Roads and Traffic Authority of NSW

Oxley Highway to Kempsey
Upgrading the Pacific Highway

Environmental Assessment

MAIN VOLUME

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GHD Pty Ltd
ABN 39 008 488 373

Level 3, GHD Tower
24 Honeysuckle Drive
NEWCASTLE NSW 2300

Phone: +61 2 4979 9999
Fax: +61 2 4979 9988
Email: ntlmail@ghd.com

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15. Flora and fauna

This Chapter addresses the terrestrial and aquatic ecology impacts associated with the Proposal and details the management measures proposed to mitigate these impacts.

The information presented in this chapter is drawn from the *Flora and Fauna Working Paper*, prepared by GHD and provided in **Volume 2** of this Environmental Assessment.

The Director-General's environmental assessment requirements identify a number of key issues to be addressed in relation to flora and fauna. **Table 15-1** indicates where the aspects of the Director-General's environmental assessment requirements that relate to flora and fauna are addressed, either in this chapter or in other chapters (in *italics*).

Table 15-1 Flora and fauna

Environmental assessment requirements	Where addressed
Flora and Fauna – including but not limited to:	
• Threatened terrestrial and aquatic species, populations, ecological communities and/or critical habitat.	**Sections 15.2** and **15.3**
• Native vegetation loss; weed infestation; habitat fragmentation; impacts to wildlife and riparian corridors; impacts to ground-water dependent communities, riparian and aquatic habitat including:	**Section 15.3**
• Seagrass and mangrove stands at the Hastings River, Wilson River and associated wetland areas evaluated in accordance with the NSW Fisheries document *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation 1999* (Section 6.4 and 6.5 specifically).	**Section 15.3**
• Regional scale cumulative impacts and identify the significance of the impacts of the project in the context of the PHUP.	**Section 15.3.4**

15.1 Assessment approach

The methodology for the flora and fauna assessment comprised:

- Literature reviews of recent assessments.
- Desktop database searches to define potential species in the region.
- Site investigations for flora and fauna species, both terrestrial and aquatic, and endangered ecological communities known to occur within the Proposal corridor.
- Ground-truthing using various survey techniques appropriate to the ecological values identified in the searches.
- Field investigations using techniques consistent with the former Department of Environment and Conservation's *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities: Working Draft* (Department of Environment and Conservation 2004).
- Aquatic assessments undertaken in accordance with the NSW Fisheries document *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation* (Department of Primary Industries 1999).

For the purposes of the flora and fauna assessment, specific terminology is used, as follows:

- The 'study locality' is the area within 10 kilometres on either side of the centreline of the Proposal.
- The 'study area' consists of a strip of land 150 metres wide along the length of the Proposal, with two wider areas at the southern end from Fernbank Creek to Cairncross State Forest and further through Cairncross State Forest to Haydons Wharf Road. It also includes all roundabouts, on- and off-ramps and interchanges.
- The 'Proposal boundary' refers to the area of land that would be acquired for the Proposal.
- The 'Proposal footprint' refers to the area where direct impacts would occur within the Proposal boundary, and includes the carriageways, service and access roads plus an allowance for clearing plus a clearing buffer of up to 6 metres to cater for utilities, services and construction activities.

It should be noted that the Proposal boundary is wider than the Proposal footprint and not all areas within the Proposal boundary would require clearing for construction. Clearing of the Proposal footprint only has been assessed in this flora and fauna assessment.

15.1.1 Desktop investigations

Several databases, existing studies and reports were interrogated for records of threatened flora and fauna in the study locality and for information on biodiversity values, including:

- The Federal Department of the Environment, Water, Heritage and the Arts (DEWHA) website-based EPBC Act Protected Matters Search Tool (as at July 2009).
- The NSW DECCW Atlas of NSW Wildlife database (as at July 2009) for the Kempsey (9435) and Camden Haven (9434) 1:100,000 map sheets.
- DECCW Threatened Species Profile Database for the Macleay Hastings subregion of the Northern Rivers Catchment Management Authority.
- The National Herbarium of NSW PlantNet database for threatened and other significant species.
- Forests NSW database.
- Royal Botanic Gardens and North Coast Regional Botanic Gardens records.
- Listings of rare or threatened species in Briggs and Leigh (1996) *Rare or Threatened Australian Plants*.
- The former NSW Fisheries threatened species profiles which describes threatened and protected aquatic species and ecological communities listed on the *Fisheries Management Act 1994*.
- NSW Bionet database for threatened terrestrial and aquatic flora and fauna.
- The Australian Museum FaunaNet database for threatened and protected aquatic species.
- *The New Atlas of Australian Birds* (Barrett et al. 2003).
- Dr. Vanessa Standing's report on koala sightings on the Pacific Highway between Port Macquarie and Kempsey.
- DII mapping of estuarine habitats in NSW (as at February 2010).

- Former NSW National Parks and Wildlife Service (2005) *Key Habitats and Corridors in North East NSW*.
- *Draft Northern Rivers Regional Biodiversity Management Plan, National Recovery Plan for the Northern Rivers* (DEWHA 2009).
- *Oxley Highway to Kempsey Route Options Development Report* (RTA 2005f) and *Oxley Highway to Kempsey Preferred Route Report* (RTA 2006e).

15.1.2 Field surveys

Detailed terrestrial and aquatic ecology surveys (including fish surveys) were undertaken throughout the study area and were designed to comply with the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities: Working Draft* (Department of Environment and Conservation 2004). Initial investigations into ecological values were undertaken at the route options development stage, broadly identifying characteristics of the landscapes. Studies were also undertaken at the preferred route stage and were reported in the *Oxley Highway to Kempsey Preferred Route Report* (RTA 2006e). Further studies were undertaken for this Environmental Assessment.

Specific activities undertaken during the ecological investigations include:

- Detailed terrestrial flora and fauna survey (over several different seasons in 2005 and 2007) using a variety of field work and survey techniques including transects, traps, scat survey, bat call detection techniques and opportunistic observations.
- Aquatic and riparian assessment of the Hastings and Wilson rivers and floodplains (in 2005) comprising survey techniques including quadrats, transects and detailed community mapping.
- Fish surveys on five watercourses crossed by the Proposal (in 2007) and a combination of active and passive survey techniques adopted including water quality and habitat assessment, seine net, fyke net, bait traps and univariate analysis.

A full description of the surveys undertaken and their results is detailed in Section 2 of the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment.

It should be noted that the field surveys covered a large study area, and were undertaken at specific times and based on targeted sampling of representative habitats. They were aimed at maximising the likelihood of detecting threatened flora and fauna species in diverse habitats. It is likely with this survey technique some species that would be expected to occur (particularly fauna) may not have been detected. Further to this, some species by their nature are difficult to detect because of their mobility and call patterns that are similar to other species. Where species are considered likely to occur in a particular habitat, but not identified during survey, a precautionary assessment of the possible impact has been carried out.

Access was not granted to survey two properties between Cairncross State Forest and the Wilson River. Therefore it was not possible to survey these properties, except for remotely viewing and inferring the vegetation types from adjoining properties and aerial photographs. One of these properties is well vegetated with swamp forest, some of which is regenerating, and the other was predominantly cleared for cattle grazing. The area of these properties not surveyed that falls within the Proposal footprint is 5.8 hectares and 14.9 hectares respectively. These properties would be surveyed prior to construction.

The study area was extended to include Stumpy Creek after the aquatic assessments were completed. A further aquatic habitat assessment would be undertaken prior to construction.

The mapped boundaries of wetlands listed under *State Environmental Planning Policy No. 14 – Coastal Wetlands* were identified during field investigations. It was determined that mapped areas were not consistent with ground conditions. A more accurate boundary would be established prior to construction through quantitative observations and surveying of the mapped boundary.

15.1.3 Groundwater dependent ecological communities

Vegetated groundwater dependent ecological communities and their degree of dependence on groundwater were inferred from the floristics and structure of the vegetation, known correlations with groundwater systems, and their position in the landscape. Rivers and streams are assumed to be groundwater dependent.

15.1.4 Statutory position

The ecological impacts of the Proposal have been assessed in accordance with the *Draft Guidelines for Threatened Species Assessment under Part 3A* of the EP&A Act (Department of Environment and Conservation 2005), and in the context of relevant State and Federal legislation and planning polices. These include:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- *Environmental Planning and Assessment Act 1979* (EP&A Act).
- *Threatened Species Conservation Act 1995* (TSC Act).
- *National Parks and Wildlife Act 1974.*
- *Native Vegetation Act 2003.*
- *Fisheries Management Act 1994*.
- *Noxious Weeds Act 1993*.
- *State Environmental Planning Policy No. 14 – Coastal Wetlands*.
- *State Environmental Planning Policy No. 26 – Littoral Rainforests*.
- *State Environmental Planning Policy No. 44 – Koala Habitat Protection.*
- *State Environmental Planning Policy No. 71 – Coastal Protection*.
- Regional Forest Agreements.

15.2 Existing environment

15.2.1 Landscape

Approximately 30 per cent of the study area is cleared and predominantly comprises paddocks as well as the existing highway and smaller roads. A further 6 to 7 per cent is plantations, partially cleared or under scrubbed with scattered trees. Rural land uses include grazing, aquaculture, orchards, tea tree plantations, vineyards, poultry farms, and other agricultural activities.

The remainder of the study area (approximately 63 per cent) supports natural vegetation of varying quality. Most of this vegetation has been disturbed at some time, and much of it is regrowth from past major disturbances such as logging or clearing for farming and grazing. This includes the vegetation within Rawdon Creek Nature Reserve, which was logged prior to the establishment of the nature reserve. Consequently, little intact mature forest occurs within the study area.

State forests located in the study area are scheduled for logging and contribute to State-wide logging production targets. Kumbatine National Park is located in the study area, on the western side of the existing highway. Cooperabung and Rawdon Creek nature reserves are also located within the study area. Maria National Park is located outside the study area.

15.2.2 Regional forest ecosystem mapping

The Proposal is situated within the North Coast Bioregion defined by DECCW. This bioregion follows the east coast of NSW from Raymond Terrace to the Queensland border. Within the North Coast Bioregion, the Proposal is located within the Macleay Hastings Catchment Management Authority sub-region.

Regional forest ecosystem mapping has been undertaken by the former National Parks and Wildlife Service as part of the regional forest agreement process. The project mapped broad floristic groups and forest structure to guide modelling of forest ecosystems, old growth forest, and flora and fauna communities. Mapping showing regional forest ecosystems in the study area is provided in **Figure 15-1a** and **Figure 15-1b**.

15.2.3 Vegetation communities

The overall vegetation condition within the study area varies widely, ranging from totally cleared grazing land to natural undisturbed bushland. Due to past clearing and ongoing disturbance within the study area, the vegetation is either much simplified in character or modified and very few patches of vegetation are undisturbed.

Ten natural vegetation communities and three artificial or highly modified vegetation communities were recorded during field surveys within the Proposal footprint, as outlined below. The corresponding numbers refer to the vegetation community descriptions outlined in the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment.

Natural communities

1. Moist Floodplain Closed Forest with Rainforest Elements.
2. Riparian Forest.
3. Paperbark Swamp Forest.
4. Swamp Mahogany / Forest Red Gum Swamp Forest.
5. Swamp Oak Forest.
6. Freshwater Wetland.
7. Moist Floodplain Forest.
8. Moist Gully Forest.
9. Moist Slopes Forest.
10. Dry Ridgetop Forest.

Artificial or highly modified communities.

11. Cleared, Open Grassland / Derived Pasture with scattered trees.
12. Plantation / Cropland / Market Garden etc.
13. Totally Cleared Open Pasture / Weedy Fallow.

Figure 15-2a to **Figure 15-2f** illustrate the vegetation communities in the Proposal boundary.

Figure 15-1a Regional forest ecosystem mapping - Sections A and B

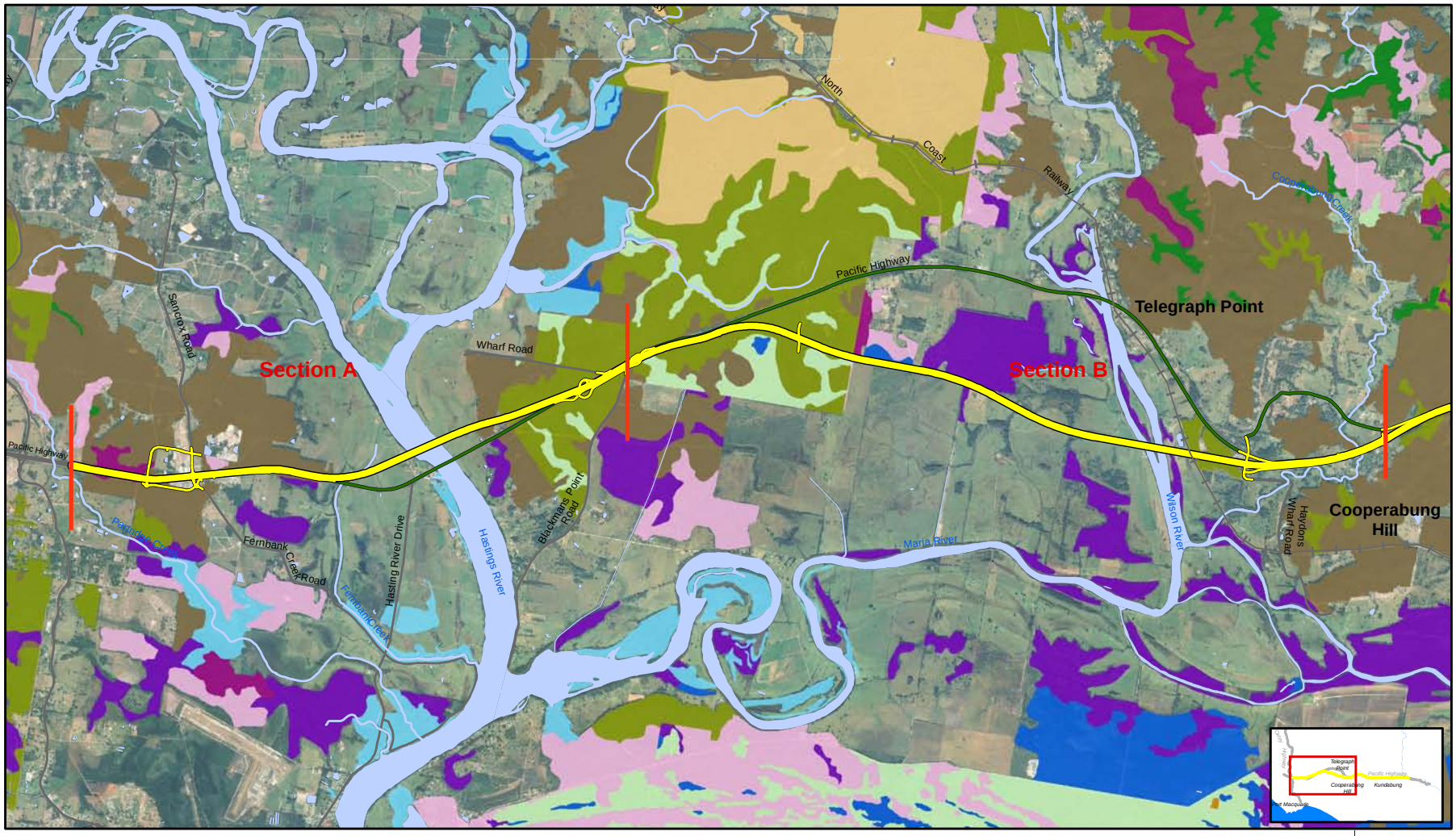


Figure 15-1b Regional forest ecosystem mapping - Sections C and D

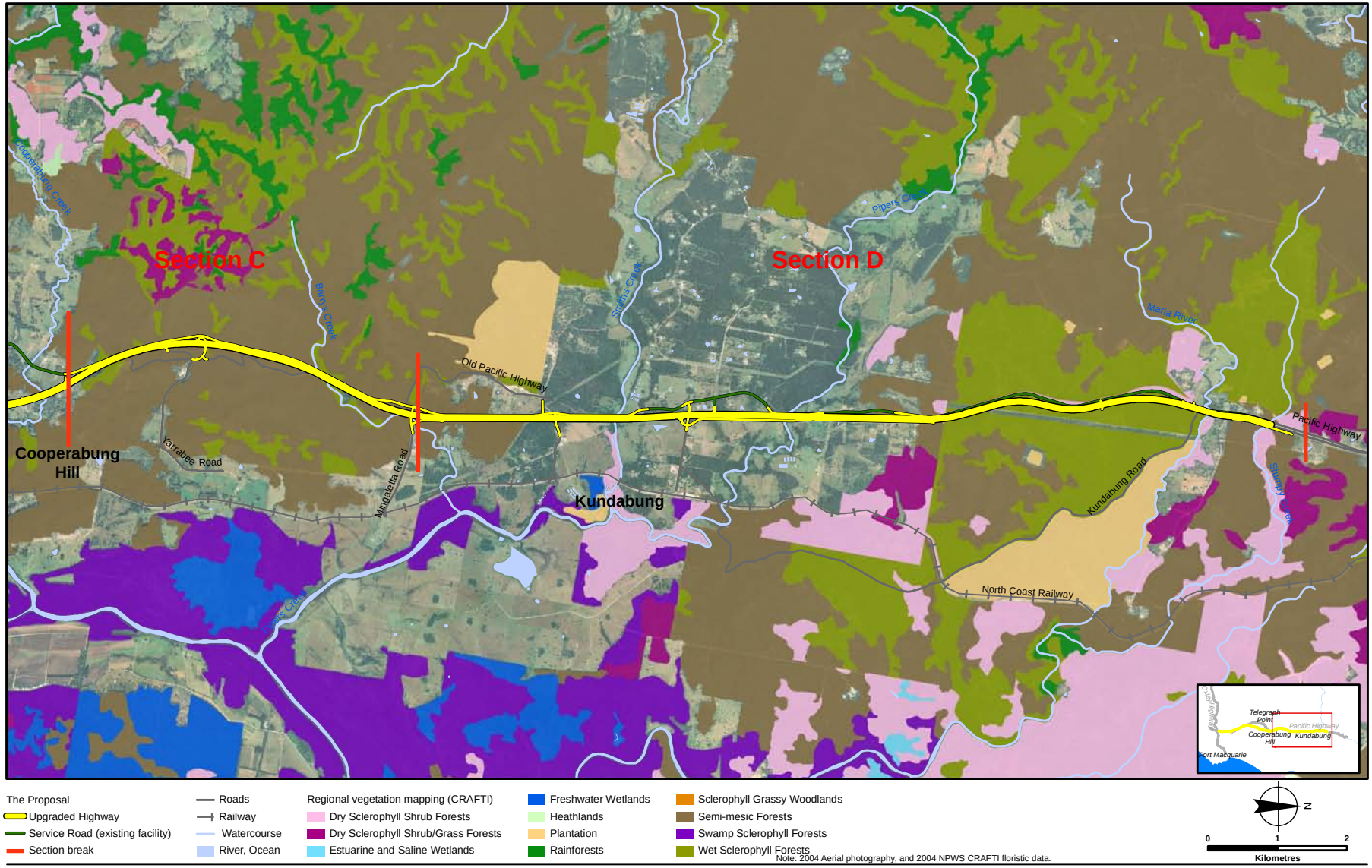


Figure 15-2a Vegetation communities and endangered ecological communities in the Proposal boundary

Figure 15-2b Vegetation communities and endangered ecological communities in the Proposal boundary

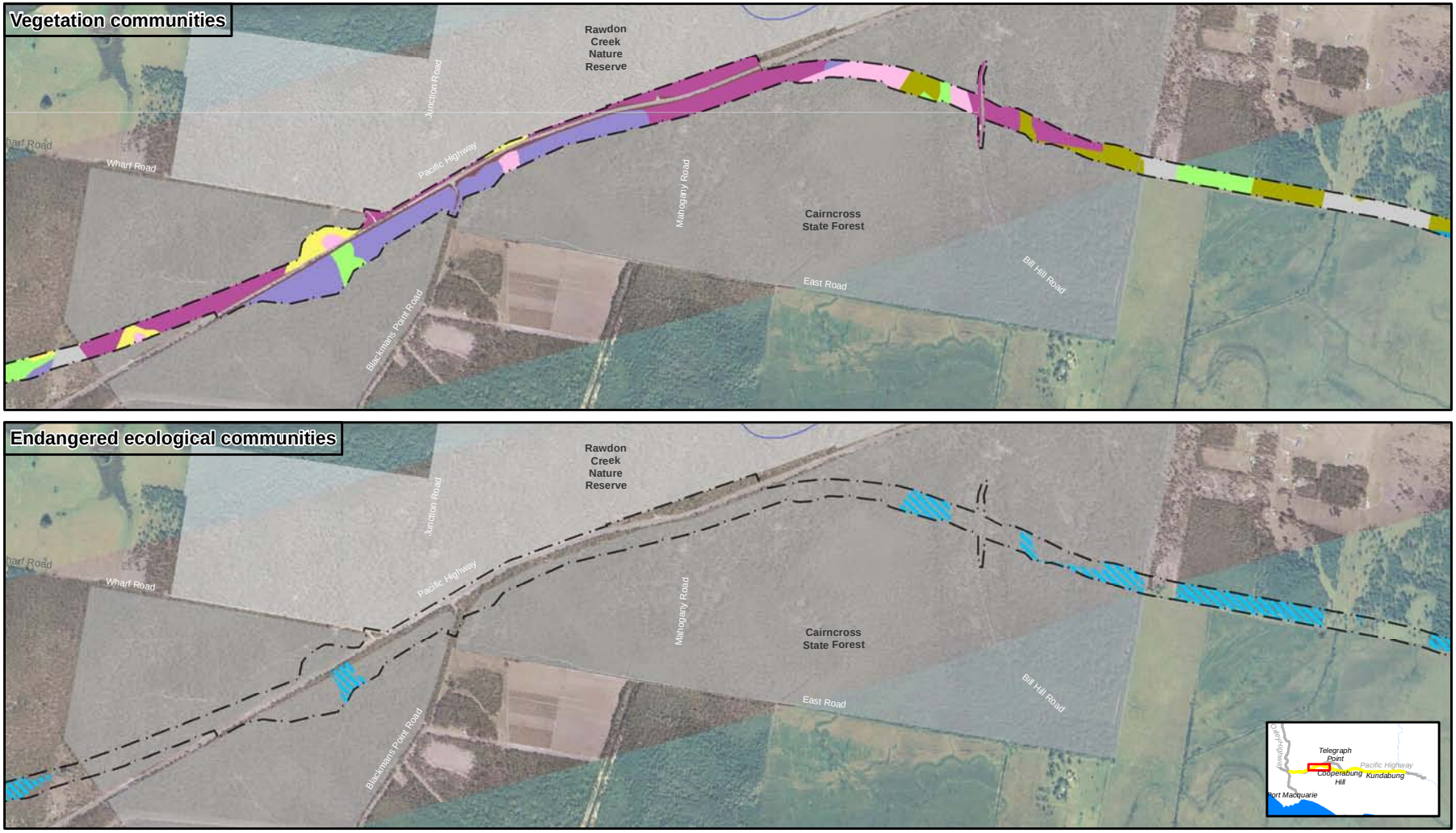


Figure 15-2c Vegetation communities and endangered ecological communities in the Proposal boundary

