

Roads and Traffic Authority

Pacific Highway Upgrade -
Oxley Highway to Kempsey
Flora and Fauna Working Paper

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3. Description of the existing environment

3.1 Regional context

The dominant vegetation community throughout the study area is dry sclerophyll forest consisting of various combinations of the dominant tree species blackbutt, tallowwood, stringybark, bloodwood, spotted gum or ironbark. 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. Small areas of freshwater wetlands also occur in the southern half of the study area.

Variations to this predominant natural vegetation community occur mainly in the vicinity of river and 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. 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.

Approximately 30 per cent of the study area is cleared. Cleared areas predominantly comprise paddocks as well as the existing highway and smaller roads. A further 6 to 7 per cent consists of plantations, is partially cleared or underscrubbed 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 (as described above). 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. Consequently, little intact mature forest occurs within the study area and mature, hollow bearing trees tend to be sparsely distributed along the Proposal, mainly concentrated in less disturbed parts of Cairncross, Ballengarra and Maria River State Forests.

Habitat for a diverse range of flora and fauna, including a number of threatened species and endangered ecological communities (EECs), can be found within the study area and surrounding landscape. These areas include key habitats and wildlife corridors as mapped by DECC (Scotts 2003) for an array of species, providing good connectivity across the landscape between a number of state forests and nature reserves.

State forests located in the study area are scheduled for logging and contribute to Statewide logging production targets. These forests include Cairncross, Ballengarra, Maria River and Kalateenee State Forests.

Nature reserves located in the study area include Rawdon Creek Nature Reserve and Cooperabung Creek Nature Reserve. Both of these nature reserves are 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. Although no comprehensive flora surveys have been carried out in either reserve, it is predicted that a wide range of threatened flora also occur within the reserves.

Kumbatine National Park is located on the western side of the existing highway in the northern end of the study area. Maria National Park is located outside the study area, to the east of the North Coast Railway Line. The Proposal does not affect either of the national parks.

Eight important wetlands identified in the North Coast Bioregion support a range of threatened bird, mammal, amphibian and reptile fauna. Threats to the wetlands in this bioregion are numerous and include changed drainage patterns from the construction of roads, drains and channels, particularly in expanding urban areas (Sattler and Creighton 2002).

Table 3-1 below provides a summary of the flora and fauna species listed on either Schedule 1 or 2 of the Threatened Species Conservation Act 1995 (TSC Act) in the North Coast Bioregion and Macleay Hastings Catchment Management Authority sub-region. The Macleay Hastings Catchment Management Authority sub-region forms part of the North Coast Bioregion. Therefore the species listed as part of the Macleay Hastings Catchment Management Authority sub-region are contained within the figures for the North Coast Bioregion and therefore do not represent an additional dataset.

Table 3-1 Threatened flora and fauna in bioregions

Description		North Coast Bioregion	Macleay Hastings Catchment Management Authority sub-region
Flora species (listed on schedule 1 or 2 of the TSC Act)	Total	252	35
	Endangered (including critically endangered and endangered populations)	108	21
	Vulnerable	89	14
Fauna species (listed on schedule 1 or 2 of the TSC Act)	Total	157	81
	Endangered (including critically endangered and endangered populations)	36	15
	Vulnerable	121	66
Endangered ecological communities		10 (NSW North Coast)	7 (Study area)
Important wetlands		8	2 (SEPP 14 wetlands)

3.1.1 Regional forest ecosystem mapping

Regional forest ecosystem mapping (referred to as CRAFTI) has been undertaken by the former National Parks and Wildlife Service as part of the regional forest agreement process. The CRAFTI project mapped broad floristic groups and forest structure to guide modelling of forest ecosystems, old growth forest, and flora and fauna communities. The CRAFTI mapping was used to provide background information and context with regard to the distribution and extent of vegetation communities surrounding the study area. This data for the study area is presented in **Figure 4a** and **Figure 4b**.

Figure 4a Regional forest ecosystem mapping - Sections A and B

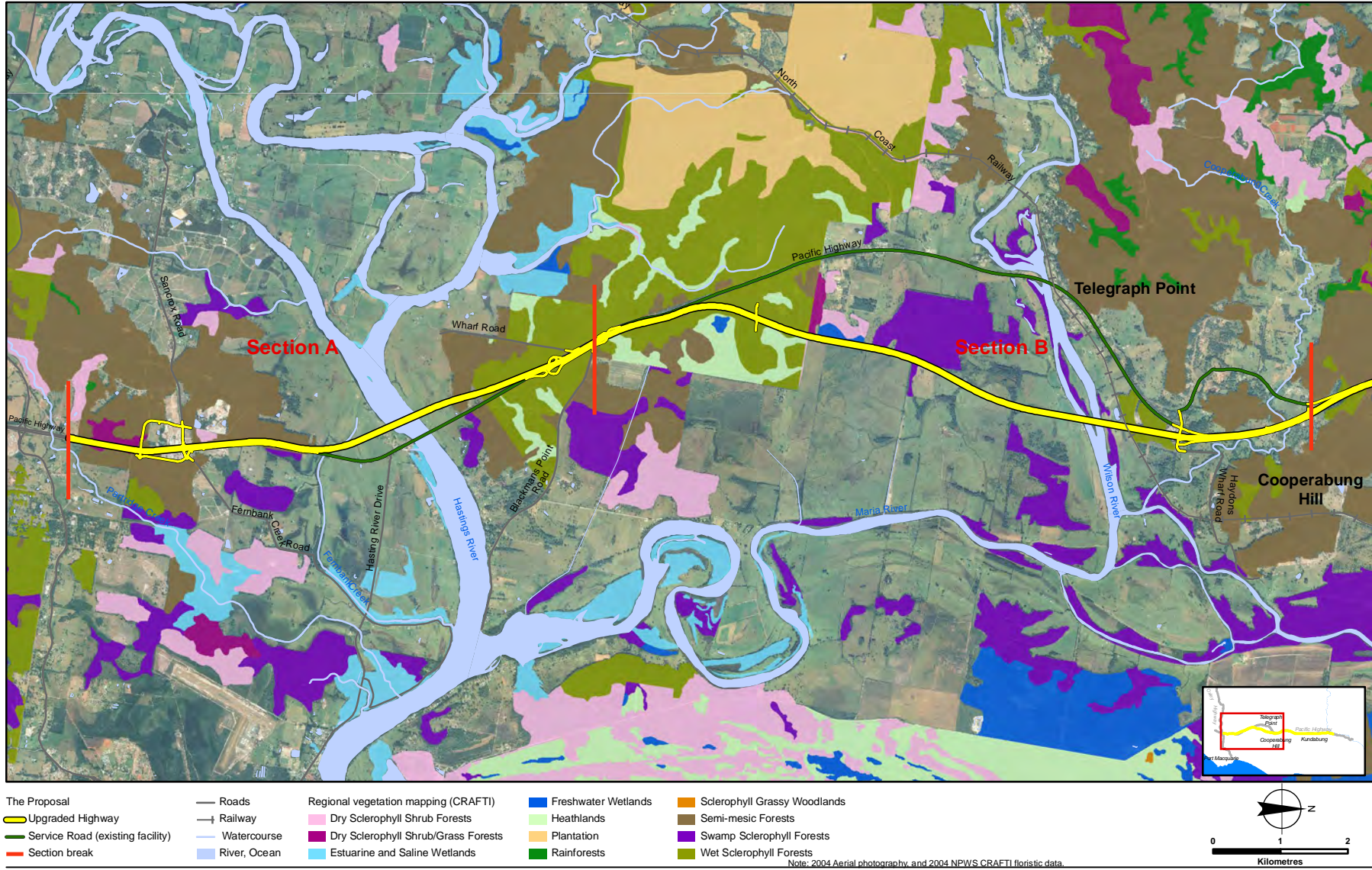
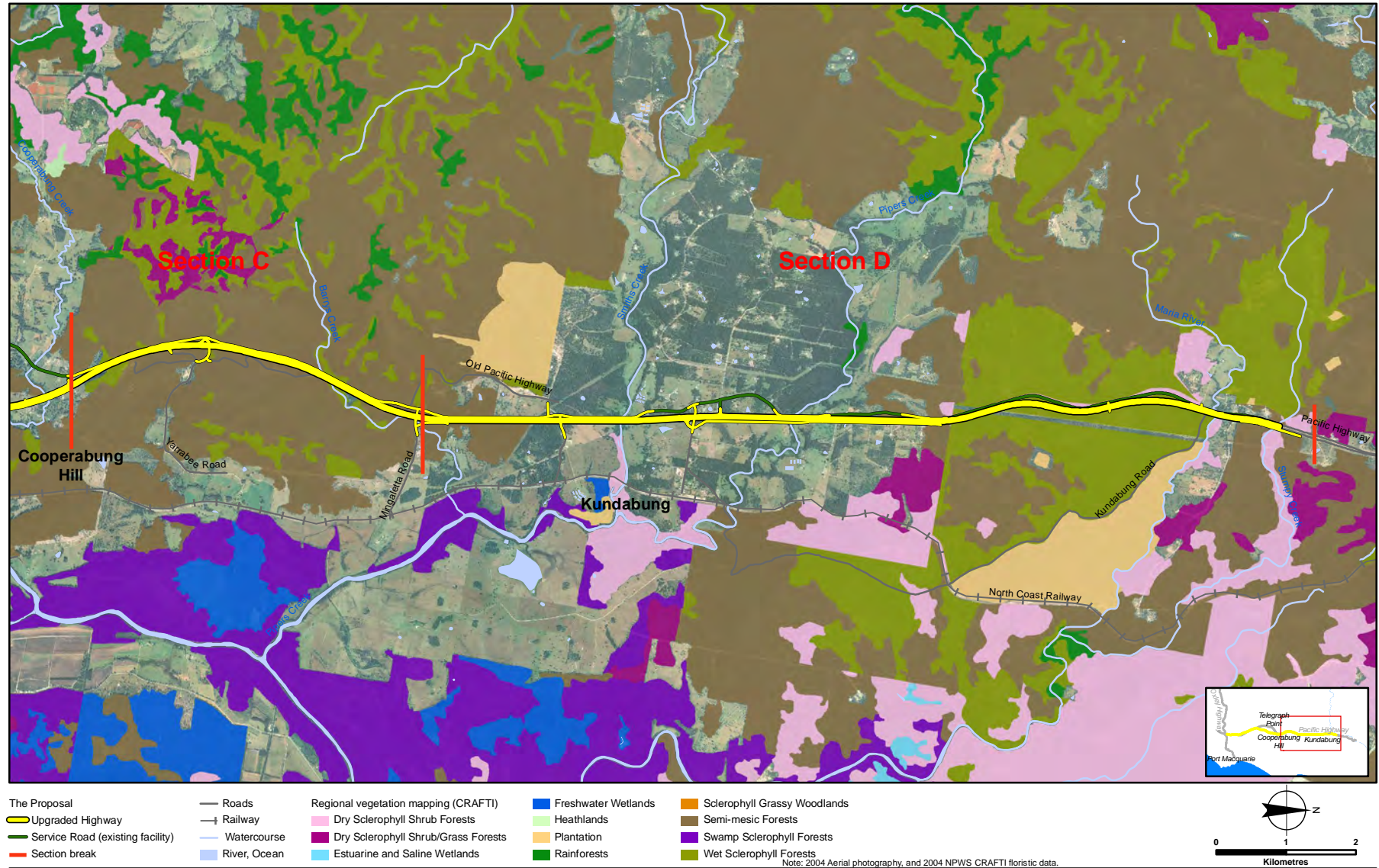


Figure 4b Regional forest ecosystem mapping - Sections C and D



3.2 Vegetation communities

Ten natural vegetation communities in an advanced state of regrowth or regeneration and three artificial or highly modified vegetation communities were recorded during field surveys within the Proposal footprint, as outlined below.

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

In addition to these communities, open water in creeklines, ponds and farm dams provides habitat for frogs and water birds, as well as a focal foraging area for insectivorous bats and birds. These features could occur in any of the identified vegetation communities, although permanent and ephemeral wet areas are generally found in communities 1, 2, 3, 4, 5 and 6.

It should be noted that access was not granted to two properties between Cairncross State Forest and the Wilson River. Even though access was not available, it was possible to view the vegetation closely enough to ascertain the vegetation community types and hence whether they constituted EECs or not with the assistance of aerial photograph interpretation. In the case of one property, the Proposal footprint appeared fully vegetated with regrowth natural vegetation at various stages of maturity. It consisted of a mixture of paperbark swamp (Community 3) in the form of regenerating dense melaleuca scrub and more mature swamp mahogany swamp forest (Community 4). In the case of the other property, this was mostly cleared open pasture (Community 13) with small remnants of swamp mahogany forest (Community 4), swamp oak forest (Community 5) and freshwater wetland (Community 6).

Table 3-2 shows the approximate area in hectares for each vegetation community within the Proposal footprint together with their approximate proportion of all vegetation as a percentage of the Proposal footprint vegetation. The existing road pavement has been excluded from these calculations. The distribution of these communities within the Proposal boundary is illustrated in **Figure 5a** to **Figure 5f**.

