Frog

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Reptile

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Fauna habitats

Dry Forest

Swamp Forest

Giant Barred Frog

Green-thighed Frog

Stephens' Banded Snake

Wallum Froglet

Fauna connectivity structures

Combined (bridge)

Combined (fauna and emu)

Combined (culvert)

Dedicated Underpass

Dedicated Arboreal

Dedicated Overpass

'/// Cleared and Modified

Estuarine Wetland

Lowland Rainforest

Freshwater Wetland

Wet and Dry Heath

Wet Sclerophyll and Floodplain Forest

Combined (Oxleyan Pygmy Perch)

Combined (emu and bridge structure)

Incidental Emu Structure (road overpass)

Incidental Emu Structure (road underpass)

Combined (emu and drainage structure)

Legend sheet B

Threatened fauna species



- 🔺 Australasian Bittern
- Black-necked Stork
- Black-chinned Honneyeater
- 🛆 Brolga
- A Brown Treecreeper
- A Bush Stone-curlew
- A Emu
- ▲ Glossy Black-cockatoo
- A Grass Owl
- ▲ Grey-crowned Babbler
- A Magpie Goose
- Masked Owl
- ▲ Osprey
- A Powerful Owl
- A Rose-crowned Fruit-dove
- △ Sooty Owl

Flying mammal

- Common Blossom-bat
- Eastern Bent-wing Bat
- Eastern Cave Bat
- Eastern False Pipistrelle
- Eastern Long-eared Bat
- Grey-headed Flying Fox
- Hoary Wattled Bat
- Little Bent-wing Bat
- Southern Myotis

Non-flying mammal



- 📥 Koala
- Rufous Bettong
- Squirrel Glider
- Yellow-bellied Glider

Invertebrate

- Y Pink Underwing Moth
- ★ Pink Underwing Moth host plant
- Pink Underwing Moth and host plant
- ★ Atlas Rainforest Ground Beetle

Figure 10-30: Legend for fauna habitat, threatened fauna and proposed fauna connectivity structures

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WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE



Figure 10-31: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 0.0 to 6.0)





00100



Figure 10-32: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 6.0 to 12.5)





WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE



Figure 10-33: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 12.5 to 19.0)



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NOOLGOO



Figure 10-34: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 19.0 to 25.0)





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MOOLCOOLC



Figure 10-35: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 25.0 to 31.5)



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DOLGOG



Figure 10-36: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 31.0 to 38.0)







Figure 10-37: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 37.0 to 44.0)









Figure 10-38: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 43.0 to 51.0)









"Refer to Legend sheet B for fauna map key

Figure 10-39: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 50.5 to 56.5)







*Refer to Legend sheet B for fauna map key

Figure 10-40: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 57.0 to 63.5)

State Forest





Figure 10-41: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 63.5 to 70.0)







Figure 10-42: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 70.0 to 77.5)







"Refer to Legend sheet B for fauna map key

Figure 10-43: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 77.5 to 83.5)







Figure 10-44: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 83.5 to 90.5)



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Figure 10-45: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 90.5 to 97.5)





WOODBURN WANS HEAD

MACLEAN YAMBA



Figure 10-46: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 97.5 to 104.0)





WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE



Figure 10-47: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 103.5 to 110.0)




Figure 10-48: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 110.0 to 116.0)





COLCOOL



Figure 10-49: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 116.0 to 122.5)







Figure 10-50: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 122.0 to 129.0)







Figure 10-51: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 128.5 to 135.0)







Figure 10-52: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 134.5 to 141.5)



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OOLGOG



Figure 10-53: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 140.5 to 148.5)







"Refer to Legend sheet B for fauna map key

Figure 10-54: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 147.5 to 155.0)



WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE



Figure 10-55: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 154.0 to 162.0)





WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE



Figure 10-56: Fauna habitat, threatened fauna and proposed fauna connectivity structures in the study area (Station 161.0 to 166.0)





10.2.5 Aquatic habitats

The project traverses the major river catchments of the Clarence and Richmond rivers and numerous other creeks and rivers. Many of the freshwater rivers and creeks in the region are influenced by tidal flows that support freshwater and estuarine flora and fauna. Key fish habitats in the project region and a list of important wetlands and SEPP (State Environmental Planning Policy No14) wetlands are identified in Table 10-7.

Eight Nationally Important Wetlands (from the Directory of Important Wetlands in Australia (2001)) are located outside of the project boundary. Most of these wetlands are recharged or fed by the Clarence River catchment.

TERM – Aquatic

Relating to or living or growing in or near water.

Table 10-7: Aquatic habitats identified near the project boundary

Section	Summary of aquatic habitats present
1	Lowland freshwater streams including Arrawarra Gully, Corindi River (Class 1 waterway), Cassons Creek (Class 1 waterway), Redbank Creek (Class 1 waterway), Dirty Creek, Dundoo Creek and sections of Halfway Creek (Class 1 waterway). All Class 1 waterways in section 1 are considered potential habitat for the endangered (FM Act & EPBC Act) Oxleyan Pygmy Perch and the endangered (FM Act) Purple-spotted Gudgeon. SEPP 14 wetlands (No. 314) are located about 60 m east of the project near Corindi Beach. There are also SEPP 14 wetlands (No. 315) associated with Arrawarra Gully; however these do not occur within the project boundary.
2	The lowland freshwater systems of Halfway Creek (Class 1 waterway), Glenugie Creek and Wells Crossing (Class 1 waterway) are located within Section 2. Halfway Creek is located about 25 kilometres north of Woolgoolga and wetlands are associated with this creek. Both Halfway Creek and Wells Crossing waterways have potential habitat for Oxleyan Pygmy Perch and Purple Spotted Gudgeon. Glenugie Creek is situated just west of the existing Pacific Highway on the boundary of the Glenugie State Forest. The creek is low flowing, at times depleted of water but provides significant habitat for fish because it has large woody debris and shading from macrophytes.
3	Lowland freshwater rivers and creeks include Pheasant Creek, Coldstream River (Class 1 waterway), Black Snake Creek (Class 1 waterway), Pillar Valley Creek (Class 1 waterway), Chaffin Creek (Class 1 waterway) and Champions Creek. Generally these creeks exhibit low flows with often no flows in their upstream reaches after periods of dry weather resulting in low dissolved oxygen and pH and often elevated turbidity. The endangered (FM Act and EPBC Act) Eastern (Freshwater) Cod also has potential habitat occurring in Coldstream River, Pillar Valley Creek and Chaffin Creek. There are small pockets of SEPP 14 wetlands adjacent to sections of Pillar Valley Creek, Champions Creek and Chaffin Creek; however these are not within the project boundary. SEPP 14 wetland No. 287 is associated with Champions Creek and is located about 0.4 km upstream of the project. SEPP 14 wetland (No. 289) associated with Chaffin Creek is located about 300 m to the west of the project. SEPP 14 wetland (No, 292) is located around 0.7 kilometres from the project. There are four Nationally Important Wetlands near this project section. These include Upper Coldstream, Lake Hiawatha and Minnie Water, Everlasting Swamp and Cowans Pond Reserve.
4	Edwards Creek, Shark Creek (Class 1 waterway) and South Arm (Clarence River) (Class 1 waterway) are tidally influenced estuarine systems, although the upstream reaches of Shark Creek is considered a lowland freshwater ecosystem. SEPP 14 wetland No 232 occurs on the eastern side of the upstream reaches of Shark Creek near the project boundary.

Section	Summary of aquatic habitats present
5	James Creek (Class 1 waterway), Clarence River (Class 1 waterway), Serpentine Channel (Class 1 waterway) and North Arm (Clarence River) (Class 1 waterway) are tidally influenced waterways and exhibit estuarine water quality characteristics. Yaegl Nature Reserve is situated on the Lower Clarence floodplain and primarily consists of an estuarine back swamp, however there are sections of James Creek along the eastern boundary of the reserve (east of the highway) that are freshwater (DECC, 2009). The Clarence River provides potential habitat for Eastern (Freshwater) Cod and the Purple-spotted Gudgeon. Water quality at these sites is generally good, although pH levels in the Clarence River has been reported to fall below the lower limit for the protection of estuarine aquatic ecosystems. The project boundary runs adjacent to SEPP 14 wetland No. 220a. James Creek flows through this wetland which extends into Yaegl Nature Reserve. SEPP 14 wetland No. 153c is located about 0.4 km west of the project boundary crossing of North Arm. There are four Nationally Important Wetlands near this project section. These include Wooloweyah Lagoon. The Broadwater, Clarence River Estuary and Bundialung National Park.
6	Section 6 crosses Tabbimoble Creek (Class 1 waterway) and is near Nyrang Creek. Tabbimoble Creek is estuarine downstream of the weir and freshwater upstream. Water quality in Tabbimoble Creek is generally good and within an ideal range for Oxleyan Pygmy Perch. Records of Oxleyan Pygmy Perch are known to occur in the Tabbimoble Floodways in association with Tabbimoble Creek. Mororo Creek is located about 80 metres west of the project. There is a SEPP 14 wetland (No. 153a) located on Tabbimoble Creek about 1 kilometre east of the project boundary. The SEPP 14 wetland (No. 153) is located to the east of the project boundary mostly within the Bundjalung National Park and Devils Pulpit State Forest and extends between the north arm of the Clarence River in the south and the Evans River in the north.
7	Several ephemeral streams. These ephemeral streams may not exhibit typical habitat characteristics for Oxleyan Pygmy Perch but they may provide important linkages to key habitats. As a precaution, some of these are likely to represent potential habitat and known records of Oxleyan Pygmy Perch were found in an unnamed creek (Class 1) in Tabbimoble State Forest (station 114.0). A SEPP 14 wetland (No. 161) is located about 260 metres east of the project.
8	Tuckombil Canal (freshwater upstream of the weir) (Class 1 waterway), McDonalds Creek (Class 1 waterway) and a number of small ephemeral streams. Despite estuarine influences of Tuckombil Canal it is considered potential habitat for Oxleyan Pygmy Perch along with Rock Mouth Creek further upstream. SEPP 14 wetland (No, 133) is located around 670 metres east of the project. SEPP 14 wetland (No 134) is located around one kilometre east of the project.
9	Tuckean Broadwater, Montis Gully and Eversons Creek. However, there is good potential habitat (paperbark and wallum heath swamp) in this section for the Oxleyan Pygmy Perch (Ecosense Consulting, 2008) with known records occurring in swamps in Broadwater National Park. SEPP 14 wetland No.119 and mangroves (<i>Avicennia marina</i> and <i>Aegiceras corniculatum</i>) are located at Tuckean Broadwater (Ecosense Consulting, 2008).
10	Richmond River (Class 1 waterway) and Randals Creek. Aquatic habitats in the Richmond River have potential to support the Eastern (Freshwater) Cod. SEPP14 wetland no.118 and 118a (northern banks) are located on the northern banks of the Richmond River, either side of the project boundary.
11	Duck Creek (Class 1 waterway) and Emigrant Creek (Class 1 waterway) are freshwater in their upstream reaches, then estuarine and tidal near the project boundary. SEPP 14 wetlands No. 108, 108a and No. 95 are located around Duck Creek and Emigrant Creek respectively. SEPP 14 wetlands 96, 97, 98 and 99 are located downstream over 50 metres away.

10.2.6 Flora species

A total of 1160 flora species from 210 plant families were confirmed through field surveys across the study area. This comprises 1002 native indigenous species (86.5 per cent of the total species) and 157 exotic species.

Fifteen NSW and Commonwealth listed threatened flora species were confirmed in the study area from the field surveys. Details on these species, including where possible, population size and distribution in relation to the project boundary, is presented in Table 10-8 and mapped in Figure 10-4 to Figure 10-29.

Seven species were found to have moderately large populations occurring within or adjacent to the project boundary. These included the *Angophora robur*, *Melaleuca irbyana*, *Eucalyptus tetrapleura*, *Arthraxon hispidus*, *Cyperus aquatilis*, *Maundia triglochinoides*, and *Lindsaea incisa*. The remaining species occur as either isolated individuals or small localised populations near the project boundary.



Photo 3: View over Bondi Hill, Tyndale, where Angophora robur was identified

Table 10-8: Threatened flora confirmed within the project boundary

Scientific Common		Status		Distribution and abundance in study area	Confirmed
name	name	TSC Act	EPBC Act		
Angophora robur	Sandstone Rough-barked Apple	V	V	Around 9000 individuals over 105 hectares based on detail surveys and mapping. The known regional distribution is estimated at 152,712 individuals over around 1818 hectares and predicted distribution is about 618,912 individuals over around 7368 hectares. The population within and adjacent to the project boundary represents the known eastern distribution of the species.	Sections 3 and 4
Arthraxon hispidus	Hairy-joint Grass	V	V	Several large populations between Coolgardie Road and Lumley's Lane. The known area of occupation of the species is 20.8 hectares.	Section 10
Archidendron hendersonii	White Laceflower	V		Eleven individuals in subtropical rainforest north of Coolgardie Road.	Section 10
Cryptocarya foetida	Stinking Cryptocarya	V	V	A total of 17 individuals were confirmed in and around the project boundary in Section 10 north of Coolgardie Road.	Section 10
Cyperus aquatilis	Water Nutgrass	E		 Previously confirmed during field surveys at six locations in Sections 6 and 7. During 2012 surveys, it could only be re-located at Mororo State Forest where a relatively large population (around 80 plants) was previously confirmed. Other records in the study area include south of Jacky Bulbin Road (around 18 plants), north of Glencoe Road (9 plants) and several locations where only 1 to 3 individuals were confirmed including Tabbimoble Floodway No. 2 and around 1 kilometres north. Individuals within the project boundary are potentially part of a larger population surrounding the project. 	Section 6, 7
Endiandra hayesii	Rusty Rose Walnut	V	V	Confirmed north of Coolgardie Road comprising a total of five larger individuals and three juveniles.	Section 10
Endiandra muelleri subsp. bracteata	Green-leaved Rose Walnut	E		Confirmed to the west of the project boundary at Maclean and in Section 10. Confirmed north of Coolgardie Road comprising 1 large individual and 3 juveniles.	Section 5 and 10
Eucalyptus tetrapleura	Square-fruited Ironbark	V	V	Several known populations near the existing Pacific Highway in Section 2. The population extends into the surrounding private properties and state forest including Wells Crossing Flora Reserve. The population is estimated at 1,213 individuals near the project boundary, comprising around 14.5 hectares of known habitat.	Section 2
Grevillea quadricauda	Four-tailed Grevillea	V	V	Confirmed in Section 3 at two different locations. This species occurs in dry sclerophyll forest on sandy soils adjacent to creek lines and surrounding slopes. It occurs in moderate abundance comprising two sub-populations totalling 46 individuals. One of these sub-populations is part of a larger population to the east of the project.	Section 3

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Scientific Common Status			Distribution and abundance in study area		
name	name	TSC Act	EPBC Act		
Lindsaea incisa	Slender Screw Fern	E	E	 Populations were found along the edges of drainage swales with sandy soils, comprising: A large population extending into the corridor to the west of the highway opposite Lemon Tree Road in Section 1 A small patch 12 metres upstream to the east of the project boundary on an elevated area in the centre of Halfway Creek, Section 2 A large population 20 m downstream to the west of the project boundary near Tucabia in section 3 A large population extending into the project boundary in Mororo State Forest in Section 6. 	Sections 1-3 and 6
Macadamia tetraphylla	Rough-shelled Bush Nut	V		Confirmed to the west of the project boundary at Maclean, in proximity to the project boundary at Section 10 and 11 and to the south of the project boundary at Section 1. The largest population comprises 68 individuals confirmed south of Coolgardie Road in Section 10 including juveniles and mature trees.	Section 1, 5 and 10-11
Maundia triglochinoides	Maundia	V		 This species has been confirmed at 15 locations. Twelve are within the project boundary, consisting of: Large populations in Halfway Creek and Wells Crossing, Section 1 Moderate to large populations in the Coldstream River, Chaffin Creek, unnamed tributaries south of Bostock Road, near Tallowwood Lane and east of Tucabia Road in Section 3 Small to moderate populations in Section 7 at Tabbimoble Floodway Number 1 and 2, and several tributaries that cross the highway north of New Italy. 	Sections 1- 3, 7 and 10
Melaleuca irbyana	Weeping Paperbark	E		Confirmed within the project boundary at New Italy (Section 7) and adjacent to the project boundary at Pillar Valley (Section 3). The population at New Italy contains around 800 individuals comprising 250 trees (greater 3 metres high) and 550 saplings and suckers, occurring over an area that extends north-south for around 200 metres m and east-west for 100 metres.	Sections 3 and 7
Olax angulata	Square- stemmed Olax	V		One individual has been confirmed within the project boundary north of Halfway Creek at Section 2. The fleshy fruit of this species is potentially attractive to fruit-eating bird species and the specimen has dispersed into the project boundary from surrounding populations.	Section 2
Prostanthera cineolifera	Singleton Mint Bush	V	V	Occurs at a single location on Tabbimoble Creek south of Tullymorgan Road. Inhabits a narrow belt of deep, sandy soil along Tabbimoble Creek.	Section 7

E = Endangered species; E2 = Endangered population (TSC Act); V = Vulnerable species

A review of relevant NSW and Commonwealth databases (refer to Section 10.1.5) identified a number of threatened flora species, that while not confirmed during field surveys, have a moderate to high likelihood of occurring in the study area. These species are therefore assumed to be present in the study area and considered in the impact assessment of the project.

Scientific name	Common name	Records within 10 km	Status	
		of Environment and Heritage 2012)	TSC Act	EPBC Act
Acronychia littoralis	Scented Acronychia	39	V	E
Centranthera cochinchinensis	Swamp Foxglove	3	E1	-
Dendrobium melaleucaphilum	Spider Orchid	3	E1	-
Desmodium acanthocladum	Thorny Pea	4	V	V
Isoglossa eranthemoides	Isoglossa	1	E	E
Marsdenia longiloba	Slender Marsdenia	14	E	V
Oberonia titania	Red flowered King of the Fairies	12	V	-
Peristeranthus hillii		7	V	-
Prostanthera palustris	Swamp Mint Bush	8	V	V
Quassia sp. 'Moonee Creek'	Moonee Quassia	70	E	E
Tinospora tinosporoides	Arrow Head Vine	51	V	V

Table 10-9: Threatened flora species predicted to occur in the study area

10.2.7 Fauna species

A total of 350 fauna species (including fish and decapods) were identified across the study area during field surveys, comprising 335 native species (95.3 per cent of all confirmed species) and 16 introduced fauna species. Fauna includes 190 bird species, 66 mammal species, 31 frog species, 31 reptile species, 24 freshwater and estuarine fish species, six species of decapods (crabs, prawns and shrimp) and two terrestrial invertebrates.

Threatened fauna species

Forty-two threatened fauna species were confirmed in the study area from the targeted field surveys.

This includes:

- Three endangered species and two vulnerable species under the *Environment Protection and Biodiversity Conservation Act* 1999
- Six endangered species, one endangered population and 35 vulnerable species listed under the *Threatened Species Conservation Act 1995.*

Details on the threatened fauna species confirmed in the project boundary are presented in Table 10-10. This includes information (where available) on population size and distribution and mapped in Figure 10-31 to Figure 10-56. An additional 24 fauna species were predicted to have a moderate to high likelihood of occurring within the study area due to presence of potential habitat. These species have also been considered in the impact assessment for the project and are listed in Table 10-10.

Table 10-10: Threatened terrestrial fauna confirmed within the project boundary

Target species, listing status and status on project	Distribution and abundance in study area
Wetland and migratory bird species	
Australasian Bittern <i>Botaurus poiciloptilus</i> Endangered (TSC Act and EPBC Act). Confirmed.	A single individual was confirmed near Champions Creek in Section 3, just north of Tyndale. The species is cryptic and difficult to detect. It is likely that a population occurs across the Clarence River floodplain wetlands, it has been historically known from this area (Smith, 2011).
Black-necked Stork <i>Ephippiorhynchus asiaticus</i> (Endangered TSC Act) Confirmed.	Numerous records exist in sections 1 and 2, particularly at Halfway Creek and Corindi River floodplain. The species is also relatively common throughout Sections 3 to 5 on the Clarence River wetlands (Clancy, 2010).
Magpie Goose Anseranas semipalmata (Vulnerable (TSC Act) Confirmed: Wants Lane, Coldstream wetland	A pair of Magpie Geese was confirmed near the lower Coldstream River in a crown reserve (Travelling Stock Route) on Wants Lane (Section 3). The species was once common in the Clarence River floodplain (Smith, 2011) although are only occasional visitors to the north coast region now, being more common across northern Australia.
Brolga <i>Grus rubicundus</i> (Vulnerable (TSC Act) Confirmed.	Commonly confirmed but patchily distributed across the study area, in particular the Clarence River wetlands (Smith, 2011) and have been observed near the project boundary in Section 1 on the Corindi River floodplain, Section 2 near Halfway Creek, and Section 3, at Ellis Swamp near Sandy Crossing. Potential habitat is widespread and the species prefers low-lying floodplain habitats, therefore may also occur in Section 7 and 9 to 11.
Large forest owls and other nocturnal birds	
Powerful Owl <i>Ninox strenua</i> (Vulnerable TSC Act) Confirmed at a number of locations	Powerful Owls were confirmed in Section 3 in dry forest on sandy soils near Pillar Valley Creek, also Section 7 at 1.5 km south of New Italy in the larger forests associated with Devils Pulpit and Doubleduke state forests and Section 9 where calls were heard at a large distance (emanating from Blackwall Range), to the west of the study area. This latter record was not confirmed due to the distance and hence low volume of the call at the observation location. The species could occur in all sections although have a restricted distribution associated with dense forests and wetter riparian areas.
Eastern Grass Owl <i>Tyto longimembris</i> (Vulnerable TSC Act) Predicted in restricted habitats	Eastern Grass Owl observed circling over a survey site at Broadwater South (Section 9). The species could occur throughout the study area and particularly low-lying floodplain habitats including at Corindi River (Section 1) Clarence Valley wetlands (Section 3-5), Tabbimoble (Section 7) and Broadwater to Ballina (sections 9 to 11).
Masked Owl <i>Tyto novaehollandiae</i> (Vulnerable TSC Act) Confirmed.	Confirmed from call playback surveys in Section 11, but was not visually identified. The species is predicted throughout the project sections particularly in larger open dry forest habitats in sections 1 to 3 and 6 to 10.

Target species, listing status and status on project	Distribution and abundance in study area
Sooty Owl <i>Tyto tenebricosa</i> (Vulnerable TSC Act) Confirmed in restricted habitats	Confirmed at one location in Newfoundland State Forest (Section 2). A single bird was observed after it responded to the call playback. This species is likely to occur along the major creeks where rainforest or moist eucalypt forest occur as riparian habitat, most likely areas being Corindi River and possibly parts of Halfway Creek and Dirty Creek, within the Dirty Creek Range (sections 1 and 2). The remainder of the study area was considered marginal for this species.
Woodland birds	
Brown Treecreeper <i>Climacteris picumnus</i> (Vulnerable TSC Act) Confirmed. Section 2	Confirmed in drier open woodland habitats near Wells Crossing at the northern end of Section 2, particularly around Bald Knob Tick Gate Road. Reported throughout Glenugie State Forest north to Six Mile Lane, may encompass the southern end of Section 3. Also confirmed in the drier habitats of Devils Pulpit State Forest and north into Tabbimoble (Section 6 and southern end of Section 7).
Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i> (Vulnerable TSC Act) Confirmed. Section 2	Confirmed in drier open woodland habitats near Wells Crossing, and is considered likely to occur in suitable habitats throughout the Section 1 and 2 and the southern end of Section 3. A population was located in the south of Section 3. It is also expected to occur in other suitable habitat throughout Sections 2 and 3.
Bush Stone-curlew <i>Burhinus grallarius</i> (Endangered TSC Act) Confirmed.	Confirmed in sections 1 and 2. The species is uncommon in northern NSW and restricted to open woodland habitats, typically spotted gum –ironbark habitat with a sparse understorey as is found in parts of sections 1 and 2 and the southern end of Section 3 around the northern end of Glenugie State Forest and Eight Mile Lane.
Forest birds	
Eastern Osprey <i>Pandion haliaetus</i> (Vulnerable TSC Act, Migratory EPBC Act) Confirmed	Reported in floodplain and estuarine habitats throughout all sections. There are no reported nests within the project boundary at the time of this assessment. Important habitat occurs within the Clarence and Richmond River floodplains (Clancy, 1991) and an artificial nest pole has been erected on the western side of the Harwood Bridge outside of the project boundary.
Glossy Black-cockatoo <i>Calyptorhynchus lathami</i> (Vulnerable TSC Act) Confirmed.	There are several records around Halfway Creek and further south in Section 1. A pair was confirmed in Section 3 near McRae Knob to the northeast of Tyndale adjoining and contiguous with Pine Brush State Forest. Glossy Black-cockatoos were also confirmed in Section 7 just south of Serendipity Road at Tabbimoble and near Wardell Road in Section 10. Preferred habitat for this species is widespread and populations of Glossy Black-cockatoos are considered likely to occur throughout the study area.
Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i> (Vulnerable TSC Act) Confirmed.	Consistently detected during surveys through Section 3 and sections 6 and 8. It was also detected in drier open woodland habitats near Wells Crossing (Section 2) and is considered likely to occur in suitable habitats throughout Sections 1 to 3. They are known to breed in habitat near Thurgates Lane (Section 10). Other nesting sites and breeding habitat have not been confirmed.
Coastal Emu <i>Dromaius novaehollandiae</i> (Endangered population TSC Act) Confirmed.	A portion of the endangered coastal emu population uses habitat in Sections 3 and 4 which includes important habitat used in pre- and post-breeding life-cycle activities associated with wetland and floodplain habitat from Pillar Valley to north of Tucabia and the Shark Creek area.

Target species, listing status and status on project	Distribution and abundance in study area
Microchiropteran bats	
Hoary Wattled Bat <i>Chalinolobus nigrogriseus</i> (Vulnerable TSC Act) Confirmed in Sections 1-3 & 6-8	In NSW (NPWS 2012), this species has been recorded in Spotted Gum (<i>Corymbia maculata</i>), Grey Box (<i>Eucalyptus moluccana</i>) and Northern Ironbark (<i>E. siderophloia</i>) and woodland characterised by Scribbly Gums (<i>E. signata</i>) and Pink Bloodwood (<i>C. intermedia</i>) and sites dominated by Blackbutt (<i>E.pilularis</i>). Hoary Wattled Bats were confirmed from call analysis in sections 1 to 3 and sections 6 to 8. Suitable habitat also occurs in sections 4 and 5 and 9 to 11.
Eastern False Pipistrelle <i>Falsistrellus tasmaniensis</i> (Vulnerable TSC Act) Confirmed in Sections 1-3	Calls were confirmed in Section 1, 2 and 3 They are expected to occur in suitable habitats throughout the entire project in particular dry sclerophyll forest on sandy or clay soils through sections 1 to 9.
Golden-tipped Bat <i>Kerivoula papuensis</i> (Vulnerable TSC Act) Confirmed in Sections 9-11	The species was confirmed in Sections 9 to11 and suitable habitat also occurs in Sections 1 to 2 and 6 to 8.
Little Bent-wing Bat <i>Miniopterus australis</i> (Vulnerable TSC Act) Confirmed in Sections 1-11	Little Bent-wing Bat were captured and confirmed in all sections and appear to be relatively common Locations of roost sites were not identified.
Eastern Bent-wing Bat <i>Miniopterus schreibersii oceanensis</i> (Vulnerable TSC Act) Confirmed in Sections 1-2 & 6-11	Calls were confirmed in sections 1 and 2, 6 and 8 and 9 and 11. They are expected to occur in suitable habitats throughout the entire project boundary.
Eastern Freetail-Bat <i>Mormopterus norfolkensis</i> (Vulnerable TSC Act) Confirmed in Sections 6-11	Eastern Freetail-bat was confirmed in sections 6 to 8 and 9 to 11. They are expected to occur in suitable habitats throughout the entire project boundary.
Southern Myotis <i>Myotis macropus</i> (Vulnerable TSC Act) Confirmed in Sections 1-2 and 6-11	Southern Myotis were confirmed in sections 1, 2, 6 to 11 from positive call identification. This species could occur along the entire project boundary.
Eastern Long-Eared Bat <i>Nyctophilus bifax</i> (Vulnerable TSC Act) Confirmed in Sections 6-11	Eastern Long-eared Bats were confirmed in Sections 6 to 8 and 9 to 11. They are expected to occur in suitable habitats throughout the entire project boundary.
Yellow-bellied Sheathtail-bat <i>Saccolaimus flaviventris</i> (Vulnerable TSC Act) Confirmed in Sections 9-11	The Yellow-bellied Sheathtail-bat was confirmed from call analysis in Sections 9 to 11 and expected across the entire project boundary.
Greater Broad-nosed Bat <i>Scoteanax rueppellii</i> (Vulnerable TSC Act) Confirmed in Sections 9-11	Confirmed in Sections 9 to11, and expected to occur across the entire project boundary.
Eastern Cave Bat <i>Vespadelus troughtoni</i> (Vulnerable TSC Act) Confirmed in Sections 6-11	Eastern Cave Bats were confirmed in Sections 6 to 8 and 9 to 11 and could occur across the entire study area.