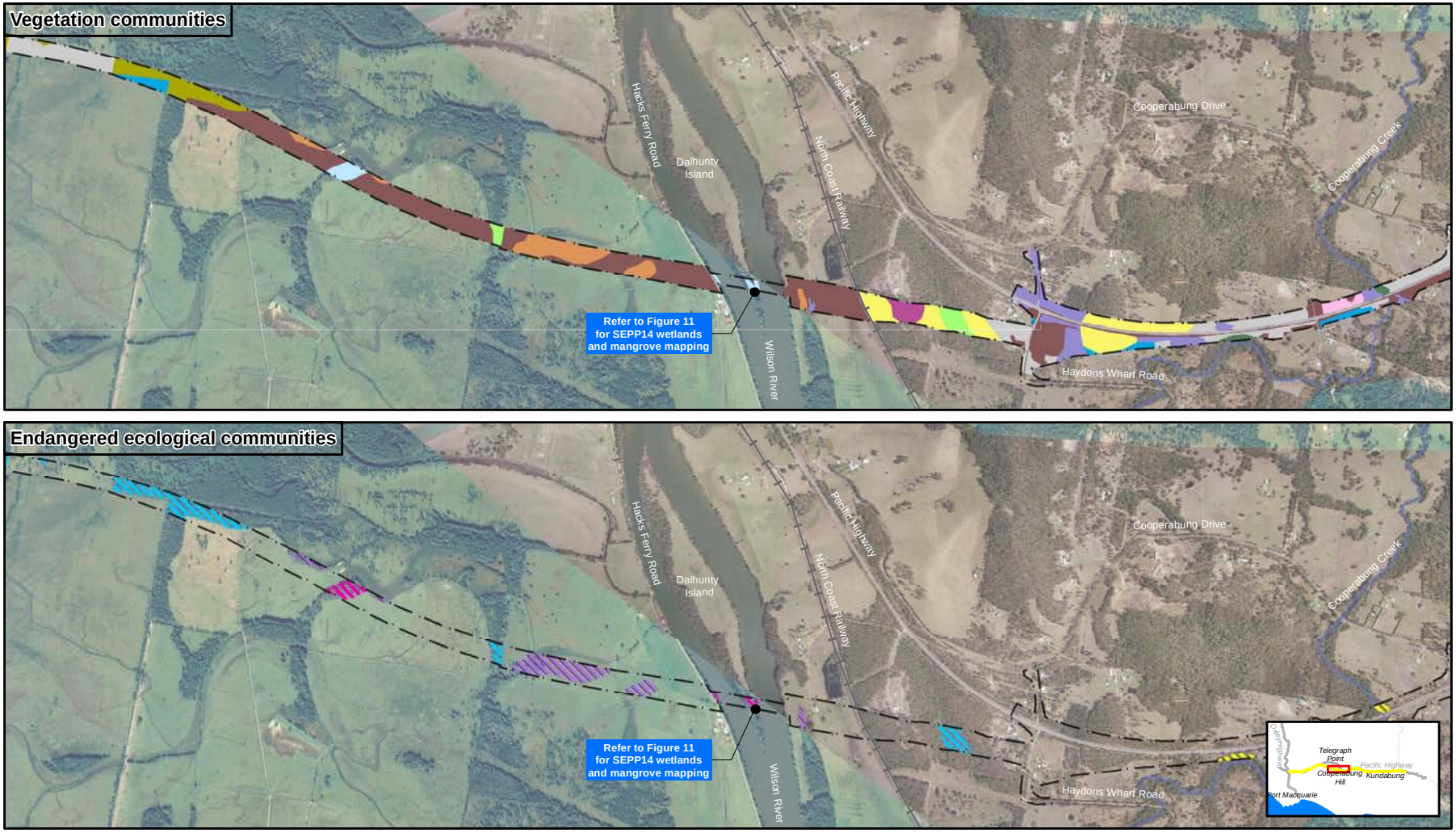


Figure 15-2d Vegetation communities and endangered ecological communities in the Proposal boundary

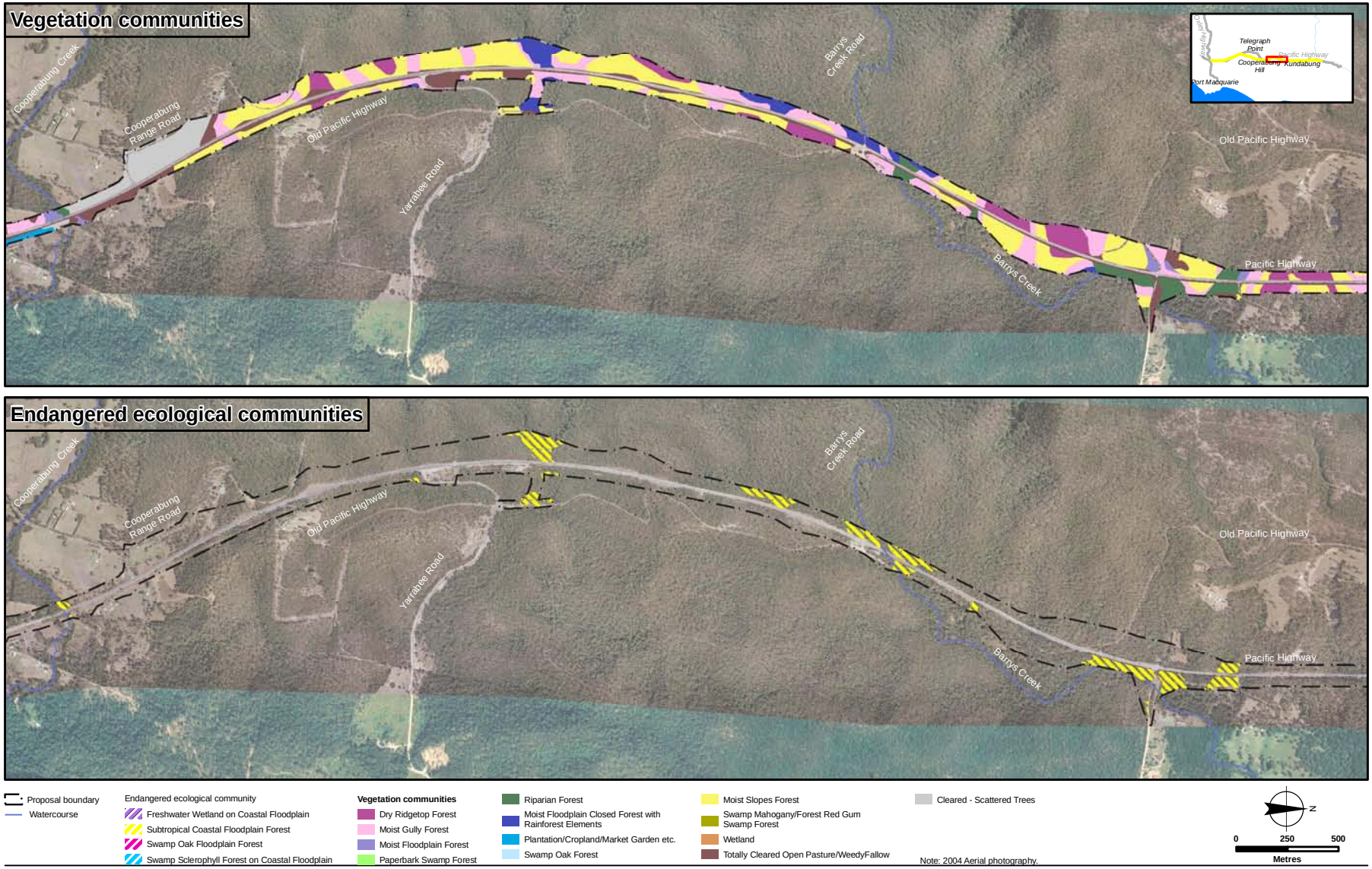


Figure 15-2e Vegetation communities and endangered ecological communities in the Proposal boundary

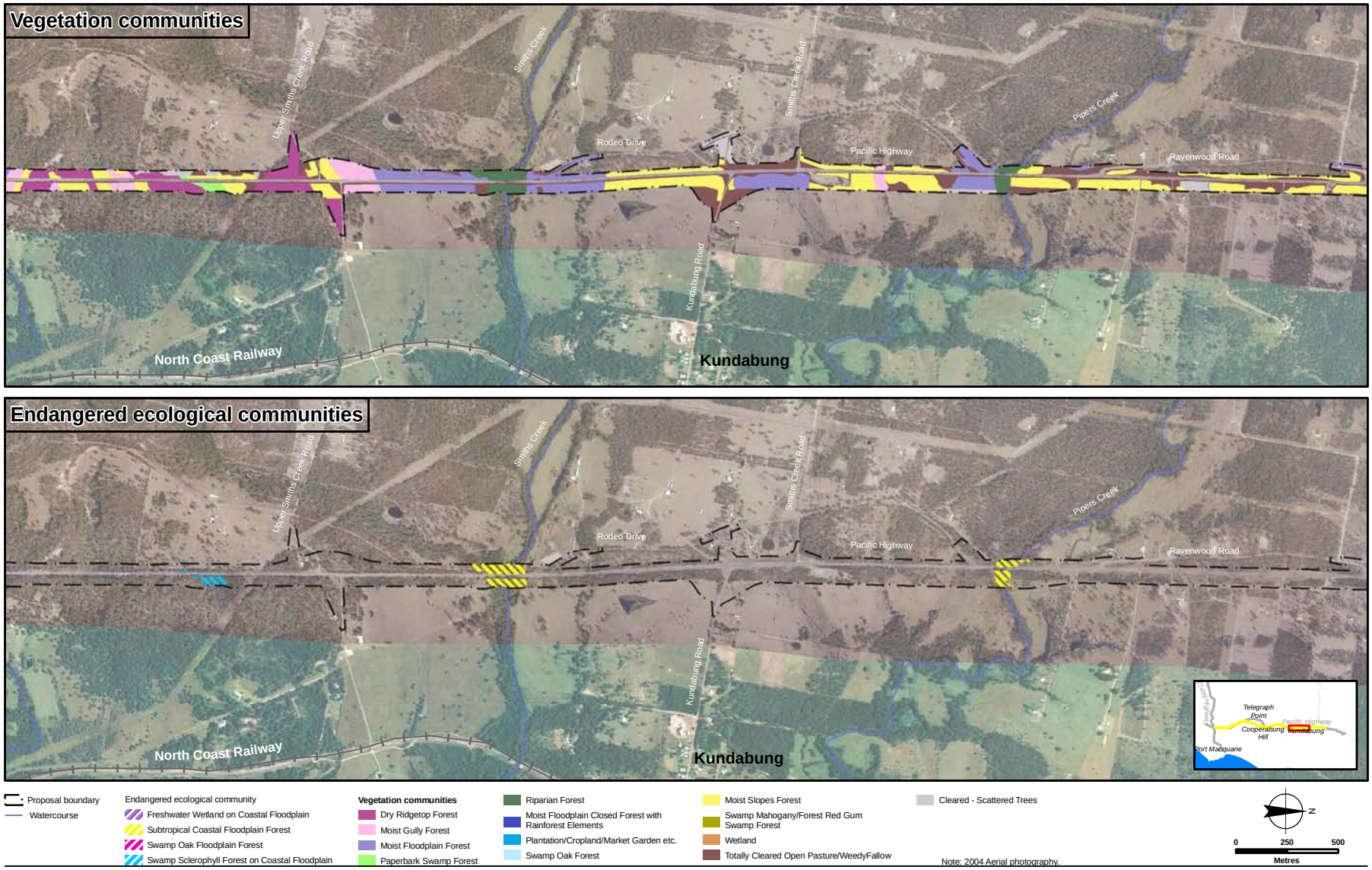
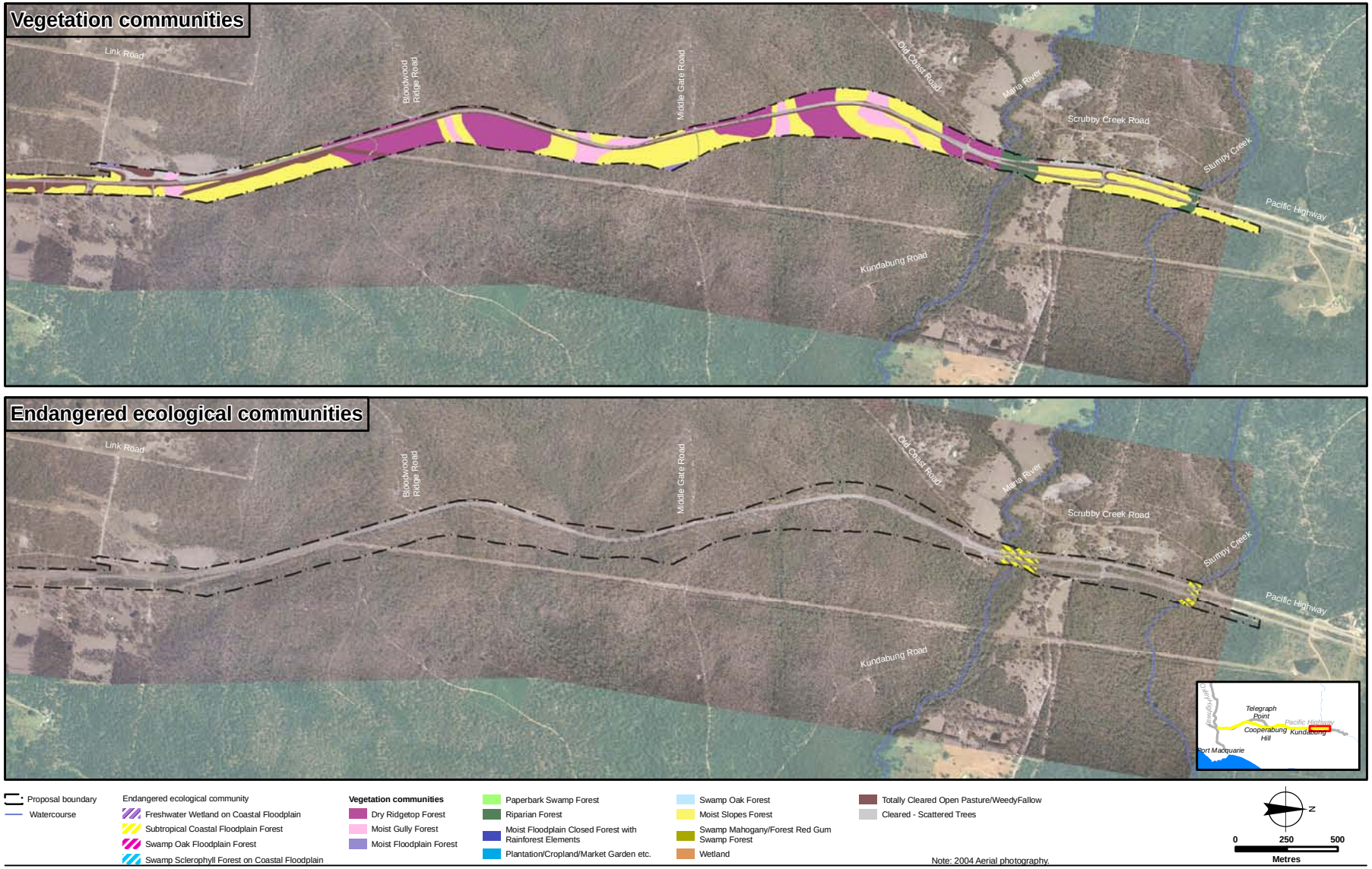


Figure 15-2f Vegetation communities and endangered ecological communities in the Proposal boundary



The dominant vegetation community in the study area is moist slopes forest. This community is characterised by forest or open forest with a sparse, grassy understorey. Dominant tree species are brushbox, blackbutt, tallowwood, spotted gum and ironbark with a combination of white mahogany, small-fruited grey gum, white stringybark, red and pink bloodwood and turpentine. Elsewhere, minor areas of swamp or riparian vegetation occur by creeks and rivers and their associated floodplains. The vegetation in these areas typically consists either of paperbarks, swamp oaks, swamp mahoganies and forest red gums on floodplains; or flooded gums, brushbox and paperbarks by creek banks. Dry sclerophyll forest occurs on ridgetops consisting of various combinations of the dominant tree species blackbutt, tallowwood, stringybark, bloodwood, spotted gum or ironbark. Small areas of freshwater wetlands also occur in the southern half of the study area.

Variations to this natural vegetation community occur mainly in the vicinity of rivers, creeks and their floodplains, and in deep gullies. Most of the land within the study area is flat or gently undulating, with the exception of Cooperabung Hill and, to a lesser extent, the Maria River State Forest. Steeper land and deeper gullies occur in the vicinity of Barrys Creek. Areas of wet sclerophyll forest with rainforest elements occur in the Barrys Creek gully area, and on the adjacent lower slopes with sheltered aspects. This forest type has also been heavily logged, but some mature trees occur.

Four endangered ecological communities listed under the TSC Act are present in the study area:

- Swamp Oak Floodplain Forest of the North Coast Sydney Basin and South East Corner bioregions (vegetation communities 3 and 4) – comprises 7.0 per cent of the total area of intact natural communities within the Proposal footprint.
- Subtropical Coastal Floodplain Forest of the North Coast Bioregion (vegetation community 5) – comprises 0.3 per cent of the total area of intact natural communities within the Proposal footprint.
- Swamp Sclerophyll Forest on Coastal Floodplains of the North Coast Sydney Basin and South East Corner Bioregions (vegetation communities 1 and 2) – comprises 4.2 per cent of the total area of intact natural communities within the Proposal footprint.
- Freshwater Wetlands on Coastal Floodplains of the North Coast Sydney Basin and South East Corner Bioregions (vegetation community 6) – comprises 1.3 per cent of the total area of intact natural communities within the Proposal footprint.

15.2.4 Terrestrial flora

No threatened flora species listed under either the TSC Act or EPBC Act or rare species listed on the Rare or Threatened Australian Plants database were recorded within the study area during targeted field investigations conducted from 2005 to 2007.

In the case of two properties that were not able to be accessed between Cairncross State Forest and the Wilson River, the presence or absence of threatened flora species could not be established directly. The area of these properties that falls within the Proposal footprint is 5.8 hectares and 14.9 hectares respectively. Given the extent of natural vegetation particularly on one property, a supplementary survey for threatened flora and endangered ecological communities would be undertaken within the Proposal footprint of each property prior to construction occurring.

From searches of the DECCW Atlas of NSW Wildlife and the DEWHA EPBC Protected Matters Search Tool, 29 threatened flora species have been previously recorded within the study locality or have distribution ranges which include the study area. An assessment of the likelihood of species occurrence in the study area is presented in Appendix E of the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment. Of the threatened plant species previously recorded in the locality, seven threatened species have the potential to occur in the study area. These are shown in **Table 15-2**.