Table 3-2 Vegetation communities in the Proposal footprint

No	Community name	Approximate affected area	% of Proposal footprint
Natural communities			
1	Moist Floodplain Closed Forest with Rainforest Elements	3.9 ha	1.4%
2	Riparian Forest	7.8 ha	2.8%
3	Paperbark Swamp Forest	9.5 ha	3.3%
4	Swamp Mahogany / Forest Red Gum Swamp Forest	10.4 ha	3.7%
5	Swamp Oak Forest	0.9 ha	0.3%
6	Freshwater Wetland	3.8 ha	1.3%
7	Moist Floodplain Forest	27.8 ha	9.8%
8	Moist Gully Forest	25.8 ha	9.1%
9	Moist Slopes Forest	73.9 ha	26.0%
10	Dry Ridgetop Forest	39.3 ha	14.0%
Total natural communities		203.1 ha	71.7%
Artificial or highly modified communities			
11	Cleared, Open Grassland / Derived Pasture with scattered trees	18.6 ha	6.5%
12	Plantation / Cropland / Market Garden etc.	1.4 ha	0.5%
13	Totally Cleared Open Pasture / Weedy Fallow	61.3 ha	21.6%
Total highly modified communities		81.3 ha	28.6%
Total natural and highly modified communities		284.4 ha	100.0%

Figure 5a Vegetation communities and endangered ecological communities in the Proposal footprint

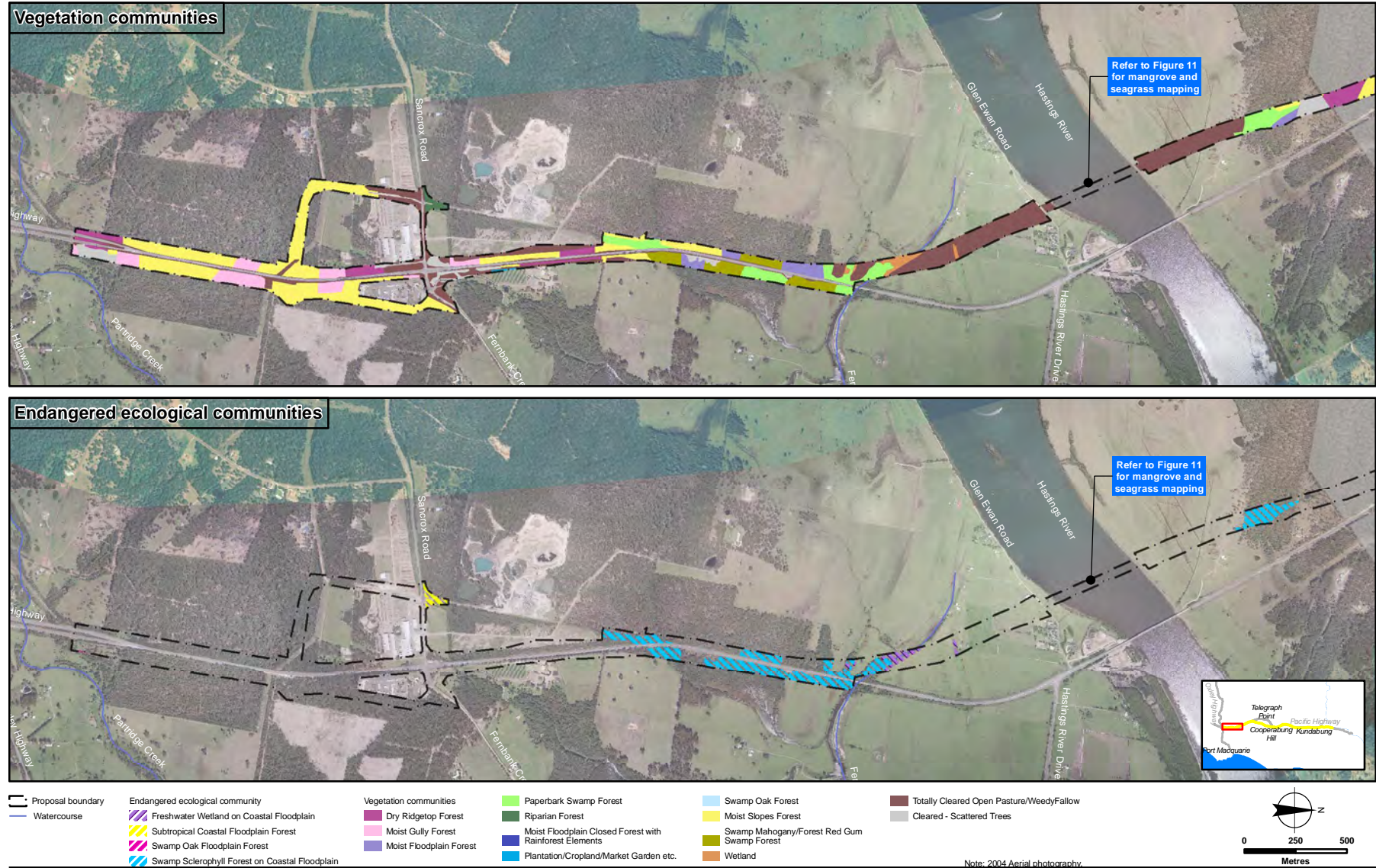


Figure 5b Vegetation communities and endangered ecological communities in the Proposal footprint

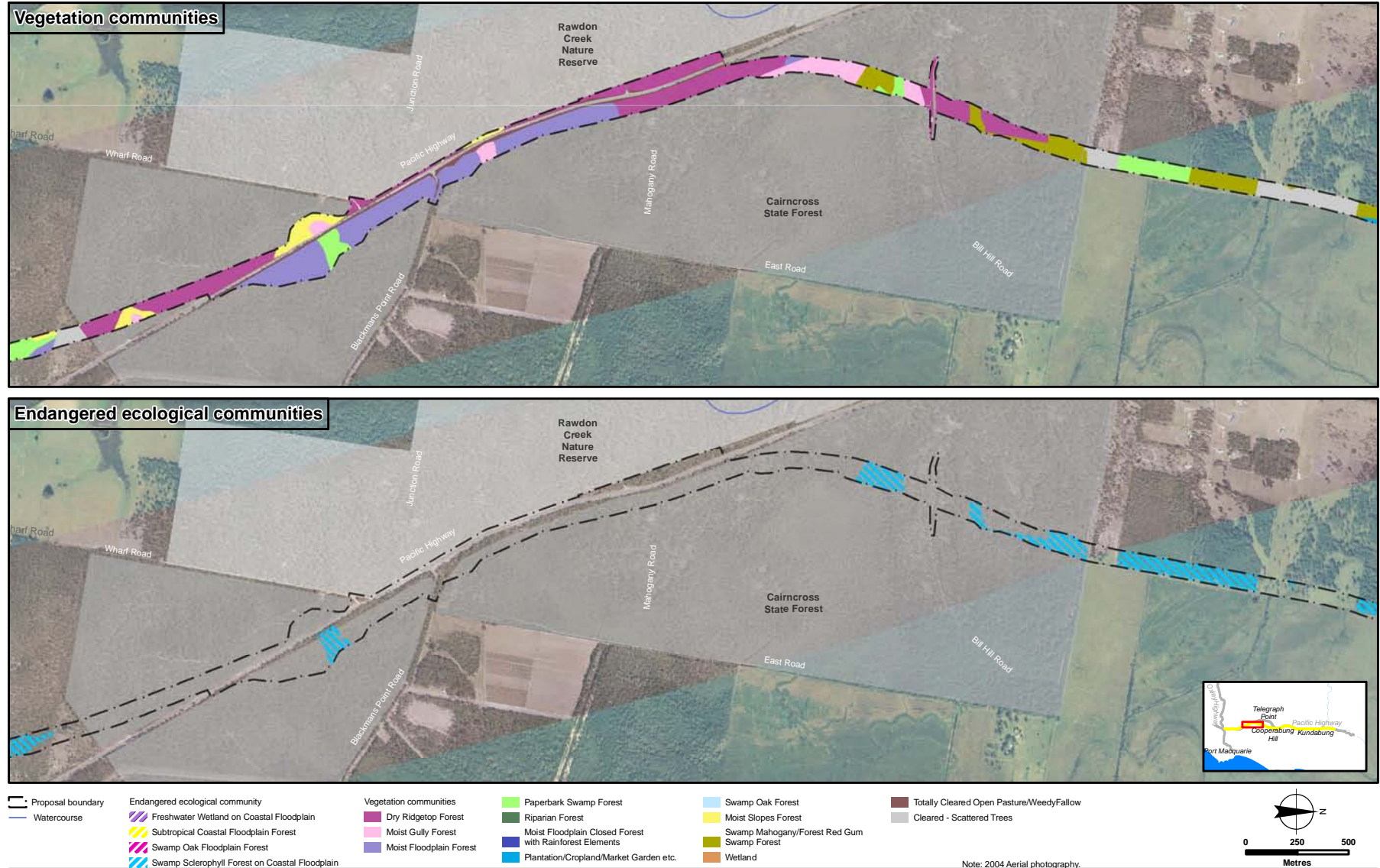


Figure 5c Vegetation communities and endangered ecological communities in the Proposal footprint

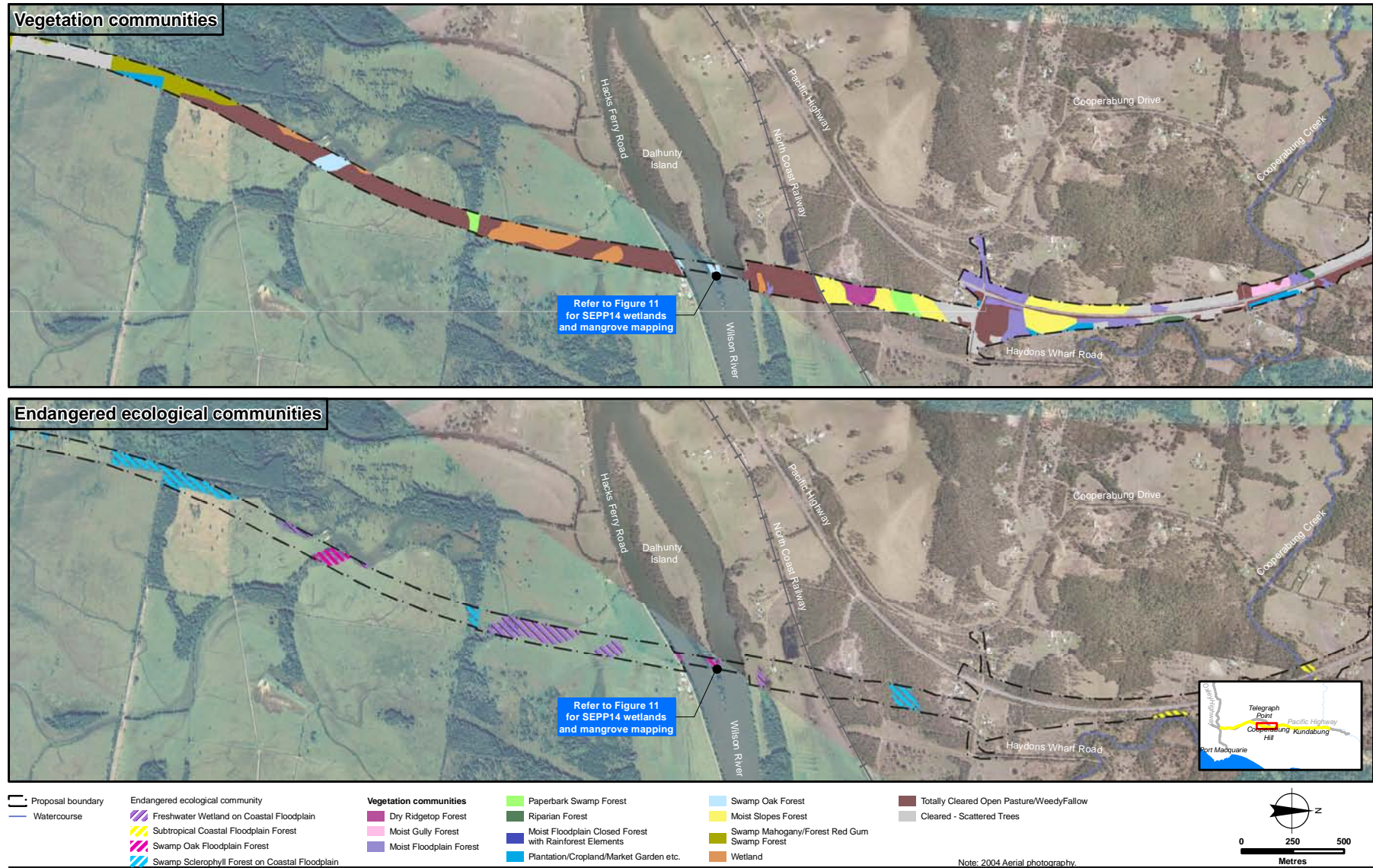


Figure 5d Vegetation communities and endangered ecological communities in the Proposal footprint

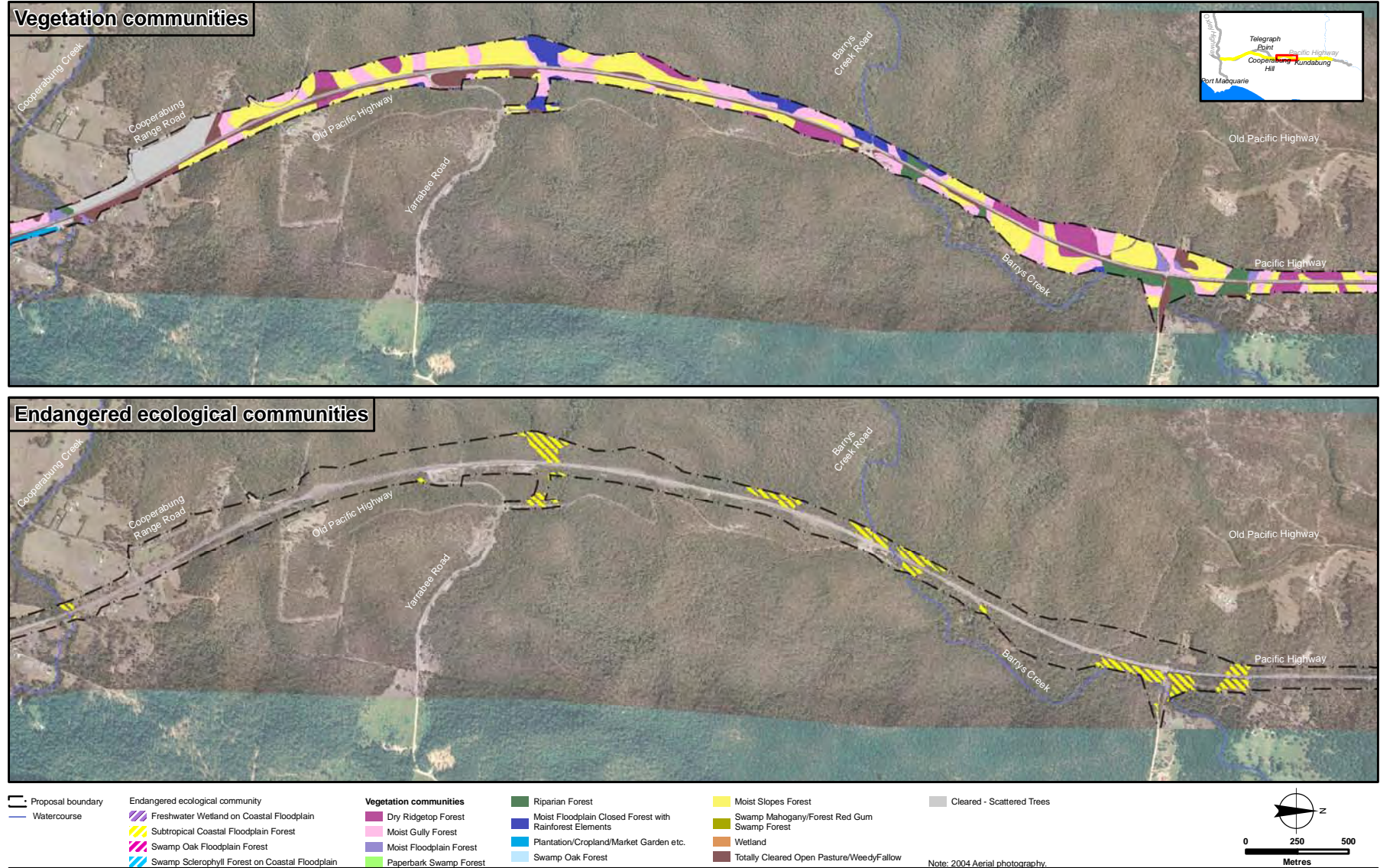


Figure 5e Vegetation communities and endangered ecological communities in the Proposal footprint

