots of algae present on the surface of the water. Creek banks and erosion could not be observed due to high water levels. The creek is situated about 165 metres from Tomago Sandbeds. Some aquatic habitat was present including macrophytes and woody debris, however the creek line was dominated by terrestrial	 Downstream of Windeyers Creek and tributary of Windeyers Creek looking upstream

Site / classification / description	Site photograph
weeds and pine plantation. Threatened fish are not likely to occur (DPI, 2016). Windeyers Creek is not mapped as KFH (DPI, 2007) as it is classified as a second order stream, therefore did not meet minimum criteria for KFH (DPI, 2013). At the time of inspection however, the site did contain aquatic and wetland habitat features, although overall the waterway did not present favourable conditions for aquatic species due to poor water quality. As such, it has been classified as 'Not KFH'. With respect to fish passage, it is classified as "Class 3 - Minimal fish habitat" (Fairfull and Witheridge, 2003) as there is permanent water present however there are multiple existing barriers to fish passage downstream including culverts and the floodgate on Windeyers Creek near the confluence with Hunter River.	 Downstream of Windeyers Creek and tributary of Windeyers Creek looking downstream
M12RT 7 **Tributary of Windeyers Creek at crossing** <u>Not KFH, Class 4</u> The unnamed tributary of Windeyers Creek is a first order, ephemeral drainage line with good channel definition. The site is situated on the Tomago Sandbeds. There was no evidence of erosion at the time of inspection and the channel has low erosion potential. Limited aquatic habitat was present however there were some large trees (*Melaleuca quinquenervia*) present within the channel and along the banks. The drainage line is boarded by a major road and cleared residential land. The creek is within 50 metres of a disturbed patch of PCT Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717). Threatened fish are not likely to occur (DPI, 2016). As the waterway is a first order, ephemeral waterway with minimal aquatic habitat, it does not meet the minimum criteria for KFH (DPI, 2013). As such, the waterway at this location has been classified as 'Not KFH'. With respect to fish passage, it is classified as "Class 4 - Unlikely fish habitat (Fairfull and Witheridge 2003) due to its ephemeral natures and because there are multiple existing barriers to fish passage downstream including culverts and the floodgate on Windeyers Creek near the confluence with Hunter River.	 Tributary of Windeyers Creek at crossing Creek looking upstream  Tributary of Windeyers Creek at crossing looking downstream
M12RT 8 **Wetland next to Botanic Gardens** <u>Not KFH, Class 3</u> The wetland next to Botanic Gardens is a first order, ephemeral waterbody containing fresh water and sand/silt substrate when water is present. The waterbody is about 80 metres wide when water is present. The wetland is situated on Tomago Sandbeds. At the time of inspection, water levels appeared high as boundaries were submerged. The downstream extent is boarded by the Pacific Highway. The wetland contains minimal bank definition and is unlikely to be affected by erosion. A variety of habitat was present including, woody debris greater than 3 metres, dense vegetation and macrophytes. The surrounding vegetation has been identified as PCT Broad-leaved	 Wetland next to Botanic Gardens

Site / classification / description	Site photograph
Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717). Threatened fish are not likely to occur (DPI, 2016). As the waterway is not a recognised and mapped stream, and it does not fall within an area mapped as SEPP listed wetland, it does not meet the minimum criteria for KFH (DPI, 2013). As such, it has been classified as 'Not KFH'. With respect to fish passage, it is classified as "Class 3 - Minimal fish habitat" (Fairfull and Witheridge, 2003) due to the presence of habitat features which may be utilised by aquatic species when water is present, although there does not appear to be any downstream drainage pathway from the wetland therefore there is not likely to be any fish migration to or from this site.	 Wetland next to Botanic Gardens
M12RT 9 **Waterbody opposite Old Punt Road** Not KFH, Class 3 The unnamed waterbody opposite Old Punt Road is an estuarine inlet connected to the Hunter River. The banks appear to have been artificially constructed in order to facilitate industrial activity which is present on the adjacent shoreline (shipyard). The waterbody spans about 215 metres at its widest point. Some mangroves were present on the banks however; no fish were observed at the time of inspection. The substrate is silty clay with large deposits of rubble and cement. There was no active erosion and low erosion potential. As the waterbody is directly connected to the Hunter River where Purple Spotted Gudgeon (*Mogurnda adspersa*) are predicted to occur (DPI, 2016), it is possible for the fish to inhabit the waterbody. However, upon inspection the water appeared highly degraded with industrial inputs likely to influence water quality. Due to the degradation, the waterway would be undesirable fish habitat. Despite the waterbody containing some mangrove habitat and being mapped as KFH (DPI, 2007), the waterbody is in a highly degraded state and has been artificially built for industrial use. Therefore, according to the KFH guidelines (DPI 2013) which state that urban and artificial ponds are not considered KFH, this waterbody is not considered KFH. With respect to fish passage, it is classified as "Class 3 – Minimal fish habitat" (Fairfull and Witheridge, 2003) as the waterbody is connected to the Hunter River but there are not many habitat features available.	 Waterbody opposite Old Punt Road  Waterbody opposite Old Punt Road
M12RT 10 **Grahamstown Drain** Not KFH, Class 3 Grahamstown Drain is a second order drainage line which runs from Grahamstown Dam and ultimately discharges to the Hunter River. The channel is surrounded by residential properties and urban parklands. The channel is about 6 metres wide and appears artificially dredged, The waterway contains a silty clay substrate with isolated areas of active erosion. There is moderate potential for further erosion. The channel is situated about 120 metres from Tomago Sandbeds. Some instream aquatic macrophytes and overhanging vegetation are present. Threatened fish are not likely to occur (DPI, 2016).	 Grahamstown Drain looking upstream

Site / classification / description	Site photograph
Despite being mapped as KFH (DPI, 2007), the waterway is a second order artificial drainage line, therefore it does not meet the minimum criteria for KFH (DPI, 2013). Further, the waterway is mainly used to transfer treated effluent from the Raymond Terrace Wastewater Treatment Works therefore is undesirable water quality for aquatic species. With respect to fish passage, it is classified as "Class 3 - Minimal fish habitat" (Fairfull and Witheridge, 2003) due to multiple existing barriers to fish passage downstream including culverts and the floodgate on Windeyers Creek near the confluence with Hunter River.	 Grahamstown Drain looking downstream
M12RT 11 **Inside bend of Hunter River in the unnamed Coastal Wetland** KFH Type 1, Class 1 This wetland is next to the Hunter River, situated on floodplain containing saline water and a sandy silt substrate. The waterbody is considered mapped as 'Coastal Wetland' under Coastal Management SEPP (2018). The wetland contains minimal bank definition and is unlikely to be affected by erosion. The waterbody is immersed in a dense bed of macrophytes including *Typha orientalis*. The vegetation on the southern bank has been identified as a mosaic of Swamp Oak (PCT 1727), Saltmarsh (PCT 1746), *Phragmites Typha* wetlands (1071) and Grey Mangrove low closed forest (PCT 1747). The site and surrounding mangrove forests on the eastern bank of the Hunter River is considered important fish refuge habitat and has potential to be utilised as habitat for spawning. Threatened fish are not likely to occur (DPI, 2016). The site has been identified as "Type 1 – Highly sensitive KFH" (DPI, 2013). With respect to fish passage, it is classified as "Class 2 – Moderate fish habitat" (Fairfull and Witheridge, 2003).	 Inside bend of Hunter River  Inside bend of Hunter River
M12RT11a **Unnamed tributary of Hunter River flowing through Unnamed Coastal Wetland** Not KFH, Class 3 This tributary is a second order, ephemeral drainage channel which flows toward the Hunter River through Coastal Wetland area on the eastern bank of the Hunter River. The creek is well defined and is about seven metres wide at this location. There was some evidence of active erosion and potential for further erosion, There was minimal instream aquatic macrophytes within the creek and no woody snags present. The riparian zone had been cleared of vegetation and the surrounding area consisted of grassland. The surrounding vegetation has been identified as Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736). Threatened fish are not likely to occur (DPI, 2016).	 Unnamed tributary looking upstream

Site / classification / description	Site photograph
Since the waterway is a second order artificial drainage line, it does not meet the minimum criteria for KFH (DPI, 2013). As such, it has been classified as 'Not KFH'. With respect to fish passage, it is classified "Class 4 – Unlikely fish habitat" (Fairfull and Witheridge, 2003) due to its ephemeral nature, minimal aquatic habitat features present and no potential for fish passage due to the presence of the floodgate downstream.	 Unnamed tributary looking downstream
M12RT 12 **Viney Creek downstream of project** <u>KFH Type 2, Class 3</u> Viney Creek is a fourth order, ephemeral stream. The channel has limited definition and consists of sprawled marshy wetland. At the time of inspection, water levels were moderate and water appeared to be slightly turbid with an oily sheen on the surface. A double culvert was present about 50 metres upstream. There was no evidence of active erosion or erosion potential. Aquatic habitat that was present at the site included dense emergent macrophyte beds and overhanging vegetation. Threatened fish are not predicted to occur (DPI, 2016). Viney Creek is mapped as KFH (DPI, 2007) and has been classified as "Type 2 - Moderately sensitive KFH" (DPI, 2013) as the site contained aquatic and wetland habitat features. Additionally, Viney Creek flows to Woodberry Swamp which is a Coastal Wetland listed under the Coastal Management SEPP (2018). With respect to fish passage, it is classified "Class 3 - Minimal fish habitat" (Fairfull and Witheridge, 2003) as it is generally isolated from upstream tributaries due to presence of culverts and other barriers including a ponded waterbody.	 Viney Creek downstream of project looking upstream  Viney Creek downstream of project looking downstream
M12RT 13 **Tributary to Viney Creek, corner of M1 Pacific Motorway and John Renshaw Drive intersection** <u>Not KFH, Class 4</u> The tributary of Viney Creek is an unnamed first order, artificial drainage line. Mapping and classification of the tributary only starts on the north side of John Renshaw Drive. Within the construction footprint, the tributary is a stormwater drain constructed for the M1 Pacific Motorway, which drains water from the western side of the motorway, under the road and into the south eastern corner of the intersection shown in the photos. At the time of inspection there was no standing water, however the drain is very thick with woody vegetation, including *Lantana camara*. It is unlikely that water is held in this location for long following rainfall and run-off.	 Viney Creek tributary looking from the intersection

Site / classification / description	Site photograph
Aquatic habitat that was present at the site included dense overhanging woody vegetation, though very limited macrophytes were present. The surrounding vegetation has been identified as PCT Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590). Threatened fish are not predicted to occur (DPI, 2016). Since the waterway is a first order artificial drainage line, it does not meet the minimum criteria for KFH (DPI, 2013). As such, it has been classified as 'Not KFH'. With respect to fish passage, it is classified "Class 4 – Unlikely fish habitat (Fairfull and Witheridge 2003) due to multiple existing barriers to fish passage downstream, including culverts, a general lack of habitat features and low flow.	 Viney Creek tributary looking downhill from the New England Highway

Appendix H. Personnel

The work to prepare this BAR was carried out by appropriately qualified and experienced ecologists as outlined in **Table H-1**.

Table H-1 Personnel involved in the development of this BAR

Personnel	Qualification	Role	Experience
Chris Thomson - Principal	Graduate Certificate in Natural Resources Bachelor of Applied Science BBAM accredited assessor (179) BAM accredited assessor (BAAS18058)	Principal - Accredited Assessor (BBAM 179). Project Lead; BBAM plot assessment, fauna survey, supplementary PCT assessment and mapping, biodiversity offset strategy and technical review of BAR	24-years' experience working on road ecology assessments in NSW including lead ecologist and peer review for 7 Pacific Highway Upgrade projects
Brenton Hays – Senior Ecologist	Bachelor of Environmental Science and Management (Hons) BAM accredited assessor	BBAM plot assessment, PCT survey and mapping, BAR preparation	6-years' experience consulting in NSW on road ecology assessments
Matt Consterdine - Ecologist	Bachelor of Environmental Science and Management BAM accredited assessor	BBAM plot assessment	6-years' experience consulting in NSW
Andrew Carty – Senior Ecologist	Bachelor of Environmental Science - University of Newcastle Natural Area Restoration and Management Cert. IV Hunter Institute TAFE Bush Regeneration Cert. II Hunter Institute TAFE BAM accredited assessor	Vegetation / PCT classification and mapping, targeted threatened flora species survey. Andrew worked on the project between 2014 and 2018 and completed the original PCT classification and mapping work.	15-years' experience in NSW as a project botanist
Lukas Clews – Senior Ecologist	Master of Scientific Studies Graduate Certificate in Applied Science Bachelor of Science Diploma in Conservation and Land Management Certified Environmental Practitioner (CEnvP) by the Environment Institute of Australia and New Zealand (EIANZ) BAM accredited assessor	Targeted threatened flora surveys	12-years' experience in NSW as a project botanist
Paul Rossington – Senior Ecologist	Master of Wildlife Management Bachelor of Science (Biology)	Targeted threatened flora surveys	12-years' experience in NSW as a project botanist

Personnel	Qualification	Role	Experience
Mark Clements – Research Scientist	Bachelor of Applied Science, (Canberra College of Advanced Education [Canberra University], 1981). Graduate Diploma of Science (Australian National University, 1983). Ph. D. (Australian National University, April, 1996).	Orchid expert consulted on habitat assessment and potential presence of threatened orchid species for input into survey design	Around 30-years' experience as a research scientist
Sarah Douglass – Senior Environmental Scientist	Masters – Environmental Management, Bachelor of Science (Environmental Biology), AUSRIVAS assessor	Lead for field and desktop assessment for aquatic habitat	Over 13-years' experience in the ecology of freshwater ecosystems and impact assessment of major and minor infrastructure projects for aquatic ecology and surface water quality.
Jorja Vernon – Environmental Scientist	Bachelor of Environmental Science (Honours)	Assistant author of the impact assessment on aquatic habitat	3-years' experience working on road, rail and energy generation infrastructure projects in NSW, assessing impacts to aquatic ecology and surface water quality.

Appendix I. Biodiversity Offset Strategy

Australian Government

BUILDING OUR FUTURE

NSW GOVERNMENT

M1 Pacific Motorway extension to Raymond Terrace

Biodiversity Offset Strategy

Transport for NSW | July 2021

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Executive summary

Background

Transport for New South Wales (Transport) proposes to construct the M1 Pacific Motorway extension to Raymond Terrace (the project). Approval is sought under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and Part 9, Division 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The project Biodiversity Assessment Report (BAR) and this Biodiversity Offset Strategy (BOS) are facilitated under Clause 27 of the Biodiversity Conservation (Savings and Transitional) Regulation 2016 which permits the proponent to submit the application in accordance with the former planning provisions. This approach was approved by the Department of Planning and Environment (as the consent authority) and detailed in the Secretary's Environmental Assessment Requirements (SEARs). As such, the former provisions of the *Threatened Species Conservation Act 1995* (TSC Act) remain in force. Accordingly, the biodiversity assessment and offset calculations has been prepared in accordance with the Framework for Biodiversity Assessment (FBA) (OEH 2014a) and the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014b).