Target species, listing status and status on project	Distribution and abundance in study area
Arboreal mammals	
Yellow-bellied Glider <i>Petaurus australis</i> (Vulnerable TSC Act) Confirmed.	Yellow-bellied Glider was confirmed in Sections 1 to 3 and 6 to 8. There are several records for the species in the Halfway Creek area (Section 2) which is considered a hotspot for this species. The species is expected to be widespread within the project boundary.
Squirrel Glider <i>Petaurus norfolcensis</i> (Vulnerable TSC Act) Confirmed.	Squirrel Gliders were widespread throughout the study area, being confirmed in all Sections 1 to 11. Most records of the species occur around Halfway Creek (Section 2), Pillar Valley to Tyndale (Section 3), and Mororo to Broadwater (Section 6-8).
Brush-tailed Phascogale <i>Phascogale tapoatafa</i> (Vulnerable TSC Act) Confirmed.	Preferred habitat is dry open forest with a sparse open understorey, however, has been located in heath, swamps and rainforest and wet sclerophyll forest (NPWS 1999b). Suitable habitat was confirmed north from Halfway Creek to Wells Crossing (Sections 1 to 4) and the species was confirmed in Sections 2, 4 and 6 to 8.
Koala <i>Phascolarctos cinereus</i> (Vulnerable TSC Act and EPBC Act) Confirmed in Section 3, predicted in all sections	Koalas are known to occur throughout the region and near the project boundary with potentially large populations in the vicinity of Broadwater National Park. Riley's Hill and in the sclerophyll forests of the Wardell heaths (Sections 7-10). Road deaths for Koalas have occurred in Section 1 and 2, and as such they are considered likely to occur throughout suitable habitat. Koalas were confirmed at two sites during surveys in Section 3.
Ground-dwelling mammals	
5	
Rufous Bettong <i>Aepyprymnus rufescens</i> (Vulnerable TSC Act) Confirmed in Section 1-3	Confirmed in Sections 1 to 3 and predicted to occur in Sections 6 to 8. Numerous records exist in dry open forest and woodlands north of the Halfway Creek Service Centre, and a number of reported road kills on Six Mile Lane and Airport Road (Sections 1 and 2 and the southern end of Section 3). Records for this population in the southern end of the project extend up to Section 3 in the Pheasants Creek and upper Coldstream localities and Sections 1 to 3 is considered a hotspot for this species.
Rufous Bettong <i>Aepyprymnus rufescens</i> (Vulnerable TSC Act) Confirmed in Section 1-3 Common Planigale <i>Planigale maculata</i> (Vulnerable TSC Act) Confirmed in Section 1-2	Confirmed in Sections 1 to 3 and predicted to occur in Sections 6 to 8. Numerous records exist in dry open forest and woodlands north of the Halfway Creek Service Centre, and a number of reported road kills on Six Mile Lane and Airport Road (Sections 1 and 2 and the southern end of Section 3). Records for this population in the southern end of the project extend up to Section 3 in the Pheasants Creek and upper Coldstream localities and Sections 1 to 3 is considered a hotspot for this species. The species was confirmed during surveys in Section 1 and 2, and is considered likely to occur in suitable habitats throughout these areas as well as part of Sections 3 and 6 to 8. The species is known to breed in Wardell heath and adjoining areas through sections 8 to 10.
Rufous Bettong Aepyprymnus rufescens (Vulnerable TSC Act) Confirmed in Section 1-3 Common Planigale Planigale maculata (Vulnerable TSC Act) Confirmed in Section 1-2 Megachiropteran bats	Confirmed in Sections 1 to 3 and predicted to occur in Sections 6 to 8. Numerous records exist in dry open forest and woodlands north of the Halfway Creek Service Centre, and a number of reported road kills on Six Mile Lane and Airport Road (Sections 1 and 2 and the southern end of Section 3). Records for this population in the southern end of the project extend up to Section 3 in the Pheasants Creek and upper Coldstream localities and Sections 1 to 3 is considered a hotspot for this species. The species was confirmed during surveys in Section 1 and 2, and is considered likely to occur in suitable habitats throughout these areas as well as part of Sections 3 and 6 to 8. The species is known to breed in Wardell heath and adjoining areas through sections 8 to 10.
Rufous Bettong Aepyprymnus rufescens (Vulnerable TSC Act) Confirmed in Section 1-3 Common Planigale Planigale maculata (Vulnerable TSC Act) Confirmed in Section 1-2 Megachiropteran bats Grey-headed Flying-fox Pteropus poliocephalus (Vulnerable TSC Act) Confirmed in Sections 1-2, 4-6, & 8-11	Confirmed in Sections 1 to 3 and predicted to occur in Sections 6 to 8. Numerous records exist in dry open forest and woodlands north of the Halfway Creek Service Centre, and a number of reported road kills on Six Mile Lane and Airport Road (Sections 1 and 2 and the southern end of Section 3). Records for this population in the southern end of the project extend up to Section 3 in the Pheasants Creek and upper Coldstream localities and Sections 1 to 3 is considered a hotspot for this species. The species was confirmed during surveys in Section 1 and 2, and is considered likely to occur in suitable habitats throughout these areas as well as part of Sections 3 and 6 to 8. The species is known to breed in Wardell heath and adjoining areas through sections 8 to 10.

Target species, listing status and status on project	Distribution and abundance in study area
Wetland and swamp dwelling frogs	
Wallum Froglet <i>Crinia tinnula</i> (Vulnerable TSC Act) Confirmed in Sections 1, 2 and between 6 and 11.	Wallum Froglet was detected in Sections 1 to 3 from Woolgoolga north to Pheasants Creek, also Sections 6 to 8 and 9 to 11.
Green-thighed Frog <i>Litoria brevipalmata</i> (Vulnerable TSC Act) Confirmed in Sections 2, 6 and 7.	Green-thighed Frogs were detected during surveys in Sections 1 and 6 to 8. The species could occur in all sections.
Stream dwelling frogs	
Giant Barred Frog <i>Mixophyes iterates</i> (Endangered TSC Act and EPBC Act) Confirmed in Section 1 and 7.	Seven individuals were confirmed at Corindi River (Section 1). Suitable habitat for the Giant- barred frog occurs at other major freshwater creeks in sections 1 and 2, particularly Dirty Creek and Halfway Creek. Generally, the remainder of the study area provides limited habitat for the Giant- barred Frog.
Reptiles	
Stephens' banded snake <i>Hoplocephalus stephensii</i> (Vulnerable TSC Act)	This species was confirmed from surveys in Sections 3 and could occur throughout all sections.
Contirmed in Section 3. Predicted in Sections 1, 2 and 6-8.	
Fish	
Oxleyan Pygmy Perch <i>Nannoperca oxleyana</i> (OPP)(Endangered TSC Act and EPBC Act) Confirmed in Section 7-9	 Presence was confirmed in a number of locations in Sections 7, 8 and 9 (Figure 10-57) including: Tabbimoble Creek Unnamed watercourse at station 114.0 McDonalds Creek Unnamed watercourse at station 134.7 Swamps in Broadwater National Park. Potential habitat for the Oxleyan Pygmy Perch was confirmed in sections 1 and 2 associated with Redbank Creek and Cassons Creek, within Section 6 around Tabbimoble, and in sections 7 and 8 from Devils Pulpit State Forest to McDonalds Creek south of Woodburn. Both species have similar and specific habitat requirements described as:
	 Depth: less than 1.5 metres Flow: Habitat preference for low flows between 0-0.3m/s however floods or other high flow events may also play an important role for the species, as temporary watercourses of overflows carry the species between otherwise isolated bodies of water Substrate: Fine sand and detritus Other features: Steep/undercut banks with aquatic vegetation, overhanging and trailing vegetation and submerged leaf litter branches Physical parameters: pH between 4.5 and 6.5 for Oxleyan Pygmy Perch, conductivity less than 350µS/cm, dissolved oxygen greater than 2mg/L, low turbidity (tannin stained)

Target species, listing status and status on project	Distribution and abundance in study area
	 Riparian and overhanging plant species: Melaleuca quinquenervia, Banksia ericifolia, Restio tetraphyllus, Gleichenia dicarpa, Gahnia sieberiana and Leucopogon lanceolatus Aquatic plant species: Baumea articulata, Sphagnum falcatulum, Philydrum lanuginosum, Lepironia articulata and Restio pallens.
Invertebrates	
Pink Underwing Moth <i>Phyllodes imperialis</i> southern subsp.(Vulnerable TSC Act and EPBC Act) Confirmed in Section 10	The Pink Underwing Moth was confirmed at the northern end of project in section 10 in a rainforest / moist forest remnant within and adjacent to the project boundary. This observation consisted of several Pink Underwing Moth larvae at two sites. The potential habitat for this species includes lowland rainforest and low elevation moist floodplain forest with high species diversity, as is found in Sections 10 and 11. Potential breeding habitat is restricted to the caterpillar's food plant, a native rainforest vine, <i>Carronia multisepalea</i> .
Atlas Rainforest Ground Beetle <i>Nurus atlas</i> (Endangered TSC Act) Confirmed in Section 10	The species was confirmed in section 10 with a rainforest remnant located within and adjacent to the project boundary. This observation comprised a single adult Atlas Rainforest Ground Beetle encountered in a burrow positioned under a large protruding root of a White Cedar (<i>Melia azedarach</i>) in soil derived from basalt. The potential habitat for this species includes lowland rainforest in Sections 10 and 11.



Figure 10-57: Known and potential Oxleyan Pygmy Perch habitat in the study area

Table 10-11: Threatened terrestrial fauna with the potential (moderate to high) to occur within the project boundary

Target species, listing status and status on project	Potential locations (project sections)
Wetland and migratory bird species	
Australian Painted Snipe <i>Rostratula australis</i> (Endangered TSC Act, Vulnerable, Migratory EPBC Act)	1-11
Pale-vented Bush Hen Amaurornis molucanna (Vulnerable TSC Act)	9-10
Comb-crested Jacana Irediparra gallinacea (Vulnerable (TSC Act)	3-9
Black Bittern Ixobrychus flavicollis (Vulnerable (TSC Act)	1-3, 6-7, 9
Freckled Duck Stictonetta naevosa (Vulnerable (TSC Act)	3-5
Large forest owls and other nocturnal birds	
Barking Owl Ninox connivens (Vulnerable TSC Act)	1-11
Woodland birds	
Swift Parrot <i>Lathamus discolor</i> (Endangered TSC Act, Endangered, Migratory EPBC Act)	1-11
Regent Honeyeater <i>Xanthomyza phrygia</i> (Endangered TSC Act and endangered and migratory EPBC Act)	1-11
Rainforest birds	
Double-Eyed Fig-Parrot <i>Cyclopsitta diophthalma coxeni</i> (Critically endangered TSC Act, endangered EPBC Act)	9-11
Wompoo Fruit-dove Ptilinopus magnificus (Vulnerable TSC Act)	1-2, 6-11
Superb Fruit-dove Ptilinopus superbus (Vulnerable TSC Act)	1-2, 8-11
Rose-crowned Fruit Dove Ptilinopus regina (Vulnerable TSC Act)	1-11
Forest birds	
Little Eagle Hieraaetus morphnoides (Vulnerable TSC Act)	1-11
Square-tailed Kite Lophoictinia isura (Vulnerable TSC Act)	1-11
Red Goshawk <i>Erythrotriorchis radiatus</i> (Critically endangered TSC Act, vulnerable EPBC Act)	1-11
Little Lorikeet Glossopsitta pusilla (Vulnerable TSC Act)	1-3, 5-7, 9
Ground Parrot (eastern subsp.) Pezoporus wallicus wallicus (Vulnerable TSC Act)	8-10
Barred Cuckoo-shrike Coracina lineata (Vulnerable TSC Act)	1-2, 6-11
Mangrove Honeyeater Lichenostomus fasciogulari (Vulnerable TSC Act)	4-5, 9-11
Large forest owls and other nocturnal birds	
Grass Owl Tyto longimembris (Vulnerable TSC Act)	1-11
Microchiropteran bats	
Large-eared Pied Bat Chalinolobus dwyeri (Vulnerable TSC Act and EPBC Act)	1-7
Beccari's Freetail-Bat Mormopterus beccarii (Vulnerable TSC Act)	1-11
Arboreal mammals	
Eastern Pygmy-possum Cercartetus nanus (Vulnerable TSC Act)	1-11
Ground-dwelling mammals	
Spotted-tailed Quoll <i>Dasyurus maculatus maculatus</i> (SE population) (Vulnerable TSC Act and Endangered EPBC Act)	1-11
Long-nosed Potoroo <i>Potorous tridactylus tridactylis</i> (Vulnerable TSC Act and EPBC Act)	1-3, 6-11
Frogs	
Olongburra Frog Litoria olongburensis (Vulnerable TSC Act and EPBC Act)	6- 11

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Target species, listing status and status on project	Potential locations (project sections)	
Reptiles		
Pale-headed Snake Hoplocephalus bitorquatus (Vulnerable TSC Act)	1-3, 6-8	
Invertebrates		
Coastal Petaltail Petalura litorea (Endangered TSC Act)	8-9	
Fish		
Purple-spotted Gudgeon Mogurnda adspersa (Endangered TSC Act)	1,2, 6-8	
Eastern Freshwater Cod Maccullochella ikei (Endangered TSC Act and EPBC Act)	3	

Another two threatened fauna species were confirmed in areas outside the project boundary, however, are not considered to be of moderate to high likelihood to be within the project boundary. These included:

- Pied Oystercatcher (*Haematopus longirostris*), an endangered species (TSC Act). Pied Oystercatcher was observed in adjacent coastal areas outside the project boundary during surveys in Sections 1, 2, 9 to11. They are known to occur in coastal habitats adjacent to the study area, but are unlikely to be critically dependent on wetland and riverine habitats within the project boundary
- Black Flying-fox (*Pteropus alecto*), a vulnerable species (TSC Act). Mangroves, paperbark forests and occasionally patches of rainforest are most commonly used for camp sites (Strahan, 1998; Churchill, 1998). Confirmed near section 1 to the south of the project, associated with a roost camp of Grey-headed Flying-fox at Woolgoolga and also outside the boundary in sections 9 to 11.

Migratory species

A total of 10 EPBC Act listed migratory species were confirmed from field surveys (Table 10-12). An additional two migratory species are considered to have a high likelihood of occurring in the study area: the Australian Painted Snipe and Spectacled Monarch.

TERM – Migratory species

Species that annually migrate across countries. These species are listed under the *Environmental Protection Biodiversity Conservation Act* 1999.

Table 10-12: Migratory fauna species confirmed or predicted within the project boundary

Migratory species	EPBC Act status	Preferred habitat	Presence
Eastern Osprey (Pandion haliaetus)	Marine; Migratory (BONN)	Occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They are mostly found in coastal areas but occasionally travel inland along major rivers.	Confirmed in several locations associated with project sections 1-6 and 9-11. Predicted across the entire study area.
Great Egret (<i>Egretta alba</i>)	Marine; Migratory (CAMBA, JAMBA)	Prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands.	Confirmed in project section 8. High likelihood that the species occurs across the entire study area. This species is commonly reported in the Clarence Valley wetlands (Smith 2011).) which is traversed by Section 3-5.
Cattle Egret (<i>Ardea ibis</i>)	Marine; Migratory (CAMBA, JAMBA)	Is found in grasslands, woodlands and wetlands particularly in coastal areas. It also uses pastures and croplands, especially where drainage is poor. Is often seen with cattle and other stock.	Commonly recorded in all project sections 1-5 and 9-11 associated with grazing paddocks particularly in floodplains. Predicted across the entire study area and commonly reported in the Clarence valley wetlands (Smith, 2011) which is traversed by section 3-5.
White-bellied Sea- Eagle (<i>Haliaeetus leucogaster</i>)	Marine; Migratory (CAMBA)	Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas (Higgins, 1999; Simpson & Day, 1999). Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away (Marchant & Higgins, 1993).	Confirmed in Section 1 near Corindi River. Predicted along the length of the study area mostly in floodplain, wetland, riverine or estuarine habitats associated with the Clarence River and Richmond River.
Satin Flycatcher (<i>Myiagra</i> cyanoleuca)	Marine; Migratory (BONN)	Associated with drier eucalypt forests, absent from rainforests (Blakers et al., 1984), open forests, often at height (Simpson & Day, 1999).	Was confirmed in a number of sites in project sections 1 and 2 and 6-8 in dense forest. Predicted throughout the study area in all forested habitats.
White Throated Needletail (<i>Hirundapus</i> <i>caudacutus</i>)	Marine; Migratory(CAMBA, JAMBA, ROKAMBA)	Forages aerially over a variety of habitats usually over coastal and mountain areas, most likely with a preference for wooded areas (Higgins, 1999; Simpson & Day, 1999). Has been observed roosting in dense foliage of canopy trees, and may seek refuge in tree hollows in inclement weather (Higgins, 1999).	Small flock confirmed near Shark Creek in project section 4. Predicted throughout the study area in all forested habitats.
Rainbow Bee- eater (<i>Merops</i> ornatus)	Marine; Migratory (JAMBA)	Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (Higgins, 1999). Usually occurs in open, cleared or lightly-timbered areas, especially in arid or semi-arid areas, in riparian, floodplain or wetland vegetation assemblages (Woinarski et al., 1988).	Confirmed near Tucabia in Section 3. Predicted throughout the study area in dry forest and woodland habitats, typically prefers more open landscapes.

Migratory species	EPBC Act status	Preferred habitat	Presence
Swift Parrot (<i>Lathamus</i> <i>discolor</i>)	Marine; Migratory; Endangered	Forages in swamp and open eucalypt forests, feeding on nectar and pollen of flowering tree species.	Predicted throughout the study area in all forested habitats. Not observed from targeted surveys.
Regent Honeyeater (<i>Xanthomyza</i> phrygia)	Migratory (JAMBA); Endangered (as Anthochaera phrygia)	Forages in swamp and open eucalypt forests, feeding on nectar and pollen of flowering tree species.	Predicted throughout the study area in all forested habitats. Not observed from targeted surveys.
Black-faced Monarch (Monarcha melanopsis)	Marine; Migratory (BONN)	Occurs in rainforest and eucalypt forests, feeding in tangled understorey (Blakers et al., 1984).	Confirmed in dry forest habitat at one site near Tucabia in project section 4. Predicted throughout the study area in all forested habitats. Confirmed in dry forest near Tucabia in Section 4.
Rufous Fantail (<i>Rhipidura</i> <i>rufifrons</i>)	Marine; Migratory (BONN)	Frequents wet forests, less often open forests and woodlands (Simpson & Day, 1999). May occur in open woodland and forest habitats throughout the north coast region.	One individual confirmed in project section 6 in Doubleduke State Forest. Predicted throughout the study area in all forested habitats.
Lathams Snipe (Gallinago harwickii)	Marine; Migratory(CAMBA, JAMBA, ROKAMBA)	Occurs in permanent and ephemeral wetlands, usually inhabiting open, freshwater wetlands with low, dense vegetation (eg swamps, flooded grasslands or heathlands, around bogs and other water bodies) (Frith et. al, 1977). However, they can also occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity (Frith et al, 1977)	One individual confirmed in project section 3 in the Coldstream wetlands. Predicted throughout the study area particularly in floodplain areas of the Richmond River, Clarence River and Corindi River.
Australian Painted Snipe (<i>Rostratula</i> <i>australis</i>)	Marine; Migratory (CAMBA)	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 treatment plants and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of <i>lignum</i> <i>Muehlenbeckia</i> or canegrass or sometimes tea-tree (Melaleuca).	Predicted throughout the study area particularly in floodplain areas of the Richmond River, Clarence River and Corindi River. Not observed during targeted field surveys.
Spectacled Monarch (<i>Monarcha</i> <i>trivirgatus</i>)	Marine; Migratory (BONN)	Occurs in rainforest and eucalypt forests, feeding in tangled understorey (Blakers et al., 1984).	Predicted throughout the study area in all forested habitats. Not observed during targeted field surveys.

BONN – BONN Convention on the conservation migratory birds; CAMBA – China-Australia Migratory Bird Agreement; JAMBA – Japan-Australia Migratory Bird Agreement; ROKAMBA – Republic of Korea-Australia Migratory Bird Agreement.

Endangered populations

The field surveys and background research conducted for the project identified that the endangered coastal emu population (Schedule 1, Part 2 of the TSC Act) was present in the study area in project sections 3 and 4.

The endangered coastal emu population comprises three sub-populations, the largest centred on Yuraygir National Park and surrounds on the southern side of the Clarence River estimated at between 80 and 120 individuals. The remaining sub-populations occur north of the river centred on Bundjalung National Park and Bungawalbin Nature Reserve. Table 10-13 describes the current status of the three sub-populations and their proximity to the project.

Table 10-13: Summary of coastal emu sub-populations in the mid north coast (source NPWS annual survey results 2002-2012; G.Hart pers.comm)

Sub-population and range	Predicted population size (2011)	Intersection with project boundary
Yuraygir sub-population: Yuraygir National Park and surrounds, including Clarence River floodplain north to Gulmarrad-Maclean, and south to Red Rock.	Largest group has remained stable at between 80 and120 individuals for last 10 years.	Intersects with sections 3 and 4
Bundjalung sub population: Bundjalung National Park from Iluka to Evans Head	Smallest population, only 20 birds estimated in 2006. No emus counted in 2010 census, current population unknown and considered possibly extinct.	Not directly affected
Bungawalbin sub-population: Bungawalbin Nature Reserve and National Park, main camp	Estimated at less than 60 birds.	Not directly affected

The habitat of the coastal emu population has been reduced and fragmented as a result of clearing for agriculture and rural and urban development, resulting in a decline in and isolation of these sub-populations. The smaller northern sub-populations in Bundjalung and Bungawalbin are possibly less viable in the long-term compared to the larger Yuraygir population.

The larger Yuraygir population occupies much of the coastal strip of Yuraygir National Park to the east of the project as well as surrounding contiguous areas in the Sandon and Brooms Head area in the north and Wooli Road and Pillar Valley in the south as far as Red Rock.

10.3 Assessment of Impacts

As a summary, biodiversity impacts that would result from the project are:

- Loss of native vegetation (including threatened flora and Threatened Ecological Communities and their habitats)
- Loss of terrestrial, riparian and aquatic habitat for protected and threatened fauna (including food resources, shelter and refuge areas during non-breeding and breeding life-cycle events)
- Direct mortality of protected and threatened fauna
- Loss of connectivity for protected and threatened flora and fauna species and populations with the degradation of wildlife and habitat corridors (including links to national parks and state forests)
- Fragmentation of terrestrial, arboreal and aquatic habitat and edge effects from road noise, light and wind turbulence
- Potential impacts to ground water dependant ecosystems and wetlands (including SEPP 14 coastal wetlands and nationally important wetlands)
- Changes to water quality as a result of works in or adjacent to aquatic habitats and alterations to natural hydrological flows
- Invasion and spread of terrestrial and aquatic weeds and pest fauna species
- Potential spread of disease pathogens
- Introduction or increased exposure to key threatening processes that may affect terrestrial and aquatic species, populations, ecological communities and their habitat (including threatened biota)
- Regional cumulative impacts affecting long term viability and survival of common and threatened species, populations and ecological communities and their habitats.

These identified potential impacts are described in detail in the following sections.

10.3.1 Ancillary facilities assessment

Eighty one potential ancillary facilities have been identified along the project length and have been selected in consideration of characteristics identified in section 6.3.1 of this EIS, including areas of low ecological value. Of the 81 sites identified, 26 are located wholly within the project boundary. The estimate of vegetation and habitat loss on the remaining 55 sites outside the project boundary has been based on desktop data and general field data for surrounding areas.

Of the land identified for potential ancillary facilities outside of the project boundary (about 233 hectares) a maximum of around 25 hectares of native vegetation may be cleared should these sites be used for the project. The CRAFTII / BioMetric broad-scale vegetation mapping identifies this vegetation to consist of the following vegetation types:

- Dry Heathy Blackbutt-Bloodwood and Cleared
- Dry Grassy Blackbutt Tallowwood, Swamp Oak and Cleared
- Northern Open Grassy Blackbutt (inland), Dry Blackbutt (inland) and Cleared
- Heathy Scribbly Gum
- Sherwood Needlebark Stringybark, Needlebark Stringybark, Lowland Red Gum winter flowering and Forest Red Gum - Grey Gum/Grey Ironbark – Rough-barked Apple
- Sandstone Spotted Gum-Blackbutt, Spotted Gum Blackbutt and Clarence Lowlands Spotted Gum.

The vegetation at identified ancillary facility locations consists of scattered trees or small fragments of vegetation on the edge of mostly cleared areas. The removal of 25 hectares of native vegetation would be the maximum expected for all identified ancillary facilities. However, the use of these sites would be subject to land owner agreement. As such, not all ancillary facilities may be used by the construction, and the vegetation loss from actual ancillary facilities is likely to be less than the 25 hectares.

The ancillary sites will be subject to further assessment (ecological field surveys) during the exhibition of the EIS. All relevant environmental matters would be assessed and the findings considered prior to the confirmation of the sites which form part of the project approval. These assessments will include consideration of matters of national environmental significance as detailed in the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The assessment of the ancillary facility sites undertaken during the exhibition period will be provided in the response to submissions report. Should any ancillary site be determined to have an unacceptable impact on the use of the site, the site would be avoided.

10.3.2 Loss of native vegetation

The project would clear about 948 hectares of native vegetation, affecting a number of vegetation types. The 25 hectares that may be required to be removed for ancillary facilities would be additional to this 948 hectares.

Clearing native vegetation is listed as a key threatening process under Schedule 3 of the TSC Act and pursuant to section 183 of the EPBC Act.

Threatened Ecological Communities

Of the 948 hectares of vegetation to be cleared, about 337.7 hectares (35 per cent) consists of Threatened Ecological Communities listed under the TSC Act. This includes 5.8 hectares of one ecological community also listed as critically endangered under the EPBC Act. The community type and amount potentially cleared are presented in Table 10-14. An additional 198 hectares of Threatened Ecological Communities would be subject to edge effects (refer to Section 10.3.7).

Two Threatened Ecological Communities are confirmed on three of the 81 identified ancillary facilities. These have been calculated as being impacted, however, no Threatened Ecological Community would be removed for the use of an ancillary facility.

Table 10-14: Summary of impact on Threatened Ecological Communities

Threatened Ecological Community (listed status)	Direct impact (hectares)	Potential edge effects (hectares)
Sub-Tropical Coastal Floodplain Forest of the NSW North Coast Bioregion (Endangered TSC Act)	137.1	60
Swamp Sclerophyll Forest On Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (Endangered TSC Act)	93.7	35.5
Swamp Oak Floodplain Forest Of The NSW North Coast, Sydney Basin And South East Corner Bioregions (Endangered TSC Act)	56.2	21.5
Coastal Cypress Pine Forest In The NSW North Coast Bioregion (Endangered TSC Act)	27.4	5
Freshwater Wetlands On Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (Endangered TSC Act)	13.0	0.8
Lowland Rainforest in NSW North Coast and Sydney Basin Bioregions (Endangered, TSC Act) *Lowland Rainforest in Sub-tropical Australia (Critically Endangered, EPBC Act)	10.3 (5.8*)	5.1

Of particular importance is the loss of 10.3 hectares of Lowland Rainforest in NSW North Coast and Sydney Basin Bioregions. This community has very small areas of remaining rainforest and the high degree of fragmentation of remaining remnants (mapped at around 1817.8 hectares (NPWS 1999a) within a 10 kilometre radius of the project). Of the 10.3 hectares of the community removed, only 5.8 hectares that meets the criteria of the EPBC Act listed Lowland Rainforest for in Sub-tropical Australia and would be removed by the project.