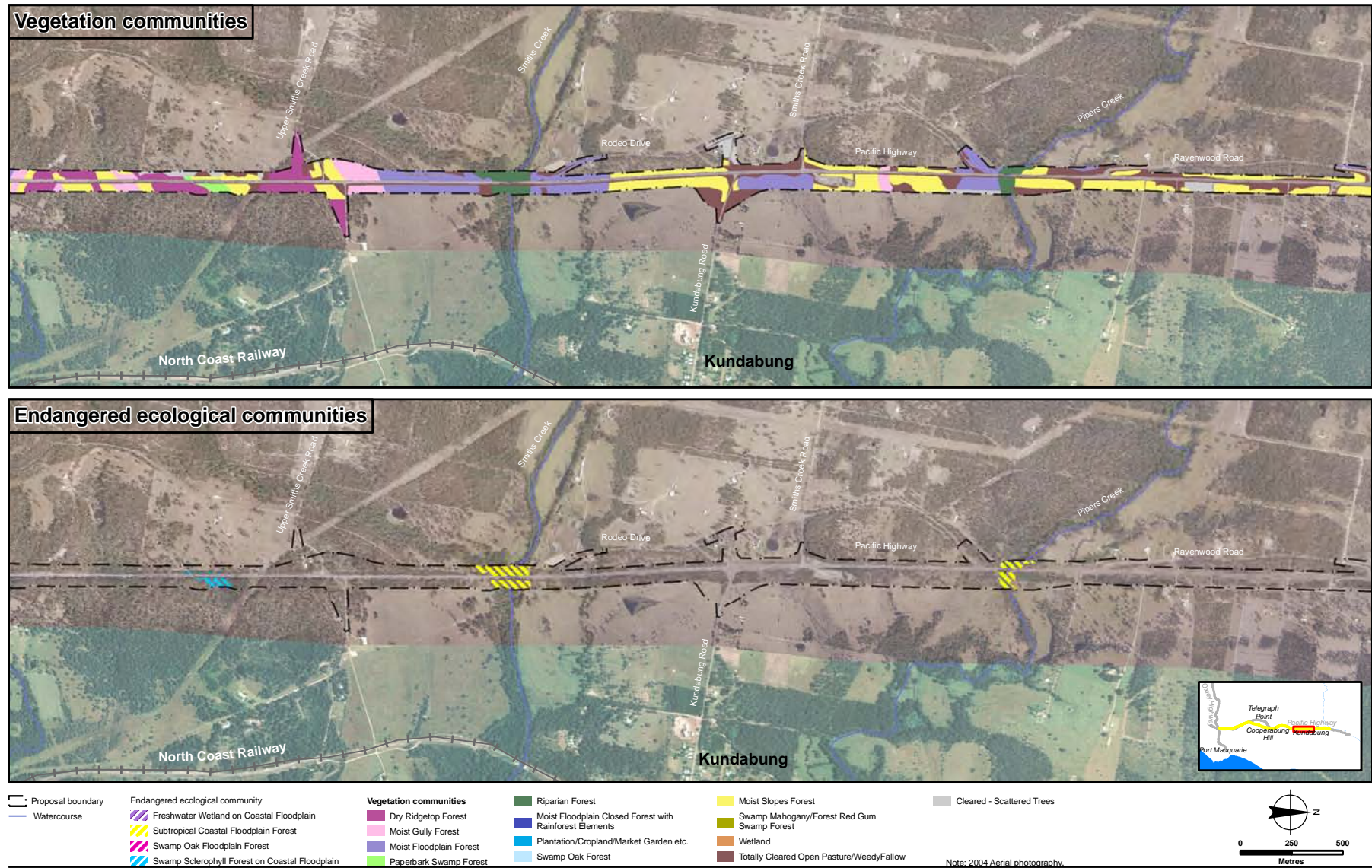
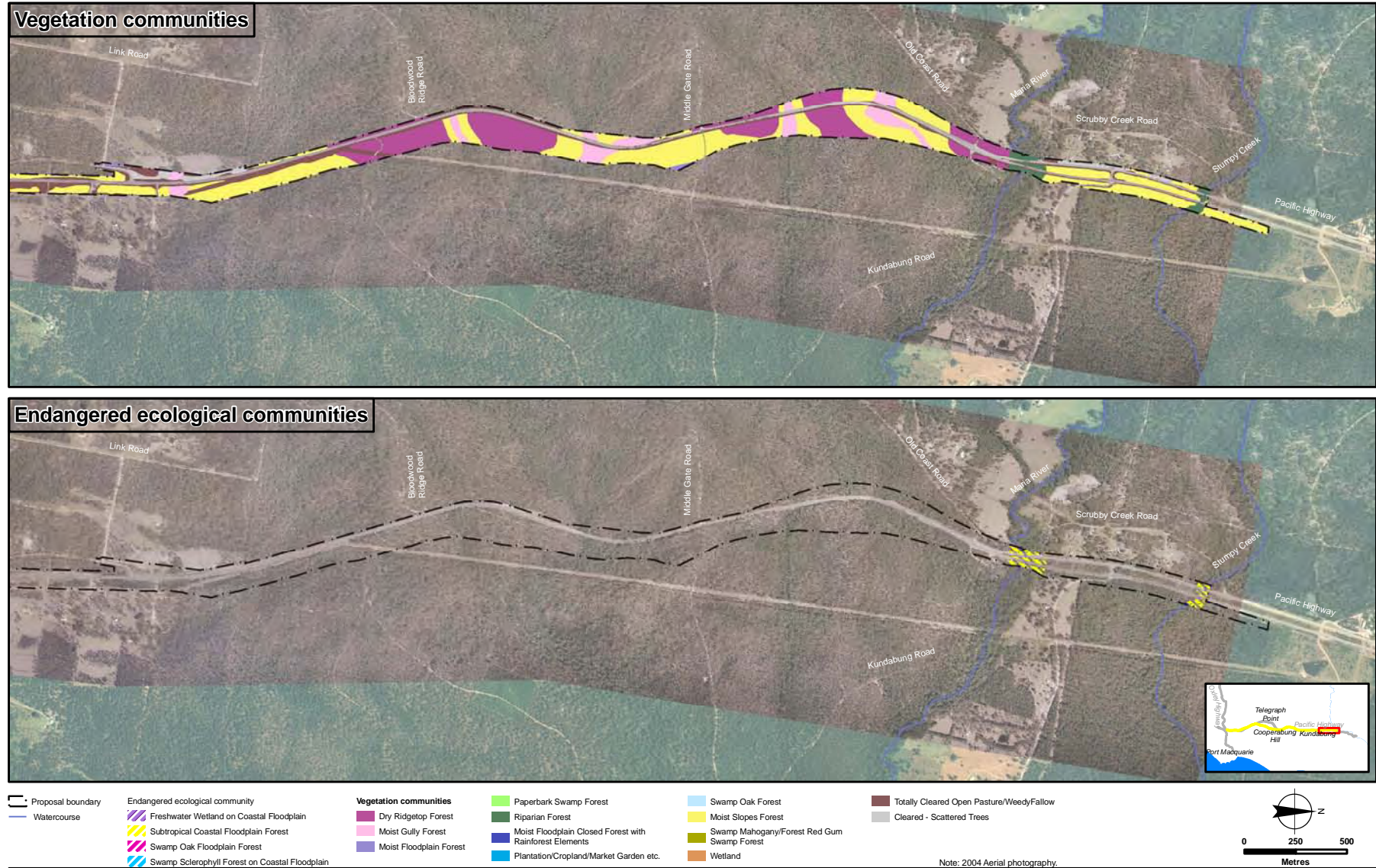


Figure 5f Vegetation communities and endangered ecological communities in the Proposal footprint



A description of the structure and floristics of the vegetation communities is described below, with full details provided in **Appendix H**.

Community 1 – Moist Floodplain Closed Forest with Rainforest Elements

This association is restricted to the floodplain of Barrys Creek and its major tributaries near the Yarrabee Road/Pacific Highway junction, within Ballengarra State Forest. These creek systems flow to Pipers Creek further to the east. The dominant tree cover in this closed forest consists of turpentine, brushbox, small-fruited grey gum, flooded gum, red mahogany and blackbutt to 30 metres. There is usually a dense sub-canopy of figs, cheese tree, lily-pilly, paperbarks and backhousia. Vines and epiphytes are common and the ground layer is sparse with ferns, lomandra, gahnia and cordylines most prominent.

Disturbance regimes in this community include past logging and weed invasion (predominantly lantana). This community is well connected to other areas of habitat as it lies entirely within Ballengarra State Forest.

Community 2 – Riparian Forest

This association is limited to remnant patches associated with creeks and watercourses in the study area, including Cooperabung Creek, Barrys Creek, Smiths Creek, Pipers Creek and Maria River. This forest consists of eucalypts to 25 metres and is dominated by flooded gums, forest red gums, tallowwood, small-fruited grey gums, pink bloodwood and brushbox. The native sub-canopy and shrub layer consists of rainforest or swamp elements, though in many places is dominated by weeds. The ground cover is generally sparse, though in some areas has a reasonable cover of *Lomandra longifolia*, ferns, sedges and grasses. The main disturbance regimes within this community are past clearing, weed invasion and human access (along informal and official maintenance tracks).

Community 3 – Paperbark Swamp Forest

This association is predominantly found south of the Wilson River, with small patches occurring in the vicinity of Fernbank Creek, immediately north of the Hastings River, Cairncross State Forest and in the floodplains immediately south of the Wilson River. Only two patches occur north of the Wilson River, one just north of Wilmaria Road and the other between Mingaletta Road and Wharf Road. Within the study area, this community was not recorded north of Kundabung.

This community consists of forest or open forest to a height of 22 metres, dominated by the broad-leaved paperbark and occasional forest red gum, swamp mahogany, red mahogany, blackbutt or turpentine, with paperbark species dominating the sub canopy layer. The shrub layer in some areas is highly invaded by lantana. There is usually a dense ground cover dominated by *Gahnia* spp., blady grass and *Lomandra* spp. Some areas of this community have permanent surface water, either in a creek or drainage line, standing pools or permanent swampy patches. All of the areas where this community occurs would have pools of water and wet areas after rain. Those patches of this community between the Hastings River and Wilson River (including one patch near Wilmaria Road just north of the Wilson River), tend to be in better quality, with a more intact native canopy, shrub and ground layer, moderate to good numbers of large mature trees, and lower levels of disturbance.

Community 4 – Swamp Mahogany/Forest Red Gum Swamp Forest

Within the study area, this community was only recorded south of the Wilson River. It occurs on the Wilson River floodplain, in Cairncross State Forest and in the Fernbank Creek area. This community is associated with drainage depressions on poorly drained soils and is dominated by tall paperbarks, swamp mahogany and red mahogany up to 30 metres in height and usually has a dense gahnia, sedge, grasses and fern understorey. In more disturbed areas the understorey is sometimes overrun with lantana, crofton weed or blackberry. Some areas of this community have permanent surface water, either in a creek or drainage line, standing pools or permanent swampy patches. All of the areas where this community occurs would have pools of water and wet areas after rain.

As with Paperbark Swamp Forest (Community 3), the better quality areas of this community lie between the Hastings River and Wilson River in Cairncross State Forest and on the Wilson River floodplain.

Community 5 – Swamp Oak Forest

This community is found in low-lying permanently wet depressions with poor drainage on floodplains, with some saline influence. Only very small patches of this community occur within the study area. A few very small stands lie on Dalhunny Island and the banks of the Wilson River, one patch lies along a drainage line on the floodplain south of the Wilson River and there is a small stand at the very southern end of the study area. All of these patches are associated with some form of drainage line or watercourse. This community is dominated by swamp oak up to 20 metres in height, with some paperbarks also occurring. The shrub layer is generally sparse, though some patches are heavily infested with lantana which forms a dense understorey. The ground layer consists of moderate to dense gahnia, sedges, grasses and ferns.

Community 6 – Freshwater Wetland

This community is found in depressions on the Wilson River and Hastings River floodplains. Within the study area it is restricted to small to medium patches in the floodplain to the south and north of the Wilson River and some small patches along Fernbank Creek. It consists of shallow fresh water containing or surrounded by macrophytes, sedges, rushes and other aquatic plants, generally less than 1.5 metres in height. This community is often fringed by paperbarks and swamp oaks.

Community 7 – Moist Floodplain Forest

This community occurs on low-lying flat floodplain areas which are usually dry but subject to occasional flooding. Along with Paperbark Swamp Forest and Swamp Mahogany/Forest Red Gum Swamp Forest (Communities 3 and 4), it would have formerly covered most of the Hastings River floodplain. This community consists of forest or open forest dominated by eucalypts to a height of 35 metres. Dominant tree species are the blackbutt, tallowwood, white mahogany, grey ironbark, white stringybark, red mahogany, red and pink bloodwood and turpentine. Paperbarks and she-oaks are common in the sub-canopy and the understorey consists of moist forest and rainforest elements.

Community 8 – Moist Gully Forest

This community occurs in moist, sheltered gullies in undulating terrain, typically at the base of steeper slopes and is generally associated with ephemeral drainage lines or minor creeklines. This forest or open forest association is dominated by eucalypts to a height of 35 metres with paperbarks and rainforest elements in the sub-canopy. Dominant tree species are the blackbutt, tallowwood, small-fruited grey gum, forest red gum, brush box and turpentine. The shrub and ground cover is usually moderate to dense, dominated by blady grass, ferns and lomandra.

Community 9 – Moist Slopes Forest

This community is the most abundant natural community in terms of area and is widespread throughout most of the study area. It occurs on slopes or low ridges with a moist/sheltered aspect and good drainage in undulating terrain. This community is characterised by forest or open forest to a height of 35 metres with a sparse, grassy understorey. Dominant tree species are the 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. She-oaks, paperbarks, acacia and tea-tree are common in the shrub layer.

Community 10 – Dry Ridgetop Forest

This association is moderately common throughout the study area and occupies higher, drier and more exposed ridgetops and upper slopes in undulating terrain, or more elevated and exposed areas above the floodplain in flatter terrain. This dry open forest reaches a height of 30 metres and the tree layer is dominated either by blackbutt, tallowwood, white stringybark, red bloodwood or by spotted gum, ironbark, small-fruited grey gum, white mahogany, white stringybark and turpentine. This community generally has a sparse shrub layer and grassy understorey. This community is mostly found in the larger bushland areas within the study area, including Cairncross State Forest, Rawdon Creek Nature Reserve, Ballengarra State Forest and Maria River State Forest.

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

These associations occur along the length of the study area and include the cleared floodplains of the Hastings and Wilson rivers and generally represent gaps in the tree cover rather than vegetated linkages between any areas of habitat. These associations are generally cleared and consist of grazing lands dominated by introduced pasture grasses. There are some small patches scattered trees. The existing road pavement is not included within these vegetation communities.

3.3 Overall condition of vegetation within the study area

The general condition of vegetation within the study area varies widely. Vegetation ranges from cleared grazing land with a mix of exotic and native pasture grasses to natural, undisturbed bushland. Because of the extent of past clearing and ongoing disturbance within the study area, the vegetation is either much simplified or characterised by various degrees of modification compared to its original condition. Very few patches of vegetation within the study area are completely undisturbed. This includes the vegetation within Rawdon Creek Nature Reserve, which was logged prior to the establishment of the nature reserve.

Some patches of vegetation have been underscrubbed and cleared for grazing. The bulk of uncleared vegetation in the study area consists of regrowth following past logging or farming/grazing activities.

3.4 Terrestrial noxious and environmental weeds

A total of 97 exotic flora species were recorded within the study area during the 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 local government areas. These, together with their relevant control classes for the local government areas, are:

- Crofton weed (*Ageratina adenophora*) – Class 4.
- Annual ragweed (*Ambrosia artemisiifolia*) – Class 5.
- Prickly pear (*Opuntia stricta*) – Class 4.
- Resurrection plant (*Bryophyllum pinnatum*) – Class 3.
- Creeping oxalis (*Oxalis corniculata*) – Class 5.
- Blackberry (*Rubus fruticosus* sp. aggr.) – Class 4.
- Lantana (*Lantana camara*) – Classes 4 & 5.