The project has also been referred under the EPBC Act (EPBC 2018/8288) and determined a controlled action to be assessed under the Bilateral Agreement made under section 45 of the EPBC Act relating to environmental assessment between the Commonwealth of Australia and the State of New South Wales. The Bilateral Agreement endorses the FBA and the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014b).

Performance outcomes

This offset strategy has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) (SSI 7319), which include the Commonwealth assessment requirements under the EPBC Act (2018/8288). In addition, the desired performance outcomes for the project in relation to biodiversity offsets as outlined in the SEARs (SSI 7319) describe the following:

- Offsets are equivalent to any remaining impacts from construction and operation of the project
- Assure the delivery of offsets and /or supplementary measures required for the project.

The Commonwealth (EPBC requirements) in relation to biodiversity offsets, state that:

- Quantification of the offset liability for each species and community significantly impacted, and information on the proposed offset strategy, including discussion of the conservation benefit for each species and community, how offsets will be secured, and the timing of protection. It is a requirement that offsets directly contribute to the ongoing viability of the specific matter impacted by a proposed action i.e. 'like-for-like'.

Overview of biodiversity offsets

In accordance with the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014b), biodiversity impacts have been avoided and minimised where possible by locating the project within or next to existing road infrastructure and in cleared rural areas. Residual impacts on biodiversity would be offset in accordance with the FBA and the NSW Biodiversity Offsets Policy for Major Projects.

The credits required to offset the residual impacts of the project were calculated using the BioBanking Assessment Methodology (BBAM) and include 8,265 ecosystem credits (equivalent to about 4,389 Biodiversity Assessment Methodology (BAM) credits) and 17,895 species credits.

The project would also impact around 16.4 hectares of mapped Coastal Management SEPP coastal wetlands, which includes about 3.53 hectares of the saltmarsh and mangrove communities. Offsets for these saline vegetation communities would be provided in accordance with the Policy and guidelines for fish habitat conservation and management update 2013 (DPI Fisheries NSW).

Offset Strategy

The offset strategy proposed for this project will prioritise like for like credits however may subsequently consist of any combination or sequence of the actions provided below:

- Confirm credit requirements at finalisation of clearances
- Purchase of available credits
- Apply for an assessment of reasonable equivalency
- Establish Biodiversity Stewardship Agreements on candidate properties
- Payment to the Biodiversity Conservation Fund
- Use of the variation criteria or use of supplementary measures if suitable credits cannot be identified
- Identify and secure appropriate offsets for saline vegetation formations in consultation with NSW DPI Fisheries
- Offsets for Matters of National Environmental Significance.

This Strategy is based on the impacts associated with the concept design for the project as presented in the EIS. This approach is in accordance with the FBA and commits to making all reasonable steps to locate appropriate like-for-like offset sites before supplementary measures can be considered.

During the detailed design or construction phase, the construction footprint may change from that assessed here which would result in a different offset requirement for the project. Any increases in clearing as a result of detailed design (which is unlikely as a “worse case” clearing footprint has been used in this assessment) would be subject to environmental assessment and any offset recalculations would be done in accordance with the FBA and the requirements of the EPBC Act Bilateral Agreement. Where a decrease in the vegetation impact is identified, any offset recalculations would be done in accordance with the FBA and reported under a revised offset strategy.

In terms of offset availability, a review of available credits on the DPIE public credit register indicates that the current credit market cannot provide all the credits required. Transport has not purchased any credits for this project to date.

Pending project approval, Transport would commence any combination of the above listed actions with a priority of like-for-like credits to satisfy the biodiversity offset requirements. Where credits cannot be purchased or generated, Transport may choose to pay into the Biodiversity Conservation Fund to satisfy the biodiversity offset requirements.

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Appendices

1. Introduction

1.1 Project background

Transport for New South Wales (Transport) proposes to construct the M1 Pacific Motorway extension to Raymond Terrace (the project). Approval is sought under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and Part 9, Division 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The project is also a controlled action under Section 75 of the EPBC Act (reference EPBC 2018/8288) for significant impact to threatened species and communities (Section 18 and Section 18A of the EPBC Act). As such, the project requires approval from the NSW Department of Planning, Infrastructure and Environment (DPIE) and the Commonwealth Government.

The project would connect the existing M1 Pacific Motorway at Black Hill and the Pacific Highway at Raymond Terrace within the City of Newcastle and Port Stephens Council local government areas. The project would provide regional benefits and substantial productivity benefits on a national scale. The project location is shown in **Figure 1-1** within its regional context.

1.2 Project description

The project would include the following key features:

- A 15 kilometre motorway comprised of a four lane divided road (two lanes in each direction)
- Motorway access from the existing road network via four new interchanges at:
  - Black Hill: connection to the M1 Pacific Motorway
  - Tarro: connection and upgrade (six lanes) to the New England Highway between John Renshaw Drive and the existing Tarro interchange at Anderson Drive
  - Tomago: connection to the Pacific Highway and Old Punt Road
  - Raymond Terrace: connection to the Pacific Highway.
- A 2.6 kilometre viaduct over the Hunter River floodplain including new bridge crossings over the Hunter River, the Main North Rail Line, and the New England Highway
- Bridge structures over local waterways at Tarro and Raymond Terrace, and an overpass for Masonite Road in Heatherbrae
- Connections and modifications to the adjoining local road network
- Traffic management facilities and features
- Roadside furniture including safety barriers, signage, fauna fencing and crossings and street lighting
- Adjustment of waterways, including at Purgatory Creek at Tarro and tributary of Viney Creek
- Environmental management measures including surface water quality control measures
- Adjustment, protection and/or relocation of existing utilities
- Walking and cycling considerations, allowing for existing and proposed cycleway route access
- Permanent and temporary property adjustments and property access refinements
- Construction activities, including establishment and use of temporary ancillary facilities, temporary access tracks, haul roads, batching plants, temporary wharves, soil treatment and environmental controls.

A detailed project description is provided in Chapter 5 of the environmental impact statement (EIS). The locality of the project is shown in **Figure 1-1**, while an overview of the project is shown in **Figure 1-2.**

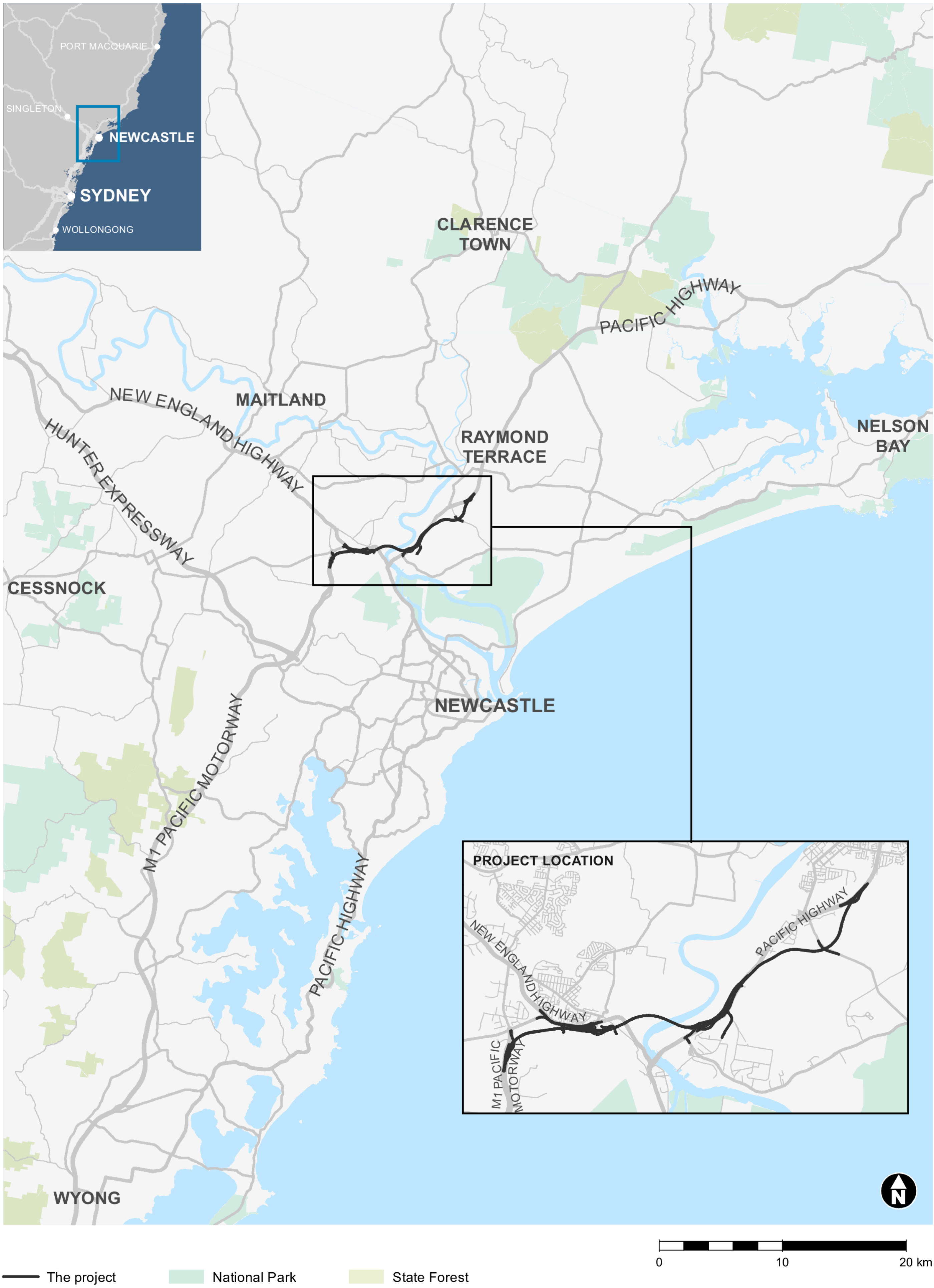

Figure 1-1 Regional context of the project

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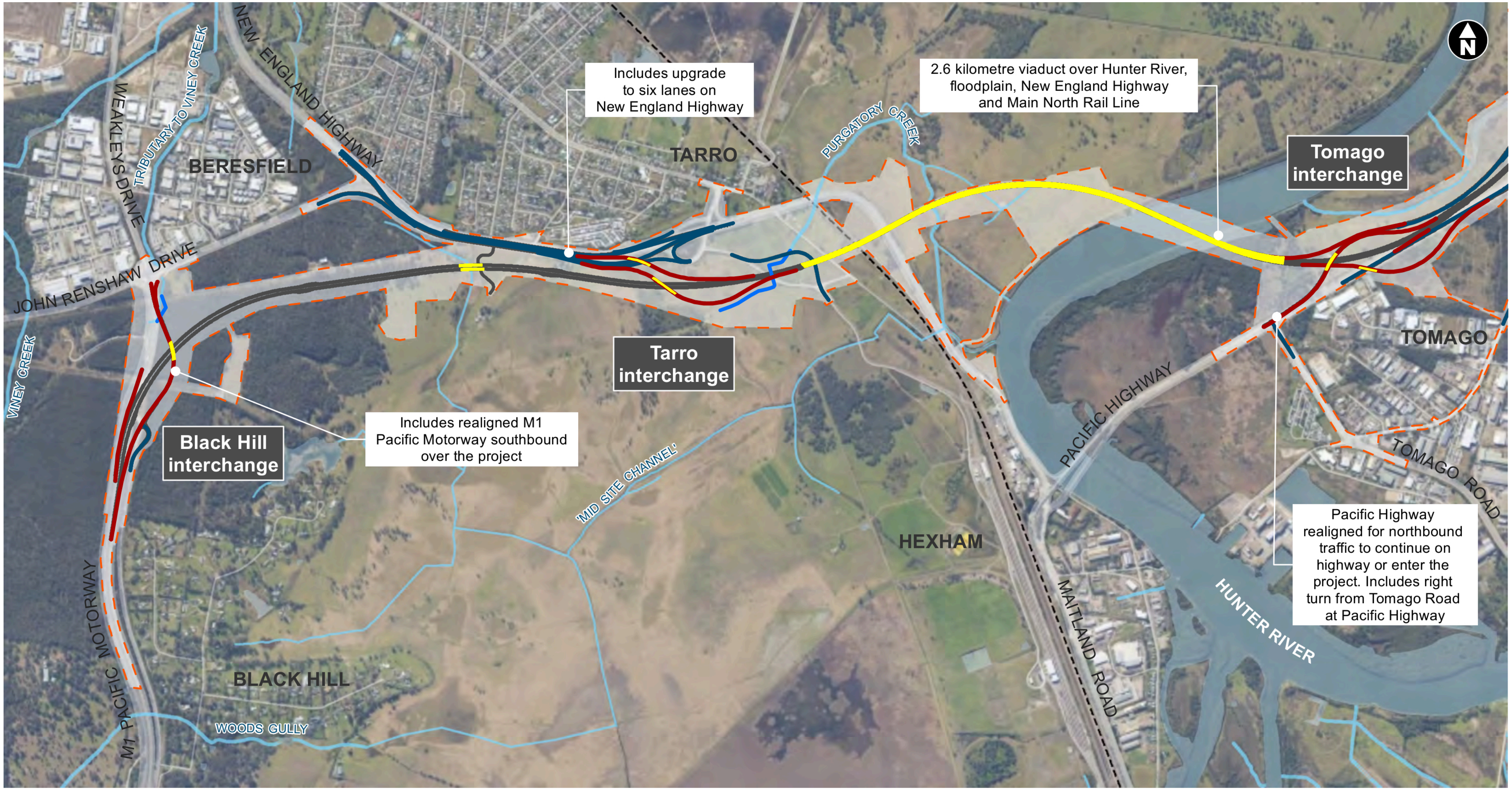

Main alignment

Adjustments to existing roads

New ramp

Creek realignment

Bridges/ Viaduct

Construction footprint

Waterways

Main North Rail Line

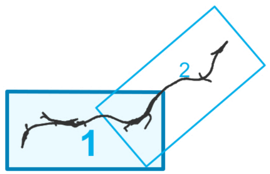

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Figure 1-2 Project key features (map 1 of 2)