Table 15-2 Threatened plant species with the potential to occur in the study area

Species	Location	TSC Act status	EPBC Act status
Scented acronychia (*Acronychia littoralis)*	2 unconfirmed records near Fernbank Creek and the Wilson River, as well as several records on the coast near Port Macquarie	Endangered	Endangered
Hairy-joint grass (*Arthraxon hispidus*)	Recorded within 2 km of the existing highway at Kundabung	Vulnerable	Vulnerable
Maundia *(Maundia triglochinoides)*	Recorded approximately 1 km south of the Oxley Highway	Vulnerable	None
Biconvex paperbark (*Melaleuca biconvexa*)	Recorded just south of the Oxley Highway / Pacific Highway interchange	Vulnerable	Vulnerable
Milky silkpod (*Parsonsia dorrigoensis*)	1 record on the coast near Port Macquarie	Vulnerable	Endangered
Swamp orchid (*Phaius tancarvilleae*)	Not previously recorded in the study locality but is known to occur in northern NSW	Endangered	Endangered
Southern swamp orchid (*Phaius australis*)	Not previously recorded in the study locality but is known to occur in the vicinity of, and north of, Port Macquarie (HWR Ecological 2005)	Endangered	Endangered

As indicated in **Table 15-2**, there are two unconfirmed records of scented acronychia within the locality (HWR Ecological 2005). One record is located just beyond the edge of the Proposal footprint in the Fernbank Creek area; the other approximately 150 metres to the west of the Proposal footprint on the floodplain south of the Wilson River. During the targeted field surveys undertaken for this assessment in 2007, the common *Acronychia oblongifolia* was recorded at the approximate location of the Fernbank Creek record of scented acronychia referred to in HWR Ecological (2005). Preferred habitat for scented acronychia is documented as being littoral rainforest on sand (DECC 2005), yet HWR Ecological reports scented acronychia as occurring within swamp sclerophyll forest. There is no indication in the HWR Ecological report that voucher specimens were forwarded to the National Herbarium for verification. Hence, the records in HWR Ecological could only be treated as unconfirmed and possible locations. It is therefore concluded that scented acronychia is not present within the Proposal footprint and that the unconfirmed records appear to be a misidentification of the species as the common *Acronychia oblongifolia*.

The Proposal encroaches on the eastern border of the Cooperabung Creek Nature Reserve for a short distance. According to the management plan for the reserve (National Parks and Wildlife Service 2003c), no comprehensive flora survey has been carried out over the reserve. However, the Forests NSW Comprehensive Regional Assessments modelling has predicted that the milky silkpod is likely to occur in the reserve.

Weeds

A total of 97 exotic flora species were recorded within the study area during flora surveys. This represents around 23 per cent of the total flora species recorded. Exotic species are defined as any species not known to occur naturally in the study locality, and include NSW or Australian native species from other regions that are likely to have become locally naturalised. Most exotic species were concentrated along the existing highway verges, cleared grazing land, tracks and other disturbed areas.

Of the exotic species recorded, seven are declared noxious pursuant to the *Noxious Weeds Act 1993* in the control areas of Port Macquarie-Hastings and Kempsey Shire councils. These are:

- Crofton weed (*Ageratina adenophora*).
- Annual ragweed (*Ambrosia artemisiifolia*).
- Prickly pear (*Opuntia stricta*).
- Resurrection plant (*Bryophyllum pinnatum*).
- Creeping oxalis (*Oxalis corniculata*).
- Blackberry (*Rubus fruticosus* sp. aggr.).
- Lantana (*Lantana camara*).

Most of the noxious species listed above were limited to a small number of locations only, and occurred at low densities. By far the most widespread and abundant noxious weed in the study area was lantana, which was recorded throughout the Proposal length and often dominated creekline communities and damp floodplain areas. 'Invasion, establishment and spread of lantana (*Lantana camara*)' is now a listed key threatening process under the TSC Act. Annual ragweed was moderately widespread, but was almost invariably restricted to highly disturbed roadside verges.

15.2.5 Terrestrial fauna habitats

The 13 vegetation communities identified through vegetation mapping constituted a good basis for assessing the availability and quality of various habitat types throughout the study area. The relative quality of fauna habitat within the study area is based on the following features:

- Presence of large dead or living trees and hollow bearing trees.
- Tree species richness and canopy cover.
- Density of shrub and ground cover.
- Presence of fallen timber and rock outcrops.
- Presence of wet areas and waterbodies.
- Disturbance regimes (eg logging, weed infestations, clearing and grazing).
- The extent of potential movement corridors and refuge areas.
- The number of threatened species known or with the potential to occur.

No areas of critical habitat declared on the Registers of Critical Habitat kept by the Director-General of the DECCW, DEWHA, or DII occur in the study area.

Moist Floodplain Closed Forest with Rainforest Elements mapped in **Figure 15-2a** and **Figure 15-2b** has been ranked as high quality fauna habitat as these areas are generally intact, provide habitat for a range of fauna and have good linkages to other areas of habitat for fauna movement. Some patches of Paperbark Swamp Forest, Swamp Mahogany/ Forest Red Gum Swamp Forest and Riparian Forest have also been mapped as high quality fauna habitat, with more disturbed patches ranked as medium quality fauna habitat.

The remainder of native vegetation communities in the study area, including Moist Floodplain Forest, Moist Gully Forest, Swamp Oak Forest, Freshwater Wetland and Dry Ridgetop Forest have been mapped as medium quality habitat, containing smaller patches of high or low quality habitat. All other patches are ranked as low quality as they have been substantially cleared or modified and provide little in the way of natural fauna habitat. Details regarding ranking is set out in Section 3.1 of the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment.

Key habitats and habitat corridors

Areas of land within the study area are identified as 'key habitats' as defined by the former National Parks and Wildlife Service Key Habitats and Corridors Project (2005). The key habitats comprise areas of predicted high conservation value for forest fauna, and include large areas of vegetated lands and important vegetation remnants. A framework of corridors which provide connectivity between key habitat areas across the landscape has been mapped and is shown in **Figure 15-3**.

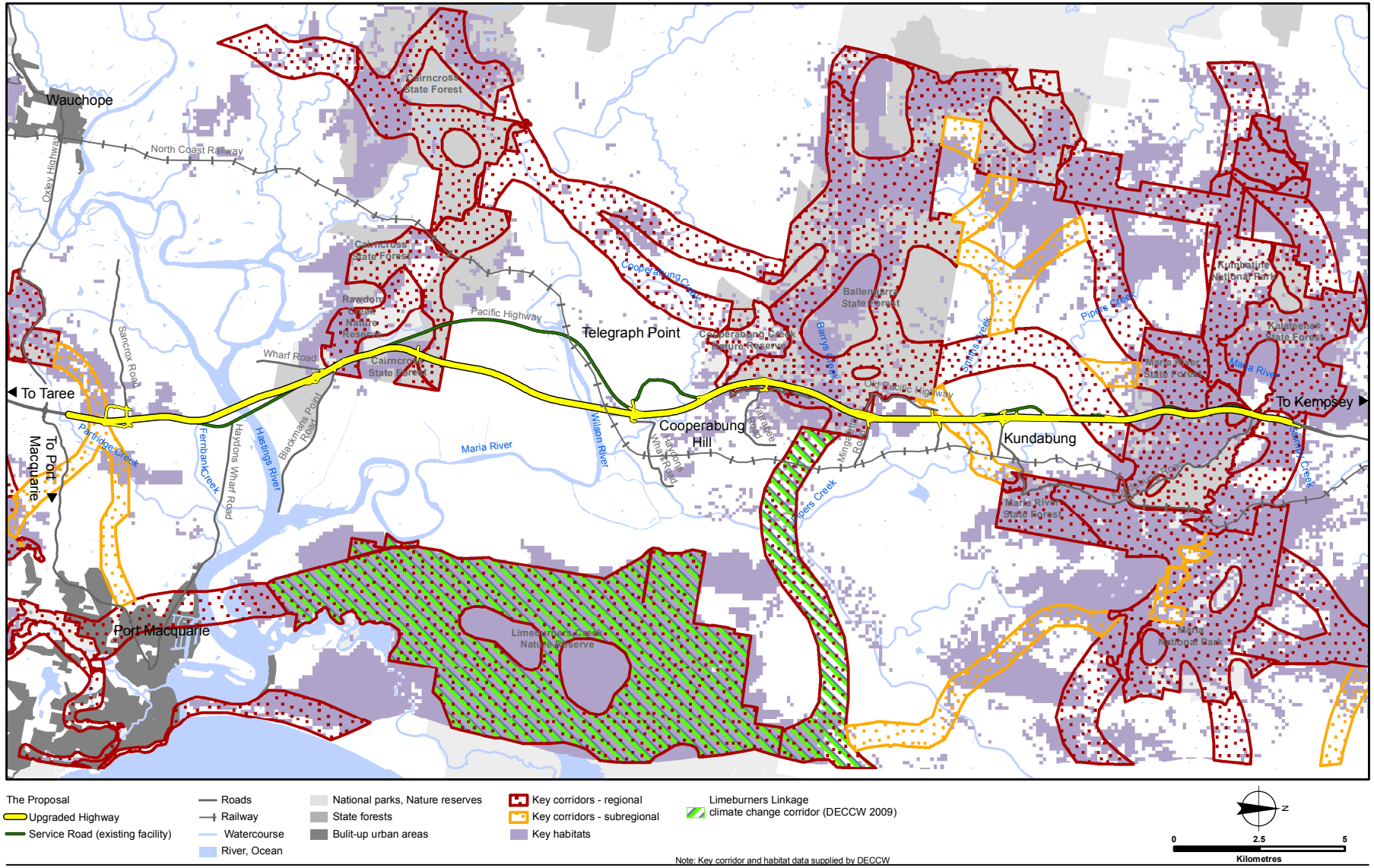
The habitat corridors facilitate important ecological processes such as migration, colonisation and interbreeding of plants and animals between two or more larger areas of habitat. This would tend to reduce the risk of local flora and fauna populations becoming isolated and therefore at risk of local extinction.

The Proposal passes through or overlaps nine of the regional and sub-regional corridors, as follows:

- Lake Innes – Cowarra sub-regional corridor.
- Rawdon Creek Nature Reserve regional corridor.
- Cooperabung Creek Nature Reserve regional corridor.
- Ballengarra State Forest regional corridor.
- Kundabung subregional corridor.
- Ballengarra – Maria River regional corridor.
- Maria River State Forest regional corridor.
- Kumbatine National Park regional corridor.
- Maria Link regional corridor.

Koala corridors have been identified near Sancrox Road, between the Hastings and Wilson rivers, Barrys Creek, Pipers Creek and Smiths Creek (Connell Wagner 2000 and Vanessa Standing pers. comm.). Regional and local habitat links for the koala (Connell Wagner 2000) have been identified as crossing the existing highway between Oxley Highway and Sancrox Road and Hastings and Wilson rivers, linking Rawdon Creek Nature Reserve and Cairncross State Forest to private lands on the floodplains to the east (Connell Wagner, 2000).

Figure 15-3 Wildlife corridors and key habitats in the study locality



However, based on the Wildlife Atlas records, road kill records and communication with local vet and koala expert, Vanessa Standing, koalas could occur anywhere along the proposed route, particularly where natural vegetation occurs on either side of the road. Similar considerations apply for other larger mobile terrestrial fauna in the study area that are likely to utilise identified corridors for movements but which may attempt crossings at any point where native vegetation occurs on either side of the road.

Reserves

Nature reserves located in the study area include Rawdon Creek Nature Reserve and Cooperabung Creek Nature Reserve. Both of these nature reserves provide known habitat for a wide range of threatened fauna, including the koala, little bent-wing bat, glossy black cockatoo, brushtailed phascogale, barking owl, sooty owl, osprey, masked owl, powerful owl, square-tailed kite, grey-headed flying-fox and green-thighed frog.

Tree hollows

Tree-hollows within the study area provide potential shelter and nesting sites for a large number of arboreal mammals, birds, including large forest owls and parrots, as well as tree-dwelling microchiropteran bats, some reptiles, frog and invertebrate species.

Tree hollows of various sizes are present but not abundant within drier vegetation communities within the study area. Tree hollows of varied sizes are more abundant within riparian and swamp communities, particularly in Ballengarra, Cairncross and Maria River state forests. These areas contain hollows suitable for larger species, including the threatened glossy black-cockatoo, masked owl, sooty owl and yellow-bellied glider that were recorded in the study area. Hollows for smaller species (including threatened microchiropteran bats recorded during the surveys) can be found in forested areas and isolated paddock trees along the Proposal route.

Koala habitat assessment

Five koala food tree species listed under Schedule 2 of *State Environmental Planning Policy No. 44 – Koala Habitat Protection* were recorded within the study area. All 10 natural vegetation communities listed in **Section 15.2.3** contain at least one listed koala food tree species.

The results of the database searches indicate numerous recent koala records within the study area. A koala was sighted crossing the Pacific Highway approximately 200 metres south of Sancrox Road during field investigations (GHD 2008). Searches for koala scats and scratches on potential feed trees also detected signs of recent koala activity within Ballengarra State Forest and south of Sancrox Road. Based on the numerous records of koalas within the study area and communication with local vet and koala expert, Vanessa Standing, this species could occur anywhere along the Proposal, particularly where habitat occurs on both sides of the road. The most likely areas would appear to be:

- Either side of Sancrox Road.
- Cairncross State Forest.
- Rawdon Creek Nature Reserve.
- Cooperabung Hill (Ballengarra State Forest and Cooperabung Nature Reserve).
- Mingaletta Road to Smiths Creek.
- Kundabung Road to north of Pipers Creek.
- Maria River State Forest.

These areas are likely to represent core koala habitat defined under *State Environmental Planning Policy No. 44 – Koala Habitat Protection* and are likely to contain a resident population of koalas.

Overall habitat values

Overall, the study area is considered to possess high habitat value given:

- The presence of relatively large tracts of low or moderately disturbed fauna habitat adjoining the study area, particularly north and south of Sancrox Road, Rawdon Creek Nature Reserve, Cairncross State Forest, Cooperabung Creek Nature Reserve, Ballengarra State Forest, Maria River State Forest and Kumbatine National Park.
- It contains remnant, contiguous vegetation which contributes to major local and regional vegetation / wildlife corridors.
- The presence of endangered ecological communities listed under the TSC Act.
- The occurrence of a variety of threatened species, including birds, mammals, bats and amphibians that were either recorded in the current investigations or within previous surveys.
- The occurrence of potential habitat for other threatened species that may occur in the study area, at least on a seasonal, nomadic or migratory basis.

15.2.6 Terrestrial fauna

Interrogation of relevant wildlife databases and the literature review identified 69 threatened fauna species listed under the TSC Act that have been recorded or are predicted to occur in the study locality, comprising 36 bird, 24 mammal, two reptile, five amphibian and two invertebrate species. 48 threatened species and 50 migratory species listed under the EPBC Act are predicted to occur within the study locality.

One endangered population listed under the TSC Act (The Emu *Dromaius novaehollandiae* population in the North Coast Bioregion and Port Stephens LGA) was identified through the desktop review as potentially occurring within the study locality. There are, however, no records of Emus within the study locality and it is therefore unlikely that the Proposal would affect this population.

Of the species previously recorded or predicted to occur, 46 threatened species under both the TSC Act and EPBC Act were assessed as likely to occur within the study area based on known records and habitat availability within the study area.

Of these 46 species, 18 threatened fauna species were recorded in the study area during the field investigations. A further five species are considered highly likely to occur in the study area based on habitat preferences and habitat availability. The remaining 23 species are considered to have some potential to occur and fall into two broad categories: those for which there is limited suitable habitat in the study area and those that could visit the study area on an occasional basis and for which there is unlikely to be a permanent resident population in the study area. **Table 15-3, Table 15-4** and **Table 15-5** list these species.

Table 15-3 Threatened fauna species recorded in the study area during field surveys

Common name	Scientific name	TSC Act	EPBC Act
black-necked stork	*Ephippiorhynchus asiaticus*	Endangered	
eastern bent-wing bat	*Miniopterus schriebersii oceanensis*	Vulnerable	
eastern false pipestrelle	*Falsistrellus tasmaniensis*	Vulnerable	
eastern freetail-bat (previously east-coast freetail-bat)	*Micronomus norfolkensis (*previously *Mormopterus norfolkensis)*	Vulnerable	
giant barred frog	*Mixophyes iteratus*	Endangered	Endangered
glossy black-cockatoo	*Calyptorhynchus lathami*	Vulnerable	
greater broad-nosed bat (probable)	*Scoteanax rueppellii*	Vulnerable	
green-thighed frog	*Litoris brevipalmata*	Vulnerable	
grey-headed flying-fox	*Pteropus poliocephalus*	Vulnerable	Vulnerable
koala	*Phascolarctos cinereus*	Vulnerable	
little bent-wing bat	*Miniopterus australis*	Vulnerable	
masked owl	*Tyto novaehollandiae*	Vulnerable	
osprey	*Pandion haliaetus*	Vulnerable	Migratory
rose-crowned fruit-dove	*Ptilinopus regina*	Vulnerable	
sooty owl	*Tyto tenebricosa*	Vulnerable	
southern myotis	*Myotis macropus*	Vulnerable	
square-tailed kite	*Lophoictinia isura*	Vulnerable	
yellow-bellied glider	*Petaurus australis*	Vulnerable	

Table 15-4 Threatened fauna species considered likely to occur in the study area

Common name	Scientific name	TSC Act	EPBC Act
brush-tailed phascogale	*Phascogale tapoatafa*	Vulnerable	
common planigale	*Planigale maculata*	Vulnerable	
powerful owl	*Ninox strenua*	Vulnerable	
spotted-tail quoll	*Dasyurus maculata*	Vulnerable	Endangered
squirrel glider	*Petaurus norfolcensis*	Vulnerable	

Table 15-5 Threatened fauna species that may potentially occur in the study area

Common name	Scientific name	TSC Act	EPBC Act
Australasian bittern	*Botaurus poicilioptilus*	Vulnerable	
Australian painted snipe	*Rostratula benghalensis*	Vulnerable	Vulnerable
barking owl	*Ninox connivens*	Vulnerable	

Common name	Scientific name	TSC Act	EPBC Act
barred cuckoo-shrike	*Coracina lineata*	Vulnerable	
black bittern	*Ixobrychus flavicollis*	Vulnerable	
comb-crested jacana	*Irediparra gallinacea*	Vulnerable	
eastern chestnut mouse	*Pseudomys gracilicaudatus*	Vulnerable	
giant dragonfly	*Petalura gigantea*	Endangered	
golden-tipped bat	*Kerivoula papuensis*	Vulnerable	
grass owl	*Tyto capensis*	Vulnerable	
green and golden bell frog	*Litoria aurea*	Endangered	Vulnerable
grey-crowned babbler	*Pomatostomas temporalis temporalis*	Vulnerable	
large-eared pied bat	*Chalinolobus dwyeri*	Vulnerable	Vulnerable
long-nosed potoroo	*Potorous tridactylus*	Vulnerable	Vulnerable
pale-headed snake	*Hoplocephalus bitorquatus*	Vulnerable	
regent honeyeater	*Xanthomyza phrygia*	Endangered	Endangered, Migratory
Stephen's banded snake	*Hoplocephalus stephensii*	Vulnerable	
stuttering frog	*Mixophyes balbus*	Endangered	Vulnerable
superb fruit-dove	*Ptilinopus superbus*	Vulnerable	
swift parrot	*Lathamus discolor*	Endangered	Endangered, Migratory
wallum froglet	*Crinia tinnula*	Vulnerable	
wompoo fruit-dove	*Ptilinopus magnificus*	Vulnerable	
yellow-bellied sheathtail bat	*Saccolaimus flaviventris*	Vulnerable	

Of the 50 migratory species listed under the EPBC Act that are predicted to occur within the study locality, 15 species were either recorded or assessed as having some potential to occur within the study area based on known records and habitat availability within the study area. These are listed in **Table 15-6** and **Table 15-7**.

Table 15-6 Migratory fauna species recorded during field surveys in the study area

Common name	Scientific name	TSC Act	EPBC Act
cattle egret	*Ardea ibis*		Migratory
black-faced monarch	*Monarcha melanopsis*		Migratory
Latham's snipe	*Gallinago hardwickii*		Migratory
osprey	*Pandion haliaetus*	Vulnerable	Migratory
rufous fantail	*Rhipidura rufifrons*		Migratory
satin flycatcher	*Myiagra cyanoleuca*		Migratory

Common name	Scientific name	TSC Act	EPBC Act
white-bellied sea-eagle	*Haliaeetus leucogaster*		Migratory
white-throated needletail	*Hirundapus caudacutus*		Migratory

Table 15-7 Migratory fauna species that may potentially occur in the study area

Common name	Scientific name	TSC Act	EPBC Act
Australian painted snipe	*Rostratula australis*		Migratory
fork-tailed swift	*Apus pacificus*		Migratory
great egret	*Ardea alba*		Migratory
rainbow bee-eater	*Merops ornatus*		Migratory
regent honeyeater	*Xanthomyza phrygia*	Endangered	Endangered, Migratory
spectacled monarch	*Monarcha trivirgatus*		Migratory
swift parrot	*Lathamus discolor*	Endangered	Endangered, Migratory

Figure 15-4 shows where threatened fauna species were recorded in the study area.

15.2.7 Aquatic flora and fauna

Watercourses and wetlands

The major watercourse crossings within the study area are over the Hastings and Wilson rivers. Both are tidal within the study area and support interrupted riparian bands of mangroves, mainly grey mangrove (*Avicennia marina*), and swamp oak (*Casuarina glauca*), as well as patches of broader estuarine wetlands. The Hastings River also supports seagrasses. There are also a number of permanent and ephemeral creeks within the study area.

There are no wetlands of national or international importance as listed on the directory of important wetlands within the study area. Two wetlands listed under *State Environmental Planning Policy No. 14 – Coastal Wetlands* are located in the study area, on Dalhunty Island and the northern banks of the Wilson River. The State listed wetlands on Dalhunty Island comprise areas of mangrove forest, closed shrubland and swamp oak swamp forest. On the northern banks of the Wilson River, the State listed wetland comprises a small area of treeless freshwater wetland and swamp oak floodplain forest. Other areas of wetlands, not State listed, occur within the Proposal footprint associated with low-lying and riparian areas. These areas have been mapped as wetland, swamp oak forest and paperbark swamp forest vegetation communities. Acidic paperbark swamp forest (wallum habitat) occurs near Fernbank Creek.