Threatened flora

The project would impact on a range of threatened flora. Table 10-15 identifies impacts on targeted threatened flora populations within the project boundary. Table 10-16 identifies smaller populations of additional threatened flora species that could be impacted by the project.

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Table 10-15: Impacts on large known populations of threatened flora

Target species, listing status and status on project	Impact assessment
Sandstone Rough Barked Apple (<i>Angophora robur</i>)	It is estimated that around 6,893 individuals are within the project boundary covering 82 hectares. This would be around 5.6% of the local population.
Vulnerable (TSC Act, EPBC Act)	There would also potentially be indirect impacts from edge effects and habitat fragmentation. <i>Angophora robur</i> was confirmed in currently edge affected habitats in the study area including open paddocks. Therefore it is likely to be somewhat tolerant of edge effects and indirect impacts are not expected to significantly impact the life cycle attributes of <i>Angophora robur</i> , particularly with appropriate mitigation to reduce these edge effects such as weed treatment, water quality controls and native landscaping.
Square-fruited Ironbark (<i>Eucalyptus tetrapleura</i>) Vulnerable (TSC Act, EPBC Act)	The potential impact from the projects represents around 0.7 per cent of the local population and around 1.1 per cent of the area of occupancy (1289 hectares). This project would have impacts to the local distribution of the species, removing part of the local gene pool and 14.6 hectares of known habitat for <i>Eucalyptus tetrapleura</i> . When considering cumulative impacts from the Glenugie upgrade and the current project, the combined impacts to the local population comprise around 7,274 individuals occurring over 50.6 hectares of habitat representing 4.6 per cent of the local population and up to 3.9 per cent of the occupied habitat. The project would result in the removal of habitat for pollinator species; however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas. When considering the cumulative impacts of the project and the Glenugie upgrade there would be a reduction to the local gene pool, however it is considered that there would be significant genetic diversity in the remaining 95 per cent of the population and sufficient habitat for pollinator species to avoid inbreeding depressions or impacts from stochastic events. The project would result in a larger fire break to bushfires approaching from the west of the existing highway, potentially resulting in the frequency of bushfire to be reduced in populations to the east. However state forest areas are likely to be fire-managed with control burns implemented in areas during cooler months. Although there is potential for fire regimes to change following the project it is considered unlikely to significantly impact the life cycle of populations of <i>Eucalyptus tetrapleura</i> . Vegetation clearing would potentially contribute to further invasion of <i>Lantana camara</i> and other exotic species particularly along the edges of the project boundary where there would be increased sunlight. Other indirect impacts from vegetation clearing would include stormwater run-off potentially increasing water and nutrient loads en
Weeping Paperbark (<i>Melaleuca irbyana</i>) Endangered (TSC Act)	It is estimated that around 514 individuals are present within the project boundary comprising 207 individuals within mature forest areas to the west and 307 individuals on the eastern side of the highway occurring as dense clusters in the power easement and road reserve. This could comprise around 60 per cent of the New Italy population

Target species, listing status and status on project	Impact assessment
Slender Screw Fern (<i>Lindsaea incisa</i>) (SF) Endangered (TSC Act)	 Around 0.4 hectares of occupied habitat is located within the project boundary, comprising 14.2 per cent of the population. The population consists of four different sub-populations in sections 1-3 and 6. Two of the four populations (in sections 1 and 6) would potentially be impacted from the project. Population numbers could not be accurately estimated from field surveys due to the abundance of fronds growing within dense understorey vegetation. As such, the area of occupancy was mapped and is used in this assessment. Around 53 per cent of the sub-population in section 1 would potentially be impacted, representing a significant proportion of the available gene pool and occupied habitat. However, the other 47 per cent is situated outside the project boundary and there is potential suitable habitat in adjacent areas not surveyed which would reduce the proportion of the population being impacted. Around 18 per cent of the sub-population in Section 6 would potentially be impacted representing a relatively significant proportion of the available gene pool, however it is likely that there are other locations of <i>Lindsaea incisa</i> in adjacent areas of habitat not surveyed which would reduce the proportion of the population to fund section.
<i>Maundia triglochinoides</i> Vulnerable (TSC Act)	The known population of <i>Maundia</i> is about three hectares and made up of 12 sub-populations across sections 2, 3 and 7. Known population areas within the project boundary are 0.2 hectares (7% of the population). The project would potentially result in the total removal of the entire area of two sub-populations (around 150 m2 in section 7), removal of 10 to 50 per cent of three sub-populations (in sections 2, 3 and 7), removal of five to 10 per cent of three sub-populations (in Sections 3 and 7) and low level impact to one population in Section 2 with the removal of around two per cent. Additional to these direct impacts there would potentially be large scale indirect impacts to populations downstream of the project boundary from altered hydrology, sedimentation and erosion.
Four-tailed Grevillea (<i>Grevillea quadricauda</i>) Vulnerable (TSC Act, EPBC Act)	While, the eight individuals in the project boundary over 0.02 hectares, the project would only result in the removal of three individuals from this population. It is considered unlikely to significantly reduce the genetic diversity within this population. However there is potential for indirect impacts to alter the habitat of the remaining individuals and mitigation measures are required to minimise indirect impacts.
Singleton Mint Bush (<i>Prostanthera cineolifera</i>) Vulnerable (TSC Act, EPBC Act)	Occurs at a single location on Tabbimoble Creek south of Tullymorgan Road. The population number is conservatively estimated to comprise 5,000-8,000 individuals occurring over 2.22 hectares. The project would result in the removal of 250 individuals and contribute to the existing fragmentation of the population.
Water Nutgrass (<i>Cyperus aquatilis</i>) Endangered (TSC Act)	This species was confirmed at numerous locations along the project. About 0.4 hectares of suitable habitat would be removed by the project (comprising around 34 per cent of the surrounding suitable habitat). There is potential for indirect impacts to alter the existing habitat attributes such as hydrology regimes and weed invasion which may limit the germination and growth of this species in remaining habitats. <i>Cyperus aquatilis</i> was confirmed in the study area in currently edge affected habitats in the study area including open paddocks, muddy trails and roadside environments. Therefore <i>Cyperus aquatilis</i> is likely to be somewhat tolerant of edge effects and indirect impacts.
Hairy-joint Grass (<i>Arthraxon hispidus</i>) Vulnerable (TSC Act, EPBC Act)	The species was confirmed in an area covering a total area of 20.8 hectares in the study area. Forty seven per cent of this area (9.8 hectares) would be removed by the project. There is potential for indirect impacts to alter the existing habitat attributes such as hydrology regimes and weed invasion which may increase the overall proportion of occupied habitat impacted.

Threatened flora species	Status	Impacts	Project section
Archidendron hendersonii White Laceflower	Vulnerable (TSC Act)	The project would require the removal of six individuals out of 11 around Coolgardie Road.	10
<i>Cryptocarya foetida</i> Stinking Cryptocarya	Vulnerable (TSC Act and EPBC Act)	The project would require the removal of 13 individuals out of 17 around Coolgardie Road. The project would intersect the population.	10
<i>Endiandra hayesii</i> Rusty Rose Walnut	Vulnerable (TSC Act and EPBC Act)	The project would require the removal of five individuals near Coolgardie Road in Section 10.	10
Endiandra muelleri subsp. bracteata Green-leaved Rose Walnut	Endangered (TSC Act)	Confirmed in a patch of subtropical rainforest near Coolgardie Road in Section 10 comprising a total eight individuals consisting of five larger individuals and three juveniles. The project would require the removal of six individuals. The project would intersect the population.	10
Macadamia tetraphylla Rough-shelled Bush Nut	Vulnerable (TSC Act)	The project would require the removal of 37 individuals near Coolgardie Road in Section 10 including juveniles and mature trees.	10
<i>Olax angulata</i> Square-stemmed Olax	Vulnerable (TSC Act and EPBC Act)	The one individual in the project boundary would be removed as part of the project.	2
Syzygium hodgkinsoniae Red Lilly Pilly	Vulnerable (TSC Act and EPBC Act)	A single individual would be removed north of Coolgardie Road as part of the project.	10

Table 10-16: Impacts to smaller populations of threatened flora in the project boundary

10.3.3 Loss of fauna habitat

The loss of fauna habitat, based on habitat type is identified in Table 10-17. The area of impact for cleared and modified lands has also been included, as it provides some limited habitat resources for fauna. The total area of native vegetation to be cleared would be 948 hectares, and 1818 hectares of potential fauna habitat including the cleared and modified land areas.

Table 10-17: Impacts to habitat type

Fauna habitat	Direct impact area (hectares)
Dry sclerophyll forests on sandy and clay soils	443.7
Wet / moist sclerophyll forests on floodplains and riparian areas	329.1
Lowland rainforest on floodplains	10.3
Swamp forests	149.9
Wet and dry heath and freshwater wetlands	13.3
Estuarine wetlands	1.5
Cleared and modified lands	870.1

Loss of hollow bearing trees

Hollow bearing trees are a critical habitat feature providing breading and/ or sheltering habitat for a number of threatened species. The loss of hollow bearing trees is listed as a key threatening process under Schedule 3 of the TSC Act.

Hollow bearing trees are present in all habitats types and in all project sections to be cleared by the project. The highest density of hollow bearing trees was recorded in the dry sclerophyll forests on clay soils, followed by moist floodplain eucalypt forests and dry forest on sandy soils. Assuming that habitat condition is homogeneous across the project, this impact would equate to a loss of 18 (\pm 8.36) trees per hectare for the dry sclerophyll forest on clay soils, 14.29 (\pm 11.34) trees per hectare for the floodplain eucalypt (\pm 11.66) trees per hectare for the dry forests on sandy soils.

Loss of hollow bearing trees would be greatest where the project would deviate from the existing Pacific Highway alignment in Section 3, Section 9 and Section 10. However, hollow bearing trees may also be present in habitats adjoining the existing highway.

The loss of hollow bearing trees would impact on species that are reliant on tree hollows for shelter and nests. Twenty-two species that rely on hollow bearing trees are listed as threatened species under the TSC Act or the EPBC Act and are present or considered likely to occur in the dominant habitat types with the most hollow bearing trees in the project boundary (refer to Table 10-18).

	Scientific nome		
Common name		TSC Act	EPBC Act
Glossy Black-cockatoo	Calyptorhynchus lathami	V	
Brown Treecreeper (eastern subsp.)	Climacteris picumnus picumnus	V	
Double-eyed Fig-parrot	Cyclopsitta diophthalma coxeni	E	
Little Lorikeet	Glossopsitta pusilla	V	
Powerful Owl	Ninox strenua	V	
Masked Owl	Tyto novaehollandiae	V	
Sooty Owl	Tyto tenebricosa	V	
Eastern Pygmy-possum	Cercartetus nanus	V	
Hoary Wattled Bat	Chalinolobus nigrogriseus	V	
Little Pied Bat	Chalinolobus picatus	V	
Spotted-tailed Quoll	Dasyurus maculatus	V	E
Eastern False Pipistrelle	Falsistrellus tasmaniensis	V	
Beccari's Freetail-bat	Mormopterus beccarii	V	
Eastern Freetail-bat	Mormopterus norfolkensis	V	
Southern Myotis	Myotis macropus	V	
Eastern Long-eared Bat	Nyctophilus bifax	V	
Yellow-bellied Glider	Petaurus australis	V	
Squirrel Glider	Petaurus norfolcensis	V	
Brush-tailed Phascogale	Phascogale tapoatafa	V	
Yellow-bellied Sheathtail-bat	Saccolaimus flaviventris	V	
Greater Broad-nosed Bat	Scoteanax rueppellii	V	
Pale-headed Snake	Hoplocephalus bitorquatus	V	
Stephen's' Banded Snake	Hoplocephalus stephensii	V	

Table 10-18: Species dependent on tree hollows potentially affected by the project

E = Endangered species; V = Vulnerable species

Loss of foraging resources

There are a number of potential impacts associated with the loss of foraging resources, including:

- Direct loss of vegetation available to herbivores and frugivores
- Decline in the extent to which remaining resources could be exploited due to increasing risk of disturbance from road operation, edge effects, fragmentation and loss of connectivity and weed infestation.

The indirect impacts of vegetation 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. It also does not consider competition for resources and forage quality and quantity per habitat type. Assessing impacts from loss of foraging resources also needs to consider species adaptation to accessing resources, as not all fauna species are affected by loss of foraging resources equally.

Removal of foliage and nectar foraging resources could impact on a number of different species. Threatened species potentially impacted at the local population level are:

- Eastern Pygmy-possum
- Squirrel Glider
- Yellow-bellied Glider
- Brush-tailed Phascogale
- Koala
- Rufous Bettong
- Small insectivorous bats.

Species expected to be impacted at the regional population level include Swift Parrot, Regent Honeyeater, Little Lorikeet, and Grey-headed Flying-fox.

A number of threatened species require winter flowering foraging resources to supply food year-round, or to coincide with migratory movements. These threatened species include Squirrel Glider, Yellowbellied Glider, Regent Honeyeater, Swift Parrot, Little Lorikeet and Grey-headed Flying-fox. Other species, such as the Yellow-bellied Glider and Squirrel Glider, rely on a tree species composition providing year-round continuity of nectar and pollen. Of the habitats impacted by the project, at least four of those are dominated by winter-flowering species including Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*E. tereticornis*), Grey Ironbark (*E.siderophloia*) and Broad-leaved Paperbark (*Melaeluca quinquenervia*).

Other foraging resources available within the project boundary include plant exudates (acacia and eucalyptus sap), foraging substrates such as tree trunks and fallen logs, creeklines (insect prey source) and Koala feed tree species (including Forest Red Gum (*E. tereticornis*), Swamp Mahogany (*E. robusta*) and Tallowwood (*E.microcorys*). Koalas are also known to browse on Broad-leaved paperbark (*Melaleuca quinquenervia*).

Koala feed trees are divided into primary and secondary (or supplementary) feed trees depending on the level of use. The total area of habitat to be removed for the project comprising primary Koala food tree species is around 548.4 hectares. An additional 297.4 hectares containing secondary Koala food tree species would also be removed, resulting in the removal of 845.8 hectares of Koala food tree species. Appendix E of the Working paper- Biodiversity details the significance assessments for threatened species, populations and communities, including the Koala.

Impacts to threatened populations

The project would impact a number of threatened fauna (including fish) populations. The potential impacts to species likely to occur within the project boundary from loss of habitat are provided in Table 10-19. Species in the table are discussed individually, however where a group of species share similar habitat requirements and life-cycle strategies, these are discussed together. Where insufficient information is available such that impacts are unknown or unpredictable, the likely impact has been estimated through a precautionary approach.

Table 10-19: Potential impacts to targeted threatened fauna

Target species and listing status	Project section	Potential impacts	
Wetland and migratory bird species			
Australasian Bittern <i>Botaurus</i> <i>poiciloptilus</i> Endangered (TSC Act and EPBC Act)	1-4, 7-11	These species are predicted across all 11 project sections; however identified sections represent a higher density of records and known breeding habitat for species. Due to the broad range of habitats frequented by these species, from riverine, freshwater wetland and lake habitats	
Australian Painted Snipe <i>Rostratula</i> australis (Endangered TSC Act, Vulnerable Migratory EPBC Act)	1-11	to swamps and wetlands and farm dams, wet pastures and meadows to cane paddocks, and tea-tree plantations, the project would only include a relatively small loss of foraging and breeding habitat.	
Black-necked Stork <i>Ephippiorhynchus</i> asiaticus (Endangered TSC Act)	1-11	foraging resources. This includes expected clearing of riparian zones and potential changes to local flood pattern Black-necked Stork is known to nest in the study area associated with the Coldstream wetlands in the Pillar Valle to Tyndale area (Section 3) where nests are in disturbed wetland habitat situated on agricultural land (Clancy, 2010). There are no known nest sites that would be directly affected by the project.	
Pale-vented Bush Hen <i>Amaurornis molucanna</i> (Vulnerable TSC Act)	9-10		
Magpie Goose Anseranas semipalmata (Vulnerable TSC Act)	2-6, 8-11		
Comb-crested <i>Jacana Irediparra</i> gallinacea (Vulnerable TSC Act)	3-9		
Black Bittern <i>Ixobrychus flavicollis</i> (Vulnerable TSC Act)	1-3, 6-7, 9		
Brolga <i>Grus rubicundus</i> (Vulnerable TSC Act)	1-11		
Freckled Duck <i>Stictonetta naevosa</i> (Vulnerable TSC Act)	3-5		
Pale-vented Bush Hen (Vulnerable TSC Act)	9-10		
Other migratory listed wetland species including but not limited to Latham's Snipe, Cattle Egret, Great Egret (Migratory, EPBC Act)			
Total area of potential impact to wetland and migratory birds within the project boundary is 455.8 hectares (potential vegetation loss/habitat area).			

Target species and listing status	Project section	Potential impacts	
Large forest owls and other nocturnal bird	ds		
Barking Owl <i>Ninox connivens</i> (Vulnerable TSC Act)	1-11	Impacts would be associated with loss of habitat including current and potential nest sites and reduction in the area of habitat available for prey and for dispersal of young. Habitat clearing of regional scale not restricting the future	
Powerful Owl <i>Ninox strenua</i> (Vulnerable TSC Act)	1-11	distribution of the species.	
Masked Owl <i>Tyto novaehollandiae</i> (Vulnerable TSC Act)	1-11		
Sooty Owl <i>Tyto tenebricosa</i> (Vulnerable TSC Act)	1-2		
Grass Owl <i>Tyto longimembris</i> (Vulnerable TSC Act)	1-11	Impacts on potential habitat for this species are relatively minor due to the existing large areas of suitable habitat in the region, in particularly north of the Richmond River, outside of the project boundary.	
Total area of potential impact to owls within the project boundary is 936.4 hectares (potential vegetation loss/habitat area).			
Woodland birds			
Brown Treecreeper <i>Climacteris</i> picumnus (Vulnerable TSC Act)	1-7	Suitable habitat for these species in the study area is limited and would be associated with woodland or forest dominated by Grey Box, Spotted Gum and Ironbark with open grassy understory. Much of this habitat in the study	
Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i> (Vulnerable TSC Act)	1-3, 6-7	area has been logged and is in low to moderate condition. This accounts for the limited distribution of the Black- chinned Honeyeater and Brown Treecreeper in the study area despite around 145 hectares of habitat being within the project boundary.	
Bush Stone-curlew <i>Burhinus grallarius</i> (Endangered TSC Act)	1-3	Impacts would be associated with habitat loss for breeding and foraging life-cycle events including free hollows used for nesting by Brown Treecreeper.	
Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i> (Vulnerable TSC Act)	1-4, 6-10		
Total area of potential impact to woodland	d birds within tl	ne project boundary is 936.4 hectares (potential vegetation type/habitat area).	
Rainforest birds			
Double-Eyed Fig-Parrot <i>Cyclopsitta</i> <i>diophthalma coxeni</i> (Critically endangered TSC Act and endangered EPBC Act)	10-11	Potential impacts are associated with loss of potential food resources, mainly associated with the loss of lowland rainforest (10 ha) further limiting the area of available habitat. This loss would further limit the area of available habitat. Impacts on the regional spatial distribution of resources for these potentially wide ranging species are not significant.	
Wompoo Fruit-dove <i>Ptilinopus magnificus</i> (Vulnerable TSC Act)	1-2, 6-11		

Target species and listing status	Project section	Potential impacts
Rose-crowned Fruit Dove <i>Ptilinopus regina</i> (Vulnerable TSC Act)	1-2, 8-11	
Superb Fruit-dove <i>Ptilinopus superbus</i> (Vulnerable TSC Act)	1-2, 8-11	
Barred Cuckoo-shrike Coracina lineata (Vulnerable TSC Act)	1-2, 8-11	
Total area of potential impact to rainfores	st birds within t	he project boundary is 516.8 hectares (potential vegetation type/habitat area).
Forest birds		
Little Eagle <i>Hieraaetus morphnoides</i> (Vulnerable TSC Act)	1-11	Impacts generally associated with the loss of hunting habitat, up to about 770 hectares of forest habitat to be removed which would impact on habitat for prey species having potential local impacts for established nesting pairs.
Square-tailed Kite <i>Lophoictinia isura</i> (Vulnerable TSC Act)	1-11	
Red Goshawk Erythrotriorchis radiatus (Critically endangered TSC Act, vulnerable EPBC Act)	1-11	
Eastern Osprey <i>Pandion haliaetus</i> (Vulnerable TSC Act, Migratory EPBC Act)	1-11	Impacts from clearing would extend into cleared and modified agricultural areas for these species in terms of removing potential nesting trees. No nest sites confirmed within the project boundary at the time of the surveys. A known nest at Harwood is at least 500 m to the west of the project boundary and would not be affected.
Glossy Black-cockatoo <i>Calyptorhynchus lathami</i> (Vulnerable TSC Act)	1-7	Glossy Black-cockatoos prefer she-oaks (mostly Allocasuarina) in forests, woodlands and along timbered watercourses. Sheoak was found to be moderately common in the drier forest types, particularly on sandy soils; however its distribution is patchy and not evenly distributed across all forest types. Therefore, it is difficult to quantify the impact in terms of loss of forest habitat. However, the project would impact on around 443 hectares of dry open forest habitat comprising potential nest hollows and food resources for this species. The species distribution would be limited by the presence of these resources. Local losses could have a significant long-term impact to the spatial distribution and breeding success of pairs.
Little Lorikeet <i>Glossopsitta pusilla</i> (Vulnerable TSC Act)	1-11	Impacts include clearing of up to 770 hectares of forest habitat providing potential food and nesting resources. This is a wide ranging nomadic species adapted to fragmented landscapes and patchy resources, including using modified habitats. Impacts unlikely to be significant to local and regional populations.
Mangrove Honeyeater <i>Lichenostomus fasciogulari</i> (Vulnerable TSC Act)	4-5, 8-10	The species occurs in mangroves swamp and estuarine wetlands which have only minor impacts from the project (1.5 hectares) relative to the extent of potential habitat in the estuaries of the lower Clarence and Richmond rivers.

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Target species and listing status	Project section	Potential impacts	
Ground Parrot (eastern subsp.) <i>Pezoporus wallicus wallicus</i> ((Vulnerable TSC Act)	8-10	Potential and known habitat in Broadwater National Park and Wardell Heath would have minimal direct impacts. The project is not expected to significantly impact on the movements of the species and large areas of habitat would remain.	
Coastal Emu <i>Dromaius</i> <i>novaehollandiae</i> (Endangered population TSC Act)	3-4	Floodplain wetlands and swamps of the Coldstream River, Chaffin Swamp, Champions Creek, Pillar Valley Creek, Tyndale Swamp and Shark Creek including associated agricultural land, support reliable food and water resources, for this species. These habitats account for observed movements in the pre and post breeding life-cycle periods of birds. The wetlands are currently contiguous with the forest and heath communities to the east of the floodplain via relatively natural and modified habitats, with the exception of a network of roads to the east of the project, to the coastal lands of Yuraygir National Park and surrounds.	
		The alignment of the project would create a barrier between the wetlands and the forest areas passing around the Coldstream wetlands, crossing Pillar Valley Creek, Chaffin Creek, Champions Creek and Shark Creek.	
		The impact to the population from the project would include the direct removal, fragmentation and isolation of important habitat. These impacts combined with the increased risk of vehicle strike, has potential to have significant long-term, cumulative impacts on the population leading to loss of viability. The project would have the greatest impact on the emu population ranging from the Pillar Valley to Tyndale.	
Total area of potential impact to forest birds within the project boundary is 947.9 hectares (potential vegetation type/habitat area).			
Microchiropteran bats			
Large-eared Pied Bat <i>Chalinolobus</i> <i>dwyeri</i> (Vulnerable TSC Act and EPBC Act)	1-7	Potential impacts on the roosting life-cycle activities of these species are difficult to assess, as no known roost sites have been reported in the study area.	
		Impacts would be associated with loss of foraging habitat and potentially short to medium term reduction in habitat for insect prey species.	
Hoary Wattled Bat <i>Chalinolobus</i> nigrogriseus (Vulnerable TSC Act)	1-11	Important life-cycle activities would be impacted by the project, including roosting and breeding. Both of these activities are typically associated with tree hollows. Foraging for insect prey would be impacted as it occurs in a	
Eastern False Pipistrelle <i>Falsistrellus tasmaniensis</i> (Vulnerable TSC Act)	1-11	variety of habitat types. The size of local populations is not known, although expected to be moderately large given the expanses of suitable habitat and tree hollow densities, particularly small hollows which are preferred by bats.	
Golden-tipped Bat <i>Kerivoula papuensis</i> (Vulnerable TSC Act)	1-11	Around 770 nectares of forest habitat containing hollow bearing trees would be cleared as part of the project.	
Beccari's Freetail-Bat <i>Mormopterus</i> beccarii (Vulnerable TSC Act)	1-11		
Eastern Freetail-Bat <i>Mormopterus</i> norfolkensis (Vulnerable TSC Act)	1-11		
Eastern Long-Eared Bat <i>Nyctophilus bifax</i> (Vulnerable TSC Act)	1-11		
Yellow-bellied Sheathtail-bat	1-11		

Target species and listing status	Project section	Potential impacts
<i>Saccolaimus flaviventris</i> (Vulnerable TSC Act)		
Greater Broad-nosed Bat Scoteanax rueppellii (Vulnerable TSC Act)	1-11	
Eastern Cave Bat Vespadelus troughtoni (Vulnerable TSC Act)	1-11	Potential impacts on the roosting life-cycle activities of these species are difficult to assess, as no known roost sites have been reported in the study area. Myotis and Miniopterus are known to roost under old bridges, both timber
Southern Myotis <i>Myotis macropus</i> (Vulnerable TSC Act)	1-11	and concrete. Inspections of the bridges to be removed by the project suggest they are currently not being used. Impacts would be associated with loss of foraging habitat and potentially short to medium term reduction in habitat
Little Bent-wing Bat <i>Miniopterus</i> australis (Vulnerable TSC Act)	1-11	tor insect prey species.
Eastern Bent-wing Bat <i>Miniopterus</i> schreibersii oceanensis (Vulnerable TSC Act)	1-11	
Total area of potential impact to microchi	ropteran bats v	within the project boundary is 947.9 hectares (potential vegetation type/habitat area).
Arboreal mammals		
Eastern Pygmy-possum <i>Cercartetus</i> nanus (Vulnerable TSC Act)	1-11	Impacts would be associated with loss of 770 hectares of forest habitat and fragmentation of forest patches.
Yellow-bellied Glider Petaurus australis (Vulnerable TSC Act)	1-2, 6-7	Potential impacts for both species are associated with the loss of habitat including potential den sites, fragmentation and the barrier effect of the project leading to increased isolation of family groups and reduced genetic diversity.
Squirrel Glider <i>Petaurus norfolcensis</i> (Vulnerable TSC Act)	1-3, 6-7	The severity of the impact on a regional scale is low as the species is widespread over a large portion of the bioregion. Localised impacts in may be more moderate. Large areas of habitat would remain in state forests and reserved habitats assisting in the longer-term viability of these species.
Brush-tailed Phascogale <i>Phascogale tapoatafa</i> (Vulnerable TSC Act)	1-4, 6-7	Potential impacts are associated with loss of habitat, in particular those containing hollow bearing trees (for Brush- tailed Phascogale), and the barrier effect of the highway. There is also potential for increased predation associated with fragmentation and degradation of habitat adjoining the project. The severity of the impact on a regional scale is low, as this species is widespread over a large portion of the bioregion.
		Brush-tailed Phascogale is tolerant of modified and fragmented habitats as evidenced by the size of the populations and habitats used in Glenugie State Forest and adjacent grazed and slashed habitats in the Pillar Valley to Tyndale area.
Koala <i>Phascolarctos cinereus</i> (Vulnerable TSC Act and EPBC Act)	1-11	There are over 11,000 recorded Koala sightings in the NSW Atlas for the NSW North Coast Bioregion, spread over all local government areas in a wide range of topographies and habitats. This suggests that Koalas could occur in all project sections in a range of habitats that would be impacted by the project. There are no data available on the size of local populations. The two main centres of high density Koala records occur around Coffs Harbour, south of

Target species and listing status	Project section	Potential impacts
		Woolgoolga (outside of the project boundary), and in Richmond Valley LGA between Woodburn and Ballina (Sections 9, 10 and 11).
		Impacts on Koala relate primarily to the clearing of around 580 hectares of habitat containing the primary Koala feed tree species Forest Red Gum (<i>E. tereticornis</i>), Swamp Mahogany (<i>E. robusta</i>) and Tallowwood (<i>E.microcorys</i>). An additional 297.4 hectares containing secondary and supplementary Koala food tree species would also be removed. The total area impacting on Koala food tree species is around 845.8 hectares. Critical habitat for Koalas is determined based on the overall canopy (refer to section 4.3.2 of the Working paper – Biodiversity). However, as this was not assessed for each biometric vegetation type. Therefore as a precautionary measure it has been estimated that the total impact of 845.8 hectares is critical habitat.
		The species could also be negatively affected by fragmentation and the barrier effect of the highway. Large areas of habitat would remain in the landscape including state forests and reserved habitats assisting in the longer-term viability of this species.
Total area of potential impact to arboreal	mammals with	nin the project boundary is 946.40 hectares (potential vegetation type/habitat area).
Ground-dwelling mammals		
Rufous Bettong <i>Aepyprymnus</i> <i>rufescens</i> (Vulnerable TSC Act)	1-4, 6-7	There is also potential for increased predation associated with fragmentation and degradation of habitat adjoining the project. The severity of the impact on a regional scale is low, as this species is widespread over a large portion of the bioregion.
		The lower Clarence Valley to Yuraygir area including Gleungie State Forest appears to be a stronghold for the Rufous Bettong and localised impacts in these areas may be more moderate. This species is tolerant of modified and fragmented habitats as evidenced by the size of the populations and habitats used in Glenugie State Forest and adjacent grazed and slashed habitats in the Pillar Valley to Tyndale area.
Common Planigale <i>Planigale maculata</i> (Vulnerable TSC Act)	1-11	Impacts associated with loss of 770 hectares of forest habitat and fragmentation of forest patches.
Long-nosed Potoroo <i>Potorous</i> <i>tridactylus tridactylis</i> (Vulnerable TSC Act and EPBC Act	10	An isolated population is known from Wardell Heath to the east of Section 10. The project would not directly involve a loss of habitat for the Long-nosed Potoroo. Potential indirect impacts may be associated with impacts on groundwater through construction potentially affecting the condition of the retained habitats and also the potential barrier effect on dispersal and movement of the species. There is limited connectivity to similar habitats for this species across the North Coast Bioregion, which explains its relative isolation. The Richmond River is a barrier to the east and the only movement opportunities are to the north across a network of existing roads. Large areas of habitat would remain in the landscape within Wardell Heath assisting in the longer-term viability of this species.
Spotted-tailed Quoll <i>Dasyurus</i> <i>maculatus maculatus</i> (SE population) (Vulnerable TSC Act and Endangered EPBC Act)	1-2, 6-7	There are no records of particular species clusters near the project that would suggest an important population exists. However based on the habitats present, in particular state forests and conservation reserves, two main areas exist which may represent important habitat for regional populations. These are the areas from Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (sections1 and 2) and Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (sections 6 and 7). These habitats are largely associated with the mature dry and moist sclerophyll forests on both sandy and clay soils.