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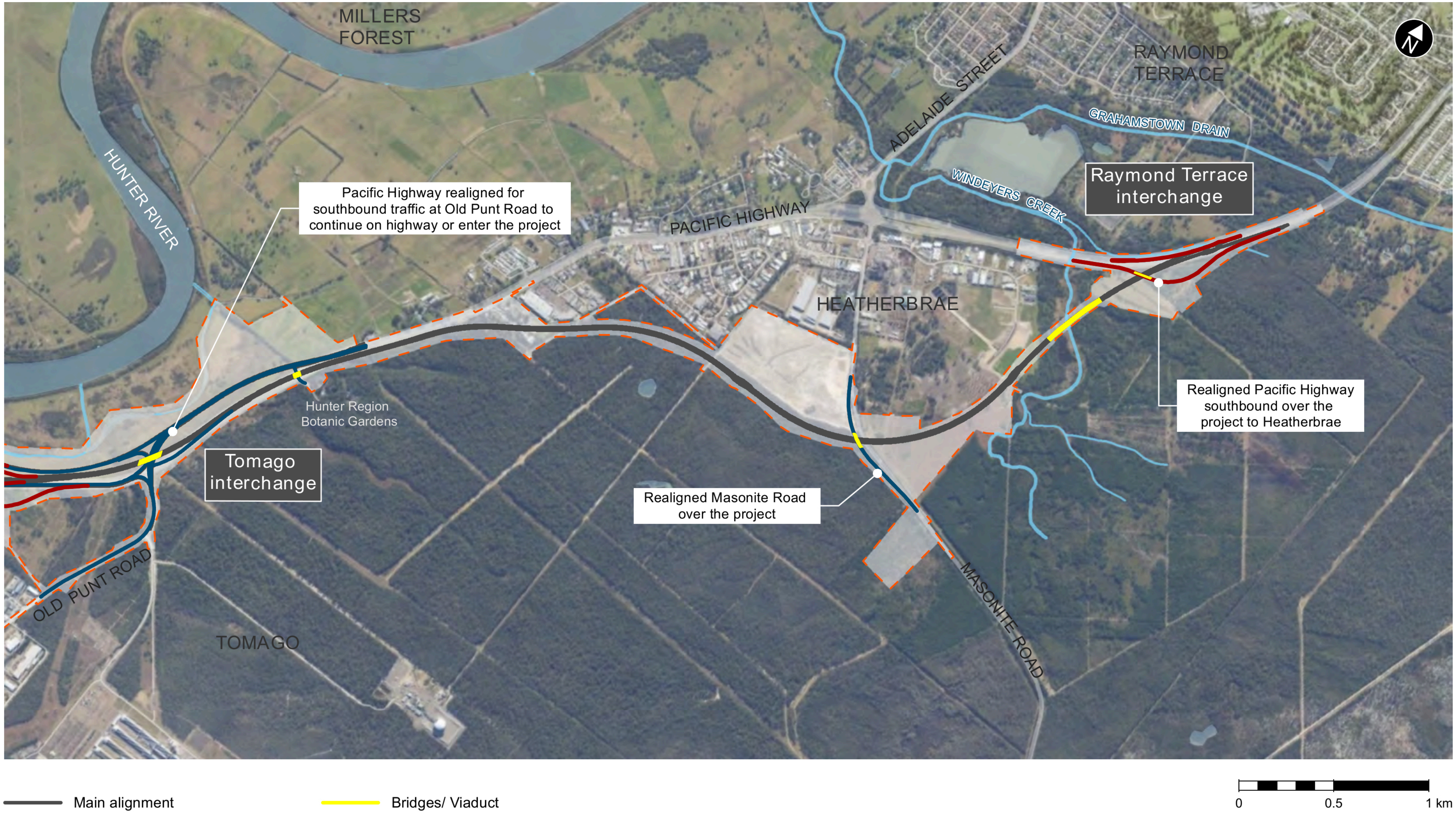

Main alignment
Adjustments to existing roads
New ramp
Bridges/ Viaduct
Construction footprint
Waterways

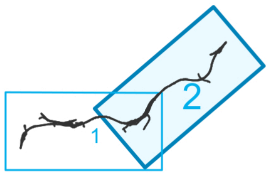

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Figure 1-2 Project key features (map 2 of 2)

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1.3 Performance outcomes

The desired performance outcomes for the project in relation to biodiversity offsets as outlined in the SEARs (SSI 7319) describe the following:

- Offsets are equivalent to any remaining impacts from construction and operation of the project (**Section 2.2**)
- Assure the delivery of offsets and /or supplementary measures required for the project (**Chapter 2**).

The Commonwealth (EPBC requirements) in relation to biodiversity offsets, state that:

- Quantification of the offset liability for each species and community significantly impacted, and information on the proposed offset strategy, including discussion of the conservation benefit for each species and community, how offsets will be secured, and the timing of protection. It is a requirement that offsets directly contribute to the ongoing viability of the specific matter impacted by a proposed action i.e. 'like-for-like' (**Section 1.5.2** and **Section 1.5.3**).

1.4 Secretary's Environmental Assessment Requirements

This Biodiversity Offset Strategy (BOS) forms part of the EIS for the project that has been prepared under Division 5.2 of the EP&A Act. This strategy specifically addresses the SEARs (SSI 7319) relating to biodiversity offsets, including the Commonwealth assessment requirements under the EPBC Act (referral 2018/8288).

Table 1-1 identifies the project SEARs relating to biodiversity offsets and references the relevant section of the report where these requirements are addressed. **Table 1-2** identifies additional requirements listed in the re-issued SEARs, as outlined by the Commonwealth, and where they have been addressed in this report. Further information on the policy, planning and Commonwealth legislative requirements as they apply to this assessment are provided in **Section 1.5.1**.

Table 1-1 SEARs relevant to biodiversity offsets

Secretary's requirement	Where addressed in this report
3. Assessment of Key Issues	
2. For each key issue the Proponent must:	
(f) detail how any residual impacts will be managed or offset, and the approach and the predicted effectiveness of these measures.	Residual impacts (following the implementation of mitigation measures) to biodiversity values as a result of the project are outlined in **Section 1.5.2** and **Section 1.5.3** with reference to the credit obligation for the project. This BOS addresses the NSW Biodiversity Offset Policy for Major Projects and the FBA by providing a proposed strategy to offset residual impacts on the project. The predicted effectiveness of measures to manage biodiversity impacts is detailed in Section 9.2 of the BAR.

Table 1-2 EPBC Act requirements relevant to biodiversity offsets

Secretary's requirement	Where addressed in this report
Attachment A of the SEARs: Commonwealth (EPBC Act) General assessment requirements	
6. Quantification of the offset liability for each species and community significantly impacted, and information on the proposed offset strategy, including discussion of the conservation benefit for each species and community, how offsets will be secured, and the timing of protection. It is a requirement that offsets directly contribute to the ongoing viability of the specific protected matter impacted by a proposed action i.e. 'like-for-like'. Like-for-like includes protection of native vegetation that is the same ecological community or habitat being impacted (preferably in the same region where the impact occurs), or funding to provide a direct benefit to the matter being impacted e.g. threat abatement, breeding and propagation programs or other relevant conservation measures.	**Section 1.5.2** and **Section 1.5.3** quantifies the offset liability for each species and vegetation community in line with the Framework for Biodiversity Assessment (FBA) (OEH 2014a) and NSW Biodiversity Offsets Policy for Major Projects. This BOS outlines a series of proposed actions describing Transport's proposed strategy to offset the impacts for the project, how like-for-like offsets will be sourced and secured consistent with the guidelines in the FBA and provides a timeframe for retiring offset credits. Once offset sites are confirmed, conservation benefits for each species and community will be documented.

1.5 Offset requirements

1.5.1 Policy and planning setting

The *Threatened Species Conservation Act 1995* (TSC Act) was repealed and replaced by the *Biodiversity Conservation Act 2016* (BC Act) on 25 August 2017; however, the NSW Government established transitional arrangements related to biodiversity assessment for the various categories of development consent or approval that are underway or have already been made. These transitional arrangements are defined in the Biodiversity Conservation (Savings and Transitional) Regulation 2017 and apply to this project. This approach was approved by the Department of Planning and Environment (as the consent authority) on 13 November 2017 and detailed in previously issued SEARs. As such, the former provisions of the TSC Act remain in force for this assessment and this project and offset calculations has been assessed under the FBA (OEH, 2014a). The BioBanking Credit Calculator (BBCC) proposal ID for the project is 179/2020/5065MP.

In accordance with the NSW Biodiversity Offsets Policy for major projects (Office of Environment and Heritage [OEH] 2014a), the FBA (OEH 2014b) provides the method to assess the impacts and offsetting requirements for this project. Accordingly, offsets must be targeted to the biodiversity values being lost or to higher conservation priorities. This generally means that like-for-like offsets are required. The NSW Biodiversity Offsets Policy for Major Projects provides flexibility for proponents to meet their offset requirements by providing various offset options while ensuring that the best and most credible offsets are provided (OEH 2014b). This flexibility includes variations to the like-for-like requirement and supplementary measures (funds for other measures that benefit biodiversity).

On 20 March 2019, the revised SEARs confirmed the project is a controlled action that will be assessed under the Bilateral Agreement made under section 45 of the EPBC Act. All impacts to Matters of National Environmental Significance (MNES) will be offset on a like-for-like basis.

1.5.2 Biodiversity credits

The required ecosystem and species credits have been calculated using the FBA and BioBanking Assessment Methodology (BBAM) credit calculator which is endorsed by the Commonwealth as part of the EPBC Act assessment Bilateral Agreement. The project BAR outlines the ecological values impacted by the project in addition to avoidance and mitigation measures. The BAR also outlines the project credit requirements for residual impacts and these credits are summarised in **Table 1-3** and **Table 1-4**.

The BC Act together with the Biodiversity Conservation Regulation 2017 commenced on 25 August 2017. They replaced the TSC Act and associated regulation. The TSC Act had previously provided the framework for creation of biodiversity credits and biodiversity credit obligations (also called offset obligations). The change in legislation also included a change in the method that was used to create biodiversity credits and to calculate offset obligations.

To ensure that BBAM credits and credit obligations created under the TSC Act could still be used or met within the newer Biodiversity Assessment Method (BAM) credit market, the Biodiversity Conservation (Savings and Transitional) Regulation 2017 (Savings and Transitions Regulation) preserved BBAM credits and credit obligations. The Savings and Transitions Regulation also provided the authority for the Environment Agency Head (EAH) to determine reasonable equivalence of BBAM credits or credit obligations, that is, to match older BBAM BioBanking credits or credit obligations to the new BAM Biodiversity Offsets Scheme credit numbers and classes.

To assist any future application for credit equivalency, this BOS contains preliminary BAM ecosystem credits have also been determined using the BAM. Vegetation Integrity plot data collected for each plot during field surveys for the BAR was entered into the Biodiversity Assessment Method Calculator (BAM-C) to provide Transport with a forward estimate of the BAM credits required should credits be sought from Biodiversity Stewardship Agreements (BSAs) in the BAM market. A BSA is a voluntary agreement between the NSW Biodiversity Conservation Trust (BCT) and a landholder to protect and manage an area of land to improve its biodiversity values and generate biodiversity credits.

The BAM credits should be viewed as an estimate only and are reported from calculations provided by the BAM-C on 29 January 2021.

The BBAM ecosystem credits were calculated based on a loss in landscape value score of 27.20, a Threatened Ecological Community (TEC) multiplier of 3.0 and threatened species multiplier of 3.0. The associated ecosystem species identified as the highest multiplier influencing the credits required is shown in the table for each Plant Community Type (PCT). A summary of ecosystem credits required are provided in **Table 1-3**.

Table 1-3 Summary of ecosystem credits required

Plant community type (PCT) (BVT)	Project impact within construction footprint (ha)	Ecosystem credits required (BBAM)	Indicative BAM credits
Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast (1717) (HU931)	10.49	469	222
Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1724) (HU938)	1.61	75	33
Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598) (HU812)	0.45	27	16

Plant community type (PCT) (BVT)	Project impact within construction footprint (ha)	Ecosystem credits required (BBAM)	Indicative BAM credits
Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (1588) (HU802)	7.60	429	212
Jointed Twig-rush sedgeland (1742) (HU956)	1.45	99	25
Phragmites australis and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (1071) (HU673)	7.71	326	235
Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716) (HU930)	1.82	103	57
Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646) (HU860)	28.59	1,421	555
Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands (1649) (HU863)	1.36	72	38
Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest (1590) (HU804)	41.88	2,327	1,142
Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast (1727) (HU941)	8.76	423	94
Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter (1736) (HU950)	59.04	2,304	1,654
Total	**170.76**	**8,076***	**4,283**

*This total is different to what is listed in the credit report as it does not include the saline communities Grey Mangrove low closed forest (HU961) or Saltmarsh Estuarine Complex (HU960). See **Section 1.5.3** for discussion. The total in this table is therefore the total provided in the credit report (i.e. 8,265 ecosystem credits) minus the credit requirements for the two saline vegetation communities.

The species credits in **Table 1-4** are calculated based on the impact of the project on the number of individuals in the case of the threatened plant species, and the area of impacted habitat for threatened fauna. Mahony’s Toadlet (*Uperoleia mahonyi*) was listed under the BC Act in 2018 and the species has not been added to the BBCC. However, assessment under Section 9 of the FBA was specified in the SEARs agency comments from the Environment, Energy and Science Group (formerly OEH). The species is assumed present in the construction footprint and the area of impact is the same as for Wallum Froglet, therefore the same credit obligation is presented. The Squirrel Glider was recorded in the study area, and under the TSC Act, this species was listed as an ecosystem species and hence the BBAM calculator has not identified credits for this species.

Table 1-4 Summary of species credits required

Species	Extent of impact (ha) or individuals	Species credits required (BBAM)
Eucalyptus parramattensis subsp. *Decadens*	34 plants	476
Diuris arenaria	161 plants	12,397
Callistemon linearifolius	157 plants	2,198
Persicaria elatior	3 plants	39
Australian Bittern	43.64 ha	567
Black Bittern	61.95 ha	805
Koala	51.12 ha	1,329
Wallum Froglet	3.21 ha	42
Mahony's Toadlet	3.21 ha	42
Total		**17,895**

1.5.3 Offsets for impacts to aquatic habitats

According to the FBA, PCTs that are classified under the BioNet Vegetation Information System (VIS) classification database as being in the saline wetlands vegetation formation must be assessed according to the Fisheries NSW policy and guidelines (DPI, 2013). There are two PCTs impacted by this project that are saline wetland formations:

- Saltmarsh estuarine complex (PCT 1746) (TYPE 1 Key Fish Habitat) – Zone 19, removal of about 1.26 hectares (12,600 square metres)
- Grey Mangrove low closed forest (PCT 1747) (TYPE 2 Key Fish Habitat) – Zone 20 and 21, removal of about 2.27 hectares (22,700 square metres).