The mapped boundaries of the above wetlands were revised based on qualitative observations during field investigations. It was determined that mapped areas were not consistent with ground conditions. A more accurate boundary would be established prior to construction through quantitative observations and surveying of the mapped boundary to enable more accurate quantification of the area of impact and to assist in the refinement of proposed management measures.

Figure 15-4 Threatened fauna recorded in the study area during surveys

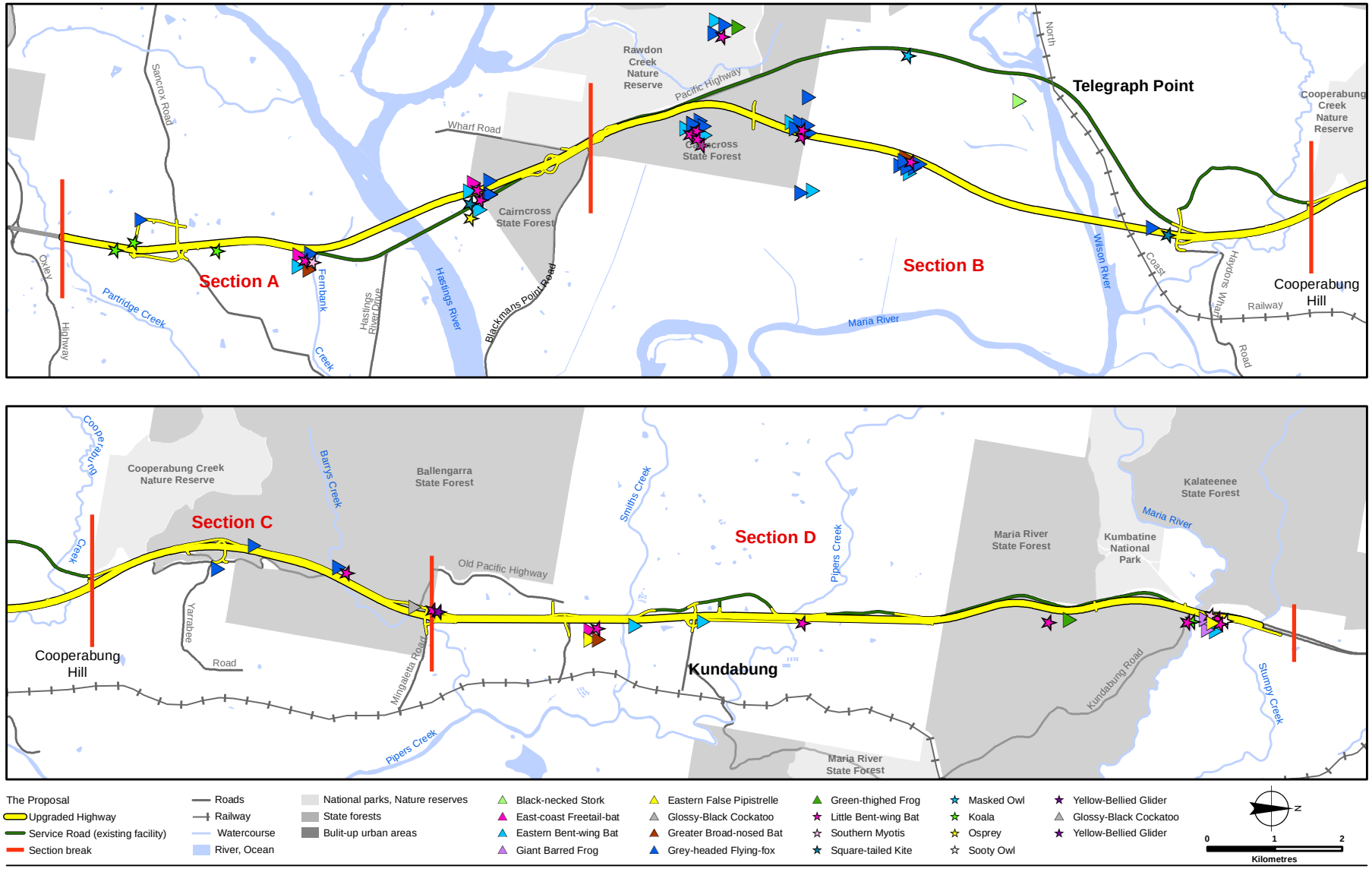


Table 15-8 summarises the watercourses and wetlands located within the study area. More detailed descriptions of these watercourses are provided in **Chapter 12 Hydrology**.

Table 15-8 Main watercourses and State listed wetlands in study area

Name	Comments	Stream order
Fernbank Creek	Acts as a flood channel for the Hastings River. Has good vegetation cover and contains areas of Endangered Ecological Communities.	2
Hastings River	The major river in the study area. It drains the entire catchment that the Proposal passes through. The river is tidally influenced and brackish.	5+
Wilson River	A large river that flows into the Maria River to the east of the Proposal. The Wilson River contains the two areas of State listed wetlands that the Proposal intersects.	5+
State listed wetland (number 484f) on Dalhunty Island	Areas of mangrove forest, closed shrubland and swamp oak swamp forest.	Not applicable-wetland area
State listed wetland (number 484e) on the northern bank of the Wilson River	Small area of treeless freshwater wetland and swamp oak floodplain forest. Disturbed by cattle movements and grazing during periods of low inundation. The surrounding swamp oak forest is in relatively good condition, although the understorey has been grazed by cattle.	Not applicable-wetland area
Cooperabung Creek	Well-vegetated banks with good habitat values.	3
Barrys Creek	Well-vegetated banks with good habitat values.	2
Smiths Creek	Densely vegetated banks with good habitat values.	3
Pipers Creek	Well-vegetated banks with good habitat values.	3
Maria River	Flows north to south, and joins the Hastings River to the east of the Proposal. The Proposal crosses the Maria River in the northern part of the study area. Water quality is poor compared to the Hastings and Wilson rivers.	3
Stumpy Creek	Well-vegetated banks with good habitat values.	2

Figure 15-5 shows State listed wetlands in the study area.

Other aquatic habitat

The other major aquatic habitat feature is the sandplain that extends from the Thrumster area (east of the existing highway between the Oxley Highway and Fernbank Creek Road) south of the Hastings River to the lower reaches of the Maria River to the north (the Maria River is generally east of and outside of the study area).

Although the floodplains of the Hastings and Wilson rivers have been cleared and used for grazing, they also provide habitat for native wet grassland/floodplain species, including frogs and some migratory wetland birds. Other patches of these communities contain scattered trees and while ranked as low quality fauna habitat, they still represent a foraging resource and occasional hollow-bearing trees provide roosting and breeding habitat for a number of hollow-reliant species.

Riparian corridors

Riparian corridors in the study area provide habitat for native fauna and opportunities for fauna movement dependent on the extent and continuity of the native riparian vegetation present. Riparian corridors can be of particular value for water dependent fauna (such as waterbirds, frogs) but also for terrestrial fauna particularly in otherwise cleared and fragmented landscapes.

A full description of riparian vegetation along watercourses in the study area (including vegetation type, condition and extent) is given in Section 3.12.5 of the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment..

Aquatic flora

A search of threatened aquatic plant records held by the NSW Government Bionet database, DECCW Wildlife Atlas and threatened aquatic species profiles listed by DII, indicates no threatened aquatic plants listed on the *Fisheries Management Act 1994* have been previously recorded in the study locality. No threatened aquatic plants are expected to occur in the Proposal footprint based on the absence of suitable habitat types (marine habitat for algae).

Aquatic fauna

No threatened fish species listed under the *Fisheries Management Act 1994* or the EPBC Act were recorded during surveys. A search of threatened and protected fish species records held by the NSW Government Bionet database indicates that the only threatened fish species previously recorded in the locality of the Proposal is the black cod (*Epinephelus daemelii*), a reef-dwelling species highly unlikely to occur in the study area due to lack of suitable habitat.

There is some potential that two additional threatened fish species, Oxleyan pygmy perch (*Nannoperca oxleyana)*, and eastern freshwater cod (*Maccullochella ikei),* both listed as Endangered under the *Fisheries Management Act 1994* and the EPBC Act, could occur in the locality based on habitat preferences. Oxleyan pygmy perch is known to occur in streams in wallum swamps north of Forster (NSW Fisheries 2002) and could potentially occur in the Thrumster floodplain area. The eastern freshwater cod is also known to inhabit rivers in the region.

However the study area is outside the known distributions for both these species, and neither was located during the fish survey despite targeted searches. .Based on these considerations, no threatened fish species listed under the *Fisheries Management Act 1994* or the EPBC Act are considered likely to occur in the study area.

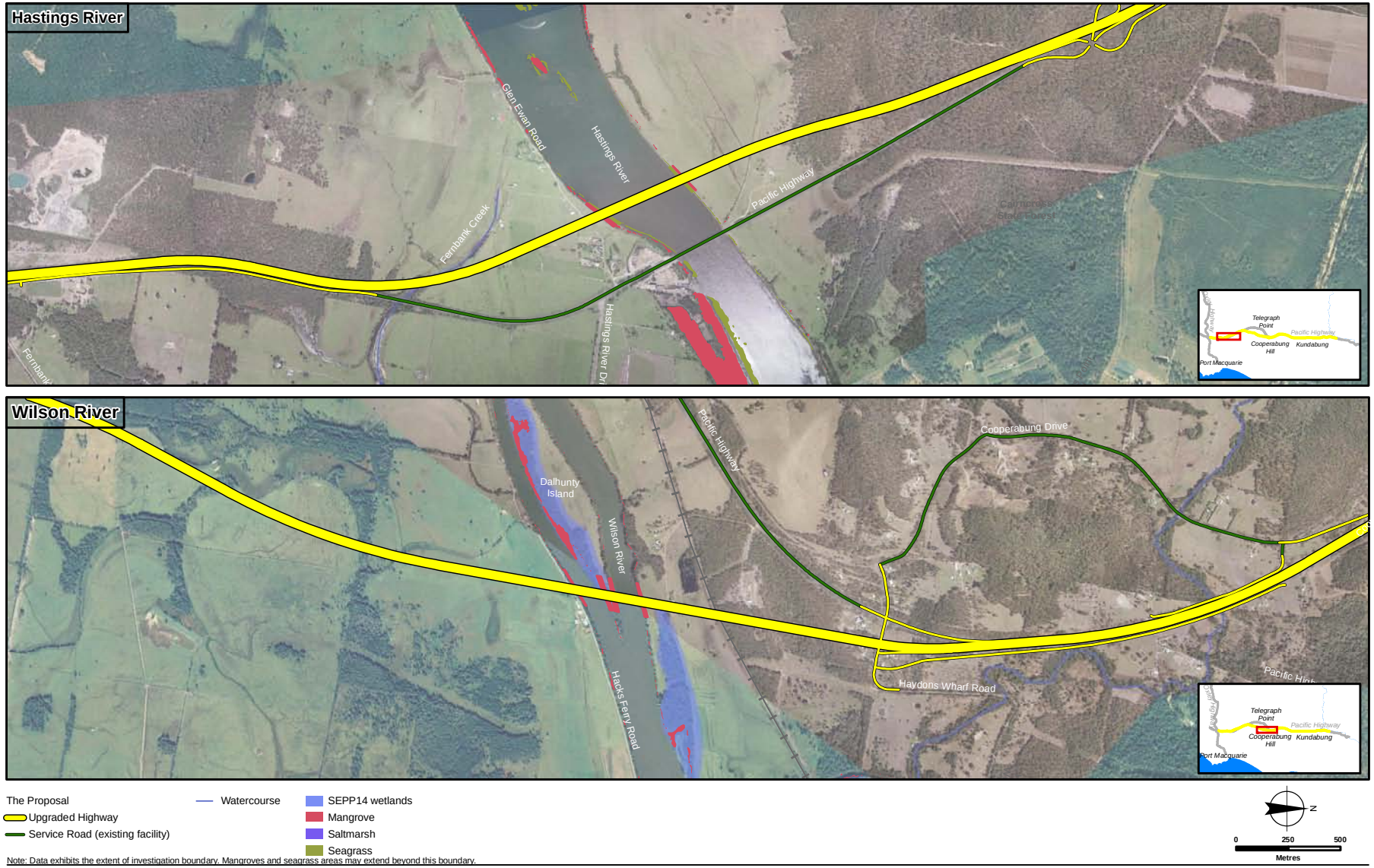
Protected aquatic species

Mangroves and seagrasses are listed as protected marine vegetation under the *Fisheries Management Act 1994*.

Areas of surveyed mangroves and seagrasses that occur within the Proposal footprint are shown on **Figure 15-5**. Mangrove forests extend along the banks of Hastings and Wilson rivers, and seagrass beds occur in shallow areas of Hastings River (DII 2010).

Saltmarshes are also listed as protected marine vegetation under the *Fisheries Management Act 1994,* and in the locality occur within the Williams and Hastings Rivers and tributaries (DII 2010). However saltmarshes were not detected during field surveys and Department of Industry and Investment (2010) mapping confirms that the nearest saltmarsh habitats are approximately 2.5km upstream (by river) from the development footprint on the Hastings River, and approximately 10km downstream on the Williams River.

Figure 15-5 Aquatic habitats - State listed wetlands, seagrasses, and mangroves



Note: Data exhibits the extent of investigation boundary. Mangroves and seagrass areas may extend beyond this boundary.

Seagrasses

Seagrass beds were present on both the northern and southern banks of the Hastings River. The seagrass beds consisted of one species, *Zostera* spp. and was found from the low tide mark extending into the river for approximately 5 metres (which generally correlated with the 1 to 1.5 metre depth mark). Approximately 0.02 hectares of seagrass occurs within the Proposal footprint. These areas of seagrass provide potential habitat for some species of Syngnathiformes (seahorses, seadragons, pipefish, pipehorses, ghost pipefish and seamoths), which are protected species under the *Fisheries Management Act 1994*.

There appears to be no significant development of seagrasses in the Wilson River (West et al 1985), confirmed during the field surveys.

Mangroves

Mangroves occur in interrupted bands of varying width along the northern and southern banks of the Hastings and Wilson rivers and on Dalhunty Island (see **Figure 15-5**). The mangrove forests surveyed were generally a mixed assemblage of both grey mangroves and river mangroves. Approximately 0.03 hectares of mangroves occurs within the Proposal footprint.

15.2.8 Groundwater dependent ecological communities

Groundwater dependent ecological communities are communities which have their species composition and their natural ecological processes determined by groundwater. Ecosystems vary greatly in the degree of their dependency on groundwater, from having no apparent dependence through to be entirely dependent on it (Department of Land and Water Conservation 2002). Groundwater dependent ecological communities can be classified into five broad types following Sinclair Knight Merz (2001):

- Terrestrial vegetation: Communities that do not rely on expressions of surface water for survival, but which have seasonal or episodic dependence on groundwater. They are more typical of semi-arid parts of NSW.
- River base flow ecosystems: Ecosystems that are dependent on groundwater derived base flow in streams and rivers. The coastal rivers of south-eastern Australia maintain base flow throughout the year and support riparian forests, scrub and sedgeland, as well as in-stream biota and aquatic vegetation.
- Athalassic wetlands: Ecosystems that are at least seasonally waterlogged or flooded, and that intersect groundwater when inundated. In coastal NSW, the wetlands that are most obviously groundwater dependent are those occurring in sand bed areas.
- Estuarine and near shore marine ecosystems: While seawater is obviously the main influence on these ecosystems, many are influenced to some degree by fresh groundwater, especially adjacent to sand beds, such that the groundwater may influence the distribution of vegetation.
- Cave and aquifer ecosystems: Ecosystems that may be found in free water within cave systems and within aquifers themselves.

In the vicinity of the study area, shallow alluvial groundwater systems are associated with the floodplains of the Hastings, Wilson and Maria rivers, with the Maria River also being associated with a coastal sand bed groundwater system outside the study area. Shallow alluvial groundwater systems of more restricted extent are also likely to be associated with smaller streams elsewhere within the study area.

Of the vegetation communities identified and mapped for the study area, there are eight that are considered to have potential as groundwater dependent ecological communities and these are discussed in **Table 15-9**. The likely groundwater dependence is based on categories outlined in Hatton and Evans (1998).

Table 15-9 Likely groundwater dependence and influence of vegetation communities within the Proposal footprint

Vegetation community	Occurrence within study area	Likely groundwater influence	Likely groundwater dependence
Moist floodplain closed forest with rainforest elements	A forest dominated by eucalypts and related species with a sub-canopy of small rainforest trees and melaleucas. Differs from the adjacent moist gully forest mainly in sub-canopy and understorey. Restricted to creek lines within Ballengarra State Forest.	Moist sub-canopy and understorey characteristics indicate average moister soil conditions than adjoining communities. This is likely due to a combination of the protected landscape position, seasonal or occasional inundation and, probably to a lesser extent, alluvial groundwater. Groundwater influence is likely to be low, and possibly only opportunistic.	Limited
Riparian forest	Somewhat similar to the previous community differing in the presence of eucalypts and more wetland elements in the understorey. Occurs along Cooperabung, Barrys, Smiths and Pipers creeks, and Maria River.	As with moist floodplain closed forest with rainforest elements, the moist characteristics are likely due to seasonal or occasional inundation and, probably to a lesser extent, alluvial groundwater. Groundwater influence is likely to be low, and possibly only opportunistic.	Limited
Paperbark swamp forest	Forest dominated by melaleucas with occasional eucalypts that are characteristic of swamp or alluvial soils. Where not weed-infested, the understorey is dominated by sedges, grasses and ferns. Occurs on the floodplains of the Hastings and Wilson rivers.	Melaleucas occur mainly in areas subject to a seasonally high watertable, and groundwater is likely to be a major influence on the hydrology of this community.	High
Swamp mahogany/ forest red gum swamp forest	Similar to paperbark swamp forest but with a greater proportion of eucalypts. Occurs on the Wilson River floodplain.	Groundwater is likely to be a major influence on the hydrology of this community.	High
Swamp oak forest	Dominated by swamp oak typically along drainage lines with some saline influence. The understorey is dominated by sedges, grasses and ferns. Only small patches of this community occur in the study area, mostly associated with the Wilson River.	Swamp oak forests occur in a variety of situations with or without strong groundwater influence, but the dominance of the understorey by sedges and ferns suggests a groundwater influence.	High

Vegetation community	Occurrence within study area	Likely groundwater influence	Likely groundwater dependence
Freshwater wetland	Small patches of open water and/or aquatic plants, usually along drainage lines and often associated with paperbark swamp forest suggesting that they may be clearing remnants of that community type. Occurs on the Hastings and Wilson river floodplains.	While some such wetlands on floodplains may be surface water influenced only, the position on floodplain drainage lines suggests a groundwater influence in addition to surface water inputs.	High
Moist floodplain forest	Dominated by eucalypts that are characteristic of moist but not swamp environments. A sub-canopy of paperbarks and she-oaks is common in areas. Probably previously dominated much of the relatively higher areas of the Hastings River floodplain, now occurs as small patches.	High soil moisture is an important influence on this community, with this being determined by a combination of rainfall, catchment runoff, occasional overbank flooding and groundwater. However, the groundwater level would be probably highly variable and the extent of reliance on groundwater is likely to be lessened by this.	Limited
Moist gully forest	Occurs in moist, sheltered gullies generally associated with ephemeral drainage lines and minor creeklines.	This community is not likely to be influenced by groundwater.	Very unlikely
Moist slopes forest	Widespread throughout the study area, it occurs on slopes or low ridges with a moist/sheltered aspect and good drainage in undulating terrain.	This community is not likely to be influenced by groundwater.	Very unlikely
Dry ridgetop forest	Occurs on higher, drier and more exposed ridgetops and upper sloes in undulating terrain, or above the floodplain in flatter terrain.	This community is not likely to be influenced by groundwater.	Very unlikely
Estuarine wetlands	Mangrove, saltmarsh and seagrass communities in the Hastings and Wilson rivers.	When adjacent to sand beds, groundwater influence is often important but less so in alluvial situations.	Limited

These communities are considered to have some groundwater influence, though the dependence on groundwater is likely to be low for some. However, it is important to note that groundwater dependence is only inferred in the absence of observational or experimental data. All of these communities occur as small remnant patches along the Proposal (see **Figure 15-2**), but some are much more extensive outside the study area, mostly associated with the floodplains of the Hastings, Wilson and Maria rivers.

15.3 Impacts on flora and fauna

15.3.1 Impacts on terrestrial flora and fauna

Loss of native vegetation

Approximately 203.1 hectares of native vegetation would need to be cleared within the Proposal footprint for construction of the Proposal. The greatest area of clearing (approximately 73.9 hectares) would occur in the moist slopes forest vegetation community, followed by dry ridgetop forest (approximately 39.3 hectares) and then moist floodplain forest (approximately 27.8 hectares).

Of the native vegetation to be cleared, approximately 36.3 hectares qualifies as endangered ecological community listed under the TSC Act and four endangered ecological communities would be directly impacted within the Proposal footprint to some degree, as shown in **Table 15-10**.

Table 15-10 Extent of impact on endangered ecological communities within the Proposal footprint

Endangered ecological community	Area directly affected	% of area of endangered ecological communities affected by the Proposal
Swamp Sclerophyll Forest	19.9 ha	55%
Swamp Oak Floodplain Forest	0.9 ha	2%
Subtropical Coastal Floodplain Forest	11.7 ha	32%
Freshwater Wetlands	3.8 ha	11%
Total	**36.3 ha**	**100%**

The total area of native vegetation, including endangered ecological communities, to be cleared does not include potential indirect impacts in areas of retained vegetation adjoining the Proposal footprint. Runoff of sediment, nutrients and pollutants could directly impact on the habitat of both ecological communities and threatened species during both the construction and operation phases of the project. There is also the potential for modification of retained habitats as a result of edge effects, including the establishment of weeds.