Target species and listing status	Project section	Potential impacts
		Potential impacts on the species include the loss of habitat including potential den sites, fragmentation and the barrier effect of the highway potentially leading to increased genetic isolation. The species is known to frequent roadsides feeding on roadkill, which may increase risks of vehicle strike. The severity of the impact on a regional scale is low as the species is very widespread over a large portion of the bioregion, although localised impacts may be more moderate. Large areas of habitat would remain in state forests and reserved habitats assisting in the longer-term viability of this species.
Total area of potential impact to ground-o	dwelling mamn	nals within the project boundary is 947.9 hectares (potential vegetation type/habitat area).
Megachiropteran bats		
Grey-headed Flying-fox <i>Pteropus</i> <i>poliocephalus</i> (Vulnerable TSC Act and EPBC Act)	1-11	No roosts sites were confirmed within the project boundary from the field surveys and background review. There are several known permanent and seasonal roosts in the region and many of the habitats to be removed would qualify as critical habitat according to the definitions of the species recovery plan (Eby, 2009). There are several known colonies in the region including Woolgoolga (Section 1), a camp at Maclean and Farlows Swamp within 2 kilometres of the boundary (Section 4-5) one at Woodburn (Section 8) and Wardell (Section 10). Impacts would occur over a large scale including up to 770 hectares of forest habitat providing potential food resources. This is a wide-ranging nomadic species adapted to fragmented landscapes and patchy resources, including using modified habitats. Impacts are unlikely to be significant to local or regional populations.
Common Blossom-bat <i>Syconycteris australis</i> (Vulnerable TSC Act)	8-11	This species has restricted habitat requirements associated with littoral rainforest for roosting. These are usually near heathland habitats for foraging. Suitable habitat is widespread through the large coastal national parks in the region, and as such, impacts on potential roosting habitat and foraging habitat are expected to be minimal.
Total area of potential impact to megachi	ropteran bats	within the project boundary is 947.9 hectares (potential vegetation type/habitat area).
Wetland and swamp dwelling frogs		
Wallum Froglet <i>Crinia tinnula</i> (Vulnerable TSC Act)	1-11	Potential impacts through loss of and degradation of habitat, not significant due to the largely coastal distribution and widespread and abundant presence of suitable habitat.
Olongburra Frog <i>Litoria olongburensis</i> (Vulnerable TSC Act and EPBC Act)	9	Potential impacts from increasing the barrier effects of the existing highway
Giant Barred Frog <i>Mixophyes iterates</i> (Endangered TSC Act and EPBC Act)	1-2, 6-7	Impacts would include direct loss of small discrete areas of habitat through crossing drainage and creek habitats. Indirect impacts would result from edge effects on habitat areas adjacent to the project. There is potential for
Green-thighed Frog <i>Litoria brevipalmata</i> (Vulnerable TSC Act)	1-2, 6-7	detrimental changes to drainage patterns in important habitats, although these would involve small areas at a local scale. Altered water quality associated with polluted water from road runoff and overflow of sediment basins in drainage areas may also impact habitat areas.
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Total area of potential impact to wetland and swamp dwelling frogs within the project boundary is 947.9 hectares (potential vegetation type/habitat area).

Target species and listing status	Project section	Potential impacts
Reptiles		
Pale-headed Snake <i>Hoplocephalus bitorquatus</i> (Vulnerable TSC Act)	1-3, 6-8	Impacts are expected from the extensive loss of potential forest habitat and fragmentation of forests, which may also isolate areas of former habitat. Prey species are expected to be abundant pre- and post-construction.
Stephens' banded snake <i>Hoplocephalus stephensii</i> (Vulnerable TSC Act)	1-3, 6-8	
Total area of potential impact to reptiles	within the proje	ect boundary is 946.4 hectares (potential vegetation type/habitat area).
Fish		
Oxleyan Pygmy Perch <i>Nannoperca</i> <i>oxleyana</i> (OPP)(Endangered TSC Act and EPBC Act)	1, 2, 6- 9	Many areas of habitat have already been lost or are threatened by coastal development and critical areas of habitat have been listed in a preliminary determination by the Department of Industry and Investment. One of these identified areas is Broadwater National Park, which is crossed by the project. The project would result in changes to potential aquatic habitat within the study area. Potential impacts may result from changes to the water quality parameters preferred by this species (In particular, any increase in total suspended solids, reduction in dissolved oxygen and/or change in pH) or by creating temporary or permanent barriers to movement and dispersal, particularly in Sections 6 to 9. Other impacts on potential habitat may be associated with loss of instream and riparian habitat, modified flow regimes and increased abundance of the noxious fish species Plague Minnow.
Purple-spotted Gudgeon <i>Mogurnda</i> adspersa (Endangered TSC Act)	1, 2, 6- 8	Construction would result in short term impacts on immediate downstream reaches. Potential impacts may result from changes to the water quality parameters preferred by this species or by creating temporary or permanent barriers to movements and dispersal. Other impacts on potential habitat may be associated with loss of instream and riparian habitat, modified flow regimes and increased abundance of the noxious fish species Plague Minnow.
Eastern Freshwater Cod <i>Maccullochella ikei</i> (Endangered TSC Act and EPBC Act)	3	Construction would result in short term impacts on immediate downstream reaches associated with potential sediment input during high rainfall events. Potential habitat confirmed in Section 3. Other impacts on potential habitat may be associated with loss of instream and riparian habitat, modified flow regimes and increased abundance of the noxious fish species Plague Minnow.

Target species and listing status	Project section	Potential impacts
Invertebrates		
Pink Underwing Moth <i>Phyllodes</i> <i>imperialis southern subsp</i> .(Vulnerable TSC Act and EPBC Act)	10	Potential impacts include the loss of habitat particular where the host plant occurs, there is scope to minimise the impact and target the use of this species in revegetation works as part of the project. The Pink Underwing Moth is also likely to breed within the study area. Its host plant is prevalent from within the alignment to a little beyond the western edge.
		The project would clear up to 10 hectares of lowland rainforest including the removal of likely breeding habitat as determined by the presence of larvae and the host plant Carronia multisepalea. The project would likely have a significant impact on the burrowing / sheltering and breeding, and foraging life-cycle activities for the local population of this species.
Atlas Rainforest Ground Beetle <i>Nurus atlas</i> (Endangered TSC Act)	10-11	The survival of this species is threatened by an extremely restricted distribution, clearing of rainforest remnants, removal of fallen timber and ground cover. The project would clear up to 10 hectares of lowland rainforest and this would have a likely significant impact on the burrowing / sheltering and breeding, and foraging life-cycle activities for this species. The records in the study area represent the first records for the region around Ballina. There is only one previous record of the ground beetle between Alstonville and Coraki.
Coastal Petaltail <i>Petalura litorea</i> (Endangered TSC Act)	8-9	The direct loss of up to 3 hectares of wetland habitats and direct impacts to adjoining wetlands may impact on the habitat of this species. However the distribution of populations is not known and there is no published data on the minimum condition of the habitat that supports this species.

Total area of potential impact to invertebrates within the project boundary is 309.1 hectares (potential vegetation type/habitat area).

Other fauna		
Swift Parrot <i>Lathamus discolor</i> (Endangered TSC Act, Endangered, Migratory EPBC Act)	1-11	Swift Parrot and Regent Honeyeater are occasional visitors to the region during peak flowering events of the dominant trees, particularly the winter flowering Spotted Gum, Swamp Mahogany and Forest Red Gum. There are no resident populations known from the study area or immediately surrounding lands. The habitat would constitute
Regent Honeyeater <i>Xanthomyza phrygia</i> (Endangered TSC Act and endangered and migratory EPBC Act)	1-11	a small percentage of the available non-breeding habitat for transient populations. Records from the study area are relatively continuous, extending over the last 30 years indicating that the region may constitute seasonally important foraging and refuge habitat for transient populations of these species, particularly during inland droughts. The current potential for these species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project. Foraging, movement and other life-cycle attributes would not be impacted suggesting that the project would not lead to a long-term decrease in the size of populations of either species.
Total area of potential impact to Swift Pa	rrat and Pagan	t Hanavastar within the project houndary is 025.7 heatares (potential vagatation type/habitat area)

Total area of potential impact to Swift Parrot and Regent Honeyeater within the project boundary is 925.7 hectares (potential vegetation type/habitat area).

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Target species and listing status	Project section	Potential impacts
Koala <i>Phascolarctos cinereus</i> (Vulnerable TSC Act and EPBC Act)	3	Koalas are known to occur throughout the region and near the project boundary with potentially important populations in the vicinity of Broadwater National Park; Riley's Hill and in the sclerophyll forests of the Wardell heaths (Sections 7-10). Road deaths for Koalas have occurred in Section 1 and 2, and as such they are considered likely to occur throughout suitable habitat. Koalas were recorded at two sites during surveys in Section 3. Impacts on Koala were discussed previously in Section 4.3.2. These relate primarily to the clearing of around 580 hectares of habitat containing the primary Koala feed tree species Forest Red Gum (E. tereticornis), Swamp Mahogany (E. robusta) and Tallowwood (E.microcorys). The species could also be negatively affected by fragmentation and the barrier effect of the highway and is regularly struck by cars where high-density populations occur in fragmented urban habitats. The impacts of the barrier effect and fragmentation have been addressed via a focus on this species in the Connectivity Strategy. Large areas of habitat would remain in the landscape including state forests and reserved habitats for the longer-term viability of this species.

10.3.4 Fauna mortality

Construction impacts

While some diurnal and mobile species, such as birds and large reptiles, may be able to move away from tree-clearing during construction, other species that are less mobile, nocturnal, or have smaller home ranges, are less inclined to move rapidly or disperse large distances away from such activity. This includes threatened species such as roosting microchiropteran bats, Squirrel Glider and Yellow-bellied Glider, Brush-tailed Phascogale, Rufous Bettong, Stephen's Banded Snake and Pale-headed Snake and a number of threatened frogs. These threatened species could be most at risk of mortality during clearing and other construction activities. To avoid or minimise mortality on these types of species and other threatened or common fauna, RMS has developed guidelines for the procedures to be used during construction (RTA, 2011b). Further details on the procedures to minimise fauna mortality are outlined in Section 10.4.

Operational impacts

Mortality due to vehicle strike has the potential to affect fauna species at the sub-population level. In general, mortality rates from vehicle strike are likely to be directly proportional to the distance of native vegetation/fauna habitat crossed by the project (Forman, 2000). However, other factors such as the design of the road (eg through road cutting or road embankment, presence of adjacent stock fences, presence of fauna exclusion fencing or fauna crossing structures) also influence vehicle strike mortality.

Road mortality can have further impacts, including reduced breeding success. Isolated populations where growth relies on breeding rather than the influx of individuals from adjacent populations, can be more greatly impacted from road mortality. For example, the endangered coastal emu population, with any further incremental losses associated with road strike may have significant long-term impacts to the sustainability of the population.

Threatened fauna that have the greatest potential to be negatively affected by vehicle strike over the length of the project include:

- Squirrel Glider
- Yellow-bellied Glider
- Koala
- Coastal Emu
- Woodland bird species such as the Grey-crowned Babbler
- Rufous Bettong
- Brush-tailed Phascogale
- Spotted-tailed Quoll
- Green-thighed Frog, Wallum Froglet and Wallum Sedge Frog.

The Connectivity Strategy identifies measures to minimise fauna mortality by vehicle strike through provision of fauna crossing structures and installation of fauna exclusion fencing (refer to Appendix A of the Working paper – Biodiversity).

10.3.5 Loss of habitat connectivity

The project has potential to create isolated remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on both a local and regional population level.

The width of the project would vary considerably according to the location, elevation and proximity of service roads and interchanges, varying between 50 and 400 metres. Large sections of the project would occur adjacent to the existing highway, such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg Sections 3, 4, 9 and 10).

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There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. Contiguous areas of forest are generally associated with state forests, national parks and conservation reserves, which have been partitioned in the landscape over time. The project largely occurs along the outer boundaries of these contiguous areas. Avoiding these areas, in addition to duplication of the existing highway corridor, has avoided further large-scale fragmentation of habitat on a regional scale.

Throughout the largely cleared or fragmented habitats, smaller east-west vegetated corridors are likely to play an important role in the wider corridor network. These include those fragmented by the existing highway such as at Yaegl Nature Reserve or Tabbimoble Nature Reserve to Doubleduke State Forest. The project would increase the level of isolation or fragmentation of some patches of vegetation that follow in an east-west direction. An increase in the width of the road is likely to increase this barrier effect for some species in some sections where regional corridors have been identified such as the Dirty Creek Range to Yuraygir National Park or Bundjalung National Park. This would be the case particularly for ground-dwelling and arboreal mammals. Mobile species such as birds and bats may not be as affected by the increase in road corridor width.

The loss of connectivity has potential to impact on populations of several NSW and Commonwealth listed fauna species including:

- Coastal Emu The project would bisect important habitat for pre and post breeding life-cycle activities
- Oxleyan Pygmy Perch
- Yellow-bellied Glider and Squirrel Glider
- Rufous Bettong, Common Planigale and Brush-tailed Phascogale
- Spotted-tailed Quoll
- Koala
- Long-nosed Potoroo
- Giant Barred Frog, Green-thighed Frog and Olongburra Frog.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where possible in strategic locations (eg key corridors). These fauna connectivity structures are shown in Chapter 5 (Description of the project- operation), with further information in the Connectivity Strategy is detailed in Appendix A of the Working paper - Biodiversity.

10.3.6 Habitat fragmentation

Fragmentation of habitat would be greatest where the project deviates from the existing Pacific Highway, particularly through Sections 3 to 4, 9 and 10. Portions of the landscape in these regions are already largely cleared; particularly the alluvial floodplain areas of the Clarence River and Richmond River where vegetation is heavily fragmented and a mosaic of different sized remnants exist. However, Section 3 would traverse the western foothills of the Summervale Range from Pillar Valley to Tyndale and this route would fragment remnant open forest habitats in moderate and high quality condition over a distance of around 23 kilometres. This includes fragmentation of a portion of the identified Sandstone Rough-barked Apple (*Angophora robur*) population and known and potential habitat for the range of threatened and common fauna species in sections 3 and 4. Much of this habitat occurs on sandy soil that is identified as having a high density of hollow bearing trees and generally higher fauna species richness. This habitat includes a range of old growth forests with minimal evidence of past logging particularly between Pine Brush State Forest and Tyndale.

The second area of major deviation from the existing highway occurs south of the Richmond River to the interchange with the existing highway north of Wardell, a distance of around 12 kilometres. This would fragment habitats of a local and regional scale of importance. These habitats are of such importance partly due to the already increased isolation of the Wardell Heath from the Blackwall Range and the localised east-west wildlife corridors that are situated north of the Richmond River.

Loss of connectivity between smaller habitat patches can cause the loss of genetic diversity in populations (Forman et al. 2003) and potentially lead in the longer term to local extinction of species. Some species are at greatest risk in fragmented landscapes than others and this relates to the biological characteristics of the species.

In general, the isolation effect is likely to be most severe for very small populations and those with specific microhabitat requirements that might not be present in small fragments, or whose rate of population growth is very low.

Further details on the fragmentation sensitivity of threatened species are identified in section 9.1.3 of the Working paper – Biodiversity.

10.3.7 Edge effects, noise and light impacts

Edge effects are zones of changed environmental conditions (ie altered light levels, windspeed, temperature and noise) occurring along the edges of habitat fragments. These new environmental conditions can promote the growth of different plants (including weeds) and altered vegetation community structures. These structures allow 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 predators and native avian predators having a long-term impact on sensitive species.

The calculation of indirect impact figure was applied where the road would create a new edge through contiguous forest, and did not include existing edge affected fragments that adjoin the project boundary nor small fragmented areas of modified habitat. The additional indirect impact associated with edge effects for the project would be around 431 hectares.

Edge effects would be greatest where the project deviates substantially from the existing Pacific Highway. Substantial clearing and creation of a new edge would occur in Section 3 along the western foothills of the Summervale Range from Pillar Valley to Tyndale. Large sections of open forest habitat in moderate to high condition would be exposed to edge effects particularly on the eastern edge of the highway. This includes habitat for the endangered Sandstone Rough-barked Apple (*Angophora robur*) and a range of threatened fauna species that are susceptible to edge effects including Squirrel Glider, Brush-tailed Phascogale, Grey-headed Flying-fox, Powerful Owl and Australasian Bittern. However, there are other species found in this area, such as Little Bentwing-bat, Whiptail Wallaby and Rufous Bettong that are more tolerant of modified habitats and edge impacts.

New edge areas would also be created by clearing of a corridor through currently contiguous habitats immediately north of the Richmond River. A number of threatened fauna species have been confirmed in this locality including Koalas.

The effects of creating a new edge in Section 3, 9 and 10 would increase the risk of predation for resident fauna including threatened species. It may also reduce the health of important habitat trees and hollow bearing trees as an indirect result.

In respect of potential impacts on edge areas from noise and light, there are two sources, firstly construction noise (eg vehicles and machinery operating) and secondly general traffic noise and road lighting associated with road operation. Lighting from vehicles and roadside lighting would mainly be an operational issue, however, there would only be limited roadside lighting (the project being mostly unlit except for at interchange roundabouts, major bridges and merge and diverge traffic lanes). Some out of hours construction work would be required as part of the construction program. This would require lighting at ancillary facility locations and at the construction site (eg at bridge locations).

Negative effects of traffic noise in all sections have been recorded mainly in species that frequently vocalise, including birds and amphibians (van der Zande et al 1980, Reijnen et al 1997) and species that rely on hearing for hunting such as forest owls. Whether noise could cause road avoidance and other barrier effects in isolation from other factors such as vehicle movements, presence of humans or edge effects remains to be ascertained (Kaseloo 2006). There is some evidence to support less vocal mammal species altering normal movement pattern to avoid traffic noise (Byrnes et al 2012).

However, it is important to consider that no multi-species study has found all species to be sensitive to roadway noise. In several studies that cover a wide range of habitat types it has been shown that while some species become less common near the road, others show the opposite effect, and the importance of these (ecotonal) species may also need to be considered in evaluating the impact of roads (Ferris 1979; Adams and Geis 1981).

Some nocturnal birds and even diurnal raptors are attracted to street lights as a source of increased prey activity; however the Masked Owl (*Tyto novaehollandiae*) is dependent on hearing for capturing small mammal prey at ground level.

The potential impacts from the project may be greatest of a range of threatened bird and amphibian species in terms of altering vocalisations and interrupting breeding cycles and also a range of small mammal species in terms of negatively affecting movement patterns and habitat connectivity.

10.3.8 Impacts to groundwater dependent ecosystems

There are several vegetation communities impacted by the project which are considered to be a form of groundwater dependent ecosystems. They comprise vegetation occurring on waterways and floodplains which are likely to be reliant on groundwater, particularly during drought periods. In the study area, there are five vegetation communities and habitats that have the potential to be affected by impacts to groundwater:

- Freshwater wetlands (13 hectares)
- Sub-tropical coastal floodplain forest (137.1 hectares)
- Swamp sclerophyll forest (93.7 hectares)
- Swamp oak floodplain forest (56.2 hectares)
- Lowland rainforest (10.3 hectares).

These communities are in part supported by shallow groundwater systems that effectively arrest the infiltration of surface waters. These systems are thus surface water reliant with the shallow groundwater acting as local storage that reduces effective evaporation and sustains each species. Elsewhere groundwater is sourced from further afield and is brought to the surface due to impediment to flow or via a topographic low. These groundwater dependent systems therefore occur in many valleys and also in coastal sand environments. Road crossings of these communities can impact on the subsurface flows by blocking drainage passages and groundwater flows. Potential impacts on groundwater recharge rates from general road construction are generally greatest in areas where significant cuttings are required as they have the potential to intersect the water table and affect groundwater levels downstream.

The greatest impacts to groundwater dependent ecosystems are likely to occur within freshwater wetlands located in low lying floodplain areas which are intersected or near the project including the Upper Coldstream Wetland (Section 3), Clarence River Estuary (Section 5), Bundjalung National Park Wetlands (Section 6) and the wetland cluster on Tabbimoble Creek (Section 6). These wetlands have already been identified as under pressure from changed hydrological conditions, exotic weeds and grazing. Oxleyan Pygmy Perch habitat is unlikely within these identified wetlands, however significant impacts to Oxleyan Pygmy Perch would be likely should significant changes to the water table height occur in other wetland habitats where Oxleyan Pygmy Perch is likely to occur such as Redbank and Cassons Creek (Section 1), Tabbimoble Swamp Nature Reserve (Section 7) and Macdonalds Creek (Section 8).

As Oxleyan Pygmy Perch are associated with swamps, streams and dune lakes that lie in the coastal lowland 'wallum' ecosystems with little or no flow, significant changes to the water table height in these ecosystems would result in a reduction in suitable habitat for the Oxleyan Pygmy Perch.

Further details on impacts to groundwater including management measures are detailed in Chapter 9 (Soils, sediment and water).

10.3.9 Impacts to aquatic ecosystems

Waterways modified by the project

A total of 344 water crossing structures (bridges, culverts and pipes) would be constructed across the project. The large majority of these (68 per cent) would be constructed across shallow ephemeral drainage lines consisting of a class 3 or class 4 waterway. The remaining structures would be built across 20 class 1 waterways (10 per cent) and seventy four class 2 waterways (22 per cent).

Water crossing structures have been designed to minimise the impacts of altering the natural flow regimes of the rivers and streams within the region. The design takes into consideration the class of waterways, in particular Class 1 waterways (Fairfull & Witheridge, 2003) as potential threatened fish habitat (including Oxleyan Pygmy Perch and the Purple-spotted Gudgeon and the unlisted Freshwater Catfish and Olive Perchlet). Detailed design of bridges and culverts would be consistent with the Connectivity Strategy design principles (refer to Appendix A of the Working paper – Biodiversity). This would include avoiding creation of barriers to fish movement, and avoiding placement of piers within the waterways, where feasible and reasonable.

Construction and operation of both permanent and temporary waterway crossings such as bridges, causeways, fords and culverts are known to have significant impacts upon passage of fish. Short term impacts include localised disturbance to riparian and instream habitats such as increased sedimentation and shading, bed and bank erosion and sedimentation and pollution (from accidental spills). Long term impacts include the impediment of fish movements or habitat changes.

Barriers to fish passage can prevent breeding or re-population of waterways through restricting access of fish to spawning grounds (Fairfull & Witheridge, 2003). Several freshwater fish species observed within the study area could be impacted by the project such as the Long-finned Eel (*Anguilla reinhardtii*), Empire Gudgeon (*Hypseleotris compressa*) and the Striped Gudgeon (*Gobiomorphus australis*).

Oxleyan Pygmy Perch are thought to use flood events of the Richmond and Clarence rivers to facilitate dispersal, thereby allowing the species to colonise new systems and/or recolonise previously disturbed areas (Knight et al., 2009). Waterway crossings have the potential to inhibit the natural flow of floodwaters, impacting the ability of the Oxleyan Pygmy Perch to recolonise areas. Culverts and causeways can also modify the natural flow of rivers by increasing, decreasing or altering the seasonality, frequency, magnitude and timing of flow.

The project has aimed to provide bridge structures for all Class 1 Waterways and waterways that provide potential habitat for Oxleyan Pygmy Perch. Nineteen out of the 21 Class 1 waterways are crossed by bridges. The remaining two class 1 watercourses (Redbank Creek region and the Unnamed Watercourse at station 134.7 are crossed by culverts). These structures would be reviewed during detailed design with the aim to changing the structure to a bridge. In addition, all drainage structures between station 134.5 to 143.0 would be reviewed in consultation with Department of Primary Industries (Fisheries) to ensure suitable connectivity for threatened fish species is maintained.

The project would result in localised disturbance to and potential removal of riparian habitat in areas crossing or in proximity to waterways. Impacts would be greatest where the project is away from the existing highway, such as at Corindi Creek or Coldstream River (in project sections 1 and 3).

Construction works undertaken within waterways (such as the construction of temporary or permanent crossings) or within 50 metres of these waterways has the potential to impact on bank stability and water quality through excavation, piling works, clearing or placement of construction stockpiles and creation of temporary crossings and adjacent construction access roads.

Water quality

Impacts to water quality during construction could come from:

- Earthworks stockpiles: Sediments could be washed into waterways, increasing turbidity and nutrient levels
- Vegetation stockpiles: Tannins could leach into the waterways, increasing organics in the waterways. This can increase stream Biological Oxygen Demand (BOD) and decrease dissolved oxygen which can affect aquatic life

- Large areas of earthworks (cut and fill embankments): Area of large earthworks in proportion to catchment area would have a greater risk to water quality
- Road/surface pollutant runoff: Pollutants in road runoff include nutrients, heavy metals, pesticides, herbicides and hydrocarbons which can be washed into waterways.

There are a number of identified stockpile sites located near a waterway and are those most likely to impact on water quality. These locations are:

- Section 1 (station 3.3 3.4) stockpile near the Corindi River
- Section 2 (station 19.1 19.8) stockpile near Halfway Creek
- Section 3 (station 45.6 46.0) stockpile near Pillar Valley Creek
- Section 4 (station 79.5 80.0) stockpile near South Arm
- Section 5 (station 86.0) stockpile near James Creek.