An explanation of the relevant control categories follows:

- Class 3 – “The plant must be fully and continuously suppressed and destroyed and the plant may not be sold, propagated or knowingly distributed.”
- Class 4 – “The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority.”
- Class 5 – “The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with.”

Most of the noxious species listed above were limited to a few locations only, and occurred at low abundance. 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 is now a listed key threatening process under the TSC Act. Control and management of lantana, particularly prevention of its spread, is likely to be a key issue during construction and operation of the Proposal. Annual ragweed was moderately widespread, but was almost invariably restricted to highly disturbed roadside verges.

3.5 Flora diversity

Because of the extent of past clearing and ongoing disturbance within the study area, the vegetation is either much simplified or characterised by various degrees of modification compared to its original condition. Some patches of vegetation are relatively undisturbed, but are a minority. The largest and least disturbed patches of vegetation occur within Cairncross State Forest.

Within the study area, a total of 425 flora species were recorded during all surveys conducted between November 2005 and February 2007. This total includes weeds and planted or cultivated species. The proportion of introduced species overall was approximately 23 per cent, indicating a moderate level of exotic species presence. The full list of species recorded is given in **Appendix F**.

For the flora survey, the study area was divided into eight sections from south to north of roughly equal length and similar topography to highlight local differences in flora species distributions. The boundaries of the sections are as follows:

1. Oxley Highway junction to Sancrox Road.
2. Sancrox Road to Cairncross State Forest southern boundary.
3. Cairncross State Forest southern boundary to Cairncross State Forest northern boundary.
4. Cairncross State Forest northern boundary to North Coast Railway, Telegraph Point.
5. North Coast Railway, Telegraph Point to Cooperabung Creek Nature Reserve boundary.
6. Cooperabung Creek Nature Reserve boundary to Mingaletta Road.
7. Mingaletta Road to Maria River State Forest southern boundary.
8. Maria River State Forest southern boundary to Stumpy Creek.

The breakdown of flora species recorded and species categories in each section is given in **Table 3-3**. Note that the total column is not simply the sum of the figures in the columns for individual sections, since many species were recorded in several or all sections.

Table 3-3 Flora species recorded in different plant categories for each section of the study area

Category	Number recorded in each section								Total
	1	2	3	4	5	6	7	8	
Total	142	200	97	86	114	155	181	204	425
Ferns	6	8	2	7	9	9	7	11	18
Conifers	0	0	0	0	0	1	1	2	2
Dicotyledons	99	139	68	58	78	110	135	147	297
Monocotyledons	37	53	27	21	27	35	38	44	108
Exotic	32	46	6	19	23	31	31	41	97
% Exotic	23%	23%	6%	22%	20%	20%	17%	20%	22.9%

Species richness varied considerably between different sections. Section 8 contained the highest species richness with 204 flora species recorded, followed closely by Section 2 (200 species) and then Section 7 (181 species). The sections with lowest species richness were Sections 4 (86 species) and 3 (97 species). The differences reflect the extent of clearing and vegetation modification within the section, the diversity of habitats and in many cases, the presence of roadside weeds.

Note that species richness alone is not a reliable measure of the 'quality' of the flora within any particular section, because high species richness may in part be due to a high presence of weed species, particularly roadside weeds. Therefore, although Section 3 contained the second lowest species richness, the percentage of exotic species was considerably lower than for any of the other sections. The presence of weeds was low in this section because it coincides with a deviation of the Proposal through Cairncross State Forest, where although subject to periodic logging, there is no influence of edge effects from the existing highway or from farming activities.

3.6 Threatened terrestrial flora

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

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 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 3-4**.

Table 3-4 Threatened plant species with the potential to occur in the study area

Species	Location	TSC Act status	EPBC Act status
Scented acronychia (<i>Acronychia littoralis</i>)	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 (<i>Arthraxon hispidus</i>)	Recorded within 2 km of the existing highway at Kundabung	Vulnerable	Vulnerable
Maundia (<i>Maundia triglochinosides</i>)	Recorded approximately 1 km south of the Oxley Highway	Vulnerable	None
Biconvex paperbark (<i>Melaleuca biconvexa</i>)	Recorded just south of the Oxley Highway / Pacific Highway interchange	Vulnerable	Vulnerable
Milky silkpod (<i>Parsonsia dorrigoensis</i>)	1 record on the coast near Port Macquarie	Vulnerable	Endangered
Swamp orchid (<i>Phaius tancaurvilleae</i>)	Not previously recorded in the study locality but is known to occur in northern NSW	Endangered	Endangered
Southern swamp orchid (<i>Phaius australis</i>)	Not previously recorded in the study locality but is known to occur in the vicinity of, and north of, Port Macquarie (HWR Ecological 2005a)	Endangered	Endangered

As indicated in **Table 3-4**, there are two unconfirmed records of scented acronychia. The records are from swamp vegetation surveyed during the floodplain investigations by HWR Ecological (2005a). The unconfirmed records are in two places, one 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. The approximate locations of these records are shown in **Figure 6**, however they are not precise and could be in error by up to 30 metres.

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 (2005a). Preferred habitat for scented acronychia is documented as being littoral rainforest on sand (DECC 2008), yet HWR (2005a) reports scented acronychia as occurring within swamp sclerophyll forest. There is no indication in the HWR (2005a) report that voucher specimens were forwarded to the National Herbarium for verification. Hence, the records in HWR Ecological (2005a) 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. However, as a precautionary measure an assessment of the possible impact of the Proposal on the species is provided in **Appendix I** and **Appendix J**.

3.6.1 Locally significant flora

One locally significant flora species, the fern austral moonwort or parsley fern (*Botrychium australe*), was recorded in the study area in Maria River State Forest, near the northern end of the study area, in only one location. This species is considered to be locally significant because, although it occurs throughout all of NSW, it is not often recorded and when it does occur, it is usually recorded in low abundance. However, populations are considered to be secure and not under threat according to any of the relevant legislation. No further action is considered to be necessary in relation to this species.

3.7 Endangered ecological communities

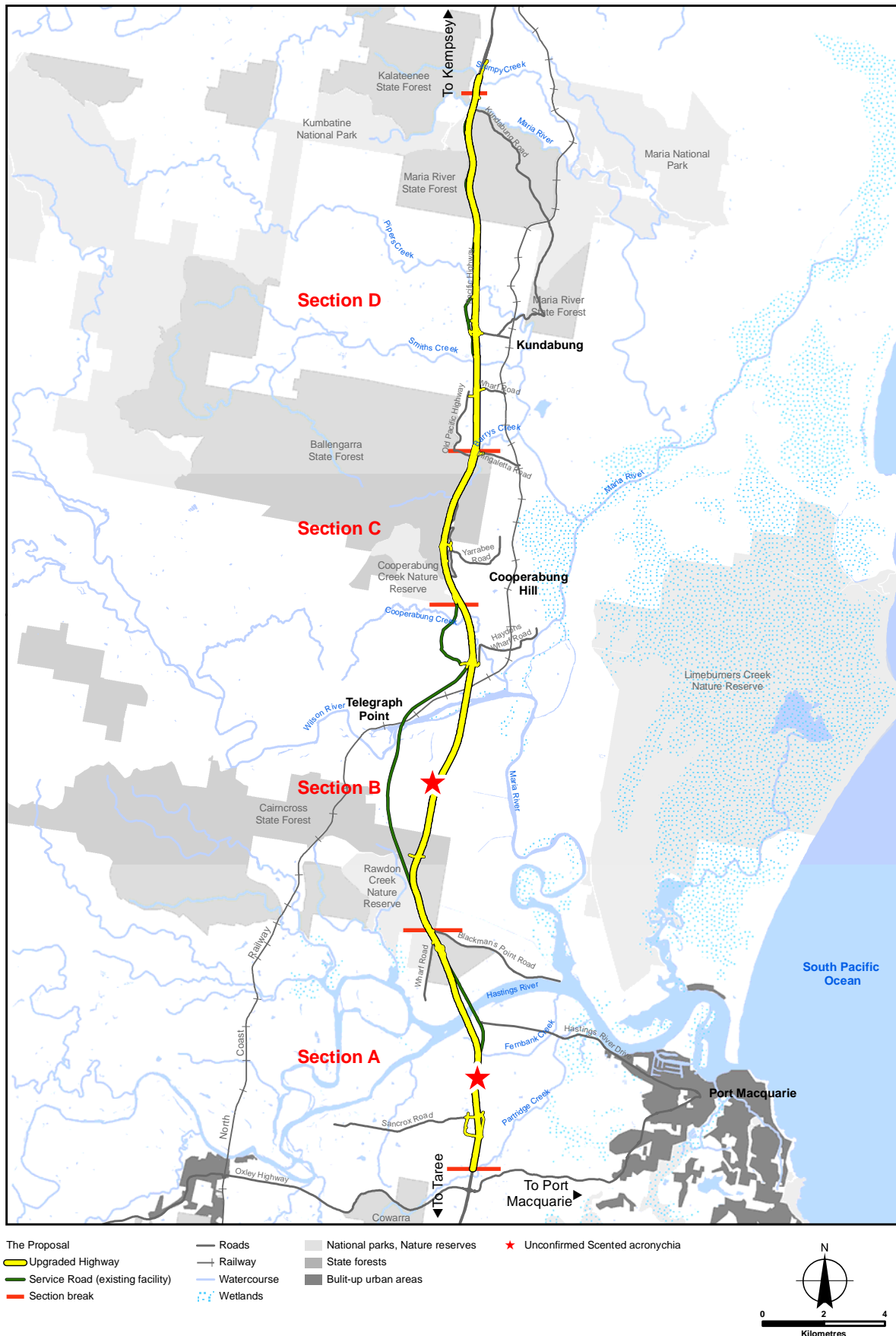
Four endangered ecological communities (EEC) listed under the TSC Act are present in the study area. These are shown in **Figure 5a** to **Figure 5f** and are described below. Areas of EECs in the study area were outlined in **Table 3-2** in **Section 3.2**.

Swamp Oak Floodplain Forest of the NSW North Coast Sydney Basin and South East Corner Bioregions

This EEC occurs in low-lying permanently wet depressions with poor drainage on floodplains, with some saline influence. It is a forest or open forest dominated by swamp oaks, occasional paperbarks and usually with a rush or sedge understorey. Eucalypts are usually absent or uncommon. Within the study area, this EEC is restricted to one small patch in the terrestrial part of the Proposal area, on the floodplain south of the Wilson River. This patch is generally in good condition and free of weeds, although minor herbaceous weeds and exotic pasture grasses have invaded the understorey.

This EEC aligns with the mapped Paperbark Swamp Forest (vegetation community 3) and Swamp Mahogany/Forest Red Gum Swamp Forest (vegetation community 4) vegetation communities.

Figure 6 Unconfirmed Scented acronychia locations



Subtropical Coastal Floodplain Forest of the NSW North Coast Bioregion

This EEC occurs along narrow floodplains and lower slopes in gullies by creeks with permanent water, including creek beds; or sheltered moist gullies connecting to creeklines. It is characterised by a closed forest with emergent eucalypts, with a lower tree layer and understorey of a mix of rainforest species, paperbarks, vines and epiphytes with a sparse ground layer. Ferns are usually abundant. Within the study area this EEC is confined to the floodplain of Barrys Creek and its major tributaries. All patches of the community occur within Ballengarra State Forest. The community is generally in good condition and free of weeds, apart from some infestations of lantana in patches and minor weeds at the boundaries of disturbed areas.

This EEC aligns with the mapped Swamp Oak Forest vegetation community (vegetation community 5).

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

This EEC occurs in low-lying permanently wet flats or depressions with poor drainage on floodplains. It has a forest or open forest dominated by swamp mahogany and/or forest red gum/cabbage gum with larger paperbarks in the canopy with usually a sedge understorey with ferns and/or grasses. Eucalypts are only common in slightly more elevated drier areas. Within the study area this EEC is restricted to south of the Wilson River. It occupies small to moderate patches associated with creeks and watercourses in the Fernbank Creek area, Cairncross State Forest and in the floodplain to the north. Most patches of the community are generally in good condition and free of weeds. In disturbed areas (regularly grazed or subject to runoff from the existing highway), significant infestations of noxious lantana, crofton weed or blackberry occur.

This EEC aligns with the mapped Moist Floodplain Closed Forest with Rainforest Elements (vegetation community 1) and Riparian Forest (vegetation community 2) vegetation communities

Freshwater Wetlands on Coastal Floodplains of the NSW North Coast Sydney Basin and South East Corner Bioregions

This EEC occurs in low lying areas on floodplains associated with or near watercourses. This community has shallow fresh water containing or surrounded by macrophytes, sedges, rushes and other aquatic plants, generally less than 1.5 metres in height, and is often fringed by paperbarks and swamp oaks. Within the study area, small patches occur along Fernbank Creek, and a series of small to larger patches occur in the floodplain both to the south and north of the Wilson River. The small patch to the north of the Wilson River is part of a wetland listed under *State Environmental Planning Policy No. 14 – Coastal Wetlands*. Most occurrences of this community are in good condition and relatively weed-free, but often subject to grazing and therefore trampling by stock. Native species are often consequently replaced by weeds and exotic pasture grasses.

This EEC aligns with the mapped Freshwater Wetland vegetation community (vegetation community 6).

3.8 Terrestrial fauna habitats

3.8.1 Habitat attributes

A variety of habitat types with high structural and floristic diversity (for example, various forest/woodland communities, gully forest with rainforest elements, swamp forest and riparian habitats) throughout the study area provide diverse resources for a large variety of native flora and fauna, including threatened species.

Key habitat elements identified within the study area include:

- An array of flowering tree and shrub species within the forest, woodland and heathland communities, providing a year-round supply of foraging resources for nectarivorous and insectivorous bird, bat and arboreal mammal species.
- Decorticating bark on paperbark trees, providing potential shelter sites for reptiles and microchiropteran bats.
- Paperbarks (*Melaleuca* sp.) and swamp mahogany within the Paperbark Swamp Forest and Swamp Mahogany / Forest Red Gum Swamp Forest stands, providing important autumn / winter foraging resources for nectar-eating birds, bats and arboreal mammals in the study area, including the threatened grey-headed flying fox.
- Hollow-bearing trees of importance to hollow-dependent fauna species, including eight threatened species recorded in the study area (ie east-coast freetail-bat, eastern false pipistrelle [possible identification only], southern myotis, greater broad-nosed bat [probable identification only], glossy black-cockatoo, masked owl, sooty owl and yellow-bellied glider).
- Known habitat for koala, including feeding resources.
- Known foraging habitat for glossy black-cockatoo. Two species of preferred feed trees for this species, black she-oak (*Allocasuarina littoralis*) and forest oak (*Allocasuarina torulosa*), occur in the study area and are common within the dry ridgetop forest community.
- Grass and sedge species, and dense groundcover within the Swamp Oak Forest and Paperbark Swamp Forest and Swamp Mahogany / Forest Red Gum Swamp Forest communities provide suitable foraging resources for granivorous and herbivorous fauna and a range of reptiles and frogs.
- Areas of dense groundcover vegetation and soft substrate, providing suitable shelter and foraging habitat for a variety of small terrestrial mammals, including bandicoots and native mice and rats. The threatened eastern chestnut mouse and long-nosed potoroo are two threatened terrestrial mammals considered likely to occur in the study area on the basis of the suitability of such habitat.
- Existing bridges and culverts provide roost sites for microchiropteran bats.
- Artificial and natural waterbodies provide foraging and breeding habitat for frogs and waterbirds as well as foraging habitat for the southern myotis.