While the proposed vegetation clearing is unlikely to result in the local extinction of any threatened flora or fauna species or endangered ecological communities, the Proposal is considered likely to contribute to the cumulative effects of habitat loss affecting these species and endangered ecological communities in the region.

It is considered unlikely that the Proposal would result in impacts of the magnitude that would cause a local population of these endangered ecological communities to become extinct, based on the following:

- Less than 0.1 per cent of the total area of any endangered ecological community in the Mid-North Coast Region of NSW would be removed or modified by the Proposal. Clearing for the Proposal would not be to the extent that a significant proportion of each endangered ecological community would be affected regionally.

- Although the Proposal would contribute to general fragmentation of natural vegetation, including at least one endangered ecological community, the remaining areas of natural vegetation on either side of the deviation through Cairncross State Forest are considered large enough to continue as functioning ecosystems.

Loss of threatened flora species

No threatened flora species were recorded within the study area during the terrestrial flora surveys. However, as a precautionary measure an assessment of the possible impact of the Proposal on seven threatened flora species that may potentially occur in areas of suitable habitat within the Proposal footprint has been undertaken. An assessment of the likely significance of impacts on threatened flora species has been prepared and is summarised in **Section 15.3.5**.

It is considered unlikely that the Proposal would result in impacts of the magnitude that would cause a local population of threatened flora to become extinct, based on the following:

- No threatened flora was recorded within the Proposal footprint.
- It is unlikely that the Proposal would fragment populations of threatened flora.
- Although the Proposal would contribute to general fragmentation of natural vegetation, the remaining areas of natural vegetation on either side of the deviation through Cairncross State Forest are considered large enough to continue as functioning ecosystems.

Loss of fauna habitat

The clearance of native vegetation for the Proposal would result in the loss of habitat for fauna species, including vegetation that contributes to 'key habitat' associated with regional and subregional corridors mapped by DECCW. **Table 15-11** shows the vegetation communities that are to be cleared within the Proposal footprint, the threatened species known to occur or which may potentially occur in these vegetation communities, and the extent of the required clearing. The extent of clearing required would be refined during detailed design.

Table 15-11 Potential fauna habitat loss

Vegetation community		Threatened fauna known or with potential to occur	Area impacted
Natural communities			
1	Moist floodplain closed forest with rainforest elements	Barred cuckoo-shrike, insectivorous bats, common planigale, owls, fruit-doves, golden-tipped bat, green-thighed frog, grey-headed flying-fox, koala, pale-headed snake, spotted-tailed quoll, square-tailed kite, Stephens' banded snake, yellow-bellied glider.	3.9 ha
2	Riparian forest	Barred cuckoo-shrike, insectivorous bats, common planigale, owls, giant barred frog, stuttering frog, green-thighed frog, grey-headed flying-fox, koala, pale-headed snake, southern myotis, spotted-tailed quoll, square-tailed kite, black bittern, yellow-bellied glider.	7.8 ha
3	Paperbark swamp forest	Barred cuckoo-shrike, insectivorous bats, common planigale, eastern chestnut mouse, owls, glossy black-cockatoo, green-thighed frog, grey-headed flying-fox, koala, long-nosed potoroo, regent honeyeater, swift parrot, spotted-tailed quoll, square-tailed kite, squirrel glider, wallum froglet.	9.5 ha

Vegetation community		Threatened fauna known or with potential to occur	Area impacted
4	Swamp mahogany/forest red gum swamp forest	Barred cuckoo-shrike, insectivorous bats, common planigale, eastern chestnut mouse, owls, fruit-doves, glossy black-cockatoo, green-thighed frog, grey-headed flying-fox, koala, long-nosed potoroo, regent honeyeater, swift parrot, spotted-tailed quoll, square-tailed kite, squirrel glider, Stephens' banded snake, wallum froglet, yellow-bellied glider.	10.4 ha
5	Swamp oak forest	Barred cuckoo-shrike, insectivorous bats, owls, koala, square-tailed kite.	0.9 ha
6	Wetland	Giant dragonfly, southern myotis, Australasian bittern, Australian painted snipe, black-necked stork, comb-crested jacana.	3.8 ha
7	Moist Floodplain Forest	Insectivorous bats, common planigale, owls, glossy black-cockatoo, green-thighed frog, grey-crowned babbler, grey-headed flying-fox, koala, pale-headed snake, spotted-tailed quoll, square-tailed kite, squirrel glider, yellow-bellied glider.	27.8 ha
8	Moist Gully Forest	Barred cuckoo-shrike, insectivorous bats, common planigale, owls, fruit-doves, glossy black-cockatoo, green-thighed frog, grey-headed flying-fox, koala, long-nosed potoroo, pale-headed snake, spotted-tailed quoll, square-tailed kite, squirrel glider, Stephens' banded snake, yellow-bellied glider.	25.8 ha
9	Moist Slopes Forest	Brush-tailed phascogale, insectivorous bats, common planigale, owls, glossy black-cockatoo, green-thighed frog, grey-crowned babbler, grey-headed flying-fox, koala, pale-headed snake, regent honeyeater, swift parrot, spotted-tailed quoll, square-tailed kite, squirrel glider, yellow-bellied glider.	73.9 ha
10	Dry Ridgetop Forest	Brush-tailed phascogale, insectivorous bats, owls, glossy black-cockatoo, grey-crowned babbler, grey-headed flying-fox, koala, pale-headed snake, regent honeyeater, swift parrot, spotted-tailed quoll, square-tailed kite, squirrel glider.	39.3 ha
Total natural communities			***203.1 ha***
Artificial or highly modified communities			
11	Cleared – Scattered Trees	Potential occasional visits by grey-headed flying-fox, swift parrot, regent honeyeater and insectivorous bats. Some large trees may provide potential roost sites for insectivorous bats or a potential nest tree for the osprey. These areas may also provide a corridor link for some species, in particular the koala.	18.6 ha
12	Plantation/Cropland/ Market Garden etc.	Potential occasional visits by grey-headed flying-fox, fruit-doves and insectivorous bats for foraging purposes.	1.4 ha
13	Totally Cleared Open Pasture/Weedy Fallow	Grass owl (in areas of long grass – mainly between Cairncross State Forest and the Wilson River) and black-necked stork (Hastings and Wilson river floodplains). Some insectivorous bats are likely forage above these areas.	61.3 ha
Total highly modified communities			***81.3 ha***
Total natural and highly modified communities			**284.4 ha**

The Proposal would result in the loss or modification of areas of 'potential' and 'core' koala habitat as defined under *State Environmental Planning Policy No. 44 – Koala Habitat Protection*, predominantly associated with swamp mahogany/forest red gum swamp forest (community 4), moist floodplain forest (community 7) and moist slopes forest (community 9), but also some areas of riparian forest (community 2) and moist gully forest (community 8).

There is a potential for the Proposal to impact on breeding habitat for the green-thighed frog and giant barred frog where it traverses Maria River State Forest. A potential green-thighed frog breeding pool located during the summer survey period is located within the Proposal footprint within Maria River State Forest. Targeted surveys would be carried out and specific mitigation measures would be developed in consultation with DECCW to minimise adverse impacts on the population and to complement existing management of the species at this location.

Both green-thighed frog and giant barred frog were recorded in Maria River State Forest (see **Figure 15-4**) and both have the potential to occur within riparian vegetation along other major freshwater creeks within the study area. The Proposal would utilise the recently constructed dual carriageway bridges at Maria River, however these species may still be impacted during construction of the Proposal in this area. The mitigation measures applied for the Maria River bridge construction would be applied at Maria River and associated tributaries during construction of the Proposal, as well as Smiths, Piper and Cooperabung creeks (see **Section 15.4.1**).

Habitat fragmentation and barrier effects

Habitat fragmentation can result in reduced dispersal and reproductive success of biota within the fragment, a decline in populations resulting from increased predation by introduced species or native species that do not normally occur in the community, and an increased probability that stochastic events (eg fire) may reduce population numbers below critical levels required for their survival (Andrew 1990). In general, larger fragments are less susceptible to adverse impacts than are smaller fragments.

The majority of the Proposal would involve constructing new carriageways adjacent to the existing Pacific Highway alignment. In these areas, there would be edge effects of vegetation clearing, and a widening of the barrier which is the existing highway, resulting in an incremental increase of habitat fragmentation. No new fragmentation of habitat would occur for most species in these areas. However for some species (for example, gliders), widening the existing highway would result in an increase in fragmentation of habitat as they are unlikely to be able to glide across the entire width of the upgraded highway.

For sections of the Proposal that would involve the construction of new alignment, there would be new habitat fragmentation. Areas along the Proposal route where there is potential for habitat fragmentation include:

- Fernbank Creek and the floodplains of the Hastings River.
- Cairncross State Forest and the floodplains of the Wilson River.
- Maria River State Forest.

The Proposal would result in a barrier through the landscape (in addition to the existing Pacific Highway and other roads and clearings) and could potentially impede native fauna movements in the locality where fauna are unwilling to attempt crossings or are subject to mortality as a result of vehicle collision. In addition to direct mortality, fauna populations could also be affected by the selective mortality of certain age classes or sex classes that may be more prone to undertake movements across road ways (for example, dispersing males) and in the longer-term this may affect the distribution and demographic characteristics of the population. The maintenance of corridor function and habitat connectivity between the coastal plain and ranges within the study area and locality is essential to ensure the long-term viability of existing fauna populations.

A discussion of the potential impacts of the Proposal on habitat connectivity for fauna groups and a selection of key threatened species of relevance to the study area is provided in Section 4.6.1 of the *Flora and Fauna Working Paper* (see Volume 2 of this Environmental Assessment). To reduce the potential for adverse impacts on native wildlife as a result of habitat fragmentation and barrier effects, dedicated fauna underpasses, combined drainage/fauna movement culverts, aerial fauna crossings and glider poles in conjunction with wildlife exclusion fencing have been incorporated into the Proposal design. The aim of these measures would be to maintain connectivity between stands of existing vegetation and facilitate continued fauna movements through the area.

Studies undertaken at other locations along the upgraded Pacific Highway (AMBS 2000-2002) have shown a wide range of fauna will use fauna underpasses of similar dimensions to those proposed as part of the Proposal. On this basis, it is considered reasonable to assume that fauna in the study area will utilise such features to cross the new road if appropriately designed and placed in the landscape.

Fauna mortality and population effects

The Proposal traverses intact stands of vegetation comprising areas of high value habitat that support high native species diversity and contribute to wildlife corridors likely to facilitate fauna movements through the landscape. There is the potential for the Proposal to result in native fauna mortality as a result of habitat clearing during the construction phase and collisions with vehicles once the road is in operation. In addition to direct mortality, fauna populations could also be affected by the selective mortality of certain age classes or sex classes that may be more prone to undertake movements across road ways (eg dispersing males) and in the longer-term this may affect the distribution and demographic characteristics of the population.

Fauna most susceptible to mortality during clearing include less mobile species and in particular nocturnal hollow-roosting fauna, such as arboreal mammals and microchiropteran bats. A range of pre-clearing survey protocols would be implemented during the construction phase of the Proposal, including inspections of hollow-bearing trees and staged clearing, to minimise the chances of death or injury to native fauna during the clearing and construction phases (refer **Section 15.4**).

The assessments of significance for the 46 threatened fauna species considered likely to occur within the study area are presented in the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment. The assessments of significance conclude that the Proposal is not considered likely to result in impacts of a magnitude that would cause a local population of threatened fauna to become extinct, based on the following:

- Fauna crossing structures, including dedicated fauna underpasses, combined drainage / fauna movement culverts, aerial fauna crossings and glider poles, in conjunction with wildlife exclusion fencing have been incorporated into the Proposal design, as outlined in **Section 6.4.16**, to reduce the potential for adverse impacts on native wildlife as a result of habitat fragmentation barrier effects and road mortality.

- A range of pre-clearing survey protocols would be implemented during the construction phase of the Proposal, including inspections of hollow-bearing trees and staged clearing, to minimise the chances of death or injury to native fauna during the clearing and construction phases.
- Appropriate mitigation measures would minimise impacts on local populations of the koala, green-thighed frog and giant-barred frog, which have been identified as species' particularly vulnerable to potential impacts associated with the Proposal. For the koala, these measures include provision of fauna crossing structures and fauna exclusion fencing. For green-thighed frog and giant barred frog, these measures include targeted surveys, a monitoring program, and consideration to construction of artificial habitat breeding ponds to provide alternative habitat. The location, size and design of these ponds would be considered at the detailed design and construction stages in consultation with DECCW.

Although the Proposal would contribute to general fragmentation of natural vegetation, including at least one endangered ecological community, the remaining areas of natural vegetation on either side of the deviation through Cairncross State Forest are considered large enough to continue as functioning ecosystems.

Mitigation measures incorporated into the Proposal's design to reduce the impact of road mortality, including the construction of wildlife exclusion fencing and fauna underpasses, are discussed in **Section 15.4**.

Edge effects

Edge effects consist of a diverse array of biotic and physical changes associated with the abrupt, artificial margins of forest fragments. Edges cause alterations in temperature, humidity, light, nutrients, exposure and moisture availability and allow the establishment of opportunistic, 'edge specialist' species that may displace native species. On average, edge effects have been estimated to occur up to 50 metres from the road edge (Bali 2005), although much greater distances have been recorded in some road studies (Forman et al. 2003).

The smaller more isolated fragments of vegetation in the study area are already affected by edge effects to varying extents. The greatest potential for adverse impacts as a result of edge effects where the Proposal would traverse large stands of vegetation in state forests. Potential edge effects in these areas as a result of the Proposal include:

- Establishment of weeds along disturbed vegetation boundaries and their incursion into native vegetation.
- Modification of habitat attributes and displacement of fauna assemblages.
- Displacement of woodland and forest bird assemblages by edge specialists.
- Increased predation of birds, small mammals, reptiles and frogs by raptors and owls which may use forest edges as foraging sites.
- Increased nest predation of small insectivorous birds at forest edges.

A range of impact mitigation measures are to be implemented to minimise edge effects on retained native vegetation within the study area, including replanting of the road reserve with local native plant species and the implementation of a weed control and management program (see **Section 15.4**).

Weeds

There is the potential for the introduction of weeds where the Proposal traverses intact stands of native vegetation. Construction also has the potential to introduce or spread of root rot *Phytophthora cinnamomi*. Without the use of appropriate weed management protocols, the Proposal has the potential to facilitate the spread of weeds into cleared areas. Mitigation measures to be implemented during the construction and operational phases of the Proposal include strategies for the management and control of noxious and environmental weeds (see **Section 15.4.2**).

15.3.2 Impacts on aquatic flora and fauna

Riparian corridors and aquatic habitat

The Proposal has the potential to impact aquatic habitat during and operation stages. The construction of new watercourse crossings would involve impacts on vegetation and habitat within the riparian corridors. Approximately 7.8 hectares of riparian forest would be cleared for the Proposal and a summary of the impacts at each watercourse crossing is provided in **Table 15-12**.

Table 15-12 Riparian vegetation impacts at watercourse crossings

Watercourse	Impact
Fernbank Creek	Supports a well vegetated riparian corridor and a section of endangered ecological community. Proposed twin bridges would result in the clearance of vegetation and overshadowing of remaining sections of vegetation.
Hastings River	Proposed twin bridges would require the clearance of mangroves, and would overshadow seagrass communities in the river.
Wilson River	Supports interrupted riparian bands of mangroves as well as patches of broader estuarine wetlands, including areas of State listed wetlands. Proposed twin bridges would result in vegetation clearance and overshadowing of remaining vegetation.
Cooperabung Creek, Smiths Creek, Pipers Creek and Stumpy Creek	Construction of new bridges would result in vegetation clearance and overshadowing of remaining vegetation.
Barrys Creek	Culverts would be constructed.

Potential impacts on water quality could occur during the construction stage through vegetation clearance and disturbance to banks and during the operation of the Proposal as a result of sedimentation in runoff or from contaminants (eg chemical and fuel spills). Potential water quality impacts are discussed in **Chapter 13 Water quality**.

Measures to minimise impacts to riparian and aquatic habitat are contained within **Section 15.4.4**.

Aquatic fauna

The Proposal is unlikely to have an adverse impact on fish assemblages in the watercourses of the study area. No threatened fish species were recorded during the aquatic field surveys. The Oxleyan pygmy perch is considered unlikely to occur in the study area given the general absence of suitable habitat in the majority of watercourses to be impacted by the Proposal and the dense populations of mosquito fish (*Gambusia holbrooki*) recorded in local watercourses that may otherwise support potential habitat for this species.

It is highly unlikely that eastern freshwater cod would occur within the Proposal footprint as the watercourses surveyed are not characteristic of the habitat requirements of the species.

Fish passage

The Proposal is unlikely to have any adverse impact on fish passage given that measures to facilitate fish and amphibian crossings would be incorporated into the detailed design in accordance with the DPI publications *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge 2003) and *Policy and Guidelines for Fish Friendly Waterway Crossings* (Department of Primary Industries 2003). Hastings River, Wilson River, Maria River, Fernbank Creek, Cooperabung Creek, Smiths Creek and Pipers Creek are all being crossed via bridges that would not impede movement of aquatic fauna.

The Proposal has the potential to result in disturbance to the bed and bank of creeks during construction, resulting in impacts to aquatic habitat. Three species identified during the aquatic survey, striped gudgeon (*Gobiomorphus australis*), short-finned eel (*Anguilla australis*) and long-finned eel (*Anguilla reinhardtii*), require unregulated longitudinal movement to facilitate and complete successful life cycles. The interruption of this could have a detrimental effect on the population dynamics of instream fauna.

Mangroves and seagrasses

The Proposal would pass through areas on the Hastings and Wilson rivers that contain mangroves, and areas of seagrass on the Hastings River. Impacts to mangroves and seagrass from the crossing of the Hastings River, and mangroves from the crossing of the Wilson River are largely unavoidable for the Proposal. The construction of the proposed twin bridges over both the Hastings and Wilson rivers would require the clearance of a discrete section of the mangroves that line the banks of both rivers.

Whilst care would be taken to minimise the areas required for clearance during construction, the long-term viability of the mangroves in the areas immediately under the bridge abutments would be compromised due to overshadowing. Effects on the mangroves would be limited to the area immediately under the proposed bridges, and the mangroves not affected by overshadowing would not be impacted.

A small area of seagrass would be cleared at the Hastings River crossing. The long-term viability of the seagrass beds under the proposed twin bridges over the Hastings River may be effected due to overshadowing. Effects would be limited to the areas immediately under the proposed bridges and seagrass beds not affected by overshadowing would not be impacted. However the shadowing effects would potentially fragment the seagrass beds in this locality, potentially resulting in two seagrass beds separated by the area affected by overshadowing.

The exact area of mangroves and seagrasses to be directly impacted by the Proposal would be determined at the detailed design stage when the precise dimensions of the structure and related overshadowing impacts can be determined. However, an approximate area of mangroves and seagrasses to be directly impacted within the Proposal footprint (a 6 metre buffer from the edge of the Proposal) and potentially impacted as a result of shadowing (a 10 metre buffer from the edge of the Proposal, including the 6 metre buffer) at the Hastings and Wilson river crossings in the worst case scenario is presented in **Table 15-13**. A 10 metre buffer has been used to calculate the potential impacts as a result of shadowing, given that mangrove and seagrass vegetation currently occurs at a distance of 10 metres from the existing bridges over these rivers, and a similar shadowing impact would be anticipated with the new structures.

Table 15-13 Estimated worst case scenario impacts of the Proposal on protected marine vegetation at the Hastings and Wilson river crossings

Protected marine vegetation	Impacted area (ha)	
	6 metre buffer	10 metre buffer
Hastings River		
Mangroves	0.003	0.004
Seagrass	0.023	0.028
Wilson River		
Mangroves	0.030	0.033

Note: The area impacted in the 10 metre buffer includes the area impacted in the 6 metre buffer

No saltmarsh would be cleared or affected by shadowing at the proposed crossings.

There is some potential for indirect impacts on mangroves, seagrasses and saltmarsh where they occur downstream of proposed river crossings as a result of erosion and sedimentation during bridge construction. Potential indirect impacts on aquatic vegetation downstream of bridge crossings would be controlled through the implementation of erosion and sedimentation mitigation measures implemented during the construction phase (see **Sections 13.4.1** and **20.3.4**). There is limited potential for such impacts on saltmarsh communities given that the nearest downstream community is located approximately 10 kilometres downstream of the proposed Wilson River crossing.

There is also potential for indirect impacts on seagrasses and mangroves as a result of increased flow velocity and associated scouring, turbidity and sedimentation, in the vicinity of the proposed bridges over the Hastings and Wilson rivers. These bridge crossings are subject to detailed design and the potential for increased flow velocities cannot be accurately identified until the final design and configuration of bridge piers is known. However, such impacts are expected to be highly localised and only small increases in flow velocities have been predicted in the channel centre and at bridge abutments as a result of the Proposal: approximately 0.3 metres per second at the Hastings River crossing; and up to 0.2 metres per second at the Wilson River crossing (Worley Parsons 2010). Potential impacts on aquatic vegetation as a result of increased flow velocities at bridge crossings would be minimised through bridge design and the implementation of scour protection and other measures to minimise impacts on geomorphology (see **Section 15.4.4**).

Wetlands

The twin bridges across the Wilson River would span the eastern portion of Dalhunty Island. Clearing of vegetation and an area of State listed wetland on Dalhunty Island may be required if the detailed design determines that bridge support structures are required on Dalhunty Island. While the final form and configuration of the twin bridges would be refined at the detailed design stage, care would be taken to avoid placing piers on the island itself where possible, thereby reducing potential impacts on the State listed wetland on Dalhunty Island and overshadowing impacts.