Main water quality impacts during construction including the release of sediments, nutrients and contaminated runoff into waterways. Project sections 5, 8, 9 and 10 have large batter areas in proportion to surface water catchment area and therefore have the greatest risk to impact water quality. These sections contain a number of waterways and SEPP14 wetlands, as documented in Section 10.2.5. The potential impacts to water quality in watercourses and SEPP14 wetlands include sedimentation, contamination and nitrification.

Increased pollutant load in road runoff is the main impact to water quality. Runoff from the project would be directed to water quality control basins before being discharged to drains and local waterways. Basins would also be located adjacent to wetlands and watercourses to protect waterways from unexpected spills.

Ensuring water quality is maintained during construction would help to prevent any increase in the numbers of the aquatic pest species which thrive in disturbed aquatic habitats such as the Plague Minnow (*Gambusia holbrooki*). This fish species is a significant predator on native fish and tadpoles, with the greatest abundance in the study area of all fish species, and was confirmed across the project length. The species proliferate in disturbed aquatic habitats and can out-compete and prey upon native species less tolerant of disturbed environments and poor water quality.

Increased sedimentation in waterways can also reduce the availability of water refuge areas for aquatic biota and smother important habitat features such as beds of aquatic macrophytes and the substrate itself. Increased turbidity can also result in a reduction of light penetration, in turn reducing the number of aquatic macrophytes or algae, altering the existing aquatic habitat.

Nutrients or contaminants present in sediments could be released through earthworks or surface runoff. Acid sulfate soils are known to occur within the region, and once disturbed, have the potential to enter water bodies, resulting in habitat degradation, fish disease or kills, losses in food resources, lowered potential for fish migration and recruitment, disturbance to water plant communities and secondary effects on water quality (Stone et al., 1998). High nutrient levels could lead to potentially toxic algal blooms resulting in negative impacts to aquatic fauna.

Poor water quality is already known to occur throughout sections of the study area including black water events within Coldstream River (Section 3) which has resulted in fish kills. Black water events can occur naturally due to the breakdown of large quantities of organic material and can result in low dissolved oxygen levels which can cause stress and eventual death of fish. Anecdotal evidence suggests poor water quality also occurs in Section 4 and 5 due to the use of floodgates and 'cane drains'. Black water can have very high acidity, toxic metals and low dissolved oxygen levels. Continued water quality monitoring is important to determine baseline conditions and ensure that the project does not exacerbate existing poor water quality during construction and operation.

Impacts are expected to be minimal due to implementation of measures such as ensuring appropriate design of water storage areas and temporary drainage systems, controlling runoff from construction areas, and the implementation of a water quality monitoring process.



Photo 4: Oxleyan Pygmy Perch (Nannoperca oxleyana)

Hydrological conditions

There are a number of freshwater and estuarine watercourses in the study area that contain permanent or near permanent flows, and support a variety of fish and macroinvertebrate families. Changes to hydrological conditions as a result of the project could include altered flow regimes, diversion of offsite flow, temporary diversion of waterways and barriers that impede flow. These changes to hydrological conditions can impact both groundwater and surface water. Changes to the hydraulic flow as a result of the installation of culverts and bridges (ie changed to flow velocities or levels) can result in barriers to aquatic fauna movements, changes to aquatic habitat including a gradual decrease in water depth and increased sediment and turbidity. These changes can lead to changes in the suitability of the habitat for fish and stream-dwelling frogs.

Threatened species Oxleyan Pygmy Perch and Purple-Spotted Gudgeon have a narrow set of habitat requirements including a habitat preference for low flows between 0-0.3m/s (Knight 2000) however floods or other high flow events are also thought to play an important role for the species, as temporary watercourses of overflows are thought to carry the species between otherwise isolated bodies of water. Instream structures such as culverts may alter or impede natural flow velocities which may disrupt natural reproductive cues and alter the natural process of erosion and sedimentation resulting in loss of aquatic habitat for threatened fish.

Removal of woody debris

Woody debris provides essential habitat for aquatic organisms, algae, plants, invertebrates and fish. It provides a refuge from predation and a resting place away from the main flow of the waterway and breeding habitat for fish including threatened species. Tree trunks and fallen branches are also structurally important for stabilising stream beds and banks. The removal of large woody debris or snags is a key threatening process under Schedule 6 of the *Fisheries Management Act 1994*.

Woody debris is a significant component of aquatic habitat throughout all waterways crossed by the project and while not quantified, was found in the majority of waterways. Construction of the project, particularly where piers are required in the waterway or near the banks of a creek, may reduce the presence and availability of woody debris and snags if not managed appropriately.

10.3.10 Weeds, pests and spread of pathogens

There are currently 11 key threatening processes listed under the NSW *Threatened Species Conservation Act 1995* that relate to the invasion and establishment of weeds and pests. These include:

- Invasion and establishment of exotic vines and scramblers
- Invasion of native plant communities by Bitou Bush & Boneseed
- Invasion of native plant communities by exotic perennial grasses
- Invasion of native plant communities by African Olive (Olea europaea L. subsp. cuspidata)
- Invasion, establishment and spread of Lantana (Lantana camara)
- Competition and grazing by the feral European rabbit
- Competition from feral honeybees
- Predation by feral cats
- Predation by the European Red Fox
- Predation by the Plague Minnow (Gambusia holbrooki)
- The biological effects including lethal toxin ingestion caused by cane toads

The construction and operation of the project has the potential to increase invasion by weed species, invasion by pest animals or spread of pathogens.

Weed invasion

A total of 154 weed species were confirmed from field surveys along the project. Of these, 21 are declared noxious species under the NSW *Noxious Weeds Act 1993*, relevant to the four local government areas. Table 10-20 identifies weeds that are identified as noxious in each of the local government areas crossed by the project. Eleven weeds of national significance were also noted. One of these, Alligator Weed (*Alternanthera philoxeroides*), was not directly observed but has been noted to occur in Tuckombil Canal (NSW DPI; pers comm.).

Alligator Weed grows in water and on land, affecting both waterways and floodplain areas. It is listed as a weed of national significance and is a major threat to wetlands, rivers and irrigation systems.

During construction there is potential to disperse weed seeds and plant material into adjoining areas of remnant vegetation where weed species do not currently occur. The most likely causes of weed dispersal would be through the movement of soil and attachment of seed (and other propagules) to construction vehicles and machinery involved with clearing of vegetation and stockpiling mulch and topsoil during earthworks. In particular, there is a potential impact of spreading aquatic weeds within the Clarence and Richmond river catchments during construction by earthmoving machinery and water storage equipment, specifically at the bypass of Woodburn over Tuckombil Canal due to the presence of Alligator Weed at this site.

Also known from the North Coast Bioregion is Tropical soda apple (*Solanum viarum*). This is an aggressive, prickly, perennial shrub one to two metres high. It invades open to semi-shaded areas including pastures, forests, riparian zones, and roadsides. It displaces native plants and disrupting ecological processes. The species was not confirmed within the project boundary but is predicted to occur. Construction equipment and movement of soil could also spread Tropical soda apple seeds.

Table 10-20: Noxious weeds and weeds of national significance

	Common name	Notional	Noxious weeds*				1-2	3-5	6-8	9-11
Scientific name		significance	Coffs Harbour	Clarence Valley	Richmond Valley	Ballina	Section	Section	Section	Section
Alternanthera philoxeroides	Alligator Weed	٠	2	2	2	2			٠	
Asparagus aethiopicus	Asparagus Fern	•						٠	٠	•
Asparagus africanus		•							٠	
Asparagus plumosus	Climbing Asparagus Fern	•								•
Ageratina adenophora	Crofton Weed		4	4	4	4	٠	٠	٠	•
Ageratina riparia	Mistflower		4	4	4	4			٠	•
Ambrosia spp.	Ragweed		5	5	5	5		٠		
Ambrosia artemisiifolia	Annual Ragweed		5	5	5	5	٠		٠	•
Baccharis halimifolia	Groundsel Bush		3	3	3	3	٠	٠	٠	•
Chrysanthemoides monilifera subsp. rotundata	Bitou Bush	٠	4	4	4	4	•		٠	•
Senecio sp.	Fireweed		4							•
Senecio madagascariensis	Fireweed	٠	4				•	•	•	•
Xanthium occidentale	Noogoora Burr		4	4	4	4		•		
Anredera cordifolia	Madeira Vine	٠							•	
Bryophyllum delagoense	Mother-of-millions		3					٠	٠	
Bryophyllum pinnatum	Live Plant			3						•
Cinnamomum camphora	Camphor Laurel			4	4	4	٠	•	•	•

			Noxious weeds*				1-2	3-5	8-9	9-11
Scientific name	Common name	significance	Coffs Harbour	Clarence Valley	Richmond Valley	Ballina	Section	Section	Section	Section
Ligustrum lucidum	Large-leaf Privet		4	4	4	4			٠	٠
Ligustrum sinense	Small-leaf Privet		4	4	4	4		٠	•	٠
Sorghum halepense	Johnson Grass		4	4	4	4			•	
Sporobolus indicus	Parramatta Grass		4	4	4	4			•	
Eichhornia crassipes	Water Hyacinth	٠	3	4	4	4			•	
Rubus fruticosus agg.	Blackberry	٠	4	4	4	4		٠		
Salvinia molesta	Salvinia	٠	3	3	3	3		٠		٠
Lantana camara	Lantana	٠	4	4	4	4	•	•	•	٠

*Noxious Weeds Act 1993 – (Sect 8) weed classes 1-5

Pests

Pest animal species can impact on native fauna through predation and competition for feeding or habitat resources. These species could also impact on vegetation through grazing. Identification of and impacts from pest animal species are discussed in Table 10-21.

Table 10-21: Pest species

Species	Impacts
Feral honey bees	Feral honey bees are introduced bees which originally escaped from hives and have subsequently established in the wild, usually centred on tree hollows. While the project would not directly increase bee numbers, the clearing of native vegetation would indirectly increase competition by native fauna with bees for pollen, nectar and nesting hollows. The loss of tree hollows via occupation by feral honeybees reduces the number of hollows available for native animals to breed and shelter. This is of particular concern for species which are threatened and include Squirrel Glider, Yellow-bellied Glider, Brush-tailed Phascogale and several bird, reptile and frog species.
Increased predation by foxes and cats	The project would impact on habitat fragmentation leading to displacement of resident fauna. This could contribute to increased levels of predation on native fauna from foxes and cats. The cat and fox are significant predators in Australia that interact with native fauna in various ways, including predation, competition for resources, and transmission of disease. The level of impact is primarily determined by prey availability. The extent to which roads influence the distribution and abundance of these species and the consequences of these for native fauna, are poorly known. It has been widely accepted that the construction of roads has the potential to facilitate the ingress of predators (including carnivorous mammals, birds and reptiles) into forest environments previously inaccessible to them (Andrews 1990;) or, at least, that the use of roads by feral predators for hunting and movement is commonplace since roads provide easy travelling conditions (Bennett 1991). Andrews (1990) proposed that feral animals are easily introduced into areas where there are roads, as the accompanying edge effect favours species with generalised ecological requirements. Roadkill is more commonplace on heavily used roads and the resulting carcasses are a potential food source for feral predators such as cats and foxes. Generally, foxes prey upon medium-sized to small prey (eg possums and rats) and consume a significant component of scavenged material and vegetation. Cats also prey upon medium- sized to small prey, but may have a greater proportion of reptiles and birds in their diet (May and Norton 1996). The species at greatest risk to increased predation are predicted to be those within a critical weight range of 35 - 55 grams (Burbidge and MacKenzie 1989). This includes a wide range of small to medium-sized mammals including the threatened Rufous Bettong, Long- nosed Potoroo and Common Planigale, all known from the study area.
Plague Minnow (<i>Gambusia</i> <i>holbrooki</i>)	As discussed previously, Plague Minnow have potential to enter stressed waterways during construction and operation. Mitigation measures that limit the disturbance to aquatic habitats and water quality, may minimise the ability for Plague Minnow to outcompete native species, however it is not possible to exclude this species from all waterways.
Rabbits	The clearing of vegetation and associated habitat fragmentation may increase the value of the habitat for rabbits around the project boundary over the long-term. As rabbits tend to colonise more disturbed and modified habitats, any increase in the population of this pest species is more likely to impact on native fauna tolerant of modified habitats. Revegetation of disturbed areas particularly formerly vegetated sites would assist in managing rabbit populations.
Cane Toads	Cane toads have potential to colonise new habitats created by the construction of sediment and detention basins both during construction and over the longer-term operation of the road. However these artificial structures are not unlike farm dams which are a common feature of the landscape surrounding the length of the project. It is unlikely that the introduction of new water basins would result in an expansion of the current range of the species; however provision of artificial structures could increase local population numbers. However, this is considered to be a small potential impact.

Spread of pathogens

Pathogens cause disease in flora and fauna and are usually living organisms such as bacterium, virus or fungus. Several pathogens known in NSW have potential to impact on biodiversity as a result their movement and infection during construction of the project and include:

- Phytopthora (*Phytopthora cinnamomi*): A soil-borne fungus that causes tree death (dieback). Attacks the roots of a wide range of native plant species. This is identified as a key threatening process under the EPBC Act and TSC Act.
- Myrtle rust (Uredo rangelli): An introduced fungus that attacks the young leaves, short tips and stems of Myrtaceous plants eventually killing the plant. Introduction and establishment of exotic Rust Fungi of the order Pucciniales on plants of the family Myrtaceae is identified as a key threatening process under the TSC Act
- Fusariumwilt / Panama disease (*Fusarium exysporum*): Widespread in banana plantations in north coast region including Woolgoolga and Coffs Harbour.
- Chytrid fungus (*Batrachocytrium dendrobatidis*): Infection by chytrid fungus resulting in an infectious disease (*chytridiomycosis*) that affects amphibians worldwide causing death. This is identified as a key threatening process under the EPBC Act and TSC Act.

The potential for pathogens to occur should be considered a high likelihood across the whole project and treated as a potential risk during construction. This is particularly a risk for the project as all sections cross waterways or floodplain habitats where the risk of transmission is higher. Pathogen management should therefore be implemented throughout all stages of construction.

10.3.11 Key threatening processes

Key threatening processes are listed under the TSC Act, FM Act and EPBC Act. Those key threatening processes relevant to the project are discussed in Table 10-22.

Table 10-22: Key threatening process relevant to the project

Key threatening process	Relevant Act	Type of threat	Potential level of threat	Potential impacts
Alteration to the natural flow regime of rivers and streams and their floodplains and wetlands	TSC Act	Habitat loss/change	High	The project would require extensive fill in low-lying areas which has potential to impact on natural surface and groundwater flows.
Bushrock removal	TSC Act	Habitat loss/change	Moderate	Extensive removal of surface rock in some sections is likely, such as sections 1 to 3 and 6 to 7
Clearing of native vegetation	TSC Act and EPBC Act	Habitat loss/change	Very high	The project would result in the clearing of up to 948 hectares of native vegetation
Competition and grazing by the feral European rabbit	TSC Act and EPBC Act	Pest animal	Low- Moderate	Rabbits common particularly in agricultural landscapes. The project is likely to create areas of suitable habitat during construction and operation. This in turn could lead to increased degradation of edge habitats and reduced plant cover.
The biological effects, including lethal toxic ingestion, caused by Cane Toads (<i>Bufo marinus</i>)	TSC Act and EPBC Act	Pest animal	Low	Cane toad could colonise new habitats such as sedimentation basins and water quality ponds. This could result in competition and predation on native fauna and result in intoxication in native fauna that may ingest the species.
Competition from feral honey bees	TSC Act	Pest animal	Moderate	The extensive clearing of vegetation would increase competition for pollen, nectar and tree hollows. In particular when combined with the reduction in hollow bearing trees that is expected from the project, this would place additional pressure on threatened species dependent on tree hollows.
Infection of native plants by <i>Phytophthora cinnamomi</i>	TSC Act and EPBC Act	Pathogen	Moderate	Spores can be dispersed over relatively large distances by surface and sub- surface water flows. Infected soil/root material may be dispersed by vehicles (eg earth moving equipment)
Infection of amphibians with chytrid fungus resulting in chytridiomycosis	TSC Act and EPBC Act	Pathogen	Moderate	Chytrid is a water-borne fungus that may be spread as a result of handling frogs or through cross contamination of water bodies by vehicles and workers.
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	TSC Act	Pathogen	Low	Myrtle rust is an air-borne fungus that may be spread by moving infected plant material, contaminated clothing, equipment and vehicles.
Invasion and establishment of exotic vines and scramblers	TSC Act	Weed	Moderate	The project would contribute to increased weed invasion in adjoining habitats during both construction and operation, and as result of ongoing edge effects.
Invasion of native plant communities by exotic perennial grasses	TSC Act	Weed	High	Several exotic perennial grasses were confirmed in disturbed and modified agricultural areas. These species have the potential to invade in areas affected

Key threatening process	Relevant Act	Type of threat	Potential level of threat	Potential impacts
				by edge effects from the project.
Invasion, establishment and spread of <i>Lantana camara</i>	TSC Act	Weed	High	The project would contribute to increased invasion potential for lantana in adjoining habitats during both construction and operation, and as result of ongoing edge effects.
Predation by feral cats	TSC Act and EPBC Act	Pest animal	Moderate	The project may contribute to increased predation from feral cats, as a result of increased habitat fragmentation, but also potentially through construction activities such as rubbish accumulation or storage at ancillary facilities.
Predation by the European Red Fox	TSC Act and EPBC Act	Pest animal	Low- Moderate	The project may contribute to additional predation from foxes, primarily through habitat fragmentation, but also potentially through construction activities such as rubbish accumulation or storage at ancillary facilities.
Predation by the Plague Minnow (Gambusia holbrooki)	TSC Act	Pest animal	Low- Moderate	The project may contribute to additional predation from Plague Minnow, through the disturbance of aquatic habitats and potential impacts to riparian conditions.
Loss of hollow bearing trees	TSC Act	Habitat loss/ change	High	The project would result in the extensive clearing of hollow bearing trees. The density of hollow bearing trees along the project was estimated at between around 4 to 7 trees per 0.1 hectare plot.
Removal of dead wood and dead trees	TSC Act	Habitat loss/ change	High	The project would result in the removal of dead wood and dead trees in all sections.
Removal of large woody debris from NSW rivers and streams	FM Act	Habitat loss/ change	Moderate	The project would result in the removal of woody debris to construct creek crossings.
Degradation of native riparian vegetation along NSW watercourses	FM Act	Habitat loss/ change	Moderate	The project would require the removal of riparian vegetation to accommodate numerous creek crossing either bridges or culverts.
Increased sedimentation and erosion during construction	FM Act	Habitat loss/ change	Low	There is potential for increased sedimentation due to the construction process.
Instream structures and other mechanisms that alter natural flow	FM Act	Habitat loss/ change	Low	The project would result in the construction of numerous box and pipe culverts and bridges which may modify the natural flow of creeks. This alteration may disrupt natural reproductive cues and natural processes of erosion and sedimentation resulting in a loss of aquatic habitat for fish and macroinvertebrates.

10.3.12 Significance assessment

Assessments of significance have been undertaken for each threatened species confirmed or predicted to have a moderate to high likelihood of occurring within the project boundary.

NSW significance assessment

Table 10-23 identifies those species listed under the *Threatened Species Conservation Act* 1995 and *Fisheries Management Act* 1994 where the project would have a significant impact. The project sections identified are where the species has been confirmed or may potentially occur. Where a significant impact only occurs for some local populations, these project sections are identified in bold.

The project would have a significant impact on 24 threatened fauna species (including one threatened fish species), 12 threatened flora species and five Threatened Ecological Communities. Full details of the assessment of significance are presented in Appendix E of the Working paper - Biodiversity.

Species	Common name	TSC Act / FM Act	Project Section*
THREATENED FAUNA			
Tree-roosting microbats			
Chalinolobus nigrogriseus	Hoary Wattled Bat	V	1-11
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	1-11
Kerivoula papuensis	Golden-tipped Bat	V	1-11
Mormopterus beccarii	Beccari's Freetail-Bat	V	1-11
Mormopterus norfolkensis	Eastern Freetail-Bat	V	1-11
Nyctophilus bifax	Eastern Long-Eared Bat	V	1-11
Saccolaimus flaviventris	Yellow-bellied Sheathtail-Bat	V	1-11
Scoteanax rueppellii	Greater Broad-nosed Bat	V	1-11
Reptiles			
Hoplocephalus bitorquatus	Pale-headed Snake	V	1-3, 6-8
Hoplocephalus stephensii	Stephens' banded snake	V	1-3, 6-8
Rainforest invertebrates			
Nurus atlas	Atlas Rainforest Ground Beetle	E	9-11
Phyllodes imperialis	Pink Underwing Moth	E	9-11
Arboreal and terrestrial mammals			
Petaurus australis	Yellow-bellied Glider	V	1-9
Petaurus norfolcensis	Squirrel Glider	V	1-11
Phascogale tapoatafa	Brush-tailed Phascogale	V	1-9
Phascolarctos cinereus	Koala	V	9-11
Dasyurus maculatus	Spotted-tailed Quoll	V	1-11
Amphibians			
Mixophyes iteratus	Giant- barred Frog	E	1-3, 6-10
Birds			
Lathamus discolor	Swift Parrot	E	1-11
Anthochaera phrygia	Regent Honeyeater	E	1-11
Dromaius novaehollandiae	Coastal Emu	E2	3-5

Table 10-23: Summary of NSW significance assessments

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

Species	Common name	TSC Act / FM Act	Project Section*
THREATENED FLORA			
Angophora robur	Sandstone Rough-barked Apple	V	3-4
Arthraxon hispidus	Hairy Joint Grass	V	9-11
Archiedendron hendersonii	White Lace Flower	V	9-11
Cryptocarya foetida	Stinking Crytpocarya	V	9-11
Cyperus aquatilis	Water Nutgrass	E	6-7
Endiandra hayseii	Rusty Rose Walnut	E	9-11
Endiandra muelleri subsp. bracteata	Green-leaved Rose Walnut	E	9-11
Lindsaea incisa	Slender Screw Fern	E	1-3 , 6-11
Macadamia tetraphylla	Macadamia	V	10
Maundia triglochinoides	-	V	1-3, 6-7
Melaleuca irbyana	Weeping Paperbark	E	1-4, 6-8
Prostanthera cineolifera	Singleton Mint Bush	V	7
THREATENED FISH			
Nannoperca oxleyana	Oxleyan Pygmy Perch	E	1-2, 6-11
ENDANGERED ECOLOGICAL COMMUN	ITIES		
Subtropical Coastal Floodplain Forest	-	E	1-11
Swamp Sclerophyll Forest	-	E	1- 10
Swamp Oak Floodplain Forest	-	E	1, 3-5, 8-11
Lowland Rainforest	-	E	3
Coastal Cypress Pine Forest	-	E	9-11

E = Endangered species; E2 = Endangered population (TSC Act); V = Vulnerable species

Commonwealth significance assessment

Significance assessments were also undertaken for those species listed under the *Environment Protection and Biodiversity Conservation Act* 1999. Table 10-24 identifies those species where the project would have a significant impact. The project would have a significant impact on the critically endangered ecological community Lowland Rainforest of Australia, four species of endangered fauna (including one endangered fish species) and six species of threatened flora. Full details of the assessment of significance for endangered communities and threatened species under the *Environment Protection and Biodiversity Conservation Act* 1999 are presented in Appendix E of the Working paper - Biodiversity.

Significance assessments were undertaken for listed migratory species (refer to section 6.4.2 and Appendix E of the Working paper – Biodiversity), however, the project was found to not have a significant impact on any migratory species.

Species	Common name	Project Section	Important population		
CRITICALLY ENDANGERED ECOLOGICAL COMMUNITY					
Lowland Rainforest of Australia					
ENDANGERED FAUNA					
Lathamus discolor	Swift Parrot	1-11	-		
Xanthomyza phrygia	Regent Honeyeater	1-11	-		
Phyllodes imperialis	Pink Underwing Moth	9-11	-		
Dasyurus maculatus maculatus	Spotted-tailed Quoll	1-11	-		
Mixophyes iteratus	Giant- barred Frog	1-4, 6-10	-		
ENDANGERED FISH					
Nannoperca oxleyana	Oxleyan Pygmy Perch	1-2, 6-11	-		
VULNERABLE FAUNA					
Phascolarctos cinereus	Koala	1-3, 6-11	-		
VULNERABLE FLORA					
Angophora robur	Sandstone Rough Barked Apple	3-4	Yes		
Arthraxon hispidus	Hairy Joint-grass	8-11	Yes		
Cryptocarya foetida	Stinking Cryptocarya	8-11	Yes		
Endiandra hayesii	Rusty Rose Walnut	8-11	Yes		
Macadamia tetraphylla	Rough-shelled Bush Nut	7-11	No		
Prostanthera cineolifera	Singleton Mint Bush	7	Yes		

Table 10-24: Summary of Commonwealth significance assessments

[^] Important Population as determined by the *Environment Protection and Biodiversity Conservation Act* 1999 is one that for a vulnerable species:

a is likely to be key source populations either for breeding or dispersal

b is likely to be necessary for maintaining genetic diversity

c is at or near the limit of the species range.



Photo 5: Giant barred Frog (Mixophyes iterates)

10.3.13 Regional 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 caused by an activity in combination with other past, present, and reasonably foreseeable human activities.

Historical vegetation loss

The data in Table 10-24 below lists each Mitchell Landscape type in the Northern Rivers Catchment Management Authority area and an estimate of the historical percentage cleared. To obtain these estimates, the NSW Landscapes coverage (Mitchell, 2003) was intersected with a presence/absence layer of native vegetation in NSW.

 Table 10-25: Mitchell Landscapes with historical per cent cleared estimates for the Northern Rivers CMA region

Project section	Mitchell (2003) ecosystems	Landscape characteristics	Historical percentage cleared*
1	Coastal barriers	Manning-Macleay Beaches and Barriers	35%
	Manning-Macleay	Manning-Macleay Coastal Alluvial Plain	64%
		Brooms Head- Kempsey Coastal Ramp	31%
2-3	Clarence Basin	Grafton-Whiporie Basin	35%
3		Summervale Range	12%
3-8, 10- 11		Clarence-Richmond Alluvial Plains	75%
6-7		Ballina Coastal Ramp	13%
8-9	Coastal Barriers	Clarence-Richmond Barriers and Beaches: Beaches	39%

The majority of the vegetation clearing in the Northern Rivers Catchment Management Authority area has historically occurred in the fertile Clarence-Richmond alluvial plains landscape (75 per cent) of which significant parts of the project would traverse (ie sections 2 to 8, 10 and 11). These sections of the project also traverse other landscape ecosystems.

The estimate of the historical clearing of Threatened Ecological Communities from the known former distribution is shown in Table 10-26. The project would result in the clearing of 337 hectares of Threatened Ecological Communities. In some instances, this includes the total distribution and includes other regions such as Sydney Basin and NSW South Coast in addition to the NSW North Coast Bioregion.

Table 10-26: Estimates historical clearing of Threatened Ecological Communities relevant to the project

Threatened Ecological Community	Estimated historically cleared
Sub-Tropical Coastal Floodplain Forest of the NSW North Coast Bioregion	40-70%
Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	75%
Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions	75%
Coastal Cypress Pine Forest in the NSW North Coast Bioregion	40%
Freshwater Wetlands On Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	40-80%
Lowland Rainforest in NSW North Coast and Sydney Basin Bioregions	97% (Floyd 1990)

Pacific Highway Upgrade Program

The contribution of the project to the potential long-term cumulative biodiversity impacts in the region has been assessed by considering the extent of native vegetation clearing associated with the entire Pacific Highway Upgrade Program. This includes the cumulative loss of Threatened Ecological Communities (Table 10-27).

The total clearing of native vegetation to-date for Pacific Highway upgrades from the F3 Freeway near Hexham to the Queensland border (with the exception of the project) is estimated to be around 1574 hectares. The project would see an additional 948 hectares cleared and increase the total clearing for the Pacific Highway upgrade to 2615 hectares. This total includes 621.7 hectares of listed Threatened
Ecological Communities. The project would contribute to about 36 per cent of the vegetation clearing across the whole Pacific Highway Upgrade Program.