The project would also impact around 16.4 hectares of mapped Coastal Management SEPP coastal wetlands, which includes about 3.53 hectares of the saltmarsh and mangrove communities (TYPE 1 and 2 habitats). The remaining 12.87 hectares of the Coastal Management SEPP coastal wetland impacted by the project are covered by the PCTs 1736 and 1071 and therefore would be offset as per the ecosystem credit calculations for these respective PCTs shown in **Table 1-3**.

2. Biodiversity offset strategy

2.1 Offset options

This BOS has been prepared subject to provisions in the NSW Biodiversity Offsets Policy for Major Projects (OEH, 2014) and the provisions of the BC Act which has introduced the option of acquitting an offset obligation through payment to the Biodiversity Conservation Fund (BCF) administered by the BCT, provided that a ‘statement of reasonable equivalence’ has been obtained from DPIE.

Accordingly, the options available to satisfy this offset requirement include:

a) Retirement of biodiversity credits from the biodiversity register established under the TSC Act
b) Payment to the BCF (once a statement of reasonable equivalence has been obtained)
c) Retirement of biodiversity credits from the biodiversity register established under the BC Act (once a ‘statement of reasonable equivalence’ has been obtained)
d) Establishment and retirement of biodiversity credits by Transport or third parties under Biodiversity Stewardship Agreement and BC Act (once a ‘statement of reasonable equivalence’ has been obtained)
e) Supplementary measures as determined in accordance with the NSW Biodiversity Offsets Policy for Major Projects (OEH, 2014)
f) A combination of the above.

2.2 Proposed Strategy

If Transport is unable to purchase like-for-like credits or establish suitable stewardship sites and retire credits after taking reasonable steps, payment to the BCF would be considered in accordance with the provisions of the EPBC Act Bilateral Agreement or Transport would seek to purchase credits in accordance with the variation rules for non-MNES.

This BOS proposed by Transport consists of any combination or sequence of the actions summarised below and outlined in detail in **Section 2.2.1** to **Section 2.2.8**, and includes:

- Confirm credit requirements at finalisation of clearances (**Section 2.2.1**)
- Purchase of available credits (**Section 2.2.2**)
- Apply for an assessment of reasonable equivalency (**Section 2.2.3**)
- Establish Biodiversity Stewardship Agreements on candidate properties (**Section 2.2.4**)
- Payment to the BCF (**Section 2.2.6**)
- Use of the variation criteria or use of supplementary measures if suitable credits cannot be identified (**Section 2.2.5**)
- Identify and secure appropriate offsets for saline vegetation formations in consultation with NSW DPI Fisheries (**Section 2.2.7**)
- Offsets for MNES (**Section 2.2.8**).

Further details on each action are described in the following sections.

2.2.1 Confirm credit requirements

This Strategy and the number of credits identified is based on the impacts associated with the 80 per cent concept design for the project. During the detailed design or construction phase, the construction footprint may change from that assessed here, which would result in a different offset requirement for the project than what is presented in this Strategy. Any increases in clearing as a result of detailed design (which is unlikely as a “worse case” clearing footprint has been used in this assessment) would be subject to environmental assessment and any offset recalculations would be done in accordance with the FBA and the requirements of the EPBC Act Bilateral Agreement. Where a decrease in the vegetation impact is identified, offset recalculations would be carried out in accordance with the FBA and reported under a revised offset strategy.

2.2.2 Purchase of available credits

DPIE maintains a public biodiversity credits register of existing biodiversity stewardship sites and associated biodiversity credits available to be retired as well as a list of expressions of interest (EOIs) for the development of biodiversity stewardship sites subject to survey and agreement.

To ensure that BioBanking credits and credit obligations created under the TSC Act (BBAM) could still be used or met within the newer credit market (BAM), the Savings and Transitions Regulation preserved these credits and credit obligations. As such, two public registers currently exist, one for BBAM credits and one for BAM credits.

Both credit registers were searched in August 2020, November 2020 and again in January 2021 to identify whether any of the required credits are currently issued for sale or listed as an EOI for future sale. Credits have been identified for like-for-like matches, however there is opportunity to also purchase credits in accordance with the variation rules as outlined in Section 10.5 of the FBA. Offset variation options have been provided in the BioBanking credit report for each PCT, which were also searched in the public register.

Ecosystem credits available

The results of the dual register search for each PCT and offset trading options and for each species credit is provided in detail for each ecosystem type in **Appendix A**, and these data are summarised in **Table 2-1** and **Table 2-2.** Note that the lists of credits available in the Biodiversity Offsets Scheme are current from the date of the searches of each register, with the status of these credits being subject to change as credits are retired.

Table 2-1 List of available BioBanking ecosystem credits in the BioBanking public register matching project ecosystem credit obligation

Plant Community Type	Formation	Class	Project credit obligation (BBAM)	TEC	Ecosystem credits available on public register (BBAM credits)					
					Same PCT (like for like)	**PCT option (trade)***	**Credit ID**	**IBRA sub-region**	**Credit status**	**Agreement ID**
1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (HU802)	Dry Sclerophyll Forests (shrub/grass sub-formation)	Hunter-Macleay Dry Sclerophyll Forest	429	No	197	-	2758	Upper Hunter	Issued	334
					117	-	2758	Upper Hunter	Issued	334
					5	-	2915	Wyong	Issued	355
					-	93	2741	Karuah Manning	Issued	330
					-	All available credits listed below for HU804 (5849 credits) are allowable trade options				
					Like-for-like total: 319 ***Variation total: 5942***					
1590 - Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (HU804)	Dry Sclerophyll Forests (shrub/grass sub-formation)	Hunter-Macleay Dry Sclerophyll Forest	2327	Yes	1633	-	2759	Upper Hunter	Issued	334
					1123	-	2745	Upper Hunter	Issued	331
					791	-	2865	Upper Hunter	Issued	347
					575	-	3229	Karuah Manning	Issued	404
					484	-	2745	Upper Hunter	Issued	331
					391	-	2742	Karuah Manning	Issued	330
					328	-	2253	Karuah Manning	Issued	214
					173	-	2759	Upper Hunter	Issued	334
					131	-	2736	Karuah Manning	Issued	329
					69	-	2760	Upper Hunter	Issued	334
					55	-	2916	Wyong	Issued	335

Plant Community Type	Formation	Class	Project credit obligation (BBAM)	TEC	Ecosystem credits available on public register (BBAM credits)					
					Same PCT (like for like)	PCT option (trade)*	Credit ID	IBRA sub-region	Credit status	Agreement ID
					47	-	2319	Karuah Manning	Issued	223
					14	-	2762	Upper Hunter	Issued	334
					14	-	2763	Upper Hunter	Issued	334
					10	-	3228	Karuah Manning	Issued	404
					6	-	3228	Karuah Manning	Issued	404
					5	-	2911	Wyong	Issued	335
					-	93	2741	Karuah Manning	Issued	330
					-	All available credits listed above for HU802 (319 credits) are allowable trade options				
					Like-for-like total: 5849 ***Variation total: 412***					
1598 - Forest Red Gum grassy open forest on floodplains of the lower Hunter (HU812)	Forested Wetlands	Coastal Swamp Forests	27	Yes	281	-	2883	Hunter	Issued	350
					15	-	2385	Hunter	Issued	237
					-	81	1905	Karuah Manning	Issued	158
					-	61	2022	Karuah Manning	Issued	173
					-	17	2743	Karuah Manning	Issued	330
					Like-for-like total: 296 ***Variation total: 159***					

Plant Community Type	Formation	Class	Project credit obligation (BBAM)	TEC	Ecosystem credits available on public register (BBAM credits)					
					Same PCT (like for like)	PCT option (trade)*	Credit ID	IBRA sub-region	Credit status	Agreement ID
1727 - Swamp Oak – Sea Rush – Baumea juncea swamp forest on the coastal lowlands of the Central Coast and Lower North Coast (HU941)	Forested Wetlands	Coastal Floodplain Wetlands	423	Yes	9	-	2407	Karuah Manning	Issued	214
					-	81	1905	Karuah Manning	Issued	158
					-	61	2022	Karuah Manning	Issued	173
					-	17	2743	Karuah Manning	Issued	330
					Like-for-like total: 9 ***Variation total: 159***					
1716 – Prickly leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (HU930)	Forested Wetlands	Coastal Swamp Forests	103	Yes	-	90	2020	Karuah Manning	Issued	173
					-	90	3165	Wyong	Issued	393
					-	40	3169	Wyong	Issued	393
					-	22	3166	Wyong	Issued	393
					-	78	2254	Karuah Manning	Issued	214
					Variation total: 320					
1717 – Broad leaved Paperbark Swamp Mahogany Swamp Oak Saw Sedge swamp forest of the Central Coast and Lower North Coast (HU931)	Forested Wetlands	Coastal Swamp Forests	469	Yes	-	90	2020	Karuah Manning	Issued	173
					-	90	3165	Wyong	Issued	393*
					-	40	3169	Wyong	Issued	393*
					-	22	3166	Wyong	Issued	393*
					-	78	2254	Karuah Manning	Issued	214
					Variation total: 320					

Plant Community Type	Formation	Class	Project credit obligation (BBAM)	TEC	Ecosystem credits available on public register (BBAM credits)					
					Same PCT (like for like)	PCT option (trade)*	Credit ID	IBRA sub-region	Credit status	Agreement ID
1724 – Broad leaved Paperbark Swamp Oak Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU938)	Forested Wetlands	Coastal Swamp Forests	75	Yes	-	90	2020	Karuah Manning	Issued	173
					-	90	3165	Wyong	Issued	393*
					-	40	3169	Wyong	Issued	393*
					-	22	3166	Wyong	Issued	393*
					-	78	2254	Karuah Manning	Issued	214
					Variation total: 320					
1742 – Jointed Twig-rush sedgeland (HU956)	Freshwater Wetlands	Coastal Freshwater Lagoons	99	Yes	-	4	3167	Wyong	Issued	393*
					Variation total: 4					

*Variation credits have been repeated for numerous PCTs where applicable and are limited to the number of credits provided in the cell.*Agreement 393 is owned by Transport

Table 2-2 List of available BAM ecosystem credits in the Biodiversity Offsets Scheme public register matching project ecosystem credit obligation

Plant Community Type	Formation	Class	Project credit obligation (BBAM)	Indicative BAM Credits	TEC	Ecosystem credits available on public register (BAM credits)				
						Same PCT (like for like)	PCT option (allowable trade)	IBRA sub-region	Credit status	Credit ID
1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast	Dry Sclerophyll Forests (shrub/grass sub-formation)	Hunter-Macleay Dry Sclerophyll Forest	429	36	No	638	-	Karuah Manning	Issued	CR-5127
						-	1,150	Upper Hunter	Issued	CR-2104
						-	445	Karuah Manning	Issued	CR-5134
1590 - Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest	Dry Sclerophyll Forests (shrub/grass sub-formation)	Hunter-Macleay Dry Sclerophyll Forest	2327	1,142	Yes	-	1,150	Upper Hunter	Issued	CR-2104
1598 - Forest Red Gum grassy open forest on floodplains of the lower Hunter	Forested Wetlands	Coastal Swamp Forests	27	16	Yes	15	-	Upper Hunter	Pending review	CR-381
1727 - Swamp Oak – Sea Rush – Baumea juncea swamp forest on the coastal lowlands of the Central Coast and Lower North Coast	Forested Wetlands	Coastal Floodplain Wetlands	423	94	Yes	-	31	Karuah Manning	Issued	CR-3673

Species credit availability

The results of the dual register search for each species credit is summarised in **Table 2-3** and **Table 2-4.** Note that the lists of credits available in the Biodiversity Offsets Scheme are current from the date of the searches of each register, with the status of these credits being subject to change as credits are retired by others.

Table 2-3 List of available BioBanking species credits in the BioBanking public register matching project species credit obligation

Species	Project credit obligation (BBAM)	Credits available (BBAM)	IBRA sub-region	Credit ID	Agreement ID	Credit status
Eucalyptus parramattensis subsp. *decadens*	476	433	Karuah Manning	302	158	Issued
Callistemon linearifolius (Netted Bottlebrush)	2,198	90	Karuah Manning	251	97	Issued
Black Bittern (*Ixobrychus flavicollis*)	805	67	SE Hills and Ranges	601	348	Issued
Wallum Froglet (*Crinia tinnula*)	42	323	Karuah Manning	303	158	Issued
		254	SE Hills and Ranges	600	348	Issued
		196	Macleay-Hastings	331	167	Issued
		191	Coffs Coast & Escarpment	745	396	Issued
		49	Wyong	736	393	Issued
		31 (Transport)	Wyong	736	393	Issued
		13	Wyong	944	219	Issued
		Total: 1,057				
Koala (*Phascolarctos cinereus*)	1329	4183	Liverpool Plains	888	398	Issued
		3410	Peel - Namoi	476	228	Issued
		2,075	Guyra Basalts	911	379	Issued
		1,650	Karuah Manning	817	258	Issued
		1,103	Clarence Lowlands	807	449	Issued
		965	Clarence Lowlands	760	402	Issued
		899	Macleay Hastings	451	212	Issued
		861	Upper Hunter	689	383	Issued
		795	Macleay Hastings	535	275	Issued

Species	Project credit obligation (BBAM)	Credits available (BBAM)	IBRA sub-region	Credit ID	Agreement ID	Credit status
		687	Karuah Manning	815	173	Issued
		604	Upper Hunter	576	331	Issued
		335	Liverpool Plains	888	398	Issued
		317	Clarence Lowlands	760	402	Issued
		253	Karuah Manning	914	225	Issued
		167	Hawkesbury/Nepean	459	215	Issued
		117	Karuah Manning	305	158	Issued
		109	Karuah Manning	454	214	Issued
		99	Hawksbury / Nepean	516	239	Issued
		98	Upper Hunter	691	384	Issued
		63	Coffs Coast & Escarpment	876	229	Issued
		59	Hawkesbury / Nepean	892	345	Issued
		Total: 18,849				

Table 2-4 List of available BAM species credits in the Biodiversity Offsets Scheme public register matching project species credit obligation

Species	Project species credits obligation (BBAM)	Species Credit Availability (BAM)	IBRA sub-region	Credit ID	Credit status
Koala	1329	4921	Castlereagh-Barwon	CR-392	Pending review
		892	Karuah Manning	CR-2107	Issued
		67	Coffs Coast & Escarpment	CR-4512	Issued
		796	Karuah Manning	CR-5128	Issued
		616	Sydney Cataract	CR-3211	Pending review
		751	-	BIMS-CR-031	Equivalence Credit
		1123	-	BIMS-CR-007	Equivalence Credit

Purchase of credits

The review of the public registers identified that credits are available for purchase from eight ecosystem credit types and five species credit type, these data are summarised in **Table 2-5** which shows the residual credits remaining after purchase. The credits identified in the preceding sections were calculated using the FBA, and therefore a credit equivalency is required, and this would inform the number of BAM credits required to be offset for any shortfall.