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

Koala feed tree species listed on Schedule 2 of *State Environmental Planning Policy 44 – Koala Habitat Protection* that occur within the study area are listed in **Table 3-5**. In addition to these, three primary koala browse tree species for the Port Macquarie-Hastings local government area (Connell Wagner 2000) were recorded within the study area: small-fruited grey gum (*Eucalyptus propinqua*), broad-leaved paperbark (*Melaleuca quinquenervia*) and blackbutt (*Eucalyptus pilularis*). One or more of these species occur in all of the mapped natural vegetation communities and also exist as scattered trees.

Table 3-5 Koala feed trees found in the study area

Scientific name	Common name	Vegetation communities
<i>Eucalyptus tereticornis</i>	Forest Red Gum	2, 3, 4, 7, 8 and 9
<i>Eucalyptus microcorys</i>	Tallowwood	2, 3, 7, 8, 9 and 10
<i>Eucalyptus punctata</i>	Grey Gum	1, 2, 3, 8, 9 and 10
<i>Eucalyptus signata</i>	Scribbly Gum	9 and 10
<i>Eucalyptus robusta</i>	Swamp Mahogany	3 and 4

Individual koalas could occur along much of the entire route. Koala feed trees are present in most vegetation communities within the study area, and are common to dominant (constituting more than 15 per cent as defined in *State Environmental Planning Policy No. 44 – Koala Habitat Protection*) within moist floodplain forest, moist slopes forest, riparian forest and swamp mahogany/ forest red gum swamp forest. Ballengarra State Forest in particular is considered good potential koala habitat, with a high concentration of grey gum, and numerous trees with koala scratches. Additionally, koala feed trees were present in all other vegetation communities apart from swamp oak forest and totally cleared open pasture/ weedy fallow.

The results of the database searches indicate numerous recent koala records within the study area (DECC 2007). A koala was sighted crossing the Pacific Highway approximately 200 metres south of Sancrox Road (GHD 2007b). 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 veterinarian and koala expert, Vanessa Standing, this species could occur anywhere along the Proposal, particularly where habitat occurs on both sides of the road.

Figure 7 shows the location of recorded koala road kill along the length of the Proposal, based on records from local veterinarian and koala expert, Vanessa Standing, and the Port Macquarie Koala Hospital. Based on these records and the DECC (2007) database search results, the most likely areas that koalas would occur within the study area 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.

Given the results of the field surveys and number of records, these areas are likely to represent core koala habitat defined under *State Environmental Planning Policy No. 44 – Koala Habitat Protection* as an area of land with a resident population of koalas, evidenced by attributes such as recent sightings, breeding individuals and historical records of a population.

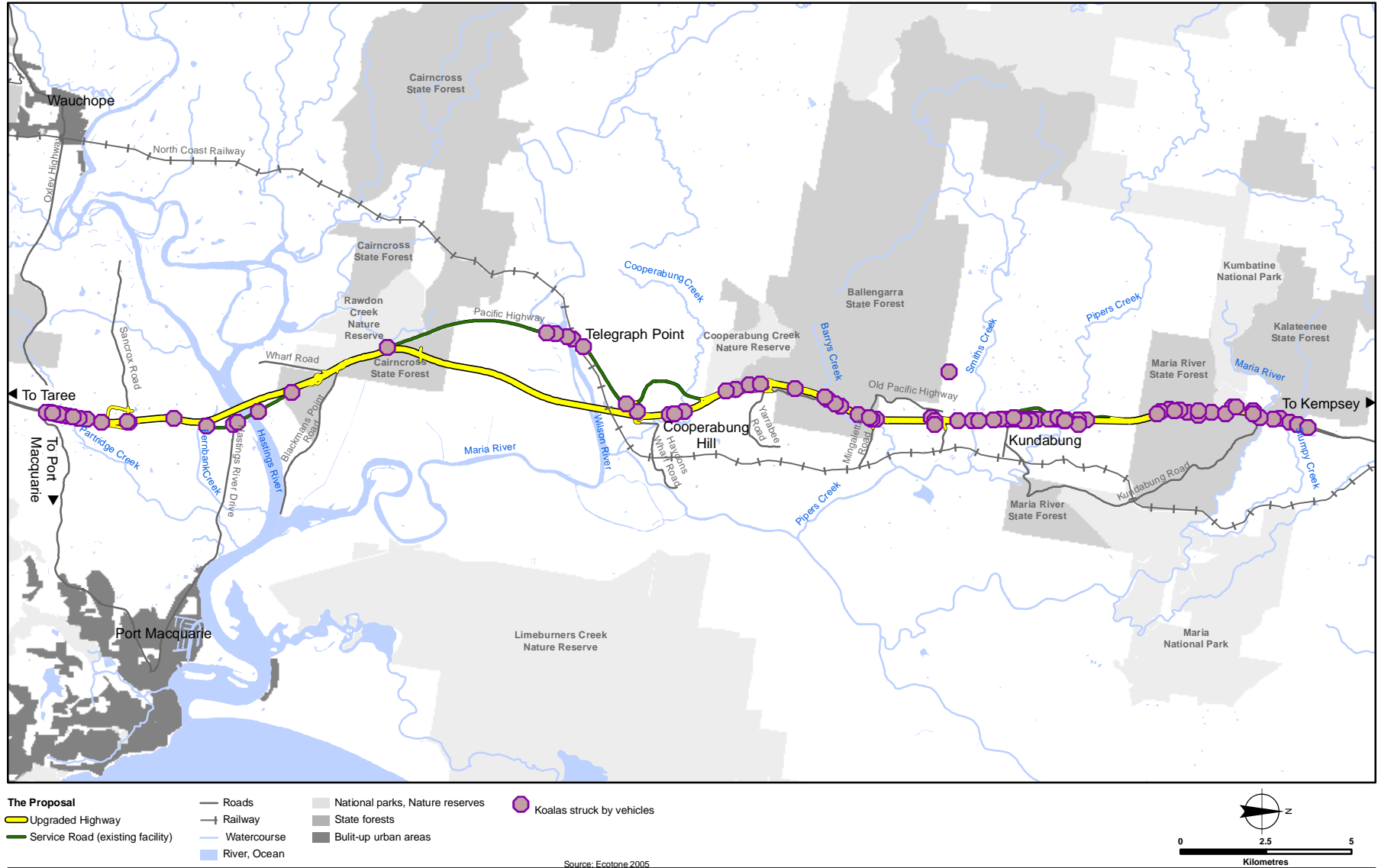
Port Macquarie-Hastings Council has prepared a draft comprehensive koala plan of management under the provisions of *State Environmental Planning Policy No. 44 – Koala Habitat Protection*. In the plan of management, most of the identified potential koala habitat within the study area occurs in the vicinity of Sancrox Road, from the junction of the existing highway to just south of the Hastings River. However the plan excludes large areas of bushland containing suitable habitat for koalas in Cairncross and Ballengarra state forests, and Rawdon Creek and Cooperabung Creek nature reserves, as these areas are managed by Forests NSW and DECCW respectively. Vegetation in the vicinity of Fernbank Creek and Telegraph Point contain areas identified as preferred and supplementary koala habitat under the plan of management.

A plan of management has also been prepared for the Thrumster area east of the existing highway between the Oxley Highway and Fernbank Creek Road (Biolink 2008). A draft koala management plan has also been prepared for the Kempsey local government area.

No major blackspots for koala deaths or injuries were identified for the Pacific Highway, however minor blackspots have been identified on the Oxley Highway near the Pacific Highway and also the forests north of Telegraph Point (Connell Wagner 2000). Regional and local habitat links (Connell Wagner 2000) have been identified as crossing the highway between:

- Oxley Highway junction and Sancrox Road.
- Hastings and Wilson rivers, linking Rawdon Creek Nature Reserve and Cairncross State Forest to privately owned land in floodplains to the east.

Figure 7 Koala road kill locations



3.8.2 Habitat types

The relative quality of fauna habitat within the Proposal boundary is shown in **Figure 8**.

Community types identified through vegetation mapping (**Figure 5a** to **Figure 5f**) constituted a good basis for assessing the availability and quality of various habitat types throughout the study area. The National Parks and Wildlife Service Key Habitats and Corridors in North East NSW Mapping Project, as discussed in **Section 3.8.4** and **Figure 9**, was also used to assist in determining overall fauna habitat values of vegetation communities.

The relative quality of fauna habitat 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 (for example, 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.

The fauna habitat attributes for each of the identified vegetation communities are discussed below.

Vegetation Community 1 – Moist Floodplain Closed Forest with Rainforest Elements

Several large hollow bearing emergent eucalypts occur along the creek lines, particularly along Barrys Creek near the existing highway crossing. Water was flowing at the time of the survey and the creek beds are rocky. Moderate levels of fallen timber were observed throughout most of this community, with some areas containing large logs and plentiful smaller fallen timber. No rock outcropping occurs. Disturbance regimes in this community include past logging and weed invasion (predominantly lantana). This community is well connected to other areas of habitat as it lies entirely within Ballengarra State Forest and forms part of a mapped key habitat area.

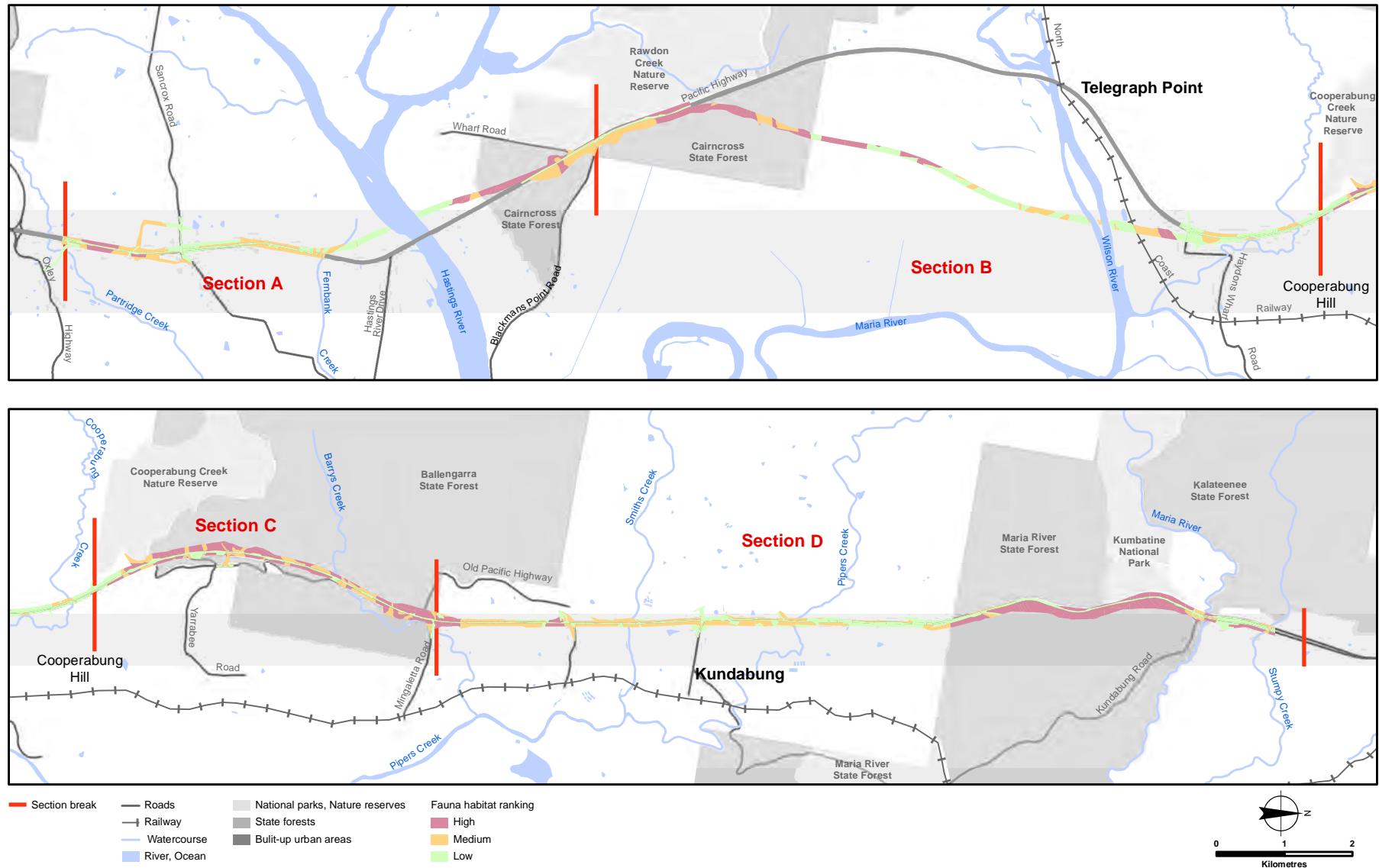
Most of this community has been ranked as high quality fauna habitat as these areas are generally intact and have good linkages to other areas of habitat for fauna movement. This community provides habitat for a range of fauna species, including hollow-reliant fauna, frogs and wet forest specialists.

Vegetation Community 2 – Riparian Forest

These patches lie within mapped key habitat and corridor areas.

Most of this community has been ranked as medium quality fauna habitat as these are generally narrow isolated patches, weed invaded, have few large mature trees and lack an intact canopy, shrub and ground layer. These areas represent a refuge for fauna in an otherwise cleared landscape and form part of a potential movement corridor following the riparian strip. Species that are reliant on larger areas of intact habitat are unlikely to reside in these areas, though they may occasionally use them when moving from one area to another.

Figure 8 Fauna habitat ranking



A number of riparian forest patches have been ranked as high quality fauna habitat and these are located along Barrys Creek near Mingaletta Road and at Maria River. Areas of riparian forest at Barrys Creek contain a good number of large mature trees with hollows and represents relatively intact habitat for native fauna. Riparian forest at Maria River is not in as good condition as at Barrys Creek, but is well connected to large areas of native vegetation in Maria River State Forest and contains known habitat for the giant barred frog and sooty owl. Riparian forest at Barrys Creek and Maria River provides habitat for a range of fauna species, including hollow-reliant fauna, frogs and wet forest specialists.

Vegetation Community 3 – Paperbark Swamp Forest

Approximately half of the patches of this community lie within mapped key habitat and corridor areas.

While the patches of paperbark swamp forest are all quite small, these high quality patches generally have good linkages to surrounding habitats, enabling them to support a wide range of fauna species, including terrestrial and arboreal mammals, frogs, reptiles and birds.

Elsewhere within the study area, patches of paperbark swamp forest have been ranked as representing medium quality fauna habitat. These areas tend to be invaded by lantana, have few hollow-bearing trees and tend to be relatively isolated from other areas of native vegetation. While these areas are unlikely to support species reliant upon large areas of intact habitat, they are likely to provide an important refuge for some species (particularly those reliant upon a dense groundcover layer). These areas would also provide an important autumn/winter foraging resource for birds and flying-foxes.