Table	10-27:	Extent	of native	vegetation	clearing	by the	Pacific	Highway	Upgrade	Program

Project	Project length (km)	Direct native vegetation clearing (hectares)	Threatened Ecological Community clearing (hectares)
Projects completed			
Raymond Terrace bypass duplication	6.5	5	2
Raymond Terrace to Karuah	17.3	37	4
Karuah Bypass	9.8	36	3
Karuah to Bulahdelah	32.4	123	9
Bulahdelah to Coolongolook	20.8	106	8
Wang Wauk to Bundacree	4.3	10	0
Bundacree Creek to Possum Brush	9.9	4	1
Coopernook Bypass	4.2	2	1
Coopernook to Moorland	10.2	8	3
Moorland to Herons Creek	22.2	64	5
Bonville Bypass	10.1	56	0
Lyons to England Road	4.5	2	1
Halfway Creek	2.5	12	0
Tandy's Lane Upgrade	6	1	1
Brunswick to Yelgun	8.6	49	8
Yelgun to Chinderah	28.9	30	12
Glenugie Upgrade	5.8	65	5
Ballina Bypass	11.2	11	9
Banora Point Upgrade	2.5	8	4
Sub-total	217.7	629 hectares	76 hectares
Projects recently approved or currently und	ler construction		
Bulahdelah Bypass	8.4	33	3
Kempsey to Eungai	40	286	63
Sapphire to Woolgoolga Upgrade	24.5	120	27
Tintenbar to Ewingsdale	17	10	2
Devils Pulpit Upgrade	7	54	12
Oxley Highway to Kempsey	37	203	36
Warrell Creek to Urunga	42	255	60
Sub-total	175.9	961 hectares	203 hectares
Projects in the planning phase			
F3 to Raymond Terrace	8.9	49	Assessment not completed
Coffs Harbour Bypass	12	21	Assessment not completed
Woolgoolga to Ballina	155	948	337.7
Sub-total	175.9	1 018 hectares	337.7 hectares
Total Pacific Highway Upgrade Program	569.5	2608 hectares	616.7 hectares

In addition to direct clearing of vegetation and fauna habitat, the cumulative impacts on biodiversity from the upgrade of the Pacific Highway includes 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.

The Pacific Highway Upgrade Program has spanned over 15 years from planning to construction. Within this time NSW Road and Maritime Services has developed and incorporated considerable knowledge through adaptive management and critical evaluation of road design. Numerous policies and best practice guidelines for appropriate avoidance and management of potential biodiversity impacts during construction and operation as well as a policy for offsetting impacts have been developed. These policies and practices have provided effective mitigation measures and procedures to manage biodiversity impacts and minimise the cumulative impacts of the Program.

10.4 Management of impacts

10.4.1 Minimisation of impacts

The route selection phase

The RMS sought to minimise biodiversity impacts through the route selection phase of the project (further information on the route selection process is provided in Chapter 4). The previous development projects identified significant ecological values to inform planning decisions, so to avoid and minimise impacts to biodiversity. This involved a preliminary examination of a number of possible route options and their potential impacts on the environment and other factors (for example, economic and social considerations).

Minimising impacts involved reducing the loss of habitat or potential impacts on state and Commonwealth listed threatened species, populations and communities. Detailed surveys of shortlisted options were undertaken to refine the alignment and width of the footprint to further minimise the loss of important vegetation communities and habitats and avoid significant plant species or fauna habitat features. The engineering constraints and RMS road design and safety standards were also considered when determining the project alignment and footprint.

The selection of the preferred route was partially influenced by the ecological investigations. The data informed both the route selection processes and the preliminary design of the preferred route corridor. The route selection process considered total potential vegetation and habitat loss in addition to habitat condition and the presence of species and ecological communities of conservation significance.

Any impacts that could not be avoided were appropriately assessed and mitigation measures identified.

Detailed design phase

While the EIS has assessed a level of disturbance and clearing of vegetation as a result of the project, there are further opportunities to avoid and minimise the loss of native vegetation and fauna habitat during the detailed design. The following actions would be prioritised during detailed design:

- · Avoiding and minimising vegetation removal wherever possible
- Selection of ancillary facilities. The ancillary facilities identified in this EIS present a number of
 potential sites. Prior to construction an evaluation should be conducted to avoid native vegetation
 clearing if possible. At some sites additional survey and assessment would be undertaken to
 survey and map hollow-bearing trees and check for large nests for species such as raptors,
 including Osprey and also Black-necked Stork at these sites
- Construction compounds and stockpile sites are to be sited in cleared or sparsely treed portions of the ancillary facility sites where feasible and reasonable, to avoid clearing of native vegetation or threatened flora species
- Water quality basins are to be placed in the optimal location for treating surface runoff. During
 detailed design, the location of water quality treatment measures are to consider the competing
 environmental requirement of minimising vegetation removal, particularly where there is the
 potential for threatened plant species, threatened fauna habitat or in identified regional wildlife
 corridors.

10.4.2 Management and mitigation measures

An overarching biodiversity management framework for the whole project has been developed. This would enable a consistent approach to the mitigation and management of biodiversity across the whole project.

The objectives of the biodiversity management framework are to:

- Maintain and protect existing biodiversity as a priority wherever possible
- · Maintain and protect species and populations of national and state conservation significance
- · Maintain existing water quality and hydrological flow regimes
- Minimise the loss of vegetation and habitat
- Minimise pollution and degradation
- Maintain habitat connectivity and facilitate fauna movements and dispersal of species in important fauna areas for both terrestrial and arboreal fauna
- Minimise fauna mortality, injury and direct damage to individual plant species
- · Provide habitat and opportunities for displaced fauna
- Offset unavoidable/residual impacts to significant biodiversity.

The biodiversity management framework includes a monitoring strategy and a Connectivity Strategy. In addition, a strategy to offset residual impacts on biodiversity has been developed. These strategies are detailed in Working paper – Biodiversity.

A range of mitigation measures have been identified to minimise the impact of habitat loss and fragmentation on threatened fauna species potentially impacted by the project. These include:

- Implementation of pre-clearing and clearing procedures
- Weeds and disease management
- Installation of fauna underpasses, overpasses and arboreal crossing structures
- Installation of fauna fencing
- Management of aquatic habitats for threatened fish.

Monitoring strategy

A monitoring strategy would assess the effectiveness and success of the proposed biodiversity mitigation and management measures for NSW and Commonwealth listed threatened species. The strategy would be a measurable and targeted monitoring program. An outline of the monitoring program is provided in Working paper – Biodiversity (Appendix B). Identification of those fauna connectivity structures that are to be targeted as part of this monitoring strategy are identified in Table 10-29. This program would be finalised following project approval to incorporate any specific conditions of consent. The monitoring program would then be implemented prior to construction of each section of the project. The program objectives would include:

- A targeted monitoring methodology for threatened species adjacent to the project
- An adaptive approach to monitoring that assesses the effectiveness of mitigation measures and allows for modification if necessary. Monitoring is to be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods following establishment of vegetation planted as part of the project
- Assessing changes to habitat usage, to identify whether the change is as a result of the project
- Details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project
- Provision for annual reporting of monitoring results.

Connectivity Strategy

The Connectivity Strategy focuses both on design and management actions that may minimise the barrier effect of the project (refer to Appendix A of the Working paper – Biodiversity).

The goal of the strategy is to maintain connectivity in the landscape, and where feasible and reasonable, enhance connectivity. The Connectivity Strategy presents:

- Guiding principles: basis for developing whole of project connectivity goals and influence decision making. These principles were developed in consultation and agreement with EPA
- Connectivity strategy goals: provides a focus for the strategy that is appropriate at a local and regional level
- Decision-making framework: presents a framework for meeting the connectivity goals including identification of the issues and how these have been met, outlines future monitoring needs and strategic connectivity enhancement opportunities
- Connectivity design measures: details the structures proposed, fencing requirements and further recommendations and design principles for consideration at detailed design.

Connectivity goals were established for key threatened species to guide the development of connectivity structures and consideration of fauna fencing. These goals are identified in Table 10-28.

Important populations	Project section	Connectivity goal
Oxleyan Pygmy Perch & Purple spotted Gudgeon	1 and 7-9	Maintain natural flooding regimes which are required for dispersal of individuals and minimise impacts on critical water quality conditions (appropriate for threatened fish) during construction and operation.
Rufous Bettong	1-3	Reduce and minimise roadkill to maintain viable populations
Common Planigale	1-3	Reduce and minimise roadkill to maintain viable populations
Yellow-bellied Glider	1-2	Promote gene flow and provide functional crossing opportunities
Squirrel Glider	1-4, 7 and 9	Promote gene flow and provide functional crossing opportunities
Brush-tailed Phascogale	1-2 and 7	Reduce and minimise roadkill to maintain viable populations
Emu population	3-4	Maintaining access to important habitat for pre-and post breeding life cycle activities and minimise road mortality to maintain a viable population.
Spotted-tailed Quoll	1-2 and 7-9	Maintain home range movements for individuals, maintenance of connectivity for populations and to prevent and minimise roadkill
Koala	7 and 9-10	Maintain home range movements for individuals, maintenance of connectivity for populations and to prevent and minimise road kill
Long-nosed Potoroo	10	Prevent and minimise roadkill
Giant Barred Frog	1-3, 6-8	Maintain access to important habitat and prevent and minimise roadkill
Green-thighed Frog	2 and 6-7	Maintain access to important habitat
Wallum Froglet	7-9	Maintain access to important habitat
Olongburra Frog	9	Maintain access to important habitat
Cioliguulta Flog	3	Maintain access to important nabitat

Table 10-28: Species specific connectivity goals

The connectivity structures addressed in the strategy include arboreal crossing structures, landbridges and underpasses. Dedicated and combined connectivity structures as well as incidental emu crossing structures, developed as part of the concept design, are detailed in Table 10-29 and shown in Figure 10-31 to Figure 10-56. Table 10-29 also identifies in the last column those structures that would be targeted as part of the monitoring program. Where those structures would be monitored for a specific species, this is identified in brackets. Further details on all connectivity structures (including incidental structures which are not detailed here) are provided in Appendix A of the Working paper- Biodiversity.



Photo 6: Example of a rope / timber pole crossing structure for arboreal mammals

Table 10-29: Fauna crossing structures

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
Project s	ection 1							
1.5	Rope or timber poles	65 metres long	Dedicated- arboreal crossing	Yellow-bellied Glider, Squirrel Glider	Yes	Class 3 & 4	Station 1.5 to 2.2	No
2.1	2 cell culvert	3 x 2.4	Combined drainage and fauna structure	Frogs, small-medium mammals, reptiles	Yes	Class 1	Station 3.0 to 4.0	No
3.5	Corindi Creek bridge	90 metres long	Combined drainage and fauna structure	Fish, small- large mammals, frogs, reptiles	Yes	Class 3 & 4	No	No
4.0	Corindi floodplain bridge	300	Combined drainage and fauna structure	Rufous Bettong, + small- large mammals, herpetofauna	No	Class 1	Yes	No
4.7	Cassons Creek bridge	76 metres long	Combined drainage and fauna structure	Oxleyan Pygmy Perch, small- medium mammals, herpetofauna	Yes	Class 1	Yes	No
5.6	1 cell culvert (service road)	2.4 x 1.2	Combined drainage and fauna structure	Oxleyan Pygmy Perch	Yes	Class 1	Yes	No
5.7	2 cell culvert (highway)	2.4 x 0.9	Combined drainage and fauna structure	Oxleyan Pygmy Perch	Yes	Class 1	Yes	Yes
6.8	1 cell culvert	3 x 3	Dedicated fauna underpass	Rufous Bettong, Spotted-tailed Quoll	Yes	Class 3 & 4	Yes	Yes (Rufous Bettong)
7.3	1 cell culvert	3 x 3	Combined drainage and fauna structure	Rufous Bettong, Spotted-tailed Quoll	Yes	N/A	Yes	Yes (Rufous Bettong)
8.5	1 cell culvert	3 x 3	Dedicated fauna underpass	Rufous Bettong, Spotted-tailed Quoll	Yes	Class 3 & 4	Yes	Yes (Rufous Bettong)
10.7	2 cell culvert	3 x 3	Combined drainage and fauna structure	Rufous Bettong, Spotted- tailed Quoll	Yes	N/A	No	No

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
11.8	1 cell culvert	3 x 3	Dedicated fauna underpass	-	Yes	Class 3 & 4	Yes	Yes
12.3	1 cell culvert	3 x 3	Combined drainage and fauna structure	Koala, Spotted-tailed Quoll	Yes	N/A	No	No
12.8	Rope or timber poles	65 metres long	Dedicated- arboreal crossing	Yellow-bellied Glider, Squirrel Glider	Yes	Class 3 & 4	Yes	Yes
12.9	1 cell culvert	3 x 3	Combined drainage and fauna structure	Rufous Bettong, Spotted-tailed Quoll, Common Planigale	Yes	Class 2	Yes	Yes
13.3	2 cell culvert	3 x 3	Combined drainage and fauna structure	Rufous Bettong, Spotted-tailed Quoll, Common Planigale	Yes	Class 2	Yes	Yes
13.8	1 cell culvert	3 x 3	Combined drainage and fauna structure	Rufous Bettong, Spotted-tailed Quoll, Common Planigale	Yes	Class 3 & 4	Yes	Yes
14.3	2 cell culvert	3 x 3	Combined drainage and fauna structure	-	No	Class 3 & 4	No	No
Project s	section 2							
17.0	Rope or timber poles	65 metres long	Dedicated arboreal crossing	Yellow-bellied Glider, Squirrel Glider	Yes	N/A	No	Yes
20.7	4 cell culvert	3 x 2.4	Combined drainage and fauna structure	Rufous Bettong, Brush-tailed Phascogale	Yes	Class 3 & 4	Yes	Yes
20.7	Halfway Creek bridge	50 metres long	Combined drainage and fauna structure	Rufous Bettong, Brush-tailed Phascogale	Yes	Class 1	Yes	Yes
20.9	1 cell culvert	3 x 2.4	Combined drainage and fauna structure	Rufous Bettong, Brush-tailed Phascogale	Yes	Class 3 & 4	Yes	Yes

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
21.3	1 cell culvert	3 x 3	Combined drainage and fauna structure	Rufous Bettong, Brush-tailed Phascogale	Yes	Class 3 & 4	Yes	Yes
22.4	Wells Crossing bridge	60 metres long	Combined drainage and fauna structure	Rufous Bettong, Brush-tailed Phascogale	Yes	Class 1	Yes	Yes
23.1	1 cell culvert	3 x 2.4	Dedicated fauna underpass	Rufous Bettong, Brush-tailed Phascogale	Yes	N/A	Yes	Yes
24.6	1 cell culvert	3 x 2.4	Combined drainage and fauna structure	Rufous Bettong, Brush-tailed Phascogale	Yes	Class 3 & 4	No	No
26.0	1 cell culvert	3 x 2.4	Dedicated fauna underpass	-	No	N/A	No	No
27.4	1 cell culvert	3.6 x 2.4	Combined drainage and fauna structure	Rufous Bettong, Brush-tailed Phascogale	Yes	Class 3 & 4	Yes	No
Project	section 3							
35.2	2 cell culvert	2.4 x 2.4	Combined drainage and fauna structure	Rufous Bettong	Yes	Class 3 & 4	Station 35.0 to 80.2	Yes
36.4	Pheasant Creek bridge	75 metres long	Combined drainage and fauna structure	Rufous Bettong	Yes	Class 3 & 4	Station 35.0 to 80.2	Yes
37.3	2 cell culvert	2.4 x 2.4	Combined drainage and fauna structure	Rufous Bettong	Yes	Class 3 & 4	Station 35.0 to 80.2	Yes
39.7	11 cell culvert	3.0 x 1.2	Combined drainage and fauna structure	Rufous Bettong, herpetofauna	Yes	Class 3 & 4	Station 35.0 to 80.2	No
42.6	Coldstream River 1 bridge	135 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Class 1	Station 35.0 to 80.2	Yes (emu)

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
43.2	Coldstream River 2 bridge	315 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Class 1	Station 35.0 to 80.2	Yes (emu)
43.9	Coldstream River 3 bridge	180 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Class 1	Station 35.0 to 80.2	Yes (emu)
45.5	Wooli Road overpass	60	Incidental Emu Structure (road overpass)	Emu	No	N/A	No	No
46.1	Pillar Valley Creek 1 bridges	100 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Class 1	Station 35.0 to 80.2	Yes (emu)
46.4	Pillar Valley Creek 2 bridges	100 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Class 1	Station 35.0 to 80.2	Yes (emu)
46.7	Pillar Valley Creek 3 bridges	75 metres long	Combined drainage and Emu structure	Emu, medium to large mammals, herpetofauna	Yes	Class 3 & 4	Station 35.0 to 80.2	Yes (emu)
47.7	Pillar Valley Creek 4 bridge	75 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Class 1	Station 35.0 to 80.2	No
48.1	Rope or timber poles	65 metres long	Dedicated arboreal crossing	Squirrel Glider, Sugar Glider	Yes	N/A	Station 35.0 to 80.2	No
48.8	Mitchell Road underpass	36 metres long	Incidental Emu Structure (road underpass)	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	N/A	Station 35.0 to 80.2	Yes (emu)
49.3	North of Pillar Valley 1 bridge	120 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	Class 3 & 4	Station 35.0 to 80.2	Yes (emu)

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
50.3	North of Pillar Valley 2 bridge	45 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	Class 3 & 4	Station 35.0 to 80.2	Yes (emu)
50.5	Rope or timber poles	65 metres long	Dedicated arboreal crossing	Squirrel Glider, Sugar Glider	Yes	N/A	Station 35.0 to 80.2	No
51.4	1 cell culvert	2.4 x 3.6	Combined drainage and fauna structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	Class 3 & 4	Station 35.0 to 80.2	Yes (emu)
51.9	Firth Heinz Road overpass	60 metres long	Incidental Emu Structure (road overpass)	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	N/A	Station 35.0 to 80.2	No
52.5	Chaffin Creek bridge	75 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Class 1	Station 35.0 to 80.2	Yes (emu)
52.6	6 cell culvert	3.6 x 2.1	Combined (fauna and emu)	small to medium mammals including Rufous Bettong and herpetofauna	Yes	Class 3 & 4	Station 35.0 to 80.2	No
53.7	1 cell culvert	3.6 x 3.6	Combined (fauna and emu)	-	Yes	Class 3 & 4	Station 35.0 to 80.2	Yes (emu)
53.9	Rope or timber poles	65 metres long	Dedicated arboreal crossing	Squirrel Glider, Sugar Glider	Yes	N/A	Station 35.0 to 80.2	No
54.7	North of Chaffin Creek bridge	90 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	Class 3 & 4	Station 35.0 to 80.2	Yes (emu)
55.5	Bostock Road overpass	60 metres long	Incidental Emu Structure (road overpass)	Emu, medium to large mammals including Rufous Bettong, herpetofauna	No	N/A	Station 35.0 to 80.2	Yes (emu)
56.9	Somervale Road underpass	30 metres long	Incidental Emu Structure (road underpass)	Emu, medium to large mammals including Rufous Bettong, herpetofauna	No	N/A	Station 35.0 to 80.2	Yes (emu)

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
57.0	Champions Creek bridge	90 metres long	Combined drainage and Emu structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna	No	N/A	Station 35.0 to 80.2	Yes (emu)
58.7	North of Champions Creek bridge	75 metres long	Combined drainage and Emu structure	Emu	No	Class 3 & 4	No	No
59.3	1 cell arch culvert	Min 5.5 high	Combined drainage and Emu structure	Emu	No	N/A	No	No
60.8	1 cell arch culvert	Min 5.5 high	Combined drainage and Emu structure	Emu	No	Class 3 & 4	No	No
61.0	Property access bridge	35 metres long	Incidental Emu Structure (road underpass)	Emu, medium to large mammals including Rufous Bettong, herpetofauna	No	N/A	Station 35.0 to 80.2	Yes (emu)
63.6	Property access overpass	100 metres long	Incidental Emu Structure (road overpass)	Emu, medium to large mammals including Rufous Bettong, herpetofauna	No	N/A	Station 35.0 to 80.2	Yes (emu)
64.5	1 cell arch culvert	Min 5.5 high	Combined drainage and Emu structure	Emu	No	N/A	No	No
64.9	Crowleys Road property access overpass	60 metres long	Incidental Emu Structure (road overpass)	Emu, medium to large mammals including Rufous Bettong, herpetofauna	No	N/A	Station 35.0 to 80.2	Yes (emu)
66.2	1 cell arch culvert	Min 4.0 high	Dedicated Emu Structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna	No	N/A	Station 35.0 to 80.2	Yes (emu)
Project s	ection 4							
70.5	Tyndale Cane Drain 1 bridge	15 metres long	Combined drainage and fauna structure	Emu	No	Class 3 & 4	Station 35.0 to 80.2	Yes (emu)

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
74.8	Shark Creek bridge	450 metres long	Combined drainage and fauna structure	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	No	Class 1	Station 35.0 to 80.2	Yes (emu)
75.6	1 cell culvert	3.6 x 2.4	Combined (fauna and emu)	Small to medium mammals	No	Class 3 & 4	Station 35.0 to 80.2	No
75.9	Rope or timber poles	65 metres long	Dedicated arboreal crossing	Possums	No	N/A	Station 35.0 to 80.2	No
75.92	Rope or timber poles	65 metres long	Dedicated arboreal crossing	Gliders	No	N/A	Station 35.0 to 80.2	No
76.5	1 cell culvert	2.4 x 2.4	Combined drainage and fauna structure	Small to medium mammals	No	Class 3 & 4	Station 35.0 to 80.2	No
Project s	section 5							
83.1	Koala Drive bridge	30 metres long	Combined access and fauna structure	Small to medium mammals, herpetofauna	No	N/A	Station 82.5 to 85.1	No
94.0	Clarence River North Arm bridge	220 metres long	Combined drainage and fauna structure	Major Fish Habitat	No	Class 1	No	No
Project s	ection 6							
99.7	1 cell culvert	3.0 x 2.4	Dedicated fauna underpass	small to medium mammals	Yes	N/A	Station 97.9 to 101.3	No
100.6	1 cell culvert	2.4 x 1.8	Combined drainage and fauna structure	small to medium mammals	Yes	Class 3 & 4	Station 97.9 to 101.3	No
101.1	1 cell culvert	3.0 x 2.4	Dedicated fauna underpass	-	No	N/A	No	No
101.5	Tabbimoble Creek bridge	130 metres long	Combined drainage and fauna structure	small to medium mammals and herpetofauna, Major fish habitat	Yes	Class 1	Station 101.3 to 101.9	No

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
Project s	section 7							
111.6	Rope or timber poles	metres long	Dedicated arboreal crossing	Gliders and possums	Yes	N/A	Yes	No
113.9	Bridge	15 metres long	Combined (Oxleyan Pygmy Perch)	Oxleyan Pygmy Perch	Yes	Class 1	No	No
115.3	Tabbimoble Floodway No 1 bridge	90 metres long	Combined drainage and fauna structure	Oxleyan Pygmy Perch, small to medium mammals, herpetofauna	Yes	Class 2	No	No
116.4	Rope or timber poles	65 metres long	Dedicated arboreal crossing	Gliders and possums	Yes	N/A	Station 111.6 to 128.4	No
118.8	Tabbimoble Nature Reserve land bridge	75 metres long	Dedicated fauna overpass	Spotted-tailed Quoll, Koala, Brush-tailed Phascogale (small, medium & large mammals, birds & herpetofauna)	Yes	N/A	Station 111.6 to 128.4	Yes
122.6	3 cell culvert	3.0 x 2.4	Combined drainage and fauna structure	small-medium mammals, herpetofauna	No	Class 3 & 4	Station 111.6 to 128.4	No
123.6	4 cell culvert	3.0 x 2.4	Combined drainage and fauna structure	small-medium mammals, herpetofauna	Yes	Class 2	Station 111.6 to 128.4	No
Project s	ection 8							
130.1	Tuckombil Canal bridge	150 metres long	Combined drainage and fauna structure	macropods, Major fish habitat	No	Class 1	No	No
131.1	Woodburn Floodway Viaduct 1 bridge	75 metres long	Combined drainage and fauna structure	Oxleyan Pygmy Perch	No	Class 2	No	No
134.6	1 cell culvert	1.8 x 1.2	Combined drainage and fauna structure	Oxleyan Pygmy Perch	No	Class 1	No	No

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
136.7	MacDonalds Creek bridge	20 metres long	Combined drainage and fauna structure	Oxleyan Pygmy Perch	Yes	Class 1	No	No
Project s	section 9							
138.4	1 cell culvert	1.2 x 1.2	Dedicated frog and small mammal underpass	Small mammals, herpetofauna	Yes	N/A	Station 137.8 to 141.0	Yes
138.8	Broadwater National Park land bridge 1	90 metres long	Dedicated fauna overpass	Koala, small to large mammals, birds, herpetofauna	Yes	N/A	Station 137.8 to 141.0	Yes
139.4	Culvert	1.2 x 1.2	Dedicated frog and small mammal underpass	Small mammals, herpetofauna	Yes	N/A	Station 137.8 to 141.0	Yes
139.9	Broadwater National Park land bridge 2	80 metres long	Dedicated fauna overpass	Koala, small to large mammals, birds, herpetofauna	Yes	N/A	Station 137.8 to 141.0	Yes
140.6	Rope or timber poles	150 metres long	Dedicated arboreal species	Gliders, possums	Yes	N/A	Station 137.8 to 141.0	No
142.2	Twin bridges	15 metres long	Combined drainage and fauna structure	Oxleyan Pygmy Perch	No	Class 2	No	No
143.2	3 cell culvert	2.4 x 0.45	Combined drainage and fauna structure	Oxleyan Pygmy Perch	Yes	Class 2	Station 142.8 to 145.1	No
143.8	1 cell culvert	3.6 x 1.2	Combined drainage and fauna structure	Small-medium mammals, herpetofauna	Yes	Class 3 & 4	Station 142.8 to 145.1	No
Project s	section 10							
145.1	Broadwater viaduct 3	75 metres long	Combined drainage and fauna structure	macropods, birds	Yes	Class 3 & 4	Station 142.8 to 145.1	No
145.3	Richmond River bridge	790 metres long	Combined drainage and fauna structure	macropods, birds, major fish habitat	Yes	Class 1	No	No

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
146.4	2 cell culvert	3 x 3	Combined (Oxleyan Pygmy Perch)	Koala, small to large mammals, Black Bittern, herpetofauna	Yes	Class 3 & 4	Station 146.1 to 159.7 (for Koalas)	No
149.2	Wardell viaduct 4: Bingal Creek	20 metres long	Combined drainage and fauna structure	-	Yes	Class 3 & 4	Station 146.1 to 159.7 (for Koalas)	No
150.0	3 cell culvert	3.6 x 1.5	Combined drainage and fauna structure	Small-medium mammals, herpetofauna	Yes	Class 3 & 4	Station 146.1 to 159.7 (for Koalas)	No
150.5	1 cell culvert	2.4 x 1.5	Combined drainage and fauna structure	Small-medium mammals, herpetofauna	Yes	Class 3 & 4	Station 146.1 to 159.7 (for Koalas)	No
150.6	5 cell culvert	3.6 x 1.6	Combined drainage and fauna structure	Small-medium mammals, herpetofauna	Yes	Class 3 & 4	Station 146.1 to 159.7 (for Koalas)	No
151.9	Wardell viaduct 6	20 metres long	Combined drainage and fauna structure	macropods, herpetofauna	No	Class 3 & 4	Station 146.1 to 159.7 (for Koalas)	No
155.4	Property access bridge	15 metres long	Combined drainage and fauna structure	-	No	Class 3 & 4	No	No
156.0	North Wardell land bridge	60 metres long	Dedicated fauna landbridge	Koala, Long-nosed Potoroo	Yes	N/A	Station 146.1 to 159.7 (for Koalas)	Yes
156.3	4 cell culvert	3.3 x 1.2	Combined drainage and fauna structure	Long-nosed Potoroo	Yes	Class 3 & 4	Station 146.1 to 159.7 (for Koalas)	Yes
157.0	3 cell culvert	1.8 x 1.2	Combined drainage and fauna structure	Long-nosed Potoroo	Yes	Class 3 & 4	Station 146.1 to 159.7 (for Koalas)	Yes
157.6	4 cell culvert	4.2 x 2.1	Combined	-	Yes	Class 3 & 4	Station 146.1	No

Station	Structure type	Approximate dimensions(m)	Functionality	Targeted fauna group	Key habitat / corridor	Waterway class	Fauna fencing required	Structure to be monitored
			drainage and fauna structure				to 159.7 (for Koalas)	
157.7	2 cell culvert	3.6 x 1.8	Combined drainage and fauna structure	-	Yes	Class 3 & 4	Station 146.1 to 159.7 (for Koalas)	No
157.8	North Wardell viaduct 7: Ravelles Creek	20 metres long	Combined drainage and fauna structure	Small-medium mammals, herpetofauna	Yes	Class 2	Station 146.1 to 159.7 (for Koalas)	No
Project s	ection 11							
158.9	4 cell culvert	3.6 x 1.8	Combined drainage and fauna structure	Small-medium mammals, herpetofauna	Yes	Class 3 & 4	No	No
164.7	Emigrant Creek bridge	220 metres long	Combined drainage and fauna structure	Major fish habitat + small- medium mammals, herpetofauna	No	Class 1	No	No

Suitability of connectivity structures

Previous studies and investigations both in Australia and internationally, have reviewed the suitability and effectiveness of road crossing structures.