Transport has not purchased any credits for this project to date. Pending project approval and the credit equivalency outcome, Transport would contact the credit holders with confirmed ecosystem and species credits available to negotiate the future sale of the credits. If agreeable, based on the process outlined in Transport's Selling biodiversity credits to Transport factsheet (Transport 2020), an agreement may be entered into for the sale of the credits identified in **Table 2-5**.

Table 2-5 Credits available for purchase in the public registers matching project species credit obligation

Biodiversity value	Credit type	Project credit obligation (BBAM)	Credits available (BBAM)	Credits / trades available	Credits remaining
1590 - Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest	Ecosystem	2,327	5,849	412 (BBAM) 1,150 (BAM)*	0
1588 – Grey Ironbark – Broad-leaved Mahogany – forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast	Ecosystem	429	319	5,942 (BBAM) 1,150 (BAM)*	0
1598 - Forest Red Gum grassy open forest on floodplains of the lower Hunter	Ecosystem	27	296	159 (BBAM)* 15 (BAM)	0
1727 – Swamp Oak – Sea Rush – Baumea juncea swamp forest on the coastal lowlands of the Central Coast and Lower North Coast	Ecosystem	423	9	159 (BBAM)*	255
1716 – Prickly leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (HU 930)	Ecosystem	103	-	310 (BBAM)*	0
1717 – Broad leaved Paperbark Swamp Mahogany Swamp Oak Saw Sedge swamp forest of the Central Coast and Lower North Coast (HU931)	Ecosystem	469	-		159
1724 – Broad leaved Paperbark Swamp Oak Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU938) (HU938)	Ecosystem	75	-		0
1742 – Jointed Twig-rush sedgeland (HU956)	Ecosystem	99	-	4 (BBAM)	95
Eucalyptus parramattensis subsp decadens	Species	476	433	-	43
Callistemon linearifolius	Species	2,198	90	-	2,108
Black Bittern (*Ixobrychus flavicollis*)	Species	805	67	-	738
Wallum Froglet (*Crinia tinnula*)	Species	42	1,057	-	0
Koala (*Phascolarctos cinereus*)	Species	1,329	18,849	9,166 (BBAM)	0

*Some credit options are shared across multiple applicable PCTs. These credits have only been compared against the individual PCT credit obligations and not the whole project.

2.2.3 Apply for an assessment of reasonable equivalency

The BAR and this BOS has calculated the BBAM credits required to satisfy the offset obligations for the project under the TSC Act. Where suitable BBAM credits are not available in the market for purchase, Transport may be required to determine the required remaining credit obligation under the under the newer BC Act and it associated BAM credits (see **Section 1.5.2**).

To convert the BBAM credits to BAM credits, Transport shall apply for an assessment of reasonable equivalence to the Department of Planning Industry and Environment. The outcome of this process is a clear understanding of the remaining BAM offset credit requirements under the BC Act. This can be applied to subsequent actions.

2.2.4 Progressing potential stewardship sites

It is likely that not all credits required by the project would be available for purchase and retiring from the open market. Hence, the following section describes the second action in the strategy which involves researching and progressing potential stewardship sites that are identified as contributing to the credit requirements.

A preliminary assessment of potential stewardship sites in the locality surrounding the project has been conducted. Additionally, other potential stewardship properties that are listed on the public register as an EOI and may contain suitable credits are also identified.

Expression of Interest Public Register – potential stewardships

An EOI has been placed on the public register for properties that contain several of the requisite ecosystem credits in addition to the Koala, Wallum Froglet and *Callistemon linearifolius* (Netted Bottlebrush). The EOI indicates that ecosystem or species credits are confirmed by observation either on an existing stewardship site (or subject to a potential variation) or on a potential stewardship site that has not progressed to an agreement. In this instance there has been no formal survey conducted to calculate the number of credits present and therefore the number of credits is not displayed in the register and is yet to be determined until such time as an application for a stewardship agreement is lodged. It is assumed that the landholder registering the EOI is seeking interest from a stakeholder to progress the stewardship agreement.

In searching for the relevant ecosystem credits on the EOI register, the IBRA sub-region was filtered to identify only those that occur either within the same IBRA sub-region as the project (i.e. Hunter and Karuah Manning) or an adjacent IBRA sub-region, consistent with the requirements of the FBA. The search for species credits was broader, however the EOI identified were also within the Karuah-Manning IBRA sub-region (**Table 2-7**).

The search has identified there is at least nine separate EOIs listed that are expected to contain PCT credits that are currently sought (**Table 2-6**). Further consultation and preliminary assessment is required with the listed contact for these EOIs to understand the likely quantum of credits generated and feasibility of funding a Biodiversity Stewardship Site Assessment Report (BSSAR).

Table 2-6 Future ecosystem credit availability associated with an EOI listed on the biodiversity offsets public register

Project PCTs with ecosystem credit obligation	PCT option (allowable trade)	IBRA sub-region	Expression of Interest - ID	Area of site (ha)
1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast	1590	Karuah-Manning	a0P7F00000DDTck	22.8
1590 - Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest	1590	Karuah-Manning	a0P7F00000DDTck	22.8
1646 - Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast	1646 & 1618	Karuah-Manning	a0P7F00000DDTWZ; a0P7F00000DDTXC; a0P7F00000DDTZo; a0P7F00000DDTcm; a0P7F00000DDTUI	0.40 1.40 49.8 153.9 4.0
1649 - Smooth-barked Apple - Red Mahogany - Swamp Mahogany - *Melaleuca sieberi* heathy swamp woodland of coastal lowlands	1649, 1716, 1717	Karuah-Manning	a0P7F00000DDTXB; a0P7F00000DDTcp; a0P7F00000DDTco	17.3 14.1 14.1
1716 - Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast	1716 & 1717	Karuah-Manning	a0P7F00000DDTXB; a0P7F00000DDTcp	17.3 14.1
1717 - Broad-leaved Paperbark – Swamp Mahogany – Swamp Oak – Saw Sedge swamp forest of the Central Coast and Lower North Coast	1716 & 1717	Karuah-Manning	a0P7F00000DDTXB; a0P7F00000DDTcp	17.3 14.1
1724 – Broad-leaved Paperbark – Swamp Oak – Saw Sedge swamp forest on the coastal lowlands of the Central Coast and Lower North Coast	1649, 1716, 1717	Karuah-Manning	a0P7F00000DDTXB; a0P7F00000DDTcp; a0P7F00000DDTco	17.3 14.1 14.1

Table 2-7 Future species credit availability associated with an EOI listed on the biodiversity offsets public register

Species	Project species credits obligation (BBAM)	IBRA Sub-region	EOI - Credit ID	Area of site (ha)
Callistemon linearifolius	2,198	Karuah Manning	a0P7F00000DDTcs	200
Wallum Froglet	42	Karuah Manning	a0P7F00000DDTWc	0.44
Koala	1,329	Karuah Manning	a0P7F00000FEQSQ	232

Desktop assessment – potential local stewardship sites

Transport has identified several parcels of land close to the project that are residual areas of a property originally purchased in entirety for the project and now owned by Transport. A desktop assessment was conducted to identify potential ecosystem and species credits that may be associated with these residual land parcels. Transport has also engaged in preliminary consultation with neighbouring landholders with a view to considering potential stewardship properties or additions to the parcels discussed. The desktop assessment however only focuses on Transport land.

The desktop investigations are preliminary and for the purpose of identifying opportunities for generating credits as part of the first stage of the offset strategy. No field validation has occurred. Pending project approval, opportunities to develop a new stewardship agreement towards meeting the credit obligation would be considered by Transport where feasible and achievable.

The desktop assessment involved the following steps:

- Develop a map layer of all property boundaries using GIS which was then overlaid with regional vegetation mapping (LHCCREMS data). Any ground-truthed vegetation mapping data generated from the project surveys was used where possible to validate the vegetation mapping. The aim of this task was to identify likely PCTs present on the residual land areas, and this was done by converting desktop data to PCTs
- Access and review BioNet wildlife atlas data to investigate records of threatened species in proximity to the residual land, with a focus on assessing the likelihood of occurrence of species credit species. Threatened species recorded for the project EIS were also used where records were within the site (e.g. *Callistemon linearifolius*) and where PCTs within the site are suitable habitat for threatened fauna (e.g. Squirrel Glider)
- Developing a preliminary case study in the BAM calculator for each parcel of land to generate an indicative credit yield. Data input for this task included quantifying the likely PCT present. Assumptions were made of the number of likely vegetation zones and integrity plot scores based on closest plots collected in the field.

Thirteen land parcels were assessed and are identified in **Table 2-8**, this includes the size of the land, the possible PCT and area of vegetation, the presence of threatened species records in proximity and the potential credit yield.

Table 2-8 Desktop data developed to identify potential biodiversity credits (BAM) generated on Transport owned land surrounding the project

Property	Lot area (ha)	PCT / BVT	PCT area (ha)	BioNet Atlas threatened species records	Possible credit yield (BAM credits)
1	23.24	1716 / HU930	1.64	No records associated with species credits species within the property. Koala record in the west adjacent to the property. 19.08 hectares of squirrel glider habitat	8
		1590 / HU804	17.44		99
2	14.58	1590 / HU804	2.94	No records associated with species credits species within the property. One *Callistemon linearifolious* plant. 2.94 hectares of squirrel glider habitat	17
3	37.42	1590 / HU804	5.76	Rest of site is cleared farmland, with scattered mature paddock trees. Site contains 97 *Callistemon linearifolious.*	33
		1588 / HU802	3		13
		C.linearifolius	97		81
4	19.93	1736 / HU950	2.32	Rest of site is cleared farmland. No records associated with species credits species within the property.	4
		1746 / HU960	1.13		1
		1071 / HU673	0.002		1
		1727 / HU941	0.2		1
		1747 / HU961	0.08		1
5	93.03	1727 / HU941	14.13	50% vegetated. No records associated with species credits species within the property.	2
		1736 / HU950	9.82		16
		1071 / HU673	0.00007		1
		1747 / HU961	0.2		1
6	125.77	1746 / HU960	0.26	No records associated with species credits species within the property.	1
		1747 / HU961	1.88		6
		1727 / HU941	31.95		5
		1736 / HU950	2.87		5
7	0.71	1736 / HU950	0.29	No records associated with species credits species within the property.	1
		1727 / HU941	0.02		1
8	1.79	1736 / HU950	0.43	No records associated with species credits species within the property.	1
		1746 / HU960	0.04		1
9	8.87	1736 / HU950	1.44	No records associated with species credits species within the property.	2
		1746 / HU960	0.03		1
10	87.43	1727 / HU941	0.79	No records associated with species credits species within the property. Koala record in the east adjacent to the property.	1
		1746 / HU960	1.22		1
		1071 / HU673	0.11		1
		1747 / HU961	0.44		1
		1736 / HU950	25.74		41

Property	Lot area (ha)	PCT / BVT	PCT area (ha)	BioNet Atlas threatened species records	Possible credit yield (BAM credits)
11	70.13	1717 / HU932	40.68	No records associated with species credits species within the property. Likely Koala habitat	123
		1646 / HU860	23.25		124
		Koala	23.25		247
12	0.39	1646 / HU860	0.28	No records associated with species credits species within the property. Scattered Koala records adjacent to the property. Likely Koala habitat	1
		Koala	0.28		1
13	3.06	1717 / HU932	0.0001	Individual Koala record located within Lot 15 DP 840996. Likely Koala habitat	1
		1646 / HU860	2.98		16
		Koala	2.98		16

Priority sites and further investigation

The desktop assessment has identified a number of potential sites where further investigation is warranted both for the EOI sites and residual lands, and these priority sites would be shortlisted to inform the offset strategy. The priority sites are considered to have a reasonable quantity of potential biodiversity credits and therefore worthy of further investigation following project approval. At this preliminary stage it is difficult to directly compare the indicative credit yield from the assessed site, with the credits generated on the project, as these were calculated using the former BioBanking assessment method associated with the FBA. As such a credit equivalency is required before this BOS can be finalised.

Table 2-9 and **Table 2-10** highlight the EOI sites and residual lands properties identified for further investigation.

Table 2-9 Desktop data developed to identify EOI sites with potential to generate sufficient credits

PCTs / Threatened species (credit requirement)	EOI ID and site area (hectares)*						
	Site Tcm	Site Txb	Site Tzo	Site Tck	Site Tcp	Site Tco	Site Tcs
PCT1646 (1241 credits)	153.9	-	49.8	-	-	-	-
PCT1649 (72 credits); PCT1716 (103 credits); PCT1717 (469 credits); PCT1724 (75 credits)	-	17.3	-	-	14.1	14.1	-
PCT1588 (429 credits); PCT1590 (2,327 credits)	-	-	-	22.8	-	-	-
Callistemon linearifolius (42 credits)	-	-	-	-	-	-	200

*Refer to **Table 2-6** and **Table 2-7**

Table 2-10 Desktop data developed to identify residual lands with potential to generate sufficient credits

PCTs / Threatened species	Indicative credits (BAM)					Total credits (BAM)
	Site 1	Site 2	Site 3	Site 11	Sites 5, 6, 9, 10	
PCT1071, PCT1716, PCT1717, PCT1727, PCT1736, PCT1746, PCT1747	-	-	-	125	130	255
PCT1590	99	17	33	-	-	140
PCT1646	-	-	-	124	-	287
Callistemon linearifolius	-	-	81	-	-	81
Diuris arenaria	-	-	-	-	-	163

The information provided above demonstrates that there are potential opportunities to develop a stewardship site on a parcel or multiple parcels of residual lands. This action would be investigated further where there is scope to maximise credit yields to meet the current obligation. This may include opportunities to work with neighbouring landholders. At this stage further consideration would also be given to the future management costs associated with establishing and maintaining a stewardship agreement and the pathway to on-selling the property as a priority once the stewardship agreement is obtained. All areas of residual land assessed have had a history of human disturbance and there is considerable scope to improve biodiversity values through securing and managing the property.

Where a potential offset site is identified as an offset for the project, this would be secured using a biodiversity stewardship agreement. This intent would be to on sell the property or transfer ownership to the National Parks and Wildlife Service with a conservation agreement and management budget attached.

2.2.5 Variation rules or supplementary measures

Section 10.5.4 of the FBA allows for variation of the offset rules (i.e. like-for-like offsets) and supplementary measures that can be used for ecosystem credits. The variation rules apply when it is evident that not all biodiversity credits are available for purchase or associated with a potential stewardship site and all reasonable steps have been taken to secure a matching ecosystem credit.