Approximately 1 hectare of State listed wetland on the northern bank of the Wilson River would be cleared to accommodate the bridge abutments. The bridge abutments would be located at the western edge of the State listed area, and would not result in the severance of this area.

Other areas of wetlands occur within the Proposal footprint associated with low-lying and riparian areas. These areas of wetland have been mapped as wetland, swamp oak forest and paperbark swamp forest vegetation communities. The Proposal has the potential to impact on wetlands during construction through the clearing of vegetation, erosion and sedimentation impacts. The significance assessments have concluded that there is unlikely to be a significant impact on vegetation communities provided appropriate mitigation and management measures are implemented. Targeted management and control of runoff as well as direct control of noxious and environmental weeds and rehabilitation of disturbed areas would be undertaken.

No significant alterations to the existing hydrology of the floodplain areas or associated impacts on watercourses or aquatic habitats are anticipated as a result of the Proposal. Indirect impacts to wetlands through changes in hydrological regimes as a result of the Proposal are therefore considered unlikely.

15.3.3 Potential impacts to groundwater dependent ecological communities

There are a range of construction techniques that could be employed in floodplain areas to treat soft soils, and de-water the soils. Each of these techniques has the potential to affect groundwater in different ways. The specific construction techniques would be determined at the detailed design stage and accordingly, the assessment of potential impacts on groundwater dependent ecological communities is necessarily general in nature. The potential impacts of construction of the Proposal on groundwater are discussed in **Chapter 14 Groundwater**.

Key potential impacts to groundwater dependent ecological communities include alteration of the water regime experienced by groundwater dependent ecological communities resulting in changes in the structure, function and/or composition of the ecosystem (Sinclair Knight Merz 2001) as well as the potential for detrimental changes to the groundwater quality to impact upon the vegetation. It is noted that impacts associated with lowered water tables upon groundwater dependent ecological communities could take place over an extended time and could lead to decline in growth, recruitment and enable invasion by exotic species (Eamus et. al. 2006).

Concern for construction impacts on groundwater dependent ecological communities are most likely to arise from groundwater drawdown in the vicinity of groundwater dependent ecological communities.

Potential impacts on groundwater and consequent potential impacts on groundwater dependent ecological communities are addressed in **Table 15-14**. Much of the discussion of groundwater dependent ecological community impacts focuses on the vegetation, but there is an implied understating that the vegetation provides habitat for fauna species which may also be affected.

Table 15-14 Potential impacts of the Proposal on groundwater dependent ecological communities

Potential impact	Implications for the Proposal	Potential impacts on groundwater dependent ecological communities
Impediment to groundwater flow by fill embankments	Embankments on the Hastings and Wilson river floodplains would be expected to be generally perpendicular to the rivers and, therefore, parallel to groundwater flows. Impacts on groundwater flows would thus be minimal.	Based on the assumption that groundwater flows are generally parallel to the proposed embankments, it is reasonable to assume that construction of the embankments would have negligible impact on groundwater dependent ecological communities in the vicinity of the road.

Potential impact	Implications for the Proposal	Potential impacts on groundwater dependent ecological communities
Impediment to groundwater flow by cuttings	The groundwater in the Proposal area is largely alluvial (plus sand bed groundwater also occurring to the east). Cuttings are unlikely to interfere with alluvial (or sand bed) groundwater due to the locations of cuttings in hillier areas rather than on the alluvial plains.	Groundwater dependent ecological communities in the study area are associated with alluvial rather than bedrock aquifers, and no impacts on groundwater dependent ecological communities are anticipated from cuttings.
Groundwater drawdown	Activities that could result in groundwater drawdown are most likely to occur in alluvial areas. However, potential drawdown is expected to be of limited duration and of limited spatial extent, although this is not defined at this stage.	As the identified groundwater dependent ecological communities mostly occur on the alluvial floodplains, they are theoretically vulnerable to groundwater drawdown in these areas. The impacts of any drawdown on groundwater dependent ecological communities would depend on the proximity of the groundwater dependent ecological communities to the construction works, the natural variability of the groundwater in that area, the duration of the drawdown, and the spatial extent of the drawdown.
Discharge of excess water to the environment	The volume, duration and location of any discharge are critical to any potential impacts. While such discharges are expected to be minor, consideration of location of discharge points could mitigate potential impacts.	The impact on groundwater dependent ecological communities would depend on the location of the discharge point relative to groundwater dependent ecological communities and the volume and duration of discharge. Prolonged discharge could result in localised dieback, whereas intermittent or short-term discharge would be likely to result in no evident changes.
Groundwater quality impacts	Potential construction impacts on groundwater quality are disturbance of acid sulfate soils, chemical spills, and saline intrusion during dewatering near the rivers. The first two can be managed as part of standard operational procedures and would not result in changes in groundwater chemistry if correctly managed. The extent of saline water intrusion would be dependent on river conditions at the time of the works, and on the duration of the dewatering.	None of the identified freshwater groundwater dependent ecological communities in the vicinity of the corridor occur close to either the Hastings or the Wilson rivers, and dewatering for bridge construction in these areas is unlikely to result in saline groundwater intrusion impacts. The other potential impacts should be effectively managed at source and not impact groundwater dependent ecological communities.

Potential impacts on groundwater are further discussed in **Chapter 14 Groundwater**.

15.3.4 Cumulative impacts

Cumulative impacts within the Mid-North Coast Region

Cumulative impacts of the Proposal have been considered in terms of the additive impacts of multiple activities within the 'Mid-North Coast Region of NSW' (as defined by National Parks and Wildlife Service 1999). The Proposal lies within a landscape impacted by several past and present land uses and activities. These impacts include clearing for agriculture and grazing land uses, as well as removal of timber during logging operations.

The Comprehensive Regional Assessment of North Eastern NSW (National Parks and Wildlife Service 1999), undertaken as part of the regional forest agreement process, mapped broad floristic groups and forest structure to guide modelling of forest ecosystems, old growth forest, and flora and fauna communities in north-eastern NSW. This mapping provides a useful basis to assess the extent of impacts on endangered ecological communities in a regional context.

Table 15-15 summarises the extent in the Mid-North Coast Region of the four endangered ecological communities found in the Proposal area, as at 1999 when the National Parks and Wildlife Service assessment was carried out. The table shows the four endangered ecological communities that would be impacted by the Proposal, the corresponding vegetation community as it was described in the Comprehensive Regional Assessment mapping, the extent of each endangered ecological community in the Region (as at 1999), an estimate of the extent to which they have been previously cleared, and their vulnerability status.

Table 15-15 Extent of endangered ecological communities within the Mid-North Coast Region of NSW

Endangered ecological community impacted by the Proposal	Corresponding NPWS 1999 vegetation community	Extent in Region in 1999	Cleared estimate for Region	Status in NPWS 1999
Swamp Sclerophyll Forest	Paperbark swamp forest	28,577 ha	75%	Vulnerable Private Land Priority
	Swamp mahogany swamp forest	578 ha	75%	Rare Private Land Priority
Swamp Oak Floodplain Forest	Swamp Oak swamp forest	2883 ha	75%	Rare Severely Depleted Highly Inadequately Reserved Private Land Priority
Subtropical Coastal Floodplain Forest	Cabbage gum open forest or woodland	3002 ha	70%	Vulnerable
	Forest red gum - swamp box	57,016 ha	60%	Severely Depleted Private Land Priority
Freshwater Wetlands	Coastal freshwater meadows, sedgelands, rushlands and forblands of lagoons and wetlands	24,118 ha	40–80%	Endangered Private Land Priority

Note: The extent of Freshwater Wetlands shown may be overestimated as the NPWS Map Unit 141 includes two vegetation communities – forested wetlands and freshwater wetlands. However only the freshwater wetland community strictly corresponds to the EEC.

Table 15-16 shows the area of the endangered ecological communities proposed to be cleared for the Proposal, and then expresses this as a percentage of the total regional estimate of the extent of the endangered ecological community as existing in 1999.

Table 15-16 Proportion of the total area of endangered ecological communities in the Mid-North Coast Region of NSW affected by the Proposal

Endangered ecological community impacted by Proposal	Total estimated extent in the Region in 1999	Area impacted by Proposal	Percentage of Regional extent impacted
Swamp Sclerophyll Forest	29,155 ha	19.9 ha	0.07%
Swamp Oak Floodplain Forest	28,833 ha	0.9 ha	0.003%
Subtropical Coastal Floodplain Forest	60,018 ha	11.7 ha	0.02%
Freshwater Wetlands	24,118 ha	3.8 ha	0.02%

Table 15-16 shows that less than 0.1 per cent of the total area of any endangered ecological community in the Mid-North Coast Region of NSW (as estimated in 1999) would be removed or modified by the Proposal. The area of each endangered ecological community indirectly affected by runoff, weed invasion and other degrading processes may slightly increase these percentages. However, even taking into account additional clearing that may have occurred between 1999 and today, the extent of clearing is not considered to be significant in the overall regional context.

Cumulative impacts of the Proposal with other large scale developments in the region

The Proposal is also one of many developments planned or underway in the Mid-North Coast Region of NSW. These developments, along with the Proposal, would contribute to the cumulative additive impacts of development in the area and include the following large-scale projects within a 20 kilometre radius of the Proposal area:

- Oxley Highway upgrade.
- Area 13 Thrumster urban investigation area to the east of the Proposal.
- Proposed industrial development on the western side of the Proposal, south of Sancrox Road.
- A possible marine development on the Hastings River in the vicinity of the existing highway.
- Le Clos Verdun rural residential re-subdivision in Sancrox Road, about 5 kilometres to the west of the Proposal.
- Upgrade of the existing Transgrid 132 kV transmission line between Kempsey and Port Macquarie, generally to the east of the Proposal.
- Area 14 Rainbow Beach urban investigation area, about 15 kilometres to the south-east of the Proposal area.
- Area 15 Camden Haven urban investigation area, about 20 kilometres to the south of the Proposal area.

The Proposal, combined with these and other large-scale developments in the region, would contribute to cumulative flora and fauna impacts in the region, including loss of native vegetation, loss of threatened species, and loss of fauna habitat. Each of these projects, including the Proposal, would implement mitigation measures at a local level to offset these impacts.

Cumulative impacts of the Proposal with the Pacific Highway Upgrade Program

The Proposal is part of the Pacific Highway Upgrade Program that includes several sections of the Pacific Highway that have been upgraded or are currently under construction within the North Coast Bioregion. The Mid-North Coast Region lies within the North Coast Bioregion. The Pacific Highway Upgrade Program in this bioregion is ongoing.

While there would be impacts associated with the Proposal on native vegetation, the cumulative impacts of the entire Pacific Highway Upgrade Program would include a greater extent of clearing of native vegetation and habitats as well as fragmentation of habitat. **Table 15-17** shows the extent of native vegetation and endangered ecological community disturbance for recently completed projects, projects under construction, and projects in the planning phase under the Pacific Highway Upgrade Program.

Table 15-17 Extent of native vegetation disturbance associated with the Pacific Highway Upgrade Program

Project	Native vegetation disturbance (hectares)	Endangered ecological community disturbance (hectares)
Projects completed		
Raymond Terrace bypass duplication	5	2
Raymond Terrace to Karuah	37	4
Karuah bypass	36	3
Karuah to Buladelah	123	9
Buladelah to Coolongolook	106	8
Wang Wauk to Bundacree	10	0
Bundacree Creek to Possum Brush	4	1
Coopernook bypass	2	1
Coopernook to Moorland	8	3
Moorland to Herons Creek	64	5
Lyons to England Road	2	1
Halfway Creek	12	0
Tandy's Lane upgrade	1	1
Brunswick Heads bypass	7	5
Brunswick to Yelgun	49	8
Yelgun to Chinderah	30	12
Sub-total – projects completed	***496 ha***	***63 ha***
Projects recently approved or currently under construction		
Bulahdelah bypass	33	3
Kempsey to Eungai upgrade	286	63
Sapphire to Woolgoolga upgrade	83	18

Project	Native vegetation disturbance (hectares)	Endangered ecological community disturbance (hectares)
Wells Crossing to Iluka Road – Glenugie Upgrade	65	5
Ballina bypass	11	9
Tintenbar to Ewingsdale [1]	10	2
Banora Point Upgrade	8	4
Sub-total – projects recently approved or currently under construction	***496 ha***	***104 ha***
Projects in the planning phase		
F3 to Raymond Terrace [2]	49	Assessment to be completed
Oxley Highway to Kempsey (the Proposal) [3]	203	36
Warrell Creek to Urunga upgrade [4]	255	60
Coffs Harbour Bypass [5]	21	Assessment to be completed
Woolgoolga to Wells Crossing [5]	230	51 (preliminary estimate)
Wells Crossing to Iluka Road – remaining [5]	345	55
Iluka Road to Woodburn – remaining [5]	Assessment to be completed	Assessment to be completed
Iluka Road to Woodburn – Devils Pulpit Upgrade [4]	54	12
Woodburn to Ballina [5]	131	56
Sub-total – projects in the planning phase	***1288 ha***	***270 ha***
Total – Pacific Highway Upgrade Program	**2280 ha**	**437 ha**

Note:
1 This project was recently approved and is currently in the detailed design phase.
2 The preferred route has been selected for this project.
3 The environmental assessment is currently being prepared for this project
4 The environmental assessment display has been completed for these projects.
5 The concept design has been finalised for these projects.

As part of the Pacific Highway Upgrade Program, the RTA is mitigating the impacts of vegetation loss from clearing operations by implementing a biodiversity offset strategy. This is in addition to the development of a highway route which avoids or minimises the impacts on sensitive areas of native vegetation where possible.

As part of this biodiversity offset strategy, the RTA purchases land as compensatory habitat, and subsequently transfers ownership of that land to DECCW for ongoing conservation. To date, about 1200 hectares of land has been acquired by the RTA to offset the clearing impacts of the Pacific Highway Upgrade Program. This area of compensatory habitat mainly covers those projects in **Table 15-17** shown as 'projects completed'.

In addition, about 1860 hectares of land is currently proposed as compensatory habitat for native vegetation and endangered ecological community impacts for a number of the projects identified in **Table 15-17** as currently under construction or still in the planning phase. The RTA is continuing consultation with DECCW and DII as appropriate for biodiversity offset packages for the remaining projects that are not covered by the compensatory habitat referred to above.

The actual land exchange ratio agreed with DECCW and DII for the biodiversity offset strategy has varied from project to project over the last 14 years. However, the general land exchange ratio adopted is about 2:1 for native vegetation, and about 4:1 for endangered ecological communities, on a like-for-like basis.

Further to this, the RTA's biodiversity offset strategy also includes revegetation in strategic locations and investment in management research related to the rehabilitation and protection of threatened species.

15.3.5 Significance of impacts

Assessments of significance under Part 3A of the EP&A Act

The removal and/or disturbance of vegetation and habitats as a result of the Proposal has the potential to affect an array of threatened species that have been recorded or have the potential to occur in the study area. Four endangered ecological communities would be impacted. An assessment of the potential significance of impacts on seven threatened flora species, four endangered ecological communities, and 46 threatened fauna species has been prepared in accordance with the assessment criteria identified in the *Guidelines for Threatened Species Assessment under Part 3A of the EPA Act* (Department of Environment and Conservation and Department of Primary Industries 2005). The assessment is presented in Section 5.1 and Appendix I of the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment.

The significance assessments have concluded that there is unlikely to be a significant impact on threatened species or ecological communities and that the Proposal would not result in impacts of a magnitude that would cause a local population of threatened flora or fauna or a local occurrence of an endangered ecological community to become extinct, provided that the proposed mitigation and management measures outlined in **Section 15.4** are implemented.

Assessments of significance under the EPBC Act

An assessment of the potential significance of impacts of the Proposal on six threatened flora species, 10 threatened fauna species, and 15 migratory species listed under the EPBC Act has been prepared in accordance with the *Significance Impact Guidelines 1.1 – Matters of National Environmental Significance* (Department of Environment and Heritage 2006). The assessment is presented in Section 5.2 and Appendix J of the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment.

The Proposal incorporates measures to minimise the clearing of vegetation, loss of habitat and drainage and sedimentation controls to manage runoff during both the construction and operation phases. On the basis of the assessments undertaken, it is concluded that the Proposal would not result in a significant impact on any matter of national environmental significance under the EPBC Act, including threatened and migratory species. As there are no endangered ecological communities under the EPBC Act present within the study area, there would not be a significant impact on endangered ecological communities. Accordingly, the Proposal has not been referred to the Federal Department of the Environment, Water, Heritage and the Arts.

Summary of assessment of significance

Table 15-18, Table 15-19 and **Table 15-20** summarises the results of the assessments of significance under both the TSC Act and EPBC Act for endangered ecological communities, threatened flora and fauna, and migratory fauna.

Table 15-18 Summary of significance assessments for endangered ecological communities and threatened flora species

Common name Scientific name	TSC Act status	EPBC Act status	Recorded/ predicted to occur	Summary of assessment of significance	Likely significant impact
Swamp Sclerophyll Forest	EEC		Recorded	No regional effects Remaining areas large enough to continue as functioning ecosystems	No
Swamp Oak Floodplain Forest	EEC		Recorded	No regional effects Remaining areas large enough to continue as functioning ecosystems.	No
Subtropical Coastal Floodplain Forest	EEC		Recorded	No regional effects Remaining areas large enough to continue as functioning ecosystems.	No
Freshwater Wetlands	EEC		Recorded	No regional effects Remaining areas large enough to continue as functioning ecosystems.	No
scented acronychia *Acronychia littoralis*	Endangered	Endangered	Predicted	Unlikely to remove, fragment, displace or disturb local population No risk of extinction	No
hairy-joint grass *Arthraxon hispidus*	Vulnerable	Vulnerable	Predicted	Unlikely to remove, fragment, displace or disturb local population No risk of extinction	No
biconvex paperbark *Melaleuca biconvexa*	Vulnerable	Vulnerable	Predicted	Unlikely to remove, fragment, displace or disturb local population No risk of extinction	No
maundia *Maundia triglochinoides*	Vulnerable		Predicted	Unlikely to remove, fragment, displace or disturb local population No risk of extinction	No
swamp orchid *Phaius tancarvilleae*	Endangered	Endangered	Predicted	Unlikely to remove, fragment, displace or disturb local population No risk of extinction	No
southern swamp orchid *Phaius australis*	Endangered	Endangered	Predicted	Unlikely to remove, fragment, displace or disturb local population No risk of extinction	No
milky silkpod *Parsonsia dorrigoensis*	Vulnerable	Endangered	Predicted	Unlikely to remove, fragment, displace or disturb local population No risk of extinction	No

Table 15-19 Summary of significance assessments for threatened fauna species

Common name Scientific name	TSC Act status	EPBC Act status	Recorded/ predicted to occur	Summary of assessment of significance	Likely significant impact
Australasian bittern *Botaurus poiciliptilus*	Vulnerable		Predicted	Unlikely to displace local population	No
Australian painted snipe *Rostratula benghalensis*	Vulnerable	Vulnerable	Predicted	Unlikely to displace local population	No
barking owl *Ninnox connivens*	Vulnerable		Predicted	Unlikely to displace local population	No
barred cuckoo-shrike *Coracina lineata*	Vulnerable		Predicted	Unlikely to disrupt breeding cycle	No
black bittern *Ixobrychus flavicollis*	Vulnerable		Predicted	Unlikely to displace local population	No
black-necked stork *Ephippiorhynchus asiaticus*	Endangered		Recorded	Unlikely to displace local population	No
brush-tailed phascogale *Phascogale tapoatafa*	Vulnerable		Predicted	Mitigation measures would ameliorate impacts	No
comb-crested jacana *Irediparra gallinacea*	Vulnerable		Predicted	Unlikely to displace local population	No
common planigale *Planigale maculata*	Vulnerable		Predicted	Mitigation measures would ameliorate impacts	No
eastern bent-wing bat *Miniopterus schriebersii oceanensis*	Vulnerable		Recorded	No suitable breeding habitat in study area	No
eastern chestnut mouse *Pseudomys gracilicaudatus*	Vulnerable		Predicted	Mitigation measures would ameliorate impacts	No
eastern false pipestrelle *Falsistrellus tasmaniensis*	Vulnerable		Recorded	Unlikely to displace local population	No
eastern freetail-bat *Micronomus norfolkensis*	Vulnerable		Recorded	Unlikely to displace local population Unlikely to disadvantage foraging	No
giant barred frog *Mixophyes iteratus*	Endangered	Endangered	Recorded	Unlikely to displace local population	No