In Australia, there are several published studies also providing measurable evidence for the effectiveness of purpose built fauna crossing structures. This includes arboreal mammals (Goldingay et al 2011), small to medium sized terrestrial mammals and amphbians and reptiles (SMEC, 2007). Among these are several threatened fauna species such as Koala, Spotted-tailed Quoll, Squirrel Glider and possibly the Long-nosed Potoroo and Black Bittern.

Land bridges are known to provide passage for macropods (Bond and Jones, 2007), particularly when fencing is used to funnel fauna and especially when land bridges contain attractive palatably grass. These structures have also been reported as important for small birds which are sensitive to fragmentation (Jones and Bond 2010).

In NSW, RMS has commissioned several long-term studies involving radio-tracking of Koalas pre-, during and post-construction to investigate the effectiveness of underpasses, overpasses and exclusion fencing incorporated into the Pacific Highway Upgrade. These studies have demonstrated the effectiveness of overpasses and underpasses (minimum 2.4 x 2.4 metres) for Koalas crossing the highway.

Fauna crossing structures are particularly effective when used with fauna exclusion fencing that direct fauna away from the road and towards the structure. Table 10-30 provides a list of common and threatened fauna species that have been reported using fauna crossing structures a number of which are identified as potentially impacted by the project.

Structure type	Known fauna groups and common fauna	Known threatened species
Land bridges (overpasses)	Frogs, birds, macropods introduced mammals, rats and mice, possums, lizards and snakes Red-necked wallaby, Northern brown bandicoot, Long-nosed bandicoot and Echidna	Spotted-tail Quoll (Fitzgerald, 2004)
Bridges, in stream structures	Frogs, birds, macropods native rodents, bats, gliders, arboreal mammals, large and small ground- dwelling mammals, introduced mammals, monotremes, lizards, snakes and invertebrates.	Koala (AMBS, 2001a; Abson and Lawrence, 2003) Eastern False Pipistrelle (Abson and Lawrence, 2003)
Underpasses (culverts)	Arboreal mammals, small mammals, rodents macropods, bats, introduced mammals, frogs, lizards, snakes, turtles, birds, Invertebrates and molluscs Common Brushtail Possum, Swamp Wallaby, Eastern Water Dragon, Long nosed bandicoot, Echidna, Bush Rat, Brown Antechinus	Long-nosed Potoroo (AMBS, 2001a; Taylor and Goldingay, 2003) Red-legged Pademelon (Goosem, 2005) Spotted-tail Quoll (AMBS, 2001b)
Canopy bridges	Small ground-dwelling mammals, large possums and pygmy possums Common Ringtail Possum, Common Brushtail Possum,	Squirrel Glider (Bax, 2006)
Glider poles	Sugar Glider, Squirrel Glider	Squirrel Glider (Goldingay, et al 2011)

Table 10-30: Fauna species recorded using fauna crossing structures

The Connectivity Strategy including provision for dedicated and combined underpass and overpass structures has a high degree of effectiveness for a wide range of fauna groups as determined by scientific research and documented design standards.

Threatened species sub-plans

The survey, avoidance, management and monitoring requirements for flora and fauna during construction would be detailed in the Fauna and Flora Management Plan. Impacts on threatened species would be managed via the management plan however there are a number of project and species specific management measures that would be managed via a number of threatened species sub-plans. These plans would focus on species identified as potentially significantly impacted by the project. A common aspect of each plan would be the provision of key goals for mitigation measures, thresholds for corrective actions and proposed corrective actions.

General mitigation measures

Mitigation measures for the construction and operation of the project are detailed in Table 10-31.

Mitigation measures would be further developed in consultation with the relevant government agencies including the agencies governing the NSW *Threatened Species Conservation Act 1995*, the NSW *Fisheries Management Act 1994* and the Commonwealth *Environmental Protection Biodiversity Conservation Act 1999*.

A register of the threatened species considered in the biodiversity assessment is also provided (refer to Table 10-32) identifying which mitigation measures (identified in Table 10-31) mitigate the impacts to that species.



Photo 7: Example of a threatened flora exclusion zone

Table 10-31: Biodiversity mitigation measures

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
Monitoring strategy	B1	 A measurable and targeted monitoring program would be developed to assess the effectiveness and success of the proposed biodiversity mitigation and management measures. The monitoring program would be prepared based on the outline in Appendix B of the Working paper – Biodiversity and in consultation with relevant state and Commonwealth agencies. This program would be finalised following project approval to incorporate any specific conditions of consent. 	Pre- construction	All
Connectivity	B2	 The Connectivity Strategy would be further developed during detailed design, in consultation with relevant state and Commonwealth agencies, building upon the Connectivity Strategy in Appendix A of the Working paper – Biodiversity. 	Pre- construction	All
Strategy	B3	 All fauna connectivity structures would be developed in accordance with the design principles outlined in the Connectivity Strategy in Appendix A of the Working paper – Biodiversity, building upon the current concept design structures. 	Pre- construction	All
Fauna exclusion fencing	B4	 Fauna exclusion fencing locations and design would be further developed in accordance with the design principles outlined in the Connectivity Strategy in Appendix A of the Working paper – Biodiversity, building upon the current concept design. 	Pre- construction and construction	All
	B5	 Fauna exclusion fencing required in low-lying floodplains would be designed to exclude emus from the road corridor. It would be placed higher on fill embankments to reduce impacts of flooding on the fauna fence. 	Construction	3 and 4
Arboreal crossing structures	B6	 Tree surveys would be conducted at proposed rope and glider crossing locations outlined in the Connectivity Strategy to determine the most appropriate location to place arboreal crossing structures. The design would aim to place arboreal crossing structures at grade level, where average tree heights exceed 20 metres, and/ or taller trees would be naturally positioned close to the road edge. 	Pre- construction	All
Widened median	B7	 Widened medians with retained vegetation are located in the design to provide connectivity for gliders. The design of fauna exclusion fencing and drainage or fauna underpass structures in widened medians would minimise vegetation clearing. 	Pre- construction and construction	1, 2 and 7
Flora and fauna management plan	В8	 An overall project Flora and Fauna Management Plan would be prepared to detail consistent guidance on the general management measures required for flora and fauna across all stages of the project. The management plan would cover: Pre-clearing process Exclusion zones Re-establishment of native vegetation 	Pre- construction	All

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
		 Clearing of vegetation and removal of bushrock Re-use of woody debris and bushrock Weed management Pathogen management Nest boxes Fauna handling Aquatic habitats and riparian zones. 		
Threatened species management sub-plans	В9	 A threatened flora management sub plan would be prepared to specifically address project sections where populations of threatened flora are known to have plants immediately adjacent to the project footprint, as identified in this assessment and include: Identification and physically surveying and mapping the specific location of individuals and patches along the edges of the project boundary to inform the management actions of the flora and fauna management plan A clearing protocol, translocation trial, seed collection, storage and propagation to use in revegetation of disturbed habitats Details for protection of retained plants, planting and maintenance and monitoring procedure during construction A revegetation monitoring program and performance criteria, reporting and adaptive management. 	Pre- construction	All
	B10	 A rainforest invertebrates management sub plan focusing on the Pink Underwing moth and Atlas Rainforest Ground Beetle would be prepared and include: Details on targeted surveys of both species within and around the project boundary to identify the extent of the population and map the distribution of suitable habitat adjacent to the project. In particular potential breeding habitat containing the caterpillars' food plant, <i>Carronia multisepalea</i> should be identified. This would inform the detailed design, flora and fauna management plan and translocation and habitat rehabilitation program. The surveys will aim to map the species distribution and correlate presence with the habitat characteristics at identified sites to accurately model the distribution of potential habitat in proximity to the project Consideration to minimise or avoid impacts, where possible. The identified potential habitat would be targeted for translocation of individuals and habitat rehabilitation as compensation for the loss of habitat from the project An outline of capture and relocation actions for Rainforest Ground Beetle and Pink Underwing Moth larvae focusing on identified suitable habitat Identify procedures for habitat rehabilitation and revegetation of suitable habitat near the project including the planting of the host plant for the Pink Underwing Moth. Details of a monitoring program for translocated individuals and retained habitat adjacent to the project. The monitoring program would include the collection of baseline data and would continue through construction and operation for a period of three years post-construction. The plan would 	Pre- construction	10, 11

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
		include clear key milestones, performance indicators, corrective actions and timeframes for the completion of all actions outline. The plan would address the success of habitat rehabilitation as well as the translocation success by monitoring populations of the target species.		
	B11	 An emu management sub plan would be prepared and include: The location of emu exclusion fencing to be implemented during construction. The plan should also consider fence design around bridges to exclude domestic stock but allow emus to cross Detailed landscape plan including locations for dense plantings of Melaleuca and Casuarina species, and other suitable species to act as a natural barrier fence and to also direct emus to crossing areas where exclusion fencing is not possible. These plantings would form a natural dense barrier up to 4 to 5 metres wide. The natural brush barrier fence is to be established immediately following property acquisition through sections 3 and 4 and well in advance of clearing of vegetation to assist in educating emus to use crossing points. Gaps would be placed where the dedicated and combined structures are to finally be located. This is designed to allow time for the vegetated barrier to achieve suitable height and also to educate emus to use the designated crossing locations prior to construction Fencing locations, including how permanent and temporary fencing should be used Baseline monitoring of emu movements prior to clearing Roadside plantings in emu habitat (Section 3 and 4) should not be within the first 40 metres of the road unless there is fauna exclusion fencing in place or as part of the exclusion barrier. In particular, common landscape species such as Dianella, Gahnia, Lomandra and Ficus in addition to Bangalow Palm (<i>Archotophoenix cunninghamian</i>) and soy, oats or rye grass cover crops should not be used as they represent food plants for emus and may attract them to the road edge Plantings under dedicated and combined bridges in emu crossing zones (Section 3 and 4) including the approaches to the crossing are to use grasses or low ground covers and avoid dense plantings of trees including low trees such as Acacia or Casuarina. This is to leave the opening clear. Ground cover crops such as soybean and o	Pre- construction	3-4
	B12	 A management sub plan for threatened fish species Oxleyan Pygmy Perch would be prepared. 	FIC-	1-4, 0-10

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
		 This would include: Measures to avoid and mitigate impacts to threatened fish species in particular the Purple-spotted Gudgeon and Oxleyan Pygmy Perch and their habitat A methodology and program for survey of potential habitat for this species at least 6 months prior to construction in the appropriate season to inform the flora and fauna management plan and monitoring program Recommendations on the location of batch plants outside and away from Oxleyan Pygmy Perch habitat where sediment erosion will not runoff into waterway Procedures to avoid in-stream works on known and potential habitat for Oxleyan Pygmy Perch or Purple-spotted Gudgeon. The in-stream construction works should avoid the critical spring-summer period (October – December) where feasible and reasonable Where feasible and reasonable, existing pools should be retained upstream and downstream of crossings within known occurrences of the Oxleyan Pygmy Perch to provide resting and refuge habitat near crossing structures. A proposed program for monitoring the species at identified known locations, to include a before-after-control-impact design and continue during construction and operation for a period of five consecutive monitoring periods. A proposed adaptive management actions to be implemented for this species in the event that any changes to the identified populations or habitat conditions are demonstrated and can be attributed to the project construction or operation. Clear key milestones, performance indicators, corrective actions and timeframes for the completion of all actions outlined 	construction	
	B13	 A threatened frog management sub plan (with a focus on the Giant Barred Frog, Green-thighed Frog, and Olongburra Frog) would be prepared and include: A program for survey or potential habitat for these species at least 6 months prior to construction to identify potential waterways and swamp habitat locations to inform the flora and fauna management plan A record of riparian / habitat condition baseline data at identified sites near the project to inform construction and post-construction monitoring program Identification of known sites, protection measures to be implemented during construction, monitoring methods and timing for species and habitat condition and monitoring mitigation measures and reporting in line with the flora and fauna management plan An outline of methods for monitoring species and habitat condition during post-construction. 	Pre- construction	All
	B14	 A Koala management sub plan would be prepared and include details on targeted surveys to identify the presence and status of koala populations near the project alignment. The surveys will focus near the project alignment and the data used to inform further development of connectivity structures. 	Pre- construction	6-10

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
	B15	 A glider management sub plan would be prepared and include: Targeted surveys for Squirrel Glider and Yellow-bellied Glider to inform the flora and fauna management plan, nest box management plan and the detailed design. The targeted surveys would inform the appropriate placement of the arboreal crossing structures and widened medians. 	Pre- construction	1-3, 6-8
	B16	• A Lowland Rainforest management sub plan would be prepared and include targeted surveys for Lowland Rainforest to more accurately identify the distribution, condition and area of this community in proximity to the alignment. The survey would concentrate on classifying the community according the criteria used under the EPBC Act to identify the patches which meet the Commonwealth listed separately to the State listed community. The data from the survey would provide input into the flora and fauna management plan and the compensatory habitat measures for this community and for dependent threatened fauna species such as the Pink Underwing Moth.	Pre- construction	8-11
Re- establishment of native vegetation	B17	 A landscape management plan would be developed to provide specific details for the re- establishment of native vegetation on batters, cut faces, surrounding sediment basins and other areas disturbed during construction. This would include details for the appropriate removal and restoration of temporary creek crossings. The landscape management plan would be developed in line with RMS Biodiversity Guidelines (RTA, 2011a), the design principles identified in the Connectivity Strategy and the design principles in Working paper – Urban design, landscape character and visual impact. The approach to landscape planting for the purposes of fauna management would be consistent with principles set out in the urban design and landscape strategy for this project (refer to Working paper- Urban design, landscape character and visual impact). 	Pre- construction	All
Minimising loss of vegetation and habitat	B18	 Disturbance and clearing of vegetation would be minimised, particularly : Avoiding and minimising vegetation removal wherever possible through the detailed design process Sensitive selection of ancillary facilities. The ancillary facilities identified present a selection of available sites; however during detailed design an evaluation should be conducted to select the minimum number of sites required with a priority to avoid native vegetation clearing if possible. A prior site inspection is required to survey and map hollow-bearing trees and check for large nests for species such as raptors, including Osprey and also Black-necked Stork at these sites Construction compounds and stockpile sites are to be sited in cleared or sparsely treed portions of the ancillary facility sites where feasible and reasonable, to avoid unnecessary clearing of vegetation and threatened flora species Water quality basins would be placed in the optimal location for treating surface runoff. During detailed design, the location of water quality treatment measures would consider the competing environmental requirement of minimising vegetation removal, particularly where there is the potential for threatened plant species, threatened flauna habitat or in identified regional wildlife corridors. 	Pre- construction and construction	All

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
	B19	 Instream structures such as bridges and culverts are to be designed and managed to minimise any potential impact to flow regimes and fish passage, in accordance with Fairfull and Witheridge (2003). Use of bridges or bebo arch is the preferred structure for Class 1 (major fish habitat) waterways. 	Pre- construction	All
	B20	 Two Class 1 waterway crossing structures have not been designed as bridges, but rather as culverts (Redbank Creek region and an Unnamed Watercourse at Station 134.7). During detailed design, the design would be reviewed to consider bridge structures at these locations. 	Pre- construction	1, 8
	B21	 All drainage structures between station 134.5 to 143.0 would be reviewed in consultation with Department of Primary Industries (Fisheries) to ensure suitable connectivity for threatened fish species is maintained. 	Pre- construction	8, 9
Bridge and culvert design	B22	 Each waterway crossing is to be designed to ensure no physical, hydraulic and behavioural barriers to aquatic fauna movements. Impacts would be minimised by ensuring that: The natural stream flow and velocity are maintained as closely as possible Surface level of any causeway is the same or lower than the natural stream bed to reduce interference with flow Habitat within a culvert is as natural as possible (eg allow rock and bed materials to infill the culvert base) There is the maximum light penetration Fauna and fish passage standards are maintained, as detailed in the Connectivity Strategy, including minimum design widths, including for natural banks, while also providing for scour protection and cut and fill batters Creek crossing structures would be designed to maximise habitat features within the passage. To achieve this, the design of bridge and culverts would encourage the deposition of sediment creating similar bed substrate to adjacent creek and the planning of specific plant species Pools would be constructed or retained upstream and downstream of the waterway crossings to provide resting and refuge habitat near the crossing structures Design culverts (specifically where Oxleyan Pygmy Perch has been confirmed) so that hydraulic habitat conditions would be suitable for fish passage Bridges would be designed and sized to limit peak flood velocities to less than 1m per second in commonly occurring flood events, similarly to the bridge design over Macdonalds Creek where Oxleyan Pygmy Perch have been confirmed. 	Pre- construction	All
	B23	 Bridge structures would be designed in light of the following principles: Bridges are to be single span bridges with piers located outside the main channel Bridge structures to be designed to prevent an increase of backup of water during times of flood, that would enable Plague Minnow to access waterbodies where they are currently not found (eg Broadwater National Park) 	Pre- construction	All

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
		 Construction would not alter or reduce flow where there are existing or potential Oxleyan Pygmy Perch populations (primarily within Sections 7, 8 and 9) which would negatively impact on this threatened species by draining the waterbodies. 		
	B24	 Where temporary access tracks are required over drainage lines with no flow, fords may be installed. 	Construction	All
	B25	 Where possible, existing crossings would be used. Where this is not feasible or reasonable, the temporary crossings would be designed to minimise impacts on the existing aquatic ecology and water quality. 	Construction	All
	B26	 Temporary crossings would be further investigated during detailed design including, location, type of structure, duration of need and rehabilitation process. 	Pre- construction	All
Temporary and permanent waterway diversions/ crossings		 General temporary waterway access track mitigation measures have been provided below: Installation and subsequent decommissioning of temporary crossings would be undertaken outside of Oxleyan Pygmy Perch spawning seasons (October to March). Temporary crossings would be constructed from clean fill using pipe or box culvert cells to carry flows. 	Construction	All
	B27	 All temporary works (eg crossings, flow diversion barriers) would be removed as soon as practicable and in a way that does not promote future channel erosion. The preferred temporary structure for crossing waterways would be consistent with Witheridge (2002) where the use of bridges is the preferred structure for Class 1 (major fish habitat waterways). Scour protection works would be established at temporary crossings as required At the completion of construction, the temporary crossings would be removed and rehabilitated. 		
Fish translocation		 Fish that become stranded due to temporary access crossings or construction of temporary or permanent creek diversions must be captured and translocated following the DPI Fisheries <i>Guidelines – A Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries</i> <i>Research.</i> General mitigation measures include: 	Construction	All
	B28	 Fish to be captured from the creek using appropriate gear for the watercourse and species present. These methods may include electrofishing, seine nets, bait and fyke traps Threatened fish species are unlikely to occur within Picaninny Creek, however, translocation would be done in the cooler months to minimise stress to the fish (as fish are less active in the cooler months) 		
		 Captured fish to be handled, transported and released in a manner that minimises any damage and stress to the fish (such as handling the fish with wet hands) Fish would be released into an equivalent watercourse with similar water quality and habitat conditions. 		

Pre-clearing surveys B29 B29 B29 B29 B29 Managing the location of any threatened flora and fauna species immediately before clearing porcess or habitats or threatened flora and fauna species, Threatened Ecological Pre-clearing survey faunch and fauna species immediately before clearing begins. This includes a targeted survey for threatened flora and fauna species immediately before clearing process or habitats or both sides of the existing highway along the length of the proposal suitable for the release of fauna that may be encountered during the pre-clearing process or habitat removal.	Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
 Pre-clearing surveys by an experienced ecologist to identify the location and extent of important habitats in the construction footprint to be salvaged for reuse/relocation, such as bushrock, hollow trees and woody debris. Pre-clearing surveys by an experienced ecologist for large bird nests, particularly for listed species such as the Black-necked Stork, Eastern Osprey, Square-tailed Kite and Little Eagle during the nesting and breeding season (July to December). If the species is present in or directly adjacent to the project footprint, measures including buffer and exclusion zones, translocation of nests or establishment of adjacent nesting platforms would be considered, if required Habitat features to be protected during construction, would be identified and marked on-site by a qualified ecologist. Checking for threatened flora and fauna species immediately before clearing begins. This includes a targeted survey for threatened flora and four any the appropriate season and a survey of any bridges or culverts to be removed to search for roosting bats Identifying nearby habitats on both sides of the existing highway along the length of the proposal suitable for the release of fauna that may be encountered during the pre-clearing process or habitat removal Mapping the location of any threatened flora and/or fauna species, Threatened Ecological 			• The capture of fish for translocation would require a Fisheries Permit and Animal Ethics Approval.		
 Communities and habitat Developing an unexpected threatened species finds procedure to be included in the CEMP as outlined in the RMS Biodiversity Guidelines (RTA, 2011a) No parking of vehicles and/or machinery and storage of equipment and resources under the dripline of any trees. Construction traffic would be restricted to defined access tracks, fenced prior to the start of construction and maintained until construction is complete. 	Pre-clearing surveys	B29	 The pre-clearing process would be consistent with RMS <i>Biodiversity Guidelines: Protecting and</i> <i>Managing Biodiversity on RTA projects</i> (RTA, 2011a) and include: Pre-clearing surveys by an experienced ecologist to identify the location and extent of important habitats in the construction footprint to be salvaged for reuse/relocation, such as bushrock, hollow trees and woody debris. Pre-clearing surveys by an experienced ecologist for large bird nests, particularly for listed species such as the Black-necked Stork, Eastern Osprey, Square-tailed Kite and Little Eagle during the nesting and breeding season (July to December). If the species is present in or directly adjacent to the project footprint, measures including buffer and exclusion zones, translocation of nests or establishment of adjacent nesting platforms would be considered, if required Habitat features to be protected during construction, would be identified and marked on-site by a qualified ecologist. Checking for threatened flora and fauna species immediately before clearing begins. This includes a targeted survey for threatened flora during the appropriate season and a survey of any bridges or culverts to be removed to search for roosting bats Identifying nearby habitats on both sides of the existing highway along the length of the proposal suitable for the release of fauna that may be encountered during the pre-clearing process or habitat removal Mapping the location of any threatened flora and/or fauna species, Threatened Ecological Communities and habitat Developing an unexpected threatened species finds procedure to be included in the CEMP as outlined in the RMS Biodiversity Guidelines (RTA, 2011a) No parking of vehicles and/or machinery and storage of equipment and resources under the dripline of any trees. 	Pre- construction and construction	All
Exclusion 2016 B30 B30 B30 Final Base B30	Exclusion zones	B30	 The location of exclusion zones would be identified, with temporary fencing or flagging tape to indicate the limits of clearing (in accordance with the RMS Biodiversity Guidelines (RTA, 2011a)). Permanent fauna exclusion fencing for the project (as described in the Connectivity Strategy), where reasonable and feasible, would be installed prior to clearing and can function as exclusion fencing. 	Construction	All
Staged removal process B31 A staged habitat removal process would be implemented consistent with the RMS <i>Biodiversity</i> Construction All process Contact vet and/or wildlife carers to ensure they are willing to assist in treating injured animals if	Staged removal process	B31	 A staged habitat removal process would be implemented consistent with the RMS <i>Biodiversity Guidelines</i> (RTA, 2011a) and involve the following steps: Contact vet and/or wildlife carers to ensure they are willing to assist in treating injured animals if 	Construction	All

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
		 necessary An experienced and licensed wildlife carer and/or ecologist would be present during all habitat removal activities to capture and relocate any encountered fauna Remove non-habitat vegetation first Identified habitat (eg hollow-bearing trees) would be left for at least 24 hours after removing non-habitat vegetation to allow fauna to escape. Remove habitat trees as carefully as possible to avoid injury to any fauna still remaining in trees. An experienced and licensed wildlife carer and/or ecologist would inspect habitat once it is removed. All hollows would be placed in adjacent habitat until the following day for further inspection by a licensed wildlife carer and/or ecologist to verify no fauna is present. If possible, the hollows would be permanently relocated in adjacent areas in accordance with the RMS Biodiversity Guidelines (RTA, 2011a). Outcomes of the clearing process would be recorded to relevant personnel (eg environment manager or RMS regional environment staff). 		
Re-use of woody debris and bushrock	B32	 Woody debris and bushrock would be re-used on site for habitat improvement where possible and would be detailed in the landscape management plan in accordance with the RMS Biodiversity Guidelines (RTA, 2011a) and include: Implementing the removal, stockpiling, transportation and relocation of woody debris and/or bushrock in a manner that minimises disturbance to native vegetation or bushrock Engaging an ecologist in the pre-clearing phase of the proposal to provide advice on the re-use of woody debris and bushrock including potential negative impacts and positioning of woody debris and bushrock including potential negative impacts and positioning of woody debris and bushrock including potential negative impacts and positioning of woody debris and bushrock at the relocation areas When relocating woody debris, placing it evenly across the site whilst keeping topsoil disturbance to a minimum Avoiding the spread of any weeds or pathogens that may be in the soil when relocating woody debris and bushrock from stockpiles Mulching would include only native vegetation and separate stockpiles need to be established for weedy vegetation and the native vegetation to be mulched. Manage stockpiles in accordance with RTA's Stockpile Site Management Guideline, RTA Environmental Protection (Management System) QA Specification G36 and RTA Vegetation QA Specification R178 Preparing a mulch tannin management plan for the project where tannins are likely to be generated. 	Construction	All
Weed management	B33	 A weed management plan would be developed as part of the CEMP, in accordance with the RMS Biodiversity Guidelines (RTA, 2011a) and the Introductory Weed Management Manual (Richards, 2004) and would include: 	Pre- construction and construction	All

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
		 Taxa and potential sources of the weed species (including alligator weed, tropical soda apple and myrtle rust) Weed management priorities and objectives Sensitive environmental areas within or adjacent to the site Location of weed infested areas Mechanical weed control methods such as slashing or mowing, as well as a range of herbicides to avoid the development of herbicide resistance Measures to prevent the spread of weeds A monitoring program to measure the success of weed management Strategic management with adjacent landowners Appropriate disposal of weed infested materials and soils to be identified in the CEMP Communication strategies to improve contractor awareness of weeds and weed management 		
	B34	 A site assessment by an ecologist or person trained in weed identification would be undertaken to identify the presence and extent of Alligator weeds. If present, management measures in the Weed Management Plan would be in accordance with the DPI Alligator Weed control manual (van Oosterhout, 2007). 	Pre- construction	7-10
Pathogen management	B35	 Measures to prevent the introduction and/or spread of pests and disease causing agents such as bacteria and fungi would be incorporated into the CEMP, in accordance with the RMS Biodiversity Guidelines (RTA, 2011a) and would include: A background search of government-maintained websites for the most up-to-date hygiene protocols for each pathogen Provide vehicle and boot wash down facilities and ensure vehicles and footwear is free of soil before entering or exiting the site The risk of spreading pathogens and the mitigation measures required on site should be regularly communicated to staff and contractors during inductions and toolbox talks Construction works would be programmed to move from uninfected areas to any known infected areas Restrict vehicles to designated tracks, trails and parking areas 	Pre- construction and construction	All
	B36	 If pathogens are identified on site: Testing may be required to confirm the presence of pathogens advice from government departments would be sought on practical hygiene management measures Fenced exclusion zones would be identified to restrict access into contaminated areas. 	Construction	All
Nest boxes	B37	 Nest boxes would be installed as per RMS Biodiversity Guidelines (RTA, 2011a) and a nest box strategy developed as part of the CEMP, detailing: 	Pre- construction	All