It is evident from the search of the available ecosystem and species credits listed on the public register and review of potential offsets sites that there are shortfalls for many of the ecosystem and species credits required for this project. As such the variation rules under the FBA apply.

Variation rules - ecosystem credits

Variation criteria that apply for ecosystem credits allow for credits created for a PCT from the same vegetation formation as the PCT being impacted. The following rules apply:

- All reasonable steps to secure a matching ecosystem credit have been taken
- The required ecosystem credit is not for a PCT associated with a Critically Endangered Ecological Community (CEEC) listed on the TSC Act or an ecological community listed on the EPBC Act
- The PCT from the same vegetation formation has a percent cleared value of the PCT in the major catchment area equal to or greater than the percent cleared of the PCT to which the required ecosystem credit relates. Where the required ecosystem credit is for a PCT that is associated with a CEEC/Endangered Ecological Community (EEC), the PCT from the same formation is also associated with an CEEC/EEC.

In relation to dot point 2, none of the PCTs impacted by the project are associated with a CEEC listed on the TSC Act or an ecological community listed on the EPBC Act, and therefore meet the variation criteria.

In relation to dot point 3, the list of available trades for each impacted PCT is identified in **Appendix A**. A search of the BBAM and BAM public databases was completed to identify if there are any credits available for these PCT trades. **Table 2-11** identifies the list of BAM credits available for PCT trades which highlights there are a considerable number of credits for vegetation within the forested wetland formation as well as credits in dry sclerophyll (shrub and grass) vegetation formations.

Table 2-11 Desktop data developed to identify possible PCT credit trades available under the FBA variation rules for ecosystem credits

Formation	Plant Community Type	PCT per cent cleared	Residual credit obligation (BBAM)	Variation PCT (same formation)	IBRA sub-region	PCT percent cleared	Credits available (BAM)	Credit ID
Dry Sclerophyll Forests (shrubby sub-formation)	1646 - Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast	45	1,421	592 - Narrow-leaved Ironbark - cypress pine - White Box shrubby open forest in the Brigalow Belt South Bioregion and Nandewar Bioregion	Kaputar	50	48	CR-2135
Forested Wetlands	1649 - Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands	46	72	1230 – Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	Clarence Sandstones	75	11	CR-2235
	1717 - Broad-leaved Paperbark – Swamp Mahogany – Swamp Oak – Saw Sedge swamp forest of the Central Coast and Lower North Coast	68	159	1064 - Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion	Clarence Lowlands	75	2,142	CR-3952
	1727 - Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast	81	423	-	-	-	-	-
Freshwater Wetlands	1736 - Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter	80	2304	-	-	-	-	-
	1742 - Jointed Twig-rush sedgeland	70	95	-	-	-	-	-
	1071 - Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion	75	326	1071 - Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion	Cumberland	75	1	CR-2282

Variation rules - species credits

Variation criteria that apply for species credits allow a different species to that impacted by the proposed development to be used to meet the offset requirement. The following applies:

- The proponent can demonstrate that all reasonable steps have been taken to secure the number and types of species credits impacted on at the development site, and
- The species to which the species credit relates is not listed on the EPBC Act or listed as critically endangered on the TSC Act.

In addition, the variation to use species credits for a different species can only be used where:

- The alternative species credits are created on land within the same IBRA region in which the proposed Major Project occurs, and
- For fauna, the alternative species is a species or population from the same Order as the fauna species impacted on at the development site. In addition, the PCT containing threatened species habitat at an offset site is a PCT, which according to the Threatened Species Profile Database, is also associated with the fauna species impacted at the development site, or
- For flora, the alternative species is, according to the Threatened Species Profile Database, from the same life-form as the flora species impacted at the development site. In addition, the PCT containing the flora species at the offset site should preferably be the same PCT within which this species was located at the development site, and
- The alternative species credits are for a species or population listed in either Schedule 1 or 1A of the TSC Act, where the species credit required for the proposed development relates to a species or population listed in Schedule 1 of the TSC Act, or
- The alternative species credits are for a species or population listed in either Schedule 1, 1A or 2 of the TSC Act, where the species credit required for the proposed development relates to a species or population listed in Schedule 2 of the TSC Act.

In relation to the species credits for this project, two of the confirmed threatened species – Drooping Red gum (*Eucalyptus parramattensis* subsp. *decadens),* and the Australasian Bittern (*Botaurus poiciloptilus*) are listed on the EPBC Act and therefore do not comply with the variation rules (dot point 2).

From consideration of the rules outlined above, and review of the species credits available for purchase on the public registers, there are no current available species credits that match the variation criteria.

Supplementary measures

Supplementary measures can be used in lieu of identifying ecosystem credits where:

- All reasonable steps have been taken by the proponent to secure a matching ecosystem credit, and
- The PCT to which a required ecosystem credit relates is associated with a CEEC/EEC or for which the impact of development does not require further consideration according to Subsection 9.2.4 of the FBA
- The supplementary measure applies to that CEEC/EEC
- The supplementary measure is carried out in accordance with the rules governing supplementary measures, including calculating the financial contribution of the supplementary measures in accordance with Appendix B of the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014).

Supplementary measures can also be used in lieu of identifying *species* credits where:

- The species or population to which the species credit relates is not a species or population for which the impact of development requires further consideration according to Subsection of the 9.2.5 FBA, and
- The proponent can demonstrate that all reasonable steps have been taken to secure the number and types of species credits impacted at the development site, and
- The proposed supplementary measure only applies to the species impacted at the development site, and

- The supplementary measure is carried out in accordance with the rules governing supplementary measures, including calculating the financial contribution of the supplementary measures in accordance with Appendix B of the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014).

There are several ecosystem and species credits for which there appear to be no credits available or likely at present. In particular, the project would have impact on a population of *Diuris arenaria*, which is a species with a restricted distribution. All reasonable steps have been taken by Transport to secure an offset for this species, although there is unlikely to be a future credit availability for the species.

Supplementary measures would feasibly apply to this species and if pursued would be carried out in accordance with the rules governing supplementary measures described or alternatively the credit obligation paid to the BCF.

2.2.6 Payment to the Biodiversity Conservation Fund

Under the NSW Biodiversity Offsets Scheme, development proponents may choose to pay into the BCF as an alternative to retiring biodiversity credits to meet their project offset obligation. Transport would apply for credit equivalency for the BBAM credits generated for this project with a view to paying into the fund and credits obligation that cannot be sourced through the credit market or through the actions described previously.

2.2.7 Other biodiversity impacts requiring offsets

Offsets for aquatic species, populations and communities should be provided in accordance with the Policy and guidelines for fish habitat conservation and management Update 2013 (DPI Fisheries NSW 2013). Offsets for aquatic biodiversity can be achieved by:

- Payment to DPI's Fish Habitat Fund; or rehabilitation activities.

There are two PCTs impacted by this project that are saline wetland formations, these are:

- Saltmarsh estuarine complex (PCT 1746) (TYPE 1 Key Fish Habitat) – Zone 19, removal of about 1.26 hectares
- Grey Mangrove low closed forest (1747) (TYPE 2 Key Fish Habitat) – Zone 20 and 21, removal of about 2.27 hectares.

The project would also impact around 16.4 hectares of mapped Coastal Management SEPP coastal wetlands, which includes about 3.53 hectares of the saltmarsh and mangrove communities (TYPE 1 and 2 habitats). The remaining areas of the Coastal Management SEPP coastal wetland impacted by the project are covered by the PCTs 1736 and 1071 and would be offset as per the ecosystem credit calculations for these respective PCTs.

NSW DPI enforces a 'no net loss' habitat policy as a condition of consent (DPI 2013). The policy and guidelines for fish habitat conservation and management (DPI 2013) identifies habitat compensation on a minimum 2:1 basis for all key fish habitat (TYPE1-3). It is recognised that there may also be alternatives to a financial compensation to provide an adequate offset or compensation (e.g. remediation work) for impacts to saline vegetation types. Consultation with NSW DPI will be carried out to discuss other potential alternative options for compensation that are consistent with meeting the 2:1 offset ratio applied.

The project would impact on about 0.6 hectares of a site with an existing BioBanking Agreement, located around the Hunter Region Botanic Gardens and east of the existing Pacific Highway. The entire BioBanking site is around 106 hectares in size. Transport will acquire this impacted land and offset the impacts to the existing Biobanking site.

2.2.8 Matters of National Environmental Significance

The Australian Government has formally endorsed the Biodiversity Offsets Scheme through the EPBC Act Condition-setting Policy. The proposed offsets discussed in this strategy are designed to meet the 'like-for-like' criteria for MNES in accordance with the Bilateral Agreement. Key impacts associated with proposed action on MNES are associated with the removal of native vegetation and habitat critical to the survival of threatened species listed under the EPBC Act (Koala, Swift Parrot, Regent Honeyeater, and Grey-headed Flying-fox). This strategy would ensure that these impacts would be appropriately offset for EPBC Act purposes. The potential impacts on the remaining nationally threatened species and ecological communities identified in the BAR were assessed as not significant and offsets are not required.

The loss of potential habitat for the Koala was identified in the BAR and using the method prescribed in the FBA, this loss generated a total of 1,329 species credits. A search of the offset public registers identified a significant number of Koala credits available for purchase (**Section 2.2.2**) and therefore it is proposed to offset this credit obligation through either purchase of available credits or retiring credits generated on a new stewardship site development by Transport (**Section 2.2.4**), if deemed to be available after further investigation.

The Regent Honeyeater is a species credit species; however, the species was not recorded during targeted surveys, nor considered to be significantly impacted and therefore a credit obligation was not determined. However, impacts to the potential habitat of this species and two ecosystem credit species (Swift Parrot and Grey-headed Flying-fox) were quantified in the BAR and the PCTs associated with this habitat would be offset by like-for-like PCTs in accordance with the FBA (refer **Table 2-12**).

Table 2-12 Habitat features and PCTs associated with impacted MNES (ecosystem credit species)

Species	Habitat feature/ component	Impacted by development (ha/individuals)	Number and type of potential credits available
Regent Honeyeater	No mapped important areas within the construction footprint. Site is considered low-quality habitat. Impact has been calculated by the area of associated within the construction footprint, including PCT ID: 1590, 1646, 1649, 1717, 1724.	83.93 ha of potential habitat	• PCT 1590: 5,756 BBAM like-for-like credits and 93 alternate credits are available. Additionally, 1,150 BAM alternate allowable credits are available • PCT 1646: The BBAM and BAM Credit Registers indicate that there are no credits available. • PCT 1649: The BBAM and BAM Credit Registers indicate that there are no credits available for this PCT • PCT 1717: BBAM and BAM credit registers indicates that there are 320 BBAM alternate credits available • PCT 1724: The BBAM and BAM credit registers indicate that there are 90 BBAM alternate credits available.
Swift Parrot	Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1590, 1646, 1716 and 1717.	82.78 ha of potential habitat	• PCT 1590: 5,756 BBAM like-for-like credits and 93 alternate credits are available. Additionally, 1,150 BAM alternate allowable credits are available. • PCT 1646: The BBAM and BAM Credit Registers indicate that there are no credits available. • PCT 1716: BBAM and BAM Credit Register indicates that there are 320 BBAM alternate credits available. • PCT 1717: BBAM and BAM credit registers indicates that there are 310 BBAM alternate credits available.

Species	Habitat feature/ component	Impacted by development (ha/individuals)	Number and type of potential credits available
Grey-headed Flying-fox	Land within 40 metres of rainforest, coastal scrub, riparian or estuarine communities Impact has been calculated by the area of associated PCTs within the construction footprint, including PCT ID:1747, 1716, 1590, 1646, 1717.	85.05 ha of potential foraging habitat	• PCT 1747: No credits available • PCT 1716: BBAM and BAM Credit Register indicates that there are 310 BBAM alternate credits available • PCT 1590: 5,756 BBAM like-for-like credits and 93 alternate credits available. Additionally, 1,150 BAM alternate allowable credits are available • PCT 1646: The BBAM and BAM Credit Registers indicate that there are no credits available • PCT 1717: BBAM and BAM credit registers indicates that there are 320 BBAM alternate credits available.

3. Summary and timeframe

The former provisions of the TSC Act remain in force for the project biodiversity assessment. Accordingly, the project has been assessed under the FBA and the BBCC was used to calculate ecosystem and species credits for the project. BBAM credits are not consistent with the BAM credits listed on the Biodiversity Offset Scheme Public Register, and as such a credit equivalency assessment is may be required where BBAM credits are not available.

This BOS proposed by Transport outlines a number of proposed steps to meet the biodiversity credit obligations of the project, relating to both ecosystem and species credits. The proposed approach is in accordance with the FBA and commits to making all reasonable steps to locate appropriate like-for-like offset sites before variations and supplementary measures are considered.

The actions below follow the rules for meeting offsets outlined in the FBA and the NSW Biodiversity Offsets Policy for Major Projects. This Strategy prioritises like-for-like credits however may subsequently consist of any combination or sequence of the actions provided below:

- Confirm credit requirements at finalisation of clearances
- Purchase of suitable available BBAM credits
- Apply for an assessment of reasonable equivalency
- Establish Biodiversity Stewardship Agreements on candidate properties
- Payment to the BCF
- Use of the variation criteria or use of supplementary measures if suitable credits cannot be identified
- Identify and secure appropriate offsets for saline vegetation formations in consultation with NSW DPI Fisheries
- Offsets for Matters of National Environmental Significance.

3.1 Proposed timeframe

This BOS has identified key actions proposed, these are summarised in **Table 3-1** along with the timeframe for implementation. The credit equivalency would identify the credit obligation and facilitate finalising the strategy. Transport is committed to finalising and implementing this BOS and retiring the credits identified in this BOS within 24 months of commencing construction of the project. The timeframe for actions in the BOS would commence when the credit equivalency is received.