Common name Scientific name	TSC Act status	EPBC Act status	Recorded/ predicted to occur	Summary of assessment of significance	Likely significant impact
giant dragonfly *Petalura gigantea*	Endangered		Predicted	Mitigation measures would ameliorate impacts	No
glossy black-cockatoo *Calyptorhynchus lathami*	Vulnerable		Recorded	No nest trees recorded in the study area	No
golden-tipped bat *Kerivoula papuensis*	Vulnerable		Predicted	Potential habitat degraded in the study area	No
grass owl Tyto capensis	Vulnerable		Predicted	Unlikely to displace local population	No
greater broad-nosed bat *Scoteanax rueppellii*	Vulnerable		Recorded	Unlikely to displace local population Unlikely to disadvantage foraging	No
green and golden bell frog *Litoria aurea*	Endangered	Vulnerable	Predicted	Unlikely to occur in study area Unlikely to affect lifecycle	No
green-thighed frog *Litoris brevipalmata*	Vulnerable		Recorded	Mitigation measures would ameliorate impacts	No
grey-crowned babbler *Pomatostomas temporalis temporalis*	Vulnerable		Predicted	Unlikely to occur in study area Unlikely to affect lifecycle	No
grey-headed flying-fox *Pteropus poliocephalus*	Vulnerable	Vulnerable	Recorded	Unlikely to displace local population Unlikely to disrupt breeding cycle or roosting behaviour	No
koala *Phascolarctos cinereus*	Vulnerable		Recorded	Unlikely to disrupt breeding cycle	No
large-eared pied bat *Chalinolobus dwyeri*	Vulnerable	Vulnerable	Predicted	No suitable breeding habitat	No
long-nosed potoroo *Potorous tridactylus*	Vulnerable	Vulnerable	Predicted	Unlikely to occur in study area Unlikely to affect lifecycle	No
little bent-wing bat *Miniopterus australis*	Vulnerable		Recorded	No suitable breeding habitat	No
masked owl *Tyto novaehollandiae*	Vulnerable		Recorded	Unlikely to displace local population	No

Common name Scientific name	TSC Act status	EPBC Act status	Recorded/ predicted to occur	Summary of assessment of significance	Likely significant impact
osprey *Pandion haliaetus*	Vulnerable		Recorded	Unlikely to affect foraging habitat	No
pale-headed snake *Hoplocephalus bitorquatus*	Vulnerable		Predicted	Unlikely to affect lifecycle	No
powerful owl *Ninox strenua*	Vulnerable		Predicted	Unlikely to displace local population	No
regent honeyeater *Xanthomyza phrygia*	Endangered	Endangered Migratory	Predicted	Unlikely to affect lifecycle	No
rose-crowned fruit-dove *Ptilinopus regina*	Vulnerable		Recorded	Opportunistic visitor to study area	No
sooty owl *Tyto tenebricosa*	Vulnerable		Recorded	Unlikely to displace local population	No
southern myotis *Myotis macropus*	Vulnerable		Recorded	Unlikely to affect foraging activity Unlikely to lead to extinction of local population	No
spotted-tailed quoll *Dasyurus maculatus*	Vulnerable	Endangered	Predicted	Unlikely for optimal denning habitat to occur	No
square-tailed kite *Lophoictinia isura*	Vulnerable		Recorded	Unlikely to displace local population No nests observed in study area	No
Stephen's banded snake *Hoplocephalus stephensii*	Vulnerable		Predicted	Unlikely to occur in study area Unlikely to affect lifecycle	No
stuttering frog *Mixophyes balbus*	Endangered	Vulnerable	Predicted	Unlikely to displace local population	No
squirrel glider *Petaurus norfolcensis*	Vulnerable		Predicted	Mitigation measures would ameliorate impacts	No
superb fruit-dove *Ptilinopus superbus*	Vulnerable		Predicted	Opportunistic visitor to study area	No
swift parrot *Lathamus discolor*	Endangered	Endangered Migratory	Predicted	Unlikely to affect lifecycle	No
wallum froglet *Crinia tinnula*	Vulnerable		Predicted	Mitigation measures would ameliorate impacts	No
wompoo fruit-dove *Ptilinopus magnificus*	Vulnerable		Predicted	Unlikely to affect lifecycle	No

Common name Scientific name	TSC Act status	EPBC Act status	Recorded/ predicted to occur	Summary of assessment of significance	Likely significant impact
yellow-bellied glider *Petaurus australis*	Vulnerable		Recorded	Mitigation measures would ameliorate impacts	No
yellow-bellied sheathtail bat *Saccolaimus flaviventris*	Vulnerable		Predicted	Unlikely to displace local population Unlikely to disadvantage foraging	No

Table 15-20 Summary of significance assessments for migratory species

Common name Scientific name	TSC Act status	EPBC Act status	Recorded/ predicted to occur	Summary of assessment of significance	Likely significant impact
Australian painted snipe *Rostratula australis*		Migratory	Predicted	Opportunistic visitor to study area No core habitat within study area	No
black-faced monarch *Monarcha melanopsis*		Migratory	Recorded	Opportunistic visitor to study area No core habitat within study area	No
cattle egret *Ardea ibis*		Migratory	Recorded	Opportunistic visitor to study area No core habitat within study area	No
fork-tailed swift *Apus pacificus*		Migratory	Predicted	Opportunistic visitor to study area No core habitat within study area	No
great egret *Ardea alba*		Migratory	Predicted	Opportunistic visitor to study area No core habitat within study area	No
Latham's snipe *Gallinago hardwickii*		Migratory	Recorded	Opportunistic visitor to study area No core habitat within study area	No
osprey *Pandion haliaetus*	Vulnerable	Migratory	Recorded	No nest sites observed or known to occur Unlikely to affect foraging habitat	No
rainbow bee-eater *Merops ornatus*		Migratory	Predicted	Opportunistic visitor to study area No core habitat within study area	No
regent honeyeater *Xanthomyza phrygia*	Endangered	Endangered Migratory	Predicted	Unlikely to affect lifecycle	No

Common name Scientific name	TSC Act status	EPBC Act status	Recorded/ predicted to occur	Summary of assessment of significance	Likely significant impact
rufous fantail *Rhipidura rufifrons*		Migratory	Recorded	Opportunistic visitor to study area No core habitat within study area	No
satin flycatcher *Myiagra cyanoleuca*		Migratory	Recorded	Opportunistic visitor to study area No core habitat within study area	No
spectacled monarch *Monarcha trivirgatus*		Migratory	Predicted	Opportunistic visitor to study area No core habitat within study area	No
swift parrot *Lathamus discolor*	Endangered	Endangered Migratory	Predicted	Unlikely to affect lifecycle	No
white-bellied sea-eagle *Haliaeetus leucogaster*		Migratory	Recorded	Opportunistic visitor to study area No core habitat within study area	No
white-throated needletail *Hirundapus caudacutus*		Migratory	Recorded	Opportunistic visitor to study area No core habitat within study area	No

15.3.6 Service roads

New service roads that would be constructed for the Proposal have been assessed as part of the Proposal footprint in the sections above. Those sections of the service road network that would use existing local roads as shown on **Figure 6-1a** to **Figure 6-1b** and **Figure 6-2a** to **Figure 6-2q** are considered below.

Subject to further assessment and detailed design, some sections of these existing local roads may require upgrading to meet the required minimum criteria for service roads. These roads are described below in the context of known vegetation mapping for these areas. To date no specific ecological investigations have been undertaken for these service roads, however some sections fall within the area of the detailed ecological investigations undertaken for the Proposal. Other areas fall within areas mapped as part of the Comprehensive Regional Assessment project undertaken for the Regional Forests Agreement. There is no other known vegetation mapping available. Flora and fauna surveys would be undertaken for service roads that fall outside the areas where ecological investigations have been undertaken. These surveys would be undertaken prior to construction.

North of the Haydons Wharf Road interchange the service road network would use existing sections of Cooperabung Drive. Detailed ecological investigations undertaken for the Proposal did not extend to this existing road. Broadscale Comprehensive Regional Assessment mapping indicates that this area is predominantly cleared. Areas of remnant vegetation occur within the existing road corridor. Beyond the road corridor, the landscape is predominantly cleared with scattered trees.

This road crosses Cooperabung Creek via an existing low level bridge. Vegetation bordering Cooperabung Creek in the vicinity of the existing highway and Proposal (approximately 600 metres downstream of this low level bridge) is mapped as riparian forest, which has been identified as Subtropical Coastal Floodplain Forest endangered ecological community. While vegetation in the vicinity of the proposed service road appears to be heavily disturbed there may be elements of this endangered ecological community present. Subject to further design to determine the extent of any required road upgrade, some of the vegetation bordering the road may be cleared. The limited extent of this clearing would not significantly alter the landscape in this location.

At Kundabung the service road network would use Rodeo Drive and Ravenswood Road. Comprehensive Regional Assessment mapping indicates that these areas are predominantly cleared. Areas of remnant vegetation occur within the existing road corridor. Beyond the road corridor, the landscape is cleared with scattered trees in parts and moderately to heavily vegetated in others. South of Kundabung Road detailed ecological investigations undertaken for the Proposal mapped vegetation communities as moist floodplain forest in the southern part of the service road and moist slopes forest immediately to the east between the service road and the existing highway.

At Ravenswood Road vegetation communities between the service road and existing highway were mapped as predominantly moist slopes forest and a small area of moist floodplain forest. Subject to further design to determine the extent of any required road upgrade, some of this vegetation may be cleared. This clearing would not significantly alter the landscape in this location.

A proposed new access road is required to connect Kemps Road from just north of Maria River to the proposed interchange at the southern limit of the Kempsey to Eungai Pacific Highway upgrade project. To the north of Stumpy Creek no detailed ecological investigations for the Proposal have been undertaken for this new access road. South of Stumpy Creek the proposed new access road has been included as part of the detailed ecological assessment for the Proposal. Broadscale Comprehensive Regional Assessment mapping indicates that this area is predominantly semi-mesic forests, which appears to correlate with moist slopes forest identified during detailed mapping for the Proposal. The proposed new access road would enter a cleared area with scattered trees at its northern limit. Construction of this new access road would require clearing of vegetation.

In summary, additional field surveys would be undertaken for service and access roads located outside the Proposal footprint. The additional impact of any required clearing in these areas is not anticipated to result in a significant impact on threatened flora, fauna or endangered ecological communities.

15.3.7 Staging implications

In preparing this Environmental Assessment, the potential flora and fauna impacts of the possible staging option described in **Section 7.3.2** in comparison to the construction of the entire Proposal to a full motorway standard have been considered as outlined below.

Should the Proposal be delivered in stages, the staging report described in **Section 7.3.3** would detail the impacts of the selected staging option on flora and fauna. If any additional or altered impacts are identified, the staging report would further assess these impacts and identify appropriate management measures.

Loss of native vegetation

The Proposal has been sited and designed to minimise loss of native vegetation, including endangered ecological communities, for both the possible staging option and motorway standard upgrade.

The possible staging option would require clearing of about 175 hectares of native vegetation, including about 31 hectares of endangered ecological communities. The total area of clearing for this staging option is 28 hectares less, and the area of cleared endangered ecological communities is about 5 hectares less, than for the ultimate motorway standard upgrade. All vegetation clearing required for this staging option would be located within the clearing footprint of the ultimate motorway standard upgrade.

There could, however, be a requirement to establish long-term soil stockpiles to store excess fill not required in this staging option but which would be required for the ultimate motorway standard upgrade. If required, these stockpiles would be located wherever possible in areas with little or no vegetation. If clearing was required for stockpiles, it is estimated that a maximum of about 10 hectares of vegetation clearing, additional to the staging option footprint, could be required. The areas that could be cleared for possible stockpiles would be located within areas that would otherwise be cleared for the ultimate motorway standard upgrade, and would therefore still be within the Proposal clearing boundary assessed in this Environmental Assessment.

Possible stockpile locations that could be considered would be within the footprints of the future eastern access road south of Pipers Creek near Kundabung, the western service road between Kundabung Road and Smiths Creek Road, and the overbridges at Mingaletta Road and Upper Smiths Creek Road/Wharf Road. Stockpile locations would be selected in accordance with the selection criteria for ancillary facilities outlined in **Section 7.6.7**, with the additional preference for stockpiles to be located in areas where fill is required for the ultimate motorway standard upgrade.

Impacts on threatened fauna

Potential impacts to threatened fauna would generally be the same for both the possible staging option and the ultimate motorway standard upgrade, although less fauna habitat would initially be disturbed in this staging option. However, the two separate construction periods could potentially increase the disturbance to threatened fauna.

All fauna crossing opportunities identified for the ultimate motorway standard upgrade would be provided for this staging option. Fauna exclusion fencing initially installed for this staging option could require relocation for the ultimate motorway standard upgrade. Any modification of fauna crossings or management measures to suit staging requirements would be undertaken in consultation with DECCW and DII.

Impact on aquatic habitat and species

Most watercourse crossing structures on the upgraded highway proposed for the motorway standard upgrade would also have to be provided for the possible staging option, and would be designed in accordance with relevant guidelines.

Those watercourse crossing structures not required for this staging option would need to be constructed in the future to cater for service roads in the ultimate motorway standard upgrade. This may potentially increase the risk of impact on aquatic habitat and species resulting from the separate construction periods. Appropriate mitigation measures as recommended in **Section 15.4.4** would be implemented for both the arterial standard and motorway upgrades.

15.4 Management of impacts

15.4.1 Minimising vegetation clearance and habitat loss

Disturbance and removal of areas of native vegetation and habitat would be unavoidable during the construction of the Proposal. However, measures would be implemented to prevent further disturbance and minimise the impacts on the native vegetation and habitat. Some of the measures that would be implemented to minimise the loss of native vegetation and habitat include:

- Vegetation clearing would be restricted to only those areas where it is necessary.
- Areas of native vegetation to be cleared would be clearly marked on maps and delineated in the field to ensure that clearing does not occur beyond the area necessary for the Proposal.
- Clearing of vegetation and fauna habitat would be carried out in accordance with the two stage clearing procedures that have been developed for Pacific Highway upgrade projects in consultation with DECCW. This would include:
    - Pre-clearing surveys of all hollow-bearing trees within the clearance corridor to determine which trees are occupied by fauna.
    - Leaving habitat trees to the second stage of clearing to increase the possibility of fauna relocating prior to removing the trees.
    - Ensuring an experienced wildlife handler is present to manage and retrieve any displaced wildlife during clearing activities.
    - Relocating displaced fauna to similar habitat at the closest available safe location.
    - Locating the construction compounds and materials stockpile areas in areas that are currently cleared or disturbed wherever possible.
- Where possible clearing activities would not take place during the spring/early summer breeding period and would also avoid mid-winter when bats enter torpor. Care would be required should clearing coincide with the koala breeding season (August to December).
- Hollow logs, leaf litter, woody debris and large boulders removed during construction would be redistributed during rehabilitation works. The DECCW benchmarks for fallen log distribution (refer to Table 6-1 in the Flora and Fauna Working Paper provided in Volume 2 of this Environmental Assessment) would be used to guide the appropriate rates of redistribution.
- A nest box strategy would be developed for the Proposal as part of the construction environmental management plan. This strategy would include installing nest boxes or relocating salvaged tree hollows in nearby habitat areas to provide alternative roosting habitat.
- Prior to construction collection of native seed from construction sites would be undertaken for use in the revegetation of cleared and/or disturbed areas.
- A qualified ecologist would inspect bridges and culverts for bats prior to their demolition in order to avoid the accidental deaths of bats that may be roosting in these structures. Inspections would involve:
    - Visual inspection prior to clearing or flushing any of the scuppers, particularly during the breeding season of the southern myotis (October – March).
    - Dark recesses within the bridge structure inspected immediately prior to the commencement of work.
    - Any swallow/fairy martin nests to be removed inspected for roosting bats prior to removal.

  - Presence of bats during inspection to require a cease work in that section of the bridge until they are moved and relocated by a bat expert. If a maternity roost were identified mitigation measures would be developed in consultation with DECCW and an appropriately qualified ecologist.

- Installation of 'bolt on' bat roosts under new bridges and underpasses, would be undertaken where the need for the roosts is identified, to increase the availability of roost sites. For example, vertical concrete shaft and/or slot roosts could be bolted on to headstocks of bridges or the ceiling of culverts.
- Targeted surveys for the threatened green-thighed frog would be undertaken prior to construction, particularly in the vicinity of the apparent breeding pool located in an ephemeral tributary of the Maria River in Maria River State Forest. This would provide more information regarding the importance of the breeding pool to the local population of the green-thighed frog and would allow minor refinements to the design, or appropriate mitigation measures to be applied. Surveys would be undertaken in late spring or summer following heavy rain in order to locate breeding aggregations of this species. In areas where known habitat for the green-thighed frog would be disturbed, measures to mitigate impacts would be discussed and negotiated with DECCW. The location, size and design of these ponds would be developed at the detailed design and construction stages and would consider features listed in the Flora and Fauna Working Paper provided in Volume 2 of this Environmental Assessment.
- The mitigation measures that were put in place to mitigate impacts on the giant barred frog during recent construction works at Maria River, including frog fencing, water quality controls, silt fencing and spill booms, would be implemented for the construction of bridges across major creeks (particularly Cooperabung, Barrys, Smiths and Pipers Creeks, and tributaries of Maria River through Maria River State Forest), in consultation with the relevant authorities.
- An adaptive monitoring program for both the green-thighed frog and giant-barred frog would be established and implemented during and following construction focusing on areas of known and potential habitat within the Proposal footprint including Maria River and associated tributaries, and Cooperabung, Barrys, Smiths and Pipers creeks to determine the species' persistence in the area and the success of the mitigation measures. Consideration would be given to constructing artificial breeding ponds to provide alternative habitat. The location, size and design of these ponds would be considered at the detailed design and construction stages.
- Chytridiomycosis is known to affect the giant barred frog and other threatened frog species with potential to occur within the study area. Chytrid fungus is a water borne pathogen and could be spread through water or mud on vehicles, machinery, footwear and other equipment. In order to prevent the spread of the water-borne chytrid fungus, appropriate cleaning and disinfection protocols would need to be followed when moving between wet-area work sites representing giant barred frog habitat (including Maria River and associated tributaries, Cooperabung, Barrys, Smiths and Pipers creeks) as per Hygiene protocol for the control of disease in frogs (National Parks and Wildlife Service 2001).
- A protocol would be developed for managing the unexpected finds of threatened plant species during construction, including the preparation of a management plan and mitigation measures in consultation with DECCW.
- Prior to construction, flora and fauna surveys would be undertaken for the two properties between Cairncross State Forest and the Wilson River as access was not previously available.

- Retention of the existing highway as part of the service and access road network would, subject to detailed design, minimise the need for additional clearing and construction. Where additional clearing is required for service or access roads, flora and fauna surveys would be undertaken prior to construction.
- The restoration, regeneration and rehabilitation of areas of cleared native vegetation within the footprint would be carried out progressively, particularly in identified regional corridors and key habitat areas, and in such a way that it increases the habitat value and visual amenity of the areas. The revegetation of these areas would incorporate locally occurring native shrubs and groundcover plants and aim to minimise edge effects by complementing and protecting adjoining native vegetation where possible.
- Revegetation would include planting of locally occurring species, winter flowering trees, and preferred food trees for native fauna including appropriate species for the koala, yellow-bellied glider and glossy black-cockatoo. DECCW would be consulted regarding the choice of species, particularly in areas adjacent to existing patches of endangered ecological communities. Monitoring and maintenance of plantings, and management and control of weeds would be undertaken.

15.4.2 Edge effects and weed infestation

The measures designed to mitigate edge effects and weed infestation are aimed at reducing impacts outside of the Proposal footprint. These measures seek to control the possible impacts at their source within the road corridor and soften the edge between the earthworks and the native vegetation. Measures, in addition to rehabilitation measures described above, include:

- Avoiding the stockpiling of materials adjacent to native vegetation wherever possible.
- Avoiding the disposal and storage of waste and / or contaminated construction materials (eg spoil material) in areas adjacent to native vegetation.
- Implementing soil erosion and sediment control measures.
- Implementing a weed management strategy for the road reserve.
- Developing protocols in consultation with DECCW to prevent the introduction or spread of root rot *Phytophthora cinnamomi* and chytrid fungus prior to commencements of construction.

A weed management strategy would be developed as part of the construction environmental management plan prior to commencement of construction. The strategy would develop measures to prevent the spread of noxious and environmental weeds beyond roadside reserves and reduce their abundance within these areas during construction. Protocols that currently exist in relation to weed management for roads managed by the RTA would be applied for the operational phase of the Proposal.

15.4.3 Fragmentation, terrestrial barrier effects and road mortality

To reduce the potential for adverse impacts on native wildlife as a result of habitat fragmentation, barrier effects and road mortality resulting from the Proposal, dedicated fauna underpasses and combined drainage/fauna movement culverts (in conjunction with wildlife exclusion fencing) and aerial fauna crossings have been incorporated into the design of the Proposal, as discussed in **Section 6.4.16**. In addition to the fauna underpasses, bridges would be designed to provide opportunities for fauna movement along the banks of watercourses.

These features aim to maintain linkages between vegetation communities and allow for the safe movement of fauna within the wildlife corridors identified in the study area. The effectiveness of such features in reducing road mortality has been shown in a number of studies (see Glista et al 2009), and even very low rates of dispersal between habitats facilitated by these structures can substantially reduce the risk of population decline and extinction of native fauna (Taylor and Goldingay 2009).

The following points were considered when determining the location for the fauna crossing structures in the Proposal:

- Regional connectivity within the study area based on the key habitats and corridors produced by the Department of Environment and Climate Change (Scotts 2003).
- The size and location of vegetation patches on both sides of the Proposal and their suitability as fauna habitat.
- Terrestrial fauna species likely to occur and use the fauna crossing structures at particular locations based on known species occurrence and/or the presence of suitable habitat.
- The feasibility of constructing a fauna crossing structure at that location due to engineering and terrain constraints.
- The proximity of crossing locations to culvert / bridge structures required for creeks / rivers.

The types of fauna crossings incorporated into the Proposal are described below

Fauna underpasses and bridges

The proposed fauna crossings fall within three categories:

- Dedicated fauna underpasses.
- Combined fauna and drainage structures.
- Incidental crossings.

The indicative location of proposed fauna crossings is shown in **Figure 15-6a** to **Figure 15-6c**. Additional information on size and type of proposed fauna crossings can be found in Section 6.3 of the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment.

The proposed fauna crossings have been located to link areas of key habitat and native vegetation, particularly within sub-regional and regional corridors. The location of the crossings has also taken into consideration the fauna species that would be likely to utilise the crossings.