Vegetation Community 4 – Swamp Mahogany/Forest Red Gum Swamp Forest

As with Community 3, the better quality areas of this community lie between the Hastings River and Wilson River in Cairncross State Forest and on the Wilson River floodplain. These areas exhibit a more intact canopy, shrub and ground layer, moderate to good numbers of large mature trees with hollows, lower levels of disturbance and moderate to good levels of fallen timber and leaf litter. These areas also exhibit better connectivity, particularly within Cairncross State Forest where patches of this community lie within mapped key habitat and corridor areas. While the patches of swamp forest tend to be relatively small, these high quality patches generally have good linkages to surrounding habitats, enabling them to support a wide range of fauna species, including terrestrial and arboreal mammals, frogs, reptiles and birds.

Around the Fernbank Creek area, this community is ranked as medium quality fauna habitat. These areas tend to be invaded by lantana, have few hollow-bearing trees and are more isolated from other areas of native vegetation. While these areas are unlikely to support species reliant upon large areas of intact habitat, they are likely to provide an important refuge for some species (particularly those reliant upon a dense groundcover layer). These areas would also provide an important autumn/winter foraging resource for birds and flying-foxes.

Vegetation Community 5 – Swamp Oak Forest

This community typically has few or no hollow-bearing trees and generally little fallen timber, though the leaf litter can be quite thick. None of the patches of this community lie within mapped key habitat or corridor areas.

The small stand at the southern end of the study area is ranked as low quality fauna habitat. Most of this area has been cleared and the community has been reduced to remnant trees along the drainage line. While some bushland lies to the north of this patch, it is relatively isolated. This area would provide habitat for some birds, reptiles and frogs. Small native terrestrial mammals are unlikely to use this area, though more robust arboreal species (for example, possums) may occur.

Elsewhere within the study area, this community is ranked as medium quality fauna habitat. The vegetation is generally in better condition, with a more intact canopy, shrub and ground layer. While these areas do not contain plentiful hollow-bearing trees, some large mature trees occur and some of these contain small hollows. Weeds are still a problem, particularly pasture grasses and occasional stands of lantana. All of these patches are quite isolated, though would represent a movement corridor for some species along the drainage line or river course where they are located. These areas would provide habitat for some birds, bats, reptiles and frogs. Small native terrestrial mammals may be present in some of these patches (particularly in the patch on the floodplain south of the Wilson River) and more robust arboreal species (for example, possums) are likely to occur.

Vegetation Community 6 – Freshwater Wetland

None of the patches of this community occur within mapped key habitat or corridor areas.

All occurrences of this community are ranked as medium value fauna habitat. This community provides habitat for waterbirds, frogs and other wetland species, including occasional shelter or foraging habitat for some migratory bird species. Most of the patches are in reasonable condition, however all are subject to some level of disturbance as they lie within cleared or partially cleared pasture land and are grazed and therefore trampled by stock. Weeds and exotic pasture grasses are prevalent in some areas.

Vegetation Community 7 – Moist Floodplain Forest

This community is dominant in the forested land east of the existing highway in the southern half of Cairncross State Forest, which forms part of a mapped key habitat and corridor area. These areas are ranked as medium quality fauna habitat as while they retain good connectivity with other bushland areas and are relatively free of weeds, due to ongoing logging they contain few large mature trees and very few or no hollow-bearing trees. Shrub and ground cover in these areas is generally sparse to moderate depending on how recently the section was logged. Scattered fallen timber occurs, sometimes in large piles as a result of logging activities, and leaf litter is generally sparse to moderate. As part of the large bushland area of Cairncross State Forest, the moist floodplain forest community provides habitat for a wide range of fauna. However due to the lack of mature and hollow-bearing trees, the community in this area would support far fewer numbers of hollow-reliant fauna (including many birds, arboreal mammals, insectivorous bats and some reptiles and frogs) than would naturally occur.

Other medium quality patches occur around Fernbank Creek, Cooperabung Creek, Smiths Creek, Pipers Creek and Kundabung. These patches are all located in fragmented landscapes and are subject to weed invasion. These areas form part of small vegetated corridors that have no direct linkages, but eventually join onto larger areas of bushland. They are unlikely to support species reliant upon large areas of intact habitat however they could provide an important link and movement corridor for a variety of species. With the exception of a patch directly south of Smiths Creek, none of these areas lie within a mapped key habitat or corridor area.

A few small patches ranked as low quality fauna habitat lie between the Wilson River and Cooperabung Creek. These patches are located on rural residential properties and generally lack hollow-bearing trees, have been underscrubbed in some areas and have only patchy connectivity to nearby bushland.

As the bulk of this community is located in fragmented pastoral areas or is regularly logged, only two areas ranked as high quality fauna habitat occur. Two very small patches are located near Mingaletta Road and one small patch occurs on private land south of Cairncross State Forest. All these patches lie within a mapped key habitat or corridor area. These areas exhibit good numbers of large mature trees, including hollow-bearing trees and have experienced only low levels of disturbance. The native canopy, shrub and ground layers are relatively intact and reasonable levels of fallen timber occur. These areas provide habitat for a wide range of species, including hollow-reliant fauna.

Vegetation Community 8 – Moist Gully Forest

Most of the patches of this community occur within mapped key habitat or corridor areas, particularly in the north of the study area in the Ballengarra and Maria River state forests. Most of the patches ranked as good quality fauna habitat lie in Maria River State Forest and in the north of Cairncross State Forest, though some small patches of high quality habitat occur at Mingaletta Road and near Cooperabung Range Road. At the time of survey, these areas had not been recently logged and contained good numbers of large mature trees, including those with hollows. Scattered fallen timber occurs and some patches contain large logs with hollows. These areas provide good habitat for a range of fauna species, including those reliant on wet areas and moist forest elements.

The remainder of this community is ranked as medium quality fauna habitat, with the exception of a few very small areas ranked as low quality. These medium quality areas generally have few or no hollow-bearing trees due to logging or past clearing. Some of these patches are more isolated from larger bushland areas and others are partially infested with weeds such as lantana and crofton weed. While these areas may be lacking some important fauna habitat features, or may be degraded in some way, they still provide important habitat for those species reliant on moist forest elements.

Vegetation Community 9 – Moist Slopes Forest

Much of this community has been ranked as providing high quality fauna habitat. A large number of these high quality patches are located in Cooperabung Creek Nature Reserve, Ballengarra State Forest and Maria River State Forest, though some smaller patches are located in Cairncross State Forest and at the southern end of the study area. These areas tend to contain good numbers of large mature trees, including those with hollows. The native canopy, shrub and ground layer are in good condition and weed invasion is minimal. Most of the good quality patches of this community lie within mapped key habitat and corridor areas in Cairncross State Forest (southern end), Cooperabung Creek Nature Reserve, Ballengarra State Forest, Maria River State Forest and north of Maria River.

Medium quality areas occur on rural residential properties north of the Wilson River and around the Smiths Creek/Pipers Creek/Kundabung area. These areas tend to be more isolated from larger areas of intact habitat and have experienced greater levels of disturbance. The vegetation tends to be in moderately good condition, though the patches contain fewer large mature trees and are subject to edge effects. Most of the medium quality areas of this community do not correspond to any mapped key habitat or corridors, though some patches intersect the mapping at Kundabung, north of the Wilson River and in Ballengarra State Forest.

Patches of this community ranked as low quality fauna habitat occur as remnant roadside stretches mainly between Pipers Creek and Maria River State Forest and north of Maria River. These areas tend to be regenerating patches, have few or no large mature trees and are subject to edge effects from roadside disturbance and weed invasion. While these areas are generally thin disturbed patches, a large number of them fall within mapped corridors.

Vegetation Community 10 – Dry Ridgetop Forest

This community is mostly located in mapped key habitat and corridor areas found in the larger bushland areas within the study area, including Cairncross State Forest, Rawdon Creek Nature Reserve, Ballengarra State Forest and Maria River State Forest. Most of the patches of this community are ranked as medium or good quality fauna habitat, with only a very few patches of low quality habitat. Few weeds occur within this community and these are mainly restricted to disturbed and edge areas. Most of this community has been subject to past logging, with the medium quality patches generally having been more recently logged while the good quality patches have had more time to recover.

Dry ridgetop forest in the study area provides habitat for fauna that prefer drier habitats and a more open understorey, as the shrub layer is generally sparse. Areas ranked as high quality fauna habitat generally had a higher number of hollow-bearing trees, providing roosting and breeding habitat for a range of hollow-reliant fauna. Those patches dominated by spotted gum and ironbark would represent an important winter foraging resource for birds and flying-foxes.

Vegetation Communities 11, 12 and 13 – Cleared, Open Grassland / Derived Pasture with scattered trees; Plantation / Cropland / Market Garden etc and Totally Cleared / Open Pasture/Weedy Fallow

None of these communities have any areas ranked as high quality fauna habitat and only one patch just south of Cairncross State Forest has been ranked as medium quality fauna 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. While some of these patches lie within mapped key habitat and corridor areas, they generally represent gaps in the tree cover rather than vegetated linkages between any areas of habitat.

The floodplains of the Hastings and Wilson rivers were difficult to rank as although they have been cleared and consist of grazing lands dominated by introduced pasture grasses, they do 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.

3.8.3 Habitats in nature reserves

Flora and fauna surveys have been previously undertaken in Rawdon Creek Nature Reserve by the National Parks and Wildlife Service (2004). No surveys have been undertaken in Cooperabung Creek Nature Reserve. Whilst the Proposal would not impact Rawdon Creek Nature Reserve, the results of these surveys have been reviewed to assist in understanding the existing environment.

The Proposal passes the eastern edge of Rawdon Creek Nature Reserve. The surveys undertaken by the National Parks and Wildlife Service revealed that dry forest types occupied 90 per cent of the reserve, with the balance being mainly moist heath and fen in the drainage lines (NPWS 2004). Surveys within the reserve found nine vegetation associations. The reserve is noted as being particularly important as it contains the largest protected stand of low relief coastal blackbutt (*Eucalyptus pilularis*), a forest ecosystem that is restricted to the region. Six locally significant flora species were also found to occur. None of these species are listed on any legislative or rare species databases, and most are quite common, but the species are locally significant by virtue of the fact that they are at or near the southern or northern limit of their distributions (NPWS 2004). The species are listed in **Table 3-6**.

Table 3-6 Locally significant flora species in Rawdon Creek Nature Reserve

Common Name	Scientific Name	Significance
geebung	<i>Persoonia stradbokensis</i>	southern limit of distribution
southern red mahogany	<i>Eucalyptus resinifera</i> subsp. <i>resinifera</i>	northern limit of distribution
pomaderris	<i>Pomaderris ferruginea</i>	northern limit of distribution
trefoil	<i>Desmodium nemorosum</i>	southern limit of distribution
solanum	<i>Solanum densevestitum</i>	southern limit of distribution
dwarf blue trumpet	<i>Brunoniella pumilio</i>	northern limit of distribution

Under the modelling for the comprehensive regional assessment process, the reserve was also considered likely to contain the threatened flora species white-flowered wax plant (*Cynanchum elegans*) and Guthrie's grevillea (*Grevillea guthrieana*), which are both listed as endangered under the TSC Act and EPBC Act. A DECCW record from 2002 for the white-flowered wax plant occurs in the study locality (**Appendix A**), but not near the study area.

Eight species of threatened fauna, all listed as vulnerable in the TSC Act, were recorded in Rawdon Creek Nature Reserve during surveys conducted in 1999 (NPWS 2004). These were the koala, little bent-wing bat, glossy black cockatoo, osprey, masked owl, powerful owl, square-tailed kite and green-thighed frog. The grass owl is reported to occur near the nature reserve (NPWS 2004), however this record does not show up in the DECCW Wildlife Atlas. The grey-headed flying-fox was predicted to occur by the comprehensive regional assessment modelling process, and has actually been recorded within the reserve (DECCW Wildlife Atlas 2007). Other species predicted to occur are the squirrel glider, yellow-bellied glider, greater broad-nosed bat, east-coast freetail-bat, southern myotis and the endangered swift parrot.

No flora and fauna surveys have been undertaken in Cooperabung Creek Nature Reserve. The Proposal encroaches on the eastern border of the Cooperabung Creek Nature Reserve for a short distance. The nature reserve would contain many similar vegetation types and species as the study area at this particular location.

According to the management plan for the reserve (NPWS 2003a), no comprehensive flora survey has been carried out over the reserve. However, the comprehensive regional assessment modelling has predicted that the milky silkpod (*Parsonsia dorrigoensis*), which is listed as vulnerable in the TSC Act and endangered in the EPBC Act, is likely to occur in the reserve. A DECCW record from 1997 for this species occurs in the study locality (**Appendix A**) but not near the study area.

Three threatened fauna species, listed as vulnerable in the TSC Act, have been recorded within Cooperabung Creek Nature Reserve, although no comprehensive fauna survey had been carried out at the time of writing the plan of management (NPWS 2003a). The threatened species recorded are the brushtailed phascogale, glossy black cockatoo and barking owl, although according to a review of the DECCW Wildlife Atlas, only the sooty owl and not the barking owl has been recorded within the reserve. The little bent-wing bat and grey-headed flying-fox have also been recorded in the reserve in the DECCW Wildlife Atlas. Other predicted species based on the comprehensive regional assessment modelling are the koala, squirrel glider, yellow-bellied glider, parma wallaby, eastern chestnut mouse, greater broad-nosed bat, east-coast freetail-bat, southern myotis, large-eared pied bat, golden-tipped bat, osprey, masked owl and green-thighed frog.

3.8.4 Key habitats and regional corridors

Habitats within the study area are already fragmented by the existing highway, other roads and tracks, and clearing for agricultural activities. The degree of fragmentation varies with areas of good north-south habitat connectivity along sections of the existing highway as a result of extensive tracts of forested land within State Forest and nature Reserves. These tracts of vegetation form part of a framework of regional and subregional corridors which provide connectivity between key habitat areas as defined and mapped by the NPWS Key Habitats and Corridors in North East NSW Mapping Project (NPWS 2005, Scotts 2003). Priority climate change corridors have also been identified in the study area (DECCW 2009).