Table 3-1 Summary of proposed actions and timeframe

Action	Proposed timeframe
Purchase and retire suitable BBAM credits	24 months after construction commencement that impacts the associated PCT or species
Credit conversion	Within 6-12 months of purchase of available BBAM credits
Consultation and investigation of credits generated on the priority EOI properties	Within 12 months after project approval
Investigate credits generated on the priority residual lands	Within 12 months after project approval
Identify and secure appropriate offsets for saline vegetation formations in consultation with NSW DPI Fisheries	Within 24 months after construction commencement that impacts the associated PCT
Advance stewardship agreement on either EOI property or residual land	Within 24-32 months after credit equivalence
Supplementary measures for *Diuris arenaria* and other species (if applicable)	Within 24 months after construction commencement that impacts the associated species

4. References

Department of Primary Industries (DPI) 2013, Policy and Guidelines for Fish Habitat Conservation and Management (Update 2013), http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/468927/Policy-and-guidelines-for-fish-habitat.pdf

Office of Environment and Heritage (OEH) 2014a. Framework for Biodiversity Assessment: NSW Biodiversity Offsets for Major Projects, http://www.environment.nsw.gov.au/resources/biodiversity/140675fba.pdf

Office of Environment and Heritage (OEH) 2014b, NSW Biodiversity Offset Policy for Major Projects, http://www.environment.nsw.gov.au/resources/biodiversity/140672biopolicy.pdf

Roads and Traffic Authority (RTA) 2011, Guideline for Biodiversity Offsets

Transport, 2020. Selling biodiversity credits to Transport. Transport for NSW, Environment and Sustainability Branch 7 Harvest Street, Macquarie Park, NSW 2113

Terms and acronyms

Term	Description
Assessment circles	Two circles (the inner and outer assessment circle) in which the per cent native vegetation cover in the landscape is assessed, considering both cover and condition of vegetation (OEH 2014).
Biodiversity credit report	The report produced by the BBAM Credit Calculator that sets out the number and type of biodiversity credits required to offset the remaining adverse impacts on biodiversity values at a development site or sets out the number and type of biodiversity credits that are created at an offset site (OEH 2014).
Construction footprint	The area of land that is directly impacted on by a proposed Major Project that is under the EP&A Act, including access roads, and areas used to store construction materials (OEH 2014). The construction footprint has the same meaning as 'development site' for the purposes of the FBA.
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 the project SEARs 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).
Ecosystem credit	Ecosystem or species credits (OEH 2014).
Ecosystem credit species	A measurement of the value of EECs, CEECs and threatened species habitat for species that can be reliably predicted to occur with a PCT. Ecosystem credits measure the loss in biodiversity values at a development site and the gain in biodiversity values at an offset site. (OEH 2014)
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).
Landscape buffer (550 metre)	An area around the construction footprint used to assess landscape value in accordance with Appendix 5 of the FBA. For linear developments, this is a 550 metre buffer from the boundary of the construction footprint.
Locality	Area within 10 kilometres from the construction footprint boundary
Matters for further consideration	Impacts that are considered to be complicated or severe that would require further consideration by the consent authority (OEH 2014). The assessment is based on thresholds detailed in Section 9 of the FBA. These can also be included as part of the project SEARs.
MNES	A matter of national environmental significance (MNES) 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 facilitates the safe movement of wildlife and/or prevents wildlife mortality.
Population	All the individuals that interbreed within a given area.
Proposed action	Refers to the project. This terminology is specific to MNES and the EPBC Act Significant impact guidelines 1.1
Species credit species	Threatened species and populations that are assessed according to Section 6.4 of the FBA (OEH 2014).

Term	Description
Stewardship site	Land that is under a Biodiversity Stewardship Agreement (BSA). A BSA is a voluntary agreement between the NSW Biodiversity Conservation Trust (BCT) and a landholder to permanently protect and manage an area of land to improve its biodiversity values and generate biodiversity credits.
Target species	A species that is the focus of a study or intended beneficiary of a conservation action or connectivity measure.

Abbreviations	Description
BAR	Biodiversity Assessment Report
BAM	Biodiversity Assessment Methodology
BBAM	BioBanking Assessment Methodology
BBCC	BioBanking Credit Calculator
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BVT	Biometric Vegetation Type
CEEC	Critically Endangered Ecological Community
CEMP	Construction Environmental Management Plan
DP&E	Department of Planning and Environment
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment
EEC	Endangered ecological community
EIS	Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FBA	Framework for Biodiversity Assessment
FM Act	*Fisheries Management Act 1994*
GDE	Groundwater dependent ecosystem
IBRA	Interim Biogeographically Regionalisation of Australia
MNES	Matters of National Environmental Significance
OEH	Office of Environment and Heritage
PCT	Plant Community Type
SEARs	Secretary’s Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SSI	State Significant Infrastructure
TBDC	Threatened Biodiversity Data Collection
TECs	Threatened Ecological Communities
Transport	Transport for New South Wales
TSC Act	*Threatened Species Conservation Act 1995* (NSW – replaced by BC Act in August 2017)
VIS	Vegetation Information System (BioNet)

Appendix A - Results of the public register searches for ecosystem credits

The following section presents information for each PCT in terms of the vegetation formation and class, the number credits required, a list of alternate and acceptable PCT trades (as identified in the BBCC), and current credit availability listed on the public register.

1717 - Broad-leaved Paperbark – Swamp Mahogany – Swamp Oak – Saw Sedge swamp forest of the Central Coast and Lower North Coast

PCT code: 1717 (HU931)

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Swamp Forests

Conservation status: Swamp Sclerophyll forest on coastal floodplains of the NSW North Coast Sydney Basin and south East Corner bioregions (Endangered, TSC Act)

Impact: 10.49 hectares

Number of BBAM credits generated on project: 469

Credits Available: A search of the BBAM and BAM credit registers indicate that there are no like for like credits available for this PCT. A search of the BBAM and BAM credit registers indicates that there are 90 BBAM alternate credits available in trades for HU931

Photograph 1: Plot 36 showing vegetation zone 11, Broad-leaved Paperbark – Swamp Mahogany – Swamp Oak – Saw Sedge swamp forest of the Central Coast and Lower North Coast

Offset options - PCTs:

This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:

- 1230 - Swamp Mahogany swamp forest on coastal lowlands of the NSW North coast bioregion and northern Sydney Basin Bioregion
- 1716 - Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast
- 1718 - Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast
- 1723 - Melaleuca biconvexa - Swamp Mahogany - Cabbage Palm swamp forest of the Central Coast
- 1730 - Swamp paperbark – *Baumea juncea* swamp shrubland on coastal lowlands of the central Coast and Lower North Coast
- 1731 - Swamp oak – Weeping Grass grassy riparian forest of the Hunter Valley

Credits available (including alternate offset options):

There are total of 90 BBAM credits available for alternate PCTs. This includes credits available for HU633 - Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion (PCT 1230) and northern Sydney Basin Bioregion and HU932 - Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast (PCT 1718).

Like for like and alternate allowable PCT offset option	IBRA sub-region	Credits available	Credit holder
HU633 - Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion (PCT 1230)	Karuah Manning	90 (BBAM)	173
	Wyong	90 (BBAM)	393*
	Wyong	40 (BBAM)	393*
	Wyong	22 (BBAM)	393*
HU932 - Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast (PCT 1718)	Karuah Manning	78 (BBAM)	214
Total available:		320 (BBAM)	

*Agreement 393 is owned by Transport

(Not registered, potential stewardship sites):

There are expressions of interest listed for credits where the quantum has yet to be determined or entered into a stewardship agreement. These sites are located in the Karuah-Manning sub-region and include likely credits for:

- 1716 - Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast
- 1717 - Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast

1724 – Broad-leaved Paperbark – Swamp Oak – Saw Sedge swamp forest on the coastal lowlands of the Central Coast and Lower North Coast

PCT code: 1724 (HU938)

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Swamp Forests

Conservation status: Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and south East Corner bioregions (Endangered, TSC Act)

Impact: 1.61 hectares

Number of BBAM credits generated on project: 75

Credits Available (Public Register): A search of the BBAM and BAM credit registers indicates that there are 90 BBAM alternate credits available in trades for HU938.

Photograph 2: Plot 49 showing vegetation zone 13, Broad-leaved Paperbark - Swamp Oak - Saw Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast

Offset options – PCTs:

This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:

- 1230 - Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion, (HU633)
- 1649 - Smooth-barked Apple - Red Mahogany - Swamp Mahogany - *Melaleuca sieberi* heathy swamp woodland of coastal lowlands, (HU863)
- 1716 - Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast, (HU930)
- 1717 - Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast, (HU931)
- 1718 - Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast, (HU932)
- 1719 - Paperbarks - Woollybutt swamp forest on coastal lowlands of the Central Coast, (HU933)
- 1722 - Swamp Mahogany - Paperbarks - Harsh Ground Fern swamp forest of the Central Coast, (HU936)
- 1723 - Melaleuca biconvexa - Swamp Mahogany - Cabbage Palm swamp forest of the Central Coast, (HU937)
- 1725 - Swamp Mahogany - Broad-leaved Paperbark - Swamp Water Fern - Plume Rush swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU939)
- 1726 - Flax-leaved Paperbark - Tall Sedge shrubland of the Sydney Basin, (HU940)
- 1730 - Swamp paperbark - *Baumea juncea* swamp shrubland on coastal lowlands of the Central Coast and Lower North Coast, (HU944)
- 1731 - Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley, (HU945).

Credits available (including alternate offset options):

There are total of 90 BBAM credits available for alternate PCTs. This includes credits available for HU633 - Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion (PCT 1230) and northern Sydney Basin Bioregion and HU932 - Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast (PCT 1718).

Like for like and alternate allowable PCT offset option	IBRA sub-region	Credits available	Credit holder
HU633 - Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion (PCT 1230)	Karuah Manning	90 (BBAM)	173
	Wyong	90 (BBAM)	393
	Wyong	40 (BBAM)	393
	Wyong	22 (BBAM)	393
HU932 - Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast	Karuah Manning	78 (BBAM)	214
Total available:		320 (BBAM)	

Not registered – potential stewardship sites:

There are expressions of interest listed for credits where the quantum has yet to be determined or entered into a stewardship agreement. These sites are located in the Karuah-Manning sub-region and include likely credits for:

- 1649 - Smooth-barked Apple - Red Mahogany - Swamp Mahogany - *Melaleuca sieberi* heathy swamp woodland of coastal lowlands
- 1716 - Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast
- 1717 - Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast.

1598 - Forest Red Gum grassy open forest on floodplains of the lower Hunter

PCT code: 1598 (HU812)

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Swamp Forests

Conservation Status: Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions (Endangered, TSC Act)

Impact: 0.45 hectares

Number of credits generated on project: 27

Credits Available (Public Register)

A search of the BBAM and BAM credits register indicates there are 296 BBAM like-for-like credits and 159 alternate credits available for HU812.Additionally, 15 BAM like-for-like credits are available for PCT1598.

Photograph 3: Plot 5 showing vegetation zone 9, Forest Red Gum grassy open forest on floodplains of the lower Hunter (1598 – Moderate)

Offset options - PCTs:

This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:

- 780 - Coastal floodplain sedgelands, rushlands, and forblands of the North Coast
- 1234 - Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion
- 1651 - Parramatta red gum - Fern-leaved banksia - *Melaleuca sieberi* swamp woodland of the Tomaree Peninsula
- 1715 - Prickly-leaved Paperbark - Flax-leaved Paperbark swamp forest on poorly drained soils of the Central Coast
- 1720 - Cabbage Gum - Forest Red Gum - Flax-leaved Paperbark Floodplain Forest of the Central Coast
- 1727 - Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast
- 1728 - Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast
- 1749 - Grey Gum - Red Gum - Paperbark shrubby open forest on coastal lowlands of the Northern Sydney Basin and Lower North Coast.

Credits available (including alternate offset options):

There are total of 296 BBAM like-for-like credits and 159 alternate credits available for HU812. Additionally, 15 BAM like-for-like credits are available for PCT1598. This includes credits available for HU812 – Forest Red Gum grassy open forest on floodplains of the lower Hunter (PCT 1598), HU532 - Coastal floodplain sedgelands, rushlands, and forblands of the North Coast (PCT 780) and PCT 1598.

Like for like and alternate allowable PCT offset option	IBRA sub-region	Credits available	Credit holder
HU812 – Forest Red Gum grassy open forest on floodplains of the lower Hunter	Hunter	281 (BBAM)	350
	Hunter	15 (BBAM)	237
HU532 - Coastal floodplain sedgelands, rushlands, and forblands of the North Coast (PCT 780)	Karuah Manning	81 (BBAM)	158
	Karuah Manning	61 (BBAM)	173
	Karuah Manning	17 (BBAM)	330
1598 - Forest Red Gum grassy open forest on floodplains of the lower Hunter	Hunter	15 (BAM)	CR-381
Total available:		455 (BBAM) 15 (BAM)	

Not registered – potential stewardship sites
There are no other suitable credits available or current expressions of interest.

1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast

PCT code: 1588 (HU802)

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

Vegetation class: Hunter-Macleay Dry Sclerophyll Forests

Conservation status: Not listed

Impact: 7.6 hectares

Number of credits generated on project: 429

Credits Available (Public Registers):

A search of the BBAM and BAM credit registers indicate there are 319 BBAM like-for-like credits and 93 alternate credits available for HU802. Additionally, 638 BAM like-for-like and 1,595 alternate allowable credits are available for PCT1588.

Photograph 4: Plot 3 showing vegetation zone 4. Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast

Offset options - PCTs:

This PCT may be offset in the Hunter sub-region and any Interim Biogeographic Regionalisation of Australia (IBRA) sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:

- 922 - Melaleuca decora low forest of the central Hunter Valley, Sydney Basin
- 1178 - Slaty Red Gum grassy woodland on hinterland foothills of the southern
- 1589 - Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast
- 1590 - Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest
- 1593 - Red Ironbark - Spotted Gum - Prickly-leaved Paperbark shrubby open forest of the Lower Hunter
- 1600 - Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter
- 1601 - Spotted Gum - Narrow-leaved Ironbark-Red Ironbark shrub - grass open forest of the central and lower Hunter
- 1602 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter
- 1608 - Grey Box - Grey Gum - Rough-barked Apple - Blakely's Red Gum grassy open forest of the central Hunter.

Credits available (including trades):

There are total of 319 BBAM like-for-like credits and 93 alternate credits available for HU802. Additionally, 638 BAM like-for-like and 1,595 alternate allowable credits are available for PCT1588. This includes credits available for HU802 – Grey Ironbark – Broad-leaved Mahogany – Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (PCT 1588), HU803 - Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast (PCT 1589) and PCT 1602.

Like for like and alternate allowable PCT offset option	IBRA sub-region	Credits available	Credit holder
HU802 – Grey Ironbark – Broad-leaved Mahogany – Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast	Upper Hunter	197 (BBAM)	334
	Upper Hunter	117 (BBAM)	334
	Wyong	5 (BBAM)	355
HU803 - Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast	Karuah Manning	93 (BBAM)	330
HU816 – Spotted Gum – Narrow-leaved Ironbark shrub – grass open forest of the central and lower Hunter (PCT 1602)	Karuah Manning	638 (BAM)	CR-5127
	Upper Hunter	1,150 (BAM)	CR-2104
	Karuah Manning	445 (BAM)	CR-5134
Total available:		412 (BBAM) 2,233 (BAM)	

Not registered – potential stewardship sites:
There are expressions of interest listed for credits where the quantum has yet to be determined or entered into a stewardship agreement, and include potential credits for this PCT within an adjoining IBRA sub-region (Karuah-Manning) and therefore represent potential offset options: • 1590 – Spotted Gum -Broad-leaved Mahogany – Red Ironbark shrubby open forest.