A number of threatened species could also utilise the proposed crossings. Having regard to the location of suitable habitat and vegetation types adjoining the Proposal it is considered that, of the 64 crossings proposed, the potential utilisation by threatened species is as follows:

- 32 crossings could be utilised by koala.
- 28 crossings could be utilised by the spotted-tailed quoll.
- Seven crossings could be utilised by the green-thighed frog.
- Two crossings could be utilised by the giant barred frog.

In addition to fauna crossings, fauna fencing would be provided in areas where there are known fauna movement corridors, in state forests and other areas where fauna movement would be considered at risk by the Proposal. Fences would need to be regularly maintained with vegetation removed on either side of the fence so that there is no touching canopy. Permanent floppy-top fencing would be installed, directing animals to fauna underpasses and culverts beneath the highway.

Bridge construction techniques such as minimising the area to be cleared on embankments, and maintaining clear passage of the stream channels would assist in mitigating the impact of construction on the various rivers and creeks within the study area. Scour protection measures would be incorporated as detailed in **Chapter 12 Hydrology**. The retention and possible enhancement of creek banks beneath the bridges would allow the channels to be maintained as crossing points for terrestrial fauna. Preliminary bridge designs for the Proposal have sought to avoid placing bridge abutments in the channels and low-flow channel banks. This would assist to maintain the clear passage opportunities on the stream channels and serve to mitigate barrier impacts associated with the Proposal.

Aerial fauna crossings

A combination of the following types of crossings for arboreal fauna which do not utilise underpasses is proposed:

- Rope ladders: principally catering for arboreal wildlife, such as possums and gliders.
- Glider poles: designed specifically for glider species.

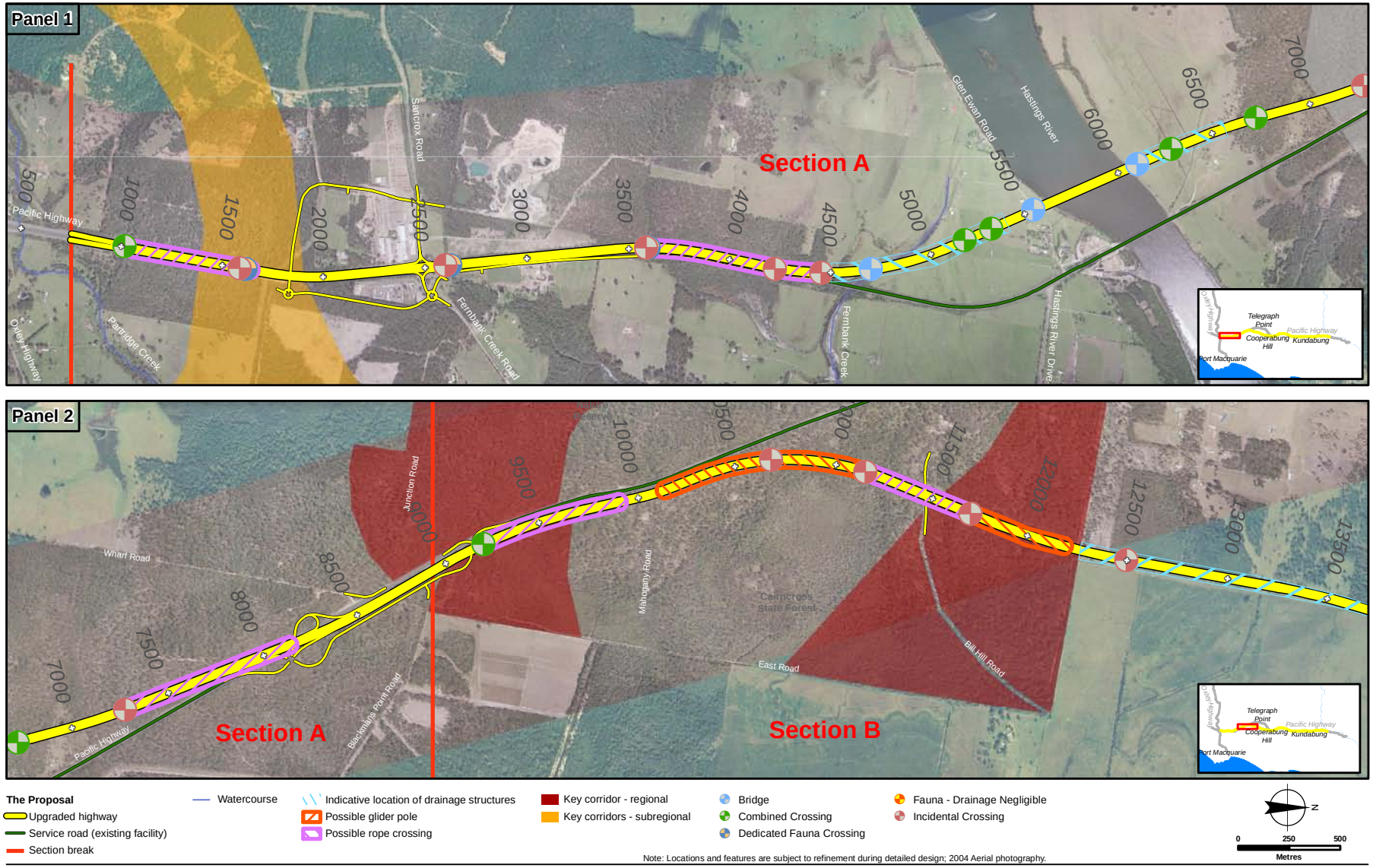
Rope ladders 25 to 50 centimetres wide provide sufficient stability to allow for the safe crossing of most arboreal species and short ropes leading from the ends of the rope ladder to nearby trees could encourage ladder use. **Figure 15-6a** to **Figure 15-6c** identify indicative areas along the Proposal for the possible installation of rope ladders.

The proposed ranges for the location of glider crossings are shown in **Figure 15-6a** to **Figure 15-6c**. The precise positioning of glider poles would be decided by an ecologist after vegetation clearing has been completed and would vary between crossings depending on the number and position of trees retained (to complement the natural connectivity of the landscape). The spacing and height of gliding poles is critical to crossing success with glide distance directly proportional to launch height.

The potential for widening the median of the Proposal at these locations where it is reasonable and feasible to do so would be further investigated in consultation with relevant government agencies and affected landowners during the detailed design phase.

The actual number, location and design of rope ladders and glider poles would be determined at the detailed design phase in consultation with DECCW. Generic design guidelines for these crossing structures can be found in Section 6.3.2 of the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment.

Figure 15-6a Fauna crossings



Note: Locations and features are subject to refinement during detailed design; 2004 Aerial photography.

Figure 15-6b Fauna crossings

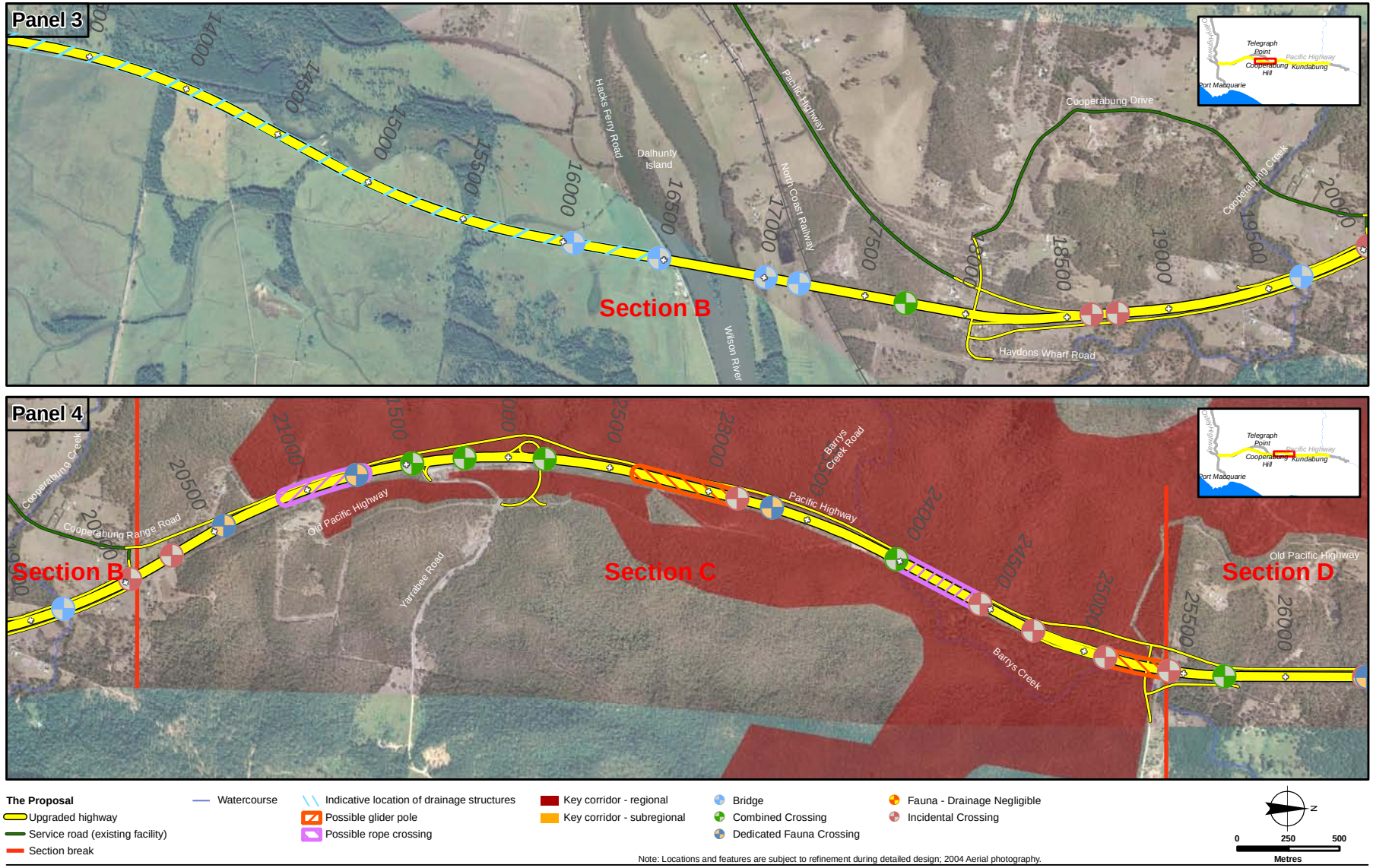
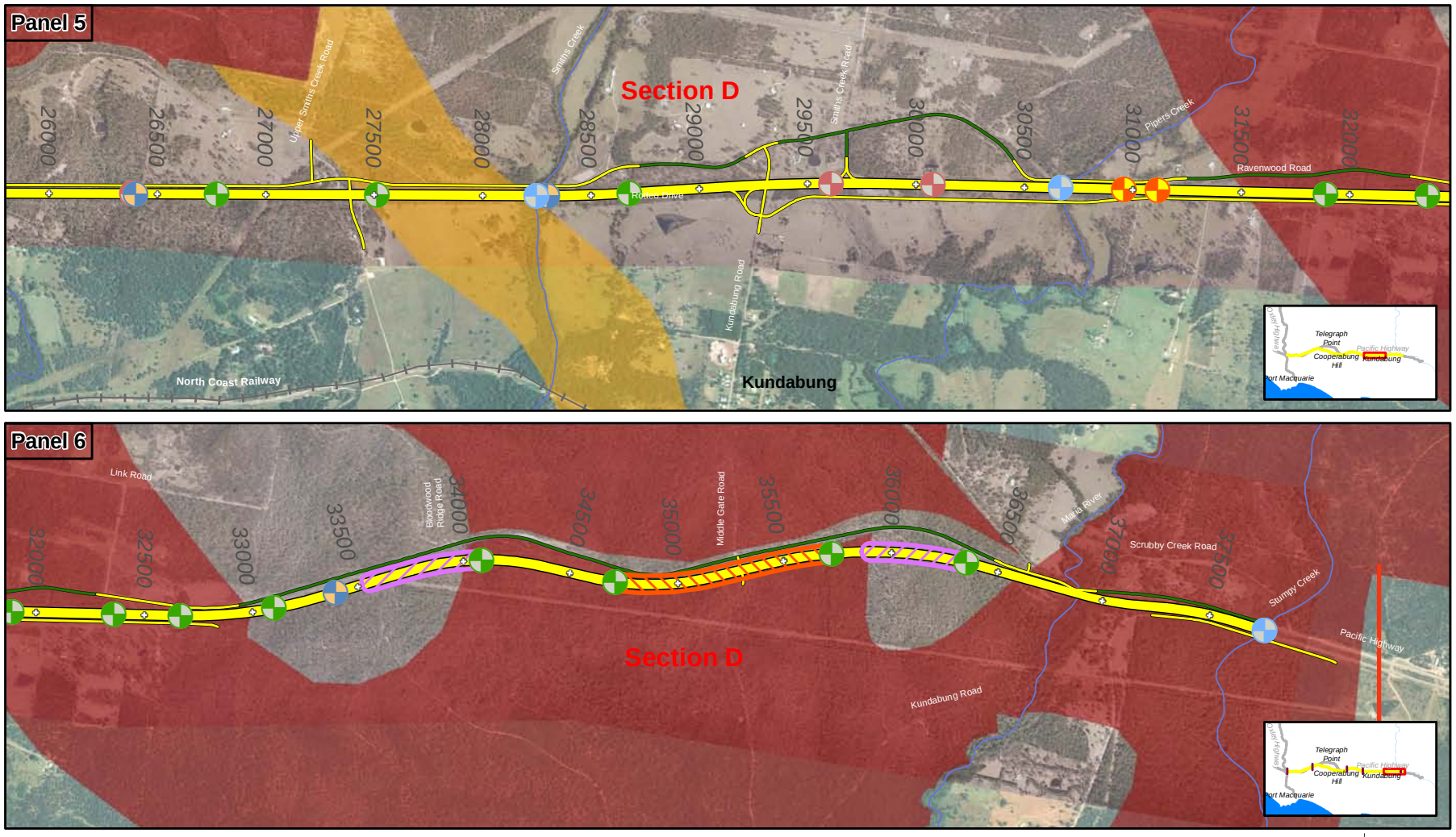


Figure 15-6c Fauna crossings



Note: Locations and features are subject to refinement during detailed design; 2004 Aerial photography.

15.4.4 Minimising impacts on aquatic ecology

Little disturbance to aquatic ecology is anticipated within the study area once the construction of watercourse crossings is completed. Damage to any aquatic habitat and riparian vegetation during construction would be minimised. Areas of riparian vegetation to be damaged or removed during construction would be replanted on completion of the works. In addition, appropriate erosion sediment control measures would be put in place around all proposed watercourse crossings prior to construction to minimise water quality impacts on the watercourses due to run-off from the construction site.

The study area was extended to include Stumpy Creek after the aquatic assessments were completed. A further aquatic habitat assessment would be undertaken prior to construction.

Maintaining aquatic fauna passage

All watercourse crossings would comply (where feasible and reasonable) with requirements contained in the DPI publications *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge 2003) and *Policy and Guidelines for Fish Friendly Waterway Crossings* (DPI 2003). Bridges proposed for the creek crossings would be designed to minimise changes to the channel's natural flow, width, roughness and base-flow water depth to maintain fish passage, as outlined in Section 6.4.1 of the *Flora and Fauna Working Paper* provided in **Volume 2** of this Environmental Assessment.

Woody snags would be treated in accordance with the requirements of NSW Fisheries, with removal of the snag being the last option. NSW Fisheries would be notified of any proposed works in relation to snags.

Measures for bridge construction

Prior to constructing crossing structures in a streambed, a work method statement would be prepared that identifies the site constraints and appropriate environmental management measures for each construction location. The work method statement would include a progressive erosion and sediment control plan which details the appropriate erosion and sedimentation control measures that would be installed around the working site. The progressive plan may include such measures as temporary diversions, silt curtains, rock barriers or other control measures as necessary and appropriate for the location. The work method statement would be implemented for the construction.

Managing changes to water quality in aquatic habitats

The measures that would be implemented to manage and mitigate the potential impacts on water quality are discussed in **Chapter 13 Water quality**.

Minimising impacts on protected aquatic vegetation and State listed wetlands

The exact area of mangroves and seagrasses to be directly impacted by the Proposal would be determined at the detailed design stage when the precise dimensions of the structure and related overshadowing impacts can be determined.

Impacts on protected marine vegetation and State listed wetlands at the Hastings and Wilson river crossings would be minimised by:

- Bridge pilings and support structures would be constructed with the aim to avoid mangrove forests and seagrass beds where possible. Where it is not possible to avoid impacts on mangroves and seagrass beds the Proposal footprint would be minimised as much as possible. Where possible, a buffer zone would be maintained around mangroves for construction activities. Restoration and rehabilitation measures for mangroves and seagrasses would be developed and incorporated into the construction environmental management plan.
- Bridge design would limit the location of structures such as piers and piles within the channel bed of the watercourses where possible to reduce the potential for impacts as a result of increased flow velocities. Piers would be designed and orientated to avoid the generation of turbulence and subsequent bed and bank erosion. Where increased velocities have the potential to cause scour and cannot be minimised by changes to the design, appropriate scour protection would be provided (see **Section 12.4.3**).
- Factors including height, orientation, slenderness, piers, deck separation and potential use of construction materials with a higher degree of transparency would be considered during the detailed design for where the Proposal crosses seagrass beds on the banks of the Hastings River, to improve light penetration to marine vegetation underneath the bridges.
- Bridge pilings and support structures would be constructed with the aim to avoid impact on State-listed wetlands where possible. Given the identified discrepancies between the mapped boundaries and the extent of the wetalnds identified during field investigations, a more accurate boundary would be established prior to construction through quantitative observations and surveying of the mapped boundary.
- Pilings and support structures would be avoided on Dalhunty Island where possible.

Final bridge designs would be undertaken at the detailed design stage. Compensatory measures (RTA 2006a) to offset residual impacts on protected aquatic vegetation would be discussed and agreed with DPI at the detailed design phase. Compensatory measures may include:

- Replacement of protected aquatic vegetation at a ratio as agreed with DII.
- Transplanting of mangroves smaller than 1 metre and seagrasses to adjacent areas in accordance with DII guidelines.
- Stabilisation of the Hastings River banks in areas of high erosion potential to protect marine vegetation from sedimentation.

15.4.5 Managing impacts on groundwater-dependent ecosystems

Measures that would be employed to minimise impacts on groundwater would be applicable to the management of impacts on groundwater dependent ecological communities. Measures to minimise impacts on groundwater are discussed in **Chapter 14 Groundwater**.

Either existing groundwater bores or purpose-installed groundwater bores near groundwater dependent ecological communities would be monitored throughout construction for groundwater level and quality. The groundwater quality could be largely limited to pH and salinity, although occasional measurements of hydrocarbons in some key bores would also be appropriate.

15.4.6 Monitoring

A comprehensive adaptive monitoring program would be developed at the detailed design phase in consultation with DECCW. The monitoring program would focus on assessing rehabilitated areas and the effectiveness of measures to mitigate impacts on native fauna and their habitats.

15.4.7 Offsets

There is the potential for a number of direct and indirect impacts to occur on biodiversity values as a consequence of the Proposal. While most of these impacts have either been avoided or minimised through design decisions or could be adequately mitigated or managed, there are some impacts that could not be adequately mitigated. The following residual impacts are likely:

- Loss and degradation of native vegetation including communities that comprise endangered ecological communities as listed under the TSC Act. The Proposal would affect approximately 203.1 hectares of native vegetation of which approximately 36.3 hectares qualify as endangered ecological communities.
- Loss of habitat for a variety of native species.

The RTA would develop an offset strategy in consultation with DECCW and DII to address the residual impacts of the Proposal. The implementation of this offset strategy would contribute to the long term conservation of biodiversity. An offset is one or more appropriate actions that are put in place to counterbalance specific impacts on biodiversity. Appropriate actions are long-term management activities to improve biodiversity conservation.

The strategy would be developed to offset the residual impacts and could include a combination of measures, some of which could include:

- Management by DECCW or DII:
  - Purchase freehold property and transfer into NSW National Parks Estate.
  - Purchase freehold property and transfer into Forests NSW Estate, with a management zoning of Zone 1 (Special Protection).
  - Negotiation with Forests NSW for extension of existing portions of Zone 1.
- Management by RTA:
  - Negotiation with Forests NSW to transfer land currently identified as Zone 4 (General Management) and preserve in a ‘road reserve’ under RTA management.
- Management by non-government conservation organisations or by private landholders:
  - Secure additional native vegetation protected through an appropriate legal instrument that ensures the land is managed for conservation transfer ownership to non-government conservation organisations.
  - Negotiation of a conservation agreement under the *National Parks and Wildlife Act 1974* or *Nature Conservation Trust Act 2001* with private landowners.

It is envisaged the quantum of the offsets would be based on a set-ratio approach to offset impacts to endangered ecological communities and broad vegetation types on a like for like basis.

In addition to providing land offsets, the RTA could also consider, in consultation with DECCW, including additional revegetation in strategic locations and/or investment in management research related to the rehabilitation and protection of relevant threatened species.

The offset strategy would involve consideration of the total impact of a number of projects within a given section of the Pacific Highway and agreement on an appropriate offset area on a regional basis. It would aim to ensure greater regional biodiversity conservation outcomes by providing larger areas of land of greatest interest to the relevant land management agencies and potentially better links to existing conserved lands. It is considered that greater regional biodiversity benefits could be achieved by adopting this approach in preference to a piecemeal project by project approach.