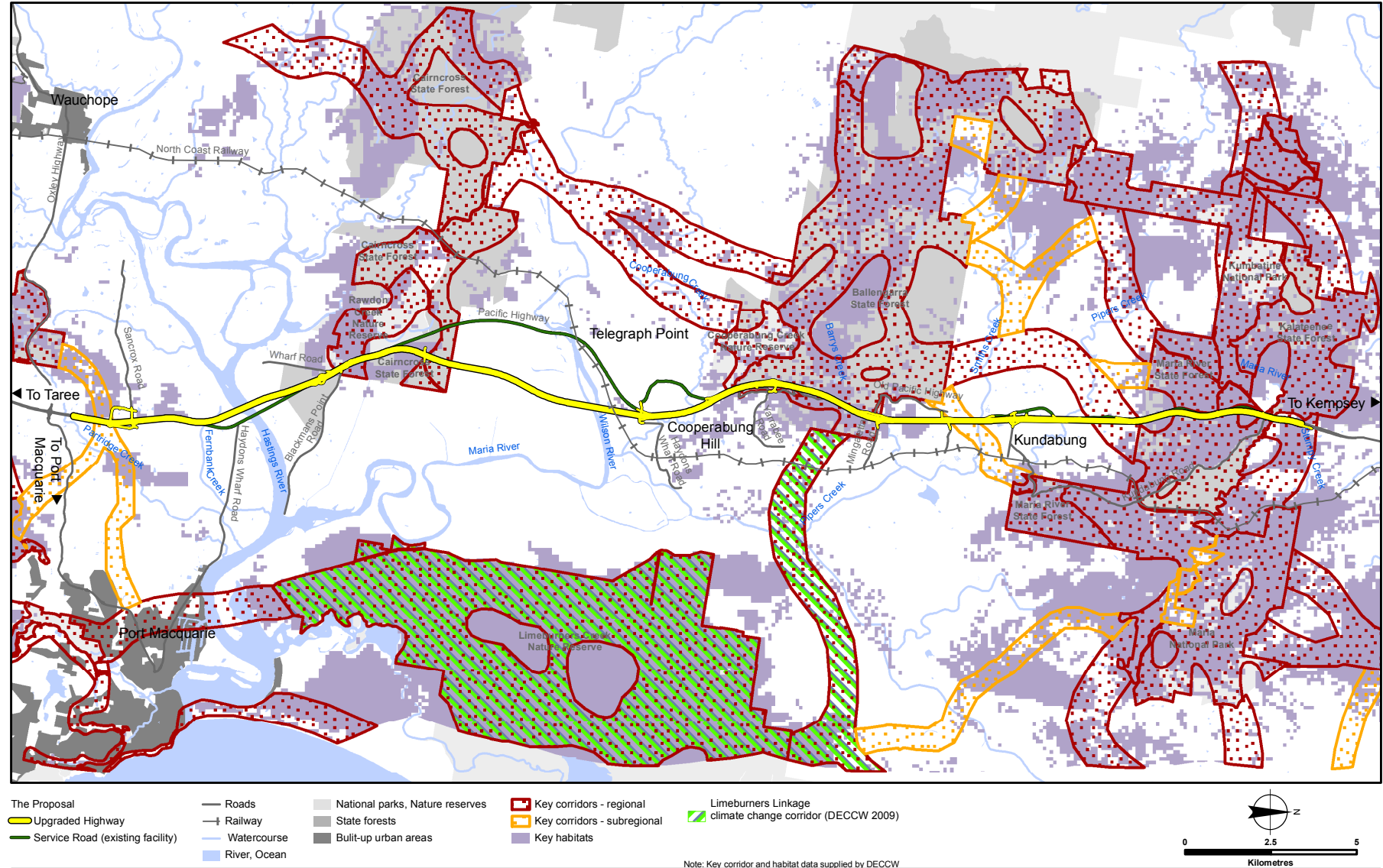
Mapped key habitats in the study area comprise areas of predicted high conservation value for forest fauna, and include large areas of vegetated lands and important vegetation remnants (NPWS 2005). The connecting framework of regional and subregional corridors facilitate important ecological processes such as migration, colonisation and interbreeding of plants and animals between two or more larger areas of habitat (NPWS 2005). This would tend to reduce the risk of local flora and fauna populations becoming isolated and therefore at risk of local extinction. Identified climate change corridors are intended to play an ameliorative role for fauna species responding to the predicted impacts of climate change (DECCW 2009).

The study area passes through or overlaps nine regional and sub-regional corridors, as shown in **Figure 9**.

A review of the key habitats indicates the following:

- Areas of key habitat are located to the west of the existing highway, to the north and south of Sancrox Road, the latter being associated with the Lake Innes – Cowarra Subregional Corridor. Some of these areas of mapped key habitat overlap sections of the western parts of the study area.
- An area of key habitat is located near Blackmans Point Road within Rawdon Creek Nature Reserve and overlaps the study area to the west of the existing highway.

Figure 9 Wildlife corridors and key habitats in the study locality



- A small area of key habitat is located to the east of the existing highway to the north of Telegraph Point, which is generally bounded by the North Coast Railway and existing highway and is partly overlapped by the Proposal.
- Areas of key habitat are located on both sides of the existing highway in the general vicinity of Cooperabung Creek Nature Reserve, Ballengarra State Forest and north of Mingaletta Road. Some of these areas overlap the Proposal.
- Areas of key habitat are located on both sides of the existing highway in the general vicinity of Kumbatine National Park and Maria River State Forest. Some of these overlap the Proposal.

The corridors that pass through the study locality are listed in **Table 3-7**, together with the Lower North Coast fauna assemblages/habitats from which the corridors are derived. Species lists for the lower north coast fauna assemblages (NPWS 2005) are listed in **Appendix K**.

Table 3-7 Wildlife corridors within the study locality

Corridor	Links between	Lower North Coast fauna assemblages			
		Dry valleys	Moist escarpment foothills	Dry coastal foothills	Coastal complex
Evermore	RTA underpass.				
Lake Innes Nature Reserve Regional	No data available on the website. Occurs to the south of the Oxley Highway junction.				
Innes Drive Regional	Koala habitat and RTA underpass linking Lake Innes Nature Reserve to Cowarra State Forest to the south of the Oxley Highway junction.				
Lake Innes – Cowarra Subregional*	Lake Innes National Park and Partridge Creek	✓	✓	✓	✓
Rawdon Creek Nature Reserve Regional*	No data available on the website. Based on survey results for the Proposal, the following fauna assemblages could occur.	✓	✓	✓	
Ballengarra – Cairncross Regional	Cooperabung Creek Nature Reserve and Wilson River	✓	✓	✓	
Cooperabung Creek Nature Reserve Regional*	No data available on the website. Based on survey results for the Proposal, the following fauna assemblages could occur.	✓	✓	✓	
Ballengarra State Forest Regional*	No data available on the website. Based on survey results for the Proposal, the following fauna assemblages could occur.	✓	✓	✓	

Corridor	Links between	Lower North Coast fauna assemblages			
		Dry valleys	Moist escarpment foothills	Dry coastal foothills	Coastal complex
Ballengarra – Limeburners Regional	Maria National Park and Goolawah Lagoon	✓	✓	✓	✓
Limeburners Linkage – Priority Corridor for Climate Change	Limeburners Creek Nature Reserve to Crescent Head and coastal complex	✓	✓	✓	✓
Kundabung Subregional*	Pipers Creek and Smiths Creek	✓	✓	✓	✓
Smiths Creek Subregional	No data available on the website. Occurs outside of the study area.				
Ballengarra – Maria River Regional*	Smiths Creek and Knaliers Road	✓	✓	✓	
Pipers Creek Subregional	Pipers Creek and Seams Road	✓	✓	✓	
Kumbatine – Maria River Regional	No data available on the website. Occurs outside of the study area.				
Maria River State Forest Regional*	No data available on the website. Based on survey results for the Proposal, the following fauna assemblages could occur.	✓	✓	✓	
Kumbatine National Park Regional*	No data available on the website. Based on survey results for the Proposal, the following fauna assemblages could occur.	✓	✓	✓	
Maria Link Regional*	Maria National Park and Kumbatine National Park	✓	✓	✓	

Notes: * Passes through or overlaps study area
Based on NPWS 2005; DECCW 2009

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.
- 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).

However, based on the Wildlife Atlas records, road kill records (see **Figure 7**) and communication with local veterinarian 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.

3.8.5 Critical habitat

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.

3.8.6 Overall terrestrial habitat values

The locality in which the study area occurs is considered to overall 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 EECs of state conservation significance.
- The occurrence of 18 threatened species, including birds, mammals, bats and amphibians.
- The occurrence of potential habitat for at least a further 27 threatened species, which may occur in the study area (as indicated in **Appendix E**).

3.9 Fauna assemblages

3.9.1 Previous survey work within the study area

Prior to the spring survey in September 2006, previous survey work within the study area had been completed by Ecotone for the proposed Oxley Highway to Kempsey Pacific Highway Upgrade (Ecotone Ecological Consultants 2006a) and for the bridge widening at Maria River (Ecotone Ecological Consultants 2006b). Results of the two main surveys are summarised below.

Preliminary fauna habitat survey work for the proposed Pacific Highway Upgrade was undertaken by Ecotone within the study area in November 2005. During this preliminary survey, opportunistic records of fauna species positively identified within the study area were recorded. A total of 61 fauna species were recorded, including 49 birds, five reptiles, four mammals and three frogs. One threatened species was recorded, the osprey (*Pandion haliaetus*), which is listed as vulnerable in the TSC Act.

Flora and fauna assessment fieldwork for the bridge widening at Maria River was undertaken in April 2006. As a result of field survey work, a total of 32 terrestrial fauna species were positively identified near the Maria River bridge area, including 16 birds, 11 mammals, three reptiles and one frog. Probable or possible identifications of three additional insectivorous bats were made based on ultrasonic call analysis. Four threatened fauna listed as vulnerable on the TSC Act were definitely

recorded, all within the riparian habitat under and either side of the existing bridges: eastern bent-wing bat (*Miniopterus schreibersii oceanensis*), little bent-wing bat (*Miniopterus australis*), southern myotis (*Myotis macropus*) and sooty owl (*Tyto tenebricosa*). The giant barred frog (*Mixophyes iteratus*), listed as endangered on the TSC Act and EPBC Act was also recorded. Two additional vulnerable species listed in the TSC Act, the eastern false pipistrelle (*Falsistrellus tasmaniensis*) and greater broad-nosed bat (*Scoteanax rueppellii*) were recorded as possibly occurring based on ultrasonic call analysis. However, the calls recorded were of short duration and poor quality and therefore, a more definite identification could not be made.

3.9.2 Results of field investigations for the Proposal

Mammals

Thirty seven native mammal species were recorded within the study area or adjoining habitats during the fauna field survey (**Appendix G**). They comprised six arboreal species (including koala), three macropods, 17 microchiropteran bat species, nine ground-dwelling species and two flying-fox species.

Arboreal mammals, such as the sugar glider (*Petaurus breviceps*) and common brushtail possum (*Trichosurus vulpecular*) were observed in wooded areas. Sugar glider feeds on the gum of acacia, the sap of eucalypts, invertebrates and invertebrate exudates, dependent on seasonal availability and is often locally common in forested habitats that provide hollows for shelter and foraging resources (Strahan 1995). Common brushtail and common ringtail possums (*Pseudocheirus peregrinus*) have a diverse diet of leaves, flowers, fruits and buds and are common and widespread throughout a wide variety of natural, rural and urban areas of south-eastern NSW (Strahan 1995).

Three macropod species, the swamp wallaby (*Wallabia bicolor*), red-necked wallaby (*Macropus rufogriseus*) and eastern grey kangaroo (*M. giganteus*) were recorded within the study area. Macropods were recorded in all habitat types along the study area either by scats or sightings.

Echidna (*Tachyglossus aculeatus*) was recorded from tracks near ant mound diggings within the study area. This species is likely to occur throughout forest and woodland/grassland ecotone areas throughout the study area and on adjoining lands. Northern brown bandicoot (*Isodon macrourus*) was trapped within Cairncross State Forest and Ballengarra State Forest. Brown antechinus (*Antechinus stuartii*), bush rat (*Rattus fuscipes*) and the introduced black rat (*Rattus rattus*) were the most common ground-dwelling mammals recorded from the Elliott A ground traps. Dusky antechinus (*Antechinus swainsonii*) and swamp rat (*Rattus lutreolus*) were identified with probable certainty from hair tubes.

The threatened yellow-bellied glider (*Petaurus australis*) was identified from calls from the northern area of Ballengarra State Forest. Whilst the study area may provide potential habitat for the yellow-bellied glider, less disturbed, mature forest containing old-growth elements within the adjoining lands provides preferred habitat for this species.

During the field surveys, a koala (*Phascolarctos cinereus*) was sighted crossing the Pacific Highway approximately 200 metres south of Sancrox Road. Searches for koala scats and scratches on potential feed trees indicated signs of recent koala activity within Ballengarra State Forest and south of Sancrox Road. The grey-headed flying-fox was recorded at numerous locations during the surveys and has potential to forage anywhere along the study area where suitable food trees occur.

Twelve introduced mammals were recorded on site, including feral species (the red fox, dogs, cats and rabbits) and domestic livestock (cows, horses, goats).

Microchiropteran bats

A diverse range of microchiropteran bat species were recorded during the field investigations (**Appendix G**). Not all of the Anabat call recording results are conclusive, as some were too short or unclear for positive species identification. However, the 17 species recorded are considered likely to occur in the study area. Based on habitats present and the species' known distributions, several other threatened microchiropteran bats that have been previously recorded in the locality are considered likely to occur in the study area.

All of the microchiropteran bats recorded within the study area are insect-eating, catching insects on the wing or gleaning them from foliage or in some instances from the ground (Churchill 1998). Foraging behaviour varies among species and may be concentrated above, below or within the tree canopy, along the edges of vegetation and cleared land, or over open grassland areas. The species recorded are likely to forage widely throughout the study area and surrounding locality.

Five threatened microchiropteran bat species, the eastern false pipistrelle (*Falsistrellus tasmaniensis*), little bentwing-bat (*Miniopterus australis*), eastern bentwing-bat (*Miniopterus schreibersii*), eastern free-tail bat (*Mormopterus norfolkensis*) and southern myotis (*Myotis macropus*, formerly *adversus*) were recorded during the fauna field surveys. The large forest bat (*Vespadelus darlingtoni*) and greater broad-nosed bat (*Scoteanax rueppellii*) were also given a probable identification based on ultrasonic call analysis.

Of those recorded, three species (eastern horseshoe bat, little bentwing-bat and eastern bentwing-bat) rely on caves or similar artificial structures (such as mines and culverts) for roosting. Culverts and bridges throughout the study area provide potential roost sites for these species and are the subject of a supplementary investigation documented by Ecotone (2007). The remainder roost in tree-hollows, amongst foliage or under bark or occasionally in caves. Many of these species will also roost in the roof-spaces of buildings, where available. Forested habitats across the study area are likely to provide roosting habitat for these species with more extensive roosting habitat occurring within the extensive tracts of forested land within the adjoining areas. Isolated hollow-bearing paddock trees can also provide important roosting or breeding habitat.

Targeted bat surveys were also conducted at the following bridge structures:

- Fernbank Creek.
- Cooperabung Creek.
- Barrys Creek.
- Smiths Creek.
- Pipers Creek.
- Maria River.
- Stumpy Creek.

The results of this survey indicated that few roosting opportunities for insectivorous bats occur under the bridges and culverts within the Proposal. This is generally a result of the design of the structures resulting in no or few dark cavities that could be used as bat roosts. The most likely species to roost in the structures are the threatened southern myotis and the protected eastern

horseshoe bat as they were recorded during this survey. The threatened little and eastern bent-wing bats could seasonally use the darker culverts, particularly during the winter.

Maternity roost sites for any of the above mentioned species are not expected to occur, although there is a possibility of a colony of the southern myotis being present in the scuppers at the Smiths Creek bridge. Individual southern myotis could also use disused welcome swallow or fairy martin nests on any of the bridge/culvert structures.

Reptiles

A total of 20 reptile species were recorded during field surveys (**Appendix G**). Reptile species were mostly recorded during specific diurnal reptile searches or opportunistically during other daytime survey activities, however three nocturnal snakes, Krefft's dwarf snake (*Cacophis krefftii*), golden crowned snake (*Cacophis squamulosus*) and eastern small-eyed snake (*Rhinoplocephalus nigrescens*), were recorded during evening spotlighting surveys and frog searches. The grass skink (*Lampropholis delicata*) was the most common reptile species and was recorded at each of the eight base sites and a number of the supplementary sites. No threatened reptile species were recorded.