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
		 The number and type of nest boxes required based on the number, quality and size of the hollows that would be removed. Specifications for nest box dimensions, installation requirements, locations of nest boxes and ongoing monitoring and maintenance. Installation timeframes, including the installation of 70 % of nest boxes prior to the removal of any vegetation. 	and construction	
Fauna handling	B38	 To prevent injury and mortality of fauna during the clearing of vegetation and drainage of farm dams an experienced and licensed wildlife carer and/or ecologist would be present to supervise vegetation clearing and capture and relocate fauna where required. Further details regarding fauna handling and vegetation clearing procedures are provided in the RMS Biodiversity Guidelines (RTA, 2011a). The following would be implemented to avoid injury and fauna mortality: Allow fauna to leave an area without intervention as much as possible In circumstances where the handling of fauna is completely unavoidable, best practice methods need to be followed as outlined in the RMS Biodiversity Guidelines – Guide 9 Fauna Handling (RTA 2011) Include the procedures in project inductions for construction staff to implement if fauna is found or injured on site and also the importance of not feeding any wildlife that may be encountered on construction sites Never deliberately kill a snake as all snakes are protected under the NSW National Parks and Wildlife Act 1974 Keep records of fauna captured and relocated Report any injury to or death of a threatened species to the RMS environmental staff. 	Construction	All
Riparian and aquatic habitat management	B39	 Prior to any disturbance of waterway banks, a thorough inspection by a qualified ecologist would be undertaken for aquatic fauna such as turtle nests. 	Construction	All
	B40	 Streams to be crossed perpendicular to flow and where possible crossing sites selected to avoid unstable banks, bends in the channel, deep pools and confluences with other channels 	Pre- construction	All
	B41	 Scour protection would be provided on any constructed works and temporary and permanent crossing structures within 50 m of Class 1 waterways or within the range of the Oxleyan Pygmy Perch as identified in section 3.9.6 of the Working paper – Biodiversity. 	Construction	All
	B42	• The bed and banks are to be reinstated to a condition similar to or better than the original condition ensuring that there are no adverse impacts on the aquatic values (different measures may be required for each crossing). Banks are to be graded to a slope that is no steeper than existing site conditions	Construction	All
	B43	• The reinstatement process would need to ensure that there is no detrimental impact on geomorphic processes which in turn impacts aquatic values	Construction	All

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
	B44	 All water way crossing construction materials (rocks and gravel) are to be washed prior to being used for construction to minimise turbidity. 	Construction	All
	B45	 Instream and riparian disturbance would be minimised and sediment, woody snags or debris removed from a stream or stream channel would be minimised. Trimming or 'lopping' of branches and logs would be considered as a first option before moving. 	Construction	All
	B46	 Any instream woody debris removed during construction would be replaced at the completion of the works within the same waterways from which it was removed. 	Construction	All
	B47	 A vegetation clearing strategy and a revegetation management strategy would be developed and implemented to minimise instream and riparian weed invasion. 	Construction	All
	B48	 Avoid in-stream works on known and potential habitat (as identified in section 3.9.6 of the Working paper – Biodiversity) for Oxleyan Pygmy Perch or Purple-spotted Gudgeon to minimise sedimentation impacts. In stream works should be timed in a manner that minimises impacts to aquatic fauna. The in-stream construction works should avoid the critical spring-summer period (October – December) where feasible and reasonable as this represents the typical water temperatures between 19-34°C and high rainfall period when aquatic habitats are flowing and the spawning season for many fish species including the Oxleyan Pygmy Perch and Purple-spotted Gudgeon 	Construction	All
	B49	 Where feasible and reasonable, existing pools would be retained upstream and downstream of crossings within known occurrences of the Oxleyan Pygmy Perch to provide resting and refuge habitat near crossing structures. 	Construction	1 to 4 and 6 to 10.
	B50	 Appropriate plant species would be incorporated into the rehabilitation of disturbed aquatic habitats and drains as a result of construction, in regions of suitable Oxleyan Pygmy Perch habitat. 	Construction	All
	B51	 All sediment and erosion control measures would be put in place during the construction process and may include sediment and erosion control curtains in the waterways to control turbidity generated during the construction and restoration process 	Construction	All
	B52	 No turbid water generated from the construction corridor or construction area is to be discharged to any waterway 	Construction	All
	B53	The proposed road surface would drain away from known Oxleyan Pygmy Perch habitat to reduce potential for pollution.	Pre- construction, construction and operation	1 to 4 and 6 to 10.
Water quality	B54	 Operational spill basins are to be installed at key locations ie near Broadwater National Park and other key drainage lines that lead directly into threatened fish habitat. 	Operation	All
	B55	Chemicals and fuels would be appropriately stored and bunded, away from waterways and	Construction	All

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
		drainage lines.		
	B56	 Discharges from sediment basins and/or treatment wetlands that do not meet the water quality parameters for Oxleyan Pygmy Perch habitat (to be determined through pre-construction water quality monitoring) would not be discharged into waterways but rather sprayed into adjacent open grass areas or used for construction purposes such as dust suppression to avoid changing water depth and physio-chemical conditions in potential threatened fish habitat. 	Construction	1 to 4 and 6 to 10.
	B57	 If not reasonable and feasible, to irrigate land to completely re-use water from sedimentation basins during construction in Oxleyan Pygmy Perch habitat, as a last resort, water could be discharged to waterways after treatment (to ensure the pH less than 6.5 and total suspended solids of less than 50mg/L) depending on environmental protection licensing requirements. 	Construction	1 to 4 and 6 to 10.
	B58	 Water quality monitoring would be undertaken to assess the effectiveness of (and where necessary amend) water, sediment and erosion management strategies that aim to protect the Oxleyan Pygmy Perch and Purple-spotted Gudgeon, their habitat and other aquatic flora and fauna species. Water quality monitoring program would be undertaken in line with details in Appendix B of the Working paper – Biodiversity. 	Construction	1 to 4 and 6 to 10.
Stockpile and ancillary facilities management	B59	 Stockpiles would be located above the 1:100 year flood level with appropriate management control measures in place such as bunding. 	Construction	All
	B60	 Stockpiling of material for bridgeworks at known areas of Oxleyan Pygmy Perch would be undertaken after April to avoid the breeding seasons of October to March. 	Construction	1 to 4 and 6 to 10.
	B61	 Batch plants would be located outside well away from Oxleyan Pygmy Perch habitat where sediment erosion would not runoff into waterways (due to the risk of high alkaline runoff) 	Construction	1 to 4 and 6 to 10.
	B62	 Ancillary facilities would be sensitively location to avoid removal of any Threatened Ecological Community. 	Pre- construction and construction	All
	B63	Stockpiles would be managed in accordance with RTA's Stockpile Site Management Guideline.	Construction	All
Slender Screw Fern	B64	 The project boundary in section 1 to be reviewed to identify any opportunities to avoid significant impacts to the existing population 	Pre- construction	1
	B65	 The project boundary and placement of sedimentation basins would be evaluated to minimise impacts to Slender Screw Fern. 	Pre- construction	6
Biodiversity	B66	The Biodiversity Offset Strategy (detailed in Appendix C of the Working paper – Biodiversity) would	Pre-	All

Issue	Mitigation ID no	Mitigation measure	Timing	Relevant section
Offset Strategy		be further developed, in consultation with relevant state and Commonwealth agencies, and	construction	
		implemented during detailed design.		

Table 10-32: Register	of relevant mitigation	measures for targeted	threatened species
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Target species, listing status and status on project	Reference to mitigation measures
THREATENED FLORA	
Sandstone Rough Barked Apple (<i>Angophora robur</i>) Vulnerable (TSC Act, EPBC Act)	Flora and fauna management plan (B8) Threatened flora management sub plan (B9) Exclusion zones (B30)
Square-fruited Ironbark (<i>Eucalyptus tetrapleura</i>) Vulnerable (TSC Act, EPBC Act)	Flora and fauna management plan (B8) Threatened flora management sub plan (B9) Exclusion zones (B30)
Weeping Paperbark (<i>Melaleuca irbyana</i>) Endangered (TSC Act)	Flora and fauna management plan (B8) Threatened flora management sub plan (B9) Exclusion zones (B30)
Slender Screw Fern (<i>Lindsaea incisa</i>) (SF) Endangered (TSC Act)	Flora and fauna management plan (B8) Threatened flora management sub plan (B9) Exclusion zones (B30) Mitigation of impacts (B65)
Maundia triglochinoides Vulnerable (TSC Act)	Flora and fauna management plan (B8) Threatened flora management sub plan (B9) Exclusion zones (B30)
Four-tailed Grevillea (<i>Grevillea quadricauda</i>) Vulnerable (TSC Act, EPBC Act)	Flora and fauna management plan (B8) Threatened flora management sub plan (B9) Exclusion zones (B30)
Singleton Mint Bush (<i>Prostanthera cineolifera</i>) Vulnerable (TSC Act, EPBC Act)	Flora and fauna management plan (B8) Threatened flora management sub plan (B9) Exclusion zones (B30)
Water Nutgrass (<i>Cyperus aquatilis</i>) Endangered (TSC Act)	Flora and fauna management plan (B8) Threatened flora management sub plan (B9) Exclusion zones (B30)
Hairy-joint Grass (<i>Arthraxon hispidus</i>) Vulnerable (TSC Act, EPBC Act)	Flora and fauna management plan (B8) Threatened flora management sub plan (B9) Exclusion zones (B30)
THREATENED FAUNA	
Wetland and migratory bird species	
Australasian Bittern <i>Botaurus poiciloptilus</i> Endangered (TSC Act and EPBC Act)	Flora and fauna management plan (B8) Pre-clearing surveys (B29)
Australian Painted Snipe <i>Rostratula australis</i> (Endangered TSC Act, Vulnerable, Migratory EPBC Act)	Staged removal process (B31) Next boxes (B37) Fauna handling (B38)
Black-necked Stork <i>Ephippiorhynchus asiaticus</i> (Endangered TSC Act)	
Pale-vented Bush Hen <i>Amaurornis molucanna</i> (Vulnerable TSC Act)	
Magpie Goose Anseranas semipalmata (Vulnerable (TSC Act)	
Comb-crested <i>Jacana Irediparra gallinacea</i> (Vulnerable (TSC Act)	
Black Bittern Ixobrychus flavicollis (Vulnerable (TSC Act)	
Brolga Grus rubicundus (Vulnerable (TSC Act)	
Freckled Duck <i>Stictonetta naevosa</i> (Vulnerable (TSC Act)	

Target species, listing status and status on project	Reference to mitigation measures	
Large forest owls and other nocturnal birds		
Barking Owl Ninox connivens (Vulnerable TSC Act)	Flora and fauna management plan (B8)	
Powerful Owl Ninox strenua (Vulnerable TSC Act)	Pre-clearing surveys (B29)	
Masked Owl <i>Tyto novaehollandiae</i> (Vulnerable TSC Act)	Next boxes (B37)	
Sooty Owl Tyto tenebricosa (Vulnerable TSC Act)		
Grass Owl Tyto longimembris (Vulnerable TSC Act)		
Woodland birds		
Brown Treecreeper <i>Climacteris picumnus</i> (Vulnerable TSC Act)	Flora and fauna management plan (B8) Pre-clearing surveys (B29)	
Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i> (Vulnerable TSC Act)	Staged removal process (B31) Next boxes (B37)	
Bush Stone-curlew <i>Burhinus grallarius</i> (Endangered TSC Act)	Fauna handling (B38)	
Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i> (Vulnerable TSC Act)		
Rainforest birds		
Double-Eyed Fig-Parrot <i>Cyclopsitta diophthalma</i> <i>coxeni</i> (Critically endangered TSC Act and endangered EPBC Act)	Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31)	
Wompoo Fruit-dove <i>Ptilinopus magnificus</i> (Vulnerable TSC Act)	Next boxes (B37) Fauna handling (B38)	
Rose-crowned Fruit Dove <i>Ptilinopus regina</i> (Vulnerable TSC Act)		
Superb Fruit-dove <i>Ptilinopus superbus</i> (Vulnerable TSC Act)		
Barred Cuckoo-shrike <i>Coracina lineata</i> (Vulnerable TSC Act)		
Forest birds		
Little Eagle <i>Hieraaetus morphnoides</i> (Vulnerable TSC Act)	Flora and fauna management plan (B8) Pre-clearing surveys (B29)	
Square-tailed Kite <i>Lophoictinia isura</i> (Vulnerable TSC Act)	Staged removal process (B31) Next boxes (B37)	
Red Goshawk <i>Erythrotriorchis radiatus</i> (Critically endangered TSC Act, vulnerable EPBC Act)	Fauna handling (B38)	
Eastern Osprey <i>Pandion haliaetus</i> (Vulnerable TSC Act, Migratory EPBC Act)		
Glossy Black-cockatoo <i>Calyptorhynchus lathami</i> (Vulnerable TSC Act)		
Little Lorikeet <i>Glossopsitta pusilla</i> (Vulnerable TSC Act)		
Mangrove Honeyeater <i>Lichenostomus fasciogulari</i> (Vulnerable TSC Act)		
Ground Parrot (eastern subsp.) <i>Pezoporus wallicus wallicus</i> (Vulnerable TSC Act)		
Microchiropteran bats		
Large-eared Pied Bat <i>Chalinolobus dwyeri</i> (Vulnerable TSC Act and EPBC Act)	Flora and fauna management plan (B8) Pre-clearing surveys (B29)	
Hoary Wattled Bat <i>Chalinolobus nigrogriseus</i> (Vulnerable TSC Act)	Staged removal process (B31)	

Target species, listing status and status on project	Reference to mitigation measures
Eastern False Pipistrelle <i>Falsistrellus tasmaniensis</i> (Vulnerable TSC Act)	Re-use of woody debris and bushrock (B32) Next boxes (B37)
Golden-tipped Bat <i>Kerivoula papuensis</i> (Vulnerable TSC Act)	Fauna handling (B38)
Beccari's Freetail-Bat <i>Mormopterus beccarii</i> (Vulnerable TSC Act)	
Eastern Freetail-Bat <i>Mormopterus norfolkensis</i> (Vulnerable TSC Act)	
Eastern Long-Eared Bat <i>Nyctophilus bifax</i> (Vulnerable TSC Act)	
Yellow-bellied Sheathtail-bat <i>Saccolaimus flaviventris</i> (Vulnerable TSC Act)	
Greater Broad-nosed Bat Scoteanax rueppellii (Vulnerable TSC Act)	
Eastern Cave Bat <i>Vespadelus troughtoni</i> (Vulnerable TSC Act)	
Southern Myotis <i>Myotis macropus</i> (Vulnerable TSC Act)	
Little Bent-wing Bat <i>Miniopterus australis</i> (Vulnerable TSC Act)	
Eastern Bent-wing Bat <i>Miniopterus schreibersii</i> oceanensis (Vulnerable TSC Act)	
Arboreal mammals	
Eastern Pygmy-possum <i>Cercartetus nanus</i> (Vulnerable TSC Act)	Arboreal crossing structures and widened median (Connectivity Strategy (B2, B3, B6, B7)) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31) Next boxes (B37) Fauna handling (B38)
Yellow-bellied Glider <i>Petaurus australis</i> (Vulnerable TSC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Arboreal crossing structures and widened median (Connectivity Strategy (B2, B3, B6, B7) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Glider management sub plan (B15) Pre-clearing surveys (B29) Staged removal process (B31) Next boxes (B37) Fauna handling (B38)
Squirrel Glider <i>Petaurus norfolcensis</i> (Vulnerable TSC Act)	Arboreal crossing structures and widened median (Connectivity Strategy (B2, B3, B6, B7) Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Glider management sub plan (B15) Pre-clearing surveys (B29) Staged removal process (B31) Next boxes (B37) Fauna handling (B38)
Target species, listing status and status on project	Reference to mitigation measures
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Brush-tailed Phascogale <i>Phascogale tapoatafa</i> (Vulnerable TSC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Arboreal crossing structures and widened median (Connectivity Strategy (B2, B3, B6, B7) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31) Next boxes (B37) Fauna handling (B38)
Ground-dwelling mammals	
Rufous Bettong <i>Aepyprymnus rufescens</i> (Vulnerable TSC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna connectivity structures (Connectivity Strategy (B2, B3) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)
Common Planigale <i>Planigale maculata</i> (Vulnerable TSC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna connectivity structures (Connectivity Strategy (B2, B3) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)
Long-nosed Potoroo <i>Potorous tridactylus tridactylis</i> (Vulnerable TSC Act and EPBC Act	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna connectivity structures (Connectivity Strategy (B2, B3) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)
Spotted-tailed Quoll <i>Dasyurus maculatus maculatus</i> (SE population) (Vulnerable TSC Act and Endangered EPBC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna connectivity structures (Connectivity Strategy (B2, B3) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)

Target species, listing status and status on project	Reference to mitigation measures
Megachiropteran bats	
Grey-headed Flying-fox <i>Pteropus poliocephalus</i> (Vulnerable TSC Act and EPBC Act)	Arboreal crossing structures and widened median (Connectivity Strategy (B2, B3, B6, B7) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31) Fauna handling (B38)
Common Blossom-bat <i>Syconycteris australis</i> (Vulnerable TSC Act)	Arboreal crossing structures and widened median (Connectivity Strategy (B2, B3, B6, B7) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31) Fauna handling (B38)
Wetland and swamp dwelling frogs	
Wallum Froglet Crinia tinnula (Vulnerable TSC Act)	Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)
Olongburra Frog <i>Litoria olongburensis</i> (Vulnerable TSC Act and EPBC Act)	Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Threatened frog management sub plan (B13) Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)
Giant Barred Frog <i>Mixophyes iterates</i> (Endangered TSC Act and EPBC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Threatened frog management sub plan (B13) Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)
Green-thighed Frog <i>Litoria brevipalmata</i> (Vulnerable TSC Act)	Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Threatened frog management sub plan (B13) Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)
Reptiles	
Pale-headed Snake <i>Hoplocephalus bitorquatus</i> (Vulnerable TSC Act)	Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8)
Stephens' banded snake <i>Hoplocephalus stephensii</i> (Vulnerable TSC Act)	Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)

Target species, listing status and status on project	Reference to mitigation measures
Fish	
Oxleyan Pygmy Perch <i>Nannoperca oxleyana</i> (OPP) (Endangered TSC Act and EPBC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna connectivity structures (Connectivity Strategy (B2, B3) Flora and fauna management plan (B8) Threatened fish management sub plan (B12) Bridge and Culvert design (B19-B23) Temporary and permanent waterway diversions/ crossings (B24-B27) Fish translocation process (B28) Pre-clearing surveys (B29) Staged removal process (B31) Riparian and aquatic habitat management (B39- B53) Water quality (B54-B58) Stockpile management (B59- B63)
Purple-spotted Gudgeon <i>Mogurnda adspersa</i> (Endangered TSC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna connectivity structures (Connectivity Strategy (B2, B3) Flora and fauna management plan (B8) Threatened fish management sub plan (B12) Bridge and Culvert design (B19-B23) Temporary and permanent waterway diversions/ crossings (B24-B27) Fish translocation process (B28) Pre-clearing surveys (B29) Staged removal process (B31) Riparian and aquatic habitat management (B39- B53) Water quality (B54-B58) Stockpile management (B59- B63)
Eastern Freshwater Cod <i>Maccullochella ikei</i> (Endangered TSC Act and EPBC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna connectivity structures (Connectivity Strategy (B2, B3) Flora and fauna management plan (B8) Bridge and Culvert design (B19-B23) Temporary and permanent waterway diversions/ crossings (B24-B27) Fish translocation process (B28) Pre-clearing surveys (B29) Staged removal process (B31) Riparian and aquatic habitat management (B39- B53) Water quality (B54-B58) Stockpile management (B59- B63)
Invertebrates	
Pink Underwing Moth <i>Phyllodes imperialis southern</i> <i>subsp.</i> (Vulnerable TSC Act and EPBC Act)	Flora and fauna management plan (B8) Pink Underwing Moth and Atlas Rainforest Ground Beetle Management Plan and targeted surveys (B10)
(Endangered TSC Act)	Pre-clearing surveys (B29) Staged removal process (B31) Re-use of woody debris and bushrock (B32) Fauna handling (B38)

Target species, listing status and status on project	Reference to mitigation measures
Other fauna	
Swift Parrot <i>Lathamus discolor</i> (Endangered TSC Act, Endangered, Migratory EPBC Act)	Flora and fauna management plan (B8) Pre-clearing surveys (B29)
Regent Honeyeater <i>Xanthomyza phrygia</i> (Endangered TSC Act and endangered and migratory EPBC Act)	Staged removal process (B31) Re-use of woody debris and bushrock (B32) Nest boxes (B37) Fauna handling (B38)
Koala <i>Phascolarctos cinereus</i> (Vulnerable TSC Act and EPBC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Flora and fauna management plan (B8) Koala management sub plan (B14) Pre-clearing surveys (B29) Staged removal process (B31) Fauna handling (B38)
Coastal Emu <i>Dromaius novaehollandiae</i> (Endangered population TSC Act)	Monitoring of fauna connectivity structures (Monitoring Strategy) (B1) Fauna connectivity structures (Connectivity Strategy (B2, B3) Fauna exclusion fencing (B4, B5) Flora and fauna management plan (B8) Emu management sub plan (B11) Pre-clearing surveys (B29) Staged removal process (B31) Fauna handling (B38)

Offset strategy

A Biodiversity Offset Strategy has been prepared (refer to Appendix C of the Working paper -Biodiversity) that outlines the requirements to offset impacts of the project identified in this assessment. The strategy considered both the *Principles for the use of biodiversity offsets in NSW* (NSW Office of Environment and Heritage, 2011) and the Commonwealth Government's Environmental Offsets Policy statement (DSEWPaC, 2012).The Offset Strategy would be further developed in consultation with the NSW Office of Environment and Heritage and DSEWPaC.

The objective of the Biodiversity Offset Strategy is to deliver a package of offsets to achieve an enhancement of biodiversity for the region. Where there is scope to reduce the impacts through the detailed design phase, the refined construction footprint would be considered in the offset calculations.

The offset methodology would take into account the value of key migratory and threatened species habitat when determining appropriate offsets. All offsets would be located within the NSW North Coast Bioregion to ensure that these offsets have similar characteristics and broad vegetation types of those to be impacted. Where it is not feasible to offset on a like for like basis other vegetation types of a similar conservation value that contain habitat suitable for the impacted threatened species would be considered in consultation with NSW Office of Environment and Heritage.

The proposed offset ratios as part of the strategy include:

- Threatened ecological communities and highly cleared vegetation communities (those with more than 75 per cent cleared in the catchment management area) ratio of 4:1 (ie for each hectare removed, four hectares would be offset)
- Areas within state forests (Forest Management Zones) ratio of 4:1
- Other vegetation communities ratio of 2:1.

The proposed offset amounts for state forest areas and other impacted vegetation types are detailed in Table 10-33 and Table 10-34. However, these are subject to further consultation with NSW Office of Environment and Heritage.

Table 10-33: Offset amount for state forest affected areas

Vegetation type/ FMZ	Area affected by project (ha)	Offset ratio	Offset area required (ha)
Forest Management Zones (FMZ)	55.48	4:1	221.92
Subtropical Coastal Floodplain Forest (TEC) outside of FMZ	13.40	4:1	53.60
Swamp Sclerophyll Forest (TEC) outside of FMZ	3.82	4:1	15.28
Highly cleared vegetation types outside of FMZ	0.42	4:1	1.68
All other vegetation types outside of FMZ	57.55	2:1	115.10
TOTAL	130.67		407.58

Table 10-34: Offset amounts for vegetation types outside of state forests

BioMetric vegetation association	Vegetation formation (Keith 2004)	Area affected by project (ha) ¹	Offset ratio	Offset target (ha)
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	Rainforest	1.9	4:1	7.60
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	Shrubby dry sclerophyll forest	102.72	2:1	205.44
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	Wet sclerophyll forest	54.52	2:1	109.04
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	Shrubby dry sclerophyll forest	32.4	4:1	129.60
Coastal Floodplain Sedgelands, Rushlands, and Forblands	Freshwater wetland	3.8	4:1	15.20
Coastal Heath on Sands of the North Coast	Heathland	2.2	2:1	4.40
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	Wet sclerophyll forest	3.6	2:1	7.20
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	Grassy woodland	90.17	4:1	360.68
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	Dry sclerophyll shrub/grass forest	52.07	2:1	104.14
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	Rainforest	0.8	4:1	3.20
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	Saline wetland	1.9	4:1	7.60
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	Grassy woodland	65.3	4:1	261.20
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	Shrubby dry sclerophyll forest	68.74	2:1	137.48
Orange Gum (<i>Eucalyptus bancroftii</i>) Open Forest of the North Coast	Shrubby dry sclerophyll forest	8.25	4:1	33.00

BioMetric vegetation association	Vegetation formation (Keith 2004)	Area affected by project (ha) ¹	Offset ratio	Offset target (ha)
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	Swamp sclerophyll forest	63.13	4:1	252.52
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	Wet sclerophyll forest	55.45	2:1	110.90
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	Shrubby dry sclerophyll forest	104.98	2:1	209.96
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	Dry sclerophyll shrub/grass forest	10.32	2:1	20.64
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	Dry sclerophyll shrub/grass forest	211.33	2:1	422.66
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	Grassy woodland	27.16	4:1	108.64
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	Swamp sclerophyll forest	57.56	4:1	230.24
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	Swamp sclerophyll forest	77.7	4:1	310.80
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	Dry sclerophyll shrub/grass forest	76	2:1	152.00
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	Wet sclerophyll forest	55.57	2:1	111.14
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	Freshwater wetland	13.7	4:1	54.80
White Booyong - Fig Subtropical Rainforest of the North Coast	Rainforest	12.9	4:1	51.60
TOTAL		1254.19		3421.68

¹ Including both direct and indirect impacted areas.

The following principles would apply to the offset strategy:

- The vegetation communities and habitat types represented in the offset areas would reflect the vegetation communities and habitat types impacted by the project
- Offset areas would contain habitat for threatened and migratory fauna (TSC Act and EPBC Act) and would contain or be suitable for re-establishing threatened flora (TSC Act and EPBC Act) affected by the project.
- A minimum ratio of 2:1 would be achieved for all remnant vegetation cleared by the project and higher ratios would apply to areas of high conservation value such as endangered ecological communities
- Offset properties would be managed under effective and secure long term management arrangements and could include:
 - Dedication of land under the National Parks and Wildlife Act 1974
 - Biobanking Agreements under the Threatened Species Conservation Act 1995
 - Conservation Agreements under the National Parks and Wildlife Act 1974
 - Trust Agreements under the Nature Conservation Trust Act 2001
 - Property vegetation Plans registered on title under the Native Vegetation Act 2003
 - Planning agreements under s93F of the Environmental Planning and Assessment Act 1979.

Regardless of the legal mechanism offset properties would be managed:

- With a principle objective of ongoing site management being biodiversity conservation in perpetuity
- In accordance with a resourced and implementable Plan of Management
- With a monitoring and accountability mechanism to ensure management objectives are achieved
- · Offset properties would be located as close to the impact site as feasible
- All offset properties would be located within the NSW North Coast Bioregion
- Offset properties would aim to protect larger patches of vegetation and habitat with preference given to sites that are connected to, or provide connectivity to, other core areas of habitat.

The strategy also identifies the method for determining the locations and areas of offsets required (first priority are properties within 30 kilometres, followed by properties within 100 kilometres of the project vegetation removed as a result of the project) and the most effective options for implementing and protecting the offsets. The strategy takes into account the identified loss of vegetation types, the condition of the habitat being lost, the species being impacted and the regional scale cumulative impacts.

Within two years of the approval of the project or otherwise agreed with the NSW Department of Planning and Infrastructure and DSEWPaC, RMS would submit to the NSW Department of Planning and Infrastructure and the Commonwealth Government, a Biodiversity Offset Package. The package would be prepared in consultation with NSW Office of Environment and Heritage and the Commonwealth Government and would include details of the final suite of measures to be implemented as a result of this strategy. The package would identify a timeline for implementation and the detail of measures, including arrangements for ongoing management of offset lands

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