1742 – Jointed Twig-rush sedgeland

PCT code: 1742 (HU956)

Vegetation formation: Freshwater Wetlands

Vegetation class: Coastal Freshwater Lagoons

Conservation status: Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, BC Act)

Impact: 1.45 hectares

Number of BBAM credits generated on project: 99

Credits Available (Public Register): A search of the BBAM and BAM Public Register indicates that there are 4 BBAM alternate credits available for HU956.

Photograph 5: Plot 30 showing vegetation zone 17, Jointed Twig-rush sedgeland

Offset options – PCTs:

This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:

- 781 – Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion
- 1071 – *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion
- 1735 – *Cladium procerum* coastal freshwater wetland
- 1736 – Water Couch – Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter
- 1737 – Typha rushland
- 1740 – Tall Spike Rush freshwater wetland
- 1741 – *Lepironia articulata* sedgeland.

Credits available (including alternate offset options):

There are total of 4 BBAM alternate credits available for alternate for HU802. This includes credits available for HU533 - Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion (PCT 781).

Like for like and alternate allowable PCT offset option	IBRA sub-region	Credits available	Credit holder
HU533 - Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion (PCT 781)	Wyong	4 (BBAM)	393
Total available:		4 (BBAM)	

Not registered – potential stewardship sites:

There are no expressions of interests applicable for these PCT options in an adjoining IBRA sub-region.

1071 – Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion

<table>
<tr><td>
PCT code: 1071 (HU673)
Vegetation formation: Freshwater Wetlands
Vegetation class: Coastal Freshwater Lagoons
Conservation status: Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, BC Act)
Impact: 7.71 hectares
Number of credits generated on project: 326
Credits Available (Public Register): A search of the BBAM and BAM Credit Registers indicate that there are no credits available for this PCT.
</td><td>

Photograph 6: Plot 11 showing vegetation zone 18, Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion
</td></tr>
<tr><td colspan="2">
Offset options – PCTs:
This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:
• 1071 – Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion
• 1735 – Cladium procerum coastal freshwater wetland
• 1736 – Water Couch – Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter.
</td></tr>
<tr><td colspan="2">
Credits available (including offset options):
There are no credits available for alternate PCTs.
</td></tr>
<tr><td colspan="2">
Not registered – potential stewardship sites:
There are no expressions of interests applicable for these PCT options in an adjoining IBRA sub-region
</td></tr>
</table>

1716 – Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast

<table>
<tr><td>
PCT code: 1716 (HU930)
Vegetation formation: Forested Wetlands
Vegetation class: Coastal Swamp Forests
Conservation status: Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and south East Corner Bioregions (Endangered, TSC Act)
Impact: 1.82 hectares
Number of BBAM credits generated on project: 103
Credits Available (Public Register):
A search of the BBAM and BAM Credit Register indicates that there are 90 BBAM alternate credits available for this PCT.
</td><td>

Photograph 7: Plot 5 showing vegetation zone 10, Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast (1716 – Good)
</td></tr>
<tr><td colspan="2">
Offset options – PCTs:
This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:
• 1230 – Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion
• 1717 – Broad-leaved Paperbark – Swamp Mahogany – Swamp Oak – Saw Sedge swamp forest of the Central Coast and Lower North Coast
• 1718 Swamp Mahogany – Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast
• 1719 – Paperbarks – Woollybutt swamp forest on coastal lowlands of the Central Coast
</td></tr>
</table>

- 1723 – Melaleuca biconvexa – Swamp Mahogany – Cabbage Palm swamp forest of the Central Coast
- 1730 – Swamp paperbark – *Baumea juncea* swamp shrubland on coastal lowlands of the Central Coast and Lower North Coast
- 1731 – Swamp Oak – Weeping Grass grassy riparian forest of the Hunter Valley.

Credits available (including offset options):

There are total of 90 BBAM credits available for alternate PCTs. This includes credits available for HU633 - Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion (PCT 1230) and northern Sydney Basin Bioregion and HU932 - Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast (PCT 1718).

Like for like and alternate allowable PCT offset option	IBRA sub-region	Credits available	Credit holder
HU633 - Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion (PCT 1230)	Karuah Manning	90 (BBAM)	173
	Wyong	90 (BBAM)	393
	Wyong	40 (BBAM)	393
	Wyong	22 (BBAM)	393
HU932 - Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast (PCT 1718)	Karuah Manning	78 (BBAM)	214
Total available:		320 (BBAM)	

Not registered – potential stewardship sites:

There are expressions of interest listed for credits where the quantum has yet to be determined or entered into a stewardship agreement. These sites are located in the Karuah-Manning sub-region and include likely credits for:

- 1716 – Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast
- 1717 – Broad-leaved Paperbark – Swamp Mahogany – Swamp Oak – Saw Sedge swamp forest of the Central Coast and Lower North Coast.

1646 – Smooth-barked Apple – Blackbutt – Old Man Banksia woodland on coastal sands of the Central and Lower North Coast

PCT code: 1646 (HU860)

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

Vegetation class: Coastal Dune Dry Sclerophyll Forests

Conservation Status: Not listed

Impact: 28.59 hectares

Number of credits generated on project: 1,421

Credits Available (Public Register):

A search of the BBAM and BAM Credit Registers indicate that there are no credits available for this PCT.

Photograph 8: Plot 27 showing vegetation zone 6, Smooth-barked Apple - Blackbutt - Old Man Banksia woodland on coastal sands of the Central and Lower North Coast (1646 – Good)

Offset options - PCTs:

This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:

- 1646 – Smooth-barked Apple – Blackbutt – Old Man Banksia woodland on coastal sands of the Central and Lower North Coast
- 1618 - Smooth-barked Apple - White Stringybark - Red Mahogany - Melaleuca sieberi shrubby open forest on lowlands of the lower North Coast
- 1637 - Scribbly gum - Wallum Banksia - Prickly-leaved Paperbark heathy coastal woodland on coastal lowlands
- 1648 - Smooth-barked Apple - Blackbutt heathy open forest of the Tomaree Peninsula.

Credits available (including offset options): No available credits were identified in the Biodiversity Offsets Scheme Public Register for this PCT. Variation of the FBA offset rules is possible for HU860/1646 and can be granted for the PCT from the same vegetation formation as the PCT subject to approval by the consent authority.
Not registered – potential offset sites: There are expressions of interest listed for credits where the quantum has yet to be determined or entered into a stewardship agreement, and include potential credits for this PCT within an adjoining IBRA sub-region (Karuah-Manning) and therefore represent potential offset options: • 1646 - Blackbutt – Old Man Banksia woodland on coastal sands of the Central and Lower North Coast • 1618 – Smooth-barked Apple – White Stringybark – Red Mahogany – *Melaleuca sieberi* shrubby open forest on lowlands of the lower North Coast.

1649 - Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands

PCT code: 1649 (HU863)

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Swamp Forests

Conservation status: Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)

Impact: 1.36 hectares

Number of credits generated on project: 72

Credits Available (Public Register)

A search of the BBAM and BAM Credit Registers indicates that there are no credits available for this PCT.

Photograph 9: Plot 28 showing vegetation zone 8, Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands

Offset options - PCTs

This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:

- 1649 – Smooth-barked Apple – Red Mahogany – Swamp Mahogany – *Melaleuca sieberi* heathy swamp woodland of coastal lowlands
- 1230 - Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion
- 1716 - Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast
- 1717 - Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast
- 1718 - Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast
- 1719 - Paperbarks - Woollybutt swamp forest on coastal lowlands of the Central Coast
- 1723 - Melaleuca biconvexa - Swamp Mahogany - Cabbage Palm swamp forest of the Central Coast
- 1726 - Flax-leaved Paperbark - Tall Sedge shrubland of the Sydney Basin
- 1730 - Swamp paperbark - *Baumea juncea* swamp shrubland on coastal lowlands of the Central Coast and Lower North Coast
- 1731 - Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley.

Credits available (including trades):

No available credits were identified in the Biodiversity Offsets Scheme Public Register for this PCT or possible alternate options. As this PCT is an EEC (NSW TSC Act) it is not possible to allow for a variation under the FBA offset rules.

Not registered – potential offset sites:

There are expressions of interest listed for credits where the quantum has yet to be determined or entered into a stewardship agreement. These sites are located in the Karuah-Manning sub-region and include likely credits for:

- 1649 - Smooth-barked Apple - Red Mahogany - Swamp Mahogany - Melaleuca sieberi heathy swamp woodland of coastal lowlands
- 1716 - Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast
- 1717 - Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast.

1590 - Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest

PCT code: 1590 (HU804)

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

Vegetation class: Hunter-Macleay Dry Sclerophyll Forests

Conservation status: Lower Hunter Spotted Gum Ironbark Forest of the Sydney Basin (Endangered, TSC Act)

Impact: 41.88 hectares

Number of credits generated on project: 2,327

Credits Available (Public Register):

A search of the BBAM and BAM credit registers indicate that there are 5,756 BBAM like-for-like credits and 93 alternate credits available for HU804. Additionally, 1,150 BAM alternate allowable credits are available for PCT1590.

Photograph 10: Plot 4 showing vegetation zone 1, Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest

Offset options - PCTs:

This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the BioBanking credit report for the project:

- 1590 – Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest
- 922 - *Melaleuca decora* low forest of the central Hunter Valley, Sydney Basin Bioregion
- 1178 - Slaty Red Gum grassy woodland on hinterland foothills of the southern North Coast
- 1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast
- 1589 - Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast
- 1592 - Spotted Gum - Red Ironbark - Grey Gum shrub - grass open forest of the Lower Hunter
- 1593 – Red Ironbark – Spotted Gum – Prickly-leaved Paperbark shrubby open forest of the Lower Hunter
- 1600 -Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter
- 1601 - Spotted Gum - Narrow-leaved Ironbark-Red Ironbark shrub - grass open forest of the central and lower Hunter
- 1602 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter
- 1608 - Grey Box - Grey Gum - Rough-barked Apple - Blakely's Red Gum grassy open forest of the central Hunter.

Credits available (including alternate offset options):

There are total of 5,756 BBAM like-for-like credits and 93 alternate credits available for HU804. Additionally, 1,150 BAM alternate allowable credits are available for PCT1590.This includes credits available for HU804 Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (PCT 1590), HU803 - Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast (PCT 1589) and PCT 1602.

Alternate allowable PCT offset option	IBRA sub-region	Credits available	Credit holder
HU804 Spotted Gum – Broad-leaved Mahogany – Red Ironbark shrubby open forest (PCT 1590)	Various (see summary Table 2-1)	5,756 (BBAM)	Various (see summary Table 2-1))
HU803 - Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast (PCT 1589)	Karuah Manning	93 (BBAM)	330
HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter (PCT 1602)	Upper Hunter	1,150 (BAM)	CR-2104
Total available:		5,849 (BBAM) 1,150 (BAM)	

Not registered – potential offset options:

The credits identified are the same as available for PCT1590 as they are located in the adjoining Upper Hunter sub-region. There are no other suitable credits available or current expressions of interest.

1727 - Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast

PCT code: 1727 (HU941)

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Floodplain Wetlands

Conservation status: Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act); Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community (Endangered, EPBC Act) – in part

Impact: 8.76 hectares

Number of BBAM credits generated on project: 423

Credits Available (Public Register): A search of the BBAM and BAM Credit Registers indicates that there are 9 BBAM like-for-like credits and 159 alternate credits available for HU941. Additionally, 31 BAM alternate allowable credits are available for PCT1727

Photograph 11: Plot 13 showing vegetation zone 14, Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast

Offset options - PCTs

This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:

- 780 - Coastal floodplain sedgelands, rushlands, and forblands of the North Coast
- 1234 - Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion
- 1651 - Parramatta red gum - Fern-leaved banksia - *Melaleuca sieberi* swamp woodland of the Tomaree Peninsula
- 1720 - Cabbage Gum - Forest Red Gum - Flax-leaved Paperbark Floodplain Forest of the Central Coast
- 1728 - Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast.

Credits available (including offset options):

There are total of 9 BBAM like-for-like credits and 159 alternate credits available for HU941. Additionally, 31 BAM alternate allowable credits are available for PCT1727. This includes credits available for HU532 - Coastal floodplain sedgelands, rushlands, and forblands of the North Coast (PCT 780),

Like for like and alternate allowable PCT offset option	IBRA sub-region	Credits available	Credit holder
1727 – Swamp Oak – Sea Rush – Baumea juncea swamp forest on the coastal lowlands of the Central Coast and Lower North Coast	Karuah-Manning	9 (BBAM)	214
		31 (BAM)	CR-3673
HU532 - Coastal floodplain sedgelands, rushlands, and forblands of the North Coast (PCT 780)	Karuah Manning	81 (BBAM)	158
	Wyong	61 (BBAM)	173
HU934 - Cabbage Gum - Forest Red Gum - Flax-leaved Paperbark Floodplain Forest of the Central Coast (PCT 1720)	Karuah Manning	17 (BBAM)	330
Total available:		168 (BBAM) 31 (BAM)	

Not registered – potential offset options:

There are no expressions of interests applicable for these PCT options in an adjoining IBRA sub-region.

1736 - Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter

<table>
<tr><td>
PCT code: 1736 (HU950)
Vegetation formation: Freshwater Wetlands
Vegetation class: Coastal Freshwater Lagoons
Conservation status: Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, BC Act)
Impact: 59.04 hectares
Number of credits generated on project: 2,304
Credits Available (Public Register): A search of the BBAM and BAM credit register indicates that there are no credits available for this PCT.
</td><td>

Photograph 12: Plot 7 showing vegetation zone 15, Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter
</td></tr>
<tr><td colspan="2">
Offset options - PCTs:
This PCT may be offset in the Hunter sub-region and any IBRA sub-region that adjoins the Hunter sub-region. There are several alternate offset options for this PCT as outlined in the credit report for the project:
• 1736 - Water Couch - Tall Spike Rush freshwater wetland of the Central Coast and lower Hunter
• 1071 - Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion
• 1735 - Cladium procerum coastal freshwater wetland.
</td></tr>
<tr><td colspan="2">
Credits available (including offset options):
There are no credits available for alternate PCTs.
</td></tr>
<tr><td colspan="2">
Not registered – potential stewardship sites:
There are no expressions of interests applicable for these PCT options in an adjoining IBRA sub-region.
</td></tr>
</table>