The study area contains areas of dense leaf litter, abundant fallen hollow logs and some bush rock within Cairncross State Forest, Rawdon Creek Nature Reserve, Ballengarra State Forest, Cooperabung Creek Nature Reserve and Maria River State Forest, providing excellent foraging and refuge habitat for a range of reptile species.

Frogs

A total of 19 frog species were recorded during specific frog searches, evening spotlighting surveys or opportunistically within the study area (**Appendix G**). The most common frog species recorded within the study area were the common eastern toadlet (*Crinia signifera*), striped marsh frog (*Limnodynastes peroni*), red-backed toadlet (*Pseudophryne coriacea*) and eastern dwarf tree frog (*Litoria fallax*). Two threatened frog species were recorded within the study area: the giant barred frog (*Mixophyes iteratus*) listed as endangered on the TSC Act and EPBC Act, and green-thighed frog (*Litoria brevipalmata*) listed as vulnerable in the TSC Act.

Potential habitat for frogs within the study area includes man-made dams, low-lying swamp forests, watercourses within national parks and state forests and private land, and several drainage lines within gullies. Watercourses consist of permanent streams, as well as ephemeral drainage lines providing suitable frog habitat in wetter periods. The creeks or watercourses that showed less erosion and less obvious adverse impacts as a result of past disturbance such as cattle grazing and previous easement clearances provide more suitable habitat for a greater range of frog species. These areas contain more varied habitat elements, including a rocky substrate, woody debris and riparian/aquatic vegetation.

Birds

The study area provides habitat for a relatively diverse array of shrubland, woodland and open forest bird species. A total of 121 species were recorded comprising 119 native and two introduced species (**Appendix G**). Seven bird species listed as threatened on the TSC Act were recorded: the black-necked stork (*Ephippiorhynchus asiaticus*), osprey (*Pandion haliaetus*), square-tailed kite (*Lophoictinia isura*), sooty owl (*Tyto tenebricosa*), glossy black-cockatoo (*Calyptorhynchus lathami*), masked owl (*Tyto novaehollandiae*), and rose-crowned fruit-dove (*Ptilinopus regina*).

Nectar-eating species included a diverse assemblage of honeyeaters, miners, rosellas and lorikeets. Common insect-eating species included thornbills, pardalotes, robins, scrubwrens, tree-creepers and fairy-wrens. Seed-eating parrots and finches (such as rosellas and redbrowed finch (*Emblema temporalis*)) were also commonly recorded foraging in open grassland areas and in fringing woodland/grassland ecotone areas. The fruit-eating mistletoebird (*Dicaeum hirundinaceum*) and a number of pigeon species were also recorded in forest and rainforest habitats.

Five raptor species, including the whistling kite (*Haliastur indus*) and Australian hobby (*Falco longipennis*), were recorded on site, either perched in trees and on stags or foraging overhead in the study area. The fragmented nature of the vegetation in the study area is of particular relevance for these species as they utilise open grassland areas for foraging, and nearby forest and woodland habitat for roosting and nesting.

Nocturnal birds recorded in the study area included owls, such as the southern boobook (*Ninox novaeseelandiae*) and tawny frogmouth (*Podargus strigoides*). Boobooks and tawny frogmouths are common and widespread species that occur throughout a range of natural and modified environments and utilise open vantage points to watch for prey. As mentioned above, the threatened sooty owl and masked owl were recorded during surveys, with the study area providing suitable habitat for threatened owl species in sections of mature forest containing old growth elements (hollow-bearing trees) present within Cairncross, Ballengarra and Maria River state forests. Owls occupy large home ranges and are likely to forage widely through woodland and forest habitats in the locality.

Only a small number of waterbirds were recorded in the study area. The low species diversity may be due to the relatively few farm dams and the paucity of open aquatic and riparian habitat, which provides foraging, refuge and nesting habitat for such species. Most of the waterbird species recorded during the field surveys, such as the Australian wood duck (*Chenonetta jubata*), pacific black duck (*Anas superciliosa*), teals and grebes, are common and widespread except for the threatened black-necked stork previously mentioned.

The small gullies and riparian forest surrounding creeklines within the study area are relatively intact and provide habitat for a range of infrequently seen species and potentially threatened species, such as the migratory black-faced monarch (*Monarcha melanopsis*). Wet sclerophyll forest and moist floodplain closed forest with rainforest elements within the study area provide habitat for doves and other rainforest species such as the threatened rose-crowned fruit dove (*Ptilinopus regina*), which was tentatively identified in the study area.

Six species listed as migratory on the EPBC Act, but not listed as threatened in either the EPBC or TSC Acts, were recorded during Ecotone surveys within the study area. These were the cattle egret (*Bubulcus ibis*), white-bellied sea-eagle (*Haliaeetus leucogaster*), Latham's snipe (*Gallinago hardwickii*), white-throated needletail (*Hirundapus caudacutus*), satin flycatcher (*Myiagra cyanoleuca*) and rufous fantail (*Rhipidura rufifrons*). One additional species, the black-faced monarch (*Monarcha melanopsis*), was recorded during supplementary surveys by GHD. These and other listed migratory species with potential to occur within the study area are listed in **Appendix B**.

3.10 Threatened terrestrial fauna

3.10.1 Vertebrate 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 (**Appendix B**). 48 threatened species and 50 migratory species listed under the EPBC Act are predicted to occur within the study locality (**Appendix B**).

An assessment of the potential for threatened fauna species to occur within the study area was undertaken based on habitat preferences and habitat availability and is provided in **Appendix B**.

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 were assessed as likely to occur within the study area based on known records and habitat availability within the study area, as detailed in **Table 3-8**.

Of these 46 species, a total of 18 threatened fauna species were recorded in the study area during the field investigations undertaken between 2005 and 2007. 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 3-8 Threatened fauna species recorded during field surveys or considered likely to occur in the study area

Common name	Scientific name	TSC Act	EPBC Act
Species recorded in the study area during field surveys			
black-necked stork	<i>Ephippiorhynchus asiaticus</i>	Endangered	
eastern bent-wing bat	<i>Miniopterus schreibersii oceanensis</i>	Vulnerable	
eastern false pipestrelle	<i>Falsistrellus tasmaniensis</i>	Vulnerable	
eastern freetail-bat (previously east-coast freetail-bat)	<i>Micronomus norfolkensis</i> (previously <i>Mormopterus norfolkensis</i>)	Vulnerable	
giant barred frog	<i>Mixophyes iteratus</i>	Endangered	Endangered
glossy black-cockatoo	<i>Calyptorhynchus lathami</i>	Vulnerable	
greater broad-nosed bat (probable)	<i>Scoteanax rueppellii</i>	Vulnerable	
green-thighed frog	<i>Litoris brevipalmata</i>	Vulnerable	
grey-headed flying-fox	<i>Pteropus poliocephalus</i>	Vulnerable	Vulnerable

Common name	Scientific name	TSC Act	EPBC Act
koala	<i>Phascolarctos cinereus</i>	Vulnerable	
little bent-wing bat	<i>Miniopterus australis</i>	Vulnerable	
masked owl	<i>Tyto novaehollandiae</i>	Vulnerable	
osprey	<i>Pandion haliaetus</i>	Vulnerable	Migratory
rose-crowned fruit-dove	<i>Ptilinopus regina</i>	Vulnerable	
sooty owl	<i>Tyto tenebricosa</i>	Vulnerable	
southern myotis	<i>Myotis macropus</i>	Vulnerable	
square-tailed kite	<i>Lophoictinia isura</i>	Vulnerable	
yellow-bellied glider	<i>Petaurus australis</i>	Vulnerable	
Species considered highly likely to occur in the study area			
brush-tailed phascogale	<i>Phascogale tapoatafa</i>	Vulnerable	
common planigale	<i>Planigale maculata</i>	Vulnerable	
powerful owl	<i>Ninox strenua</i>	Vulnerable	
spotted-tail quoll	<i>Dasyurus maculata</i>	Vulnerable	Endangered
squirrel glider	<i>Petaurus norfolcensis</i>	Vulnerable	
Species that may potentially occur in the study area			
Australasian bittern	<i>Botaurus poicilloptilus</i>	Vulnerable	
Australian painted snipe	<i>Rostratula benghalensis</i>	Vulnerable	Vulnerable
barking owl	<i>Ninox connivens</i>	Vulnerable	
barred cuckoo-shrike	<i>Coracina lineata</i>	Vulnerable	
black bittern	<i>Ixobrychus flavicollis</i>	Vulnerable	
comb-crested jacana	<i>Irediparra gallinacea</i>	Vulnerable	
eastern chestnut mouse	<i>Pseudomys gracilicaudatus</i>	Vulnerable	
giant dragonfly	<i>Petalura gigantea</i>	Endangered	
golden-tipped bat	<i>Kerivoula papuensis</i>	Vulnerable	
grass owl	<i>Tyto capensis</i>	Vulnerable	
green and golden bell frog	<i>Litoria aurea</i>	Endangered	Vulnerable
grey-crowned babbler	<i>Pomatostomas temporalis temporalis</i>	Vulnerable	
large-eared pied bat	<i>Chalinolobus dwyeri</i>	Vulnerable	Vulnerable
long-nosed potoroo	<i>Potorous tridactylus</i>	Vulnerable	Vulnerable
pale-headed snake	<i>Hoplocephalus bitorquatus</i>	Vulnerable	
regent honeyeater	<i>Xanthomyza phrygia</i>	Endangered	Endangered, Migratory

Common name	Scientific name	TSC Act	EPBC Act
Stephen's banded snake	<i>Hoplocephalus stephensii</i>	Vulnerable	
stuttering frog	<i>Mixophyes balbus</i>	Endangered	Vulnerable
superb fruit-dove	<i>Ptilinopus superbus</i>	Vulnerable	
swift parrot	<i>Lathamus discolor</i>	Endangered	Endangered, Migratory
wallum froglet	<i>Crinia tinnula</i>	Vulnerable	
wompoo fruit-dove	<i>Ptilinopus magnificus</i>	Vulnerable	
yellow-bellied sheathtail bat	<i>Saccolaimus flaviventris</i>	Vulnerable	

The locations of threatened fauna species recorded during surveys within the study area are shown in **Figure 10**. These recorded species are discussed below.

Black-necked stork

Two black-necked storks were recorded flying over Stoney Creek Water Sports Park on the Wilson River floodplain during spring surveys (September 2006).

Eastern bent-wing bat

This species was recorded at nine sites by Ecotone and again by GHD in supplementary surveys. Small numbers of this species may seasonally roost under bridge and culverts along the existing highway. Maternity roost caves for this species occur at Yessabah caves, west of Kempsey. This species is known to travel up to 20 kilometres at night to feed.

Eastern false pipistrelle

Possible recordings of this species were made by Ecotone between Smiths Creek and Wharf Road, and positively recorded by GHD in supplementary surveys.

Eastern freetail bat

This species was recorded near Fernbank Creek as well as another survey site via ultrasonic call detection (Anabat).

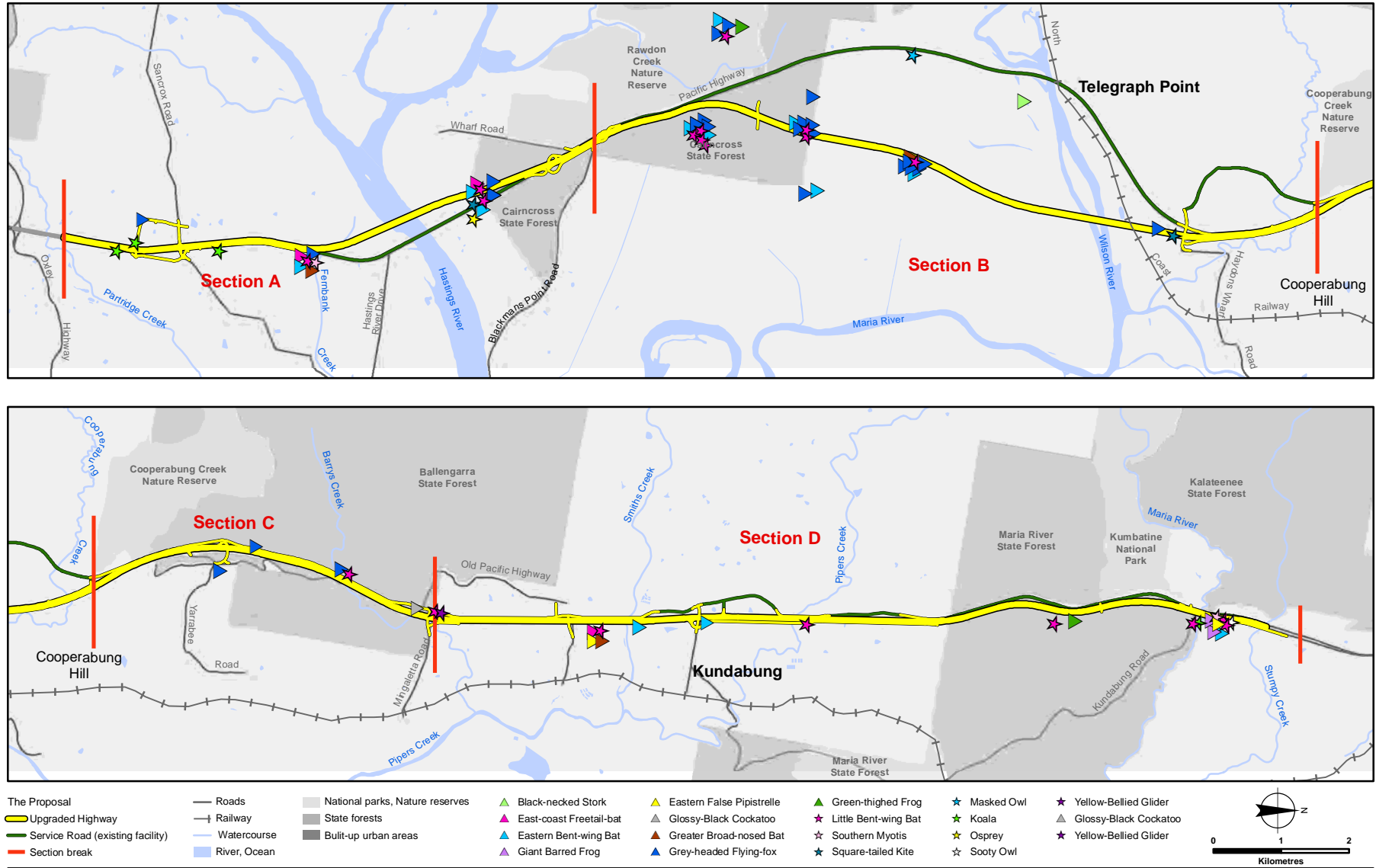
Giant barred frog

This species was recorded at the Maria River, with two individuals observed near the existing northbound bridge during summer surveys (February 2007). Subsequent visits to the site have also detected this species present, indicating a resident population occurs at the site. It is likely that this species occurs at other locations along the study area as well, such as riparian areas associated with Smiths, Pipers and Cooperabung creeks.

Glossy black-cockatoo

Two species of preferred feed trees for glossy black-cockatoo, black she-oak (*Allocasuarina littoralis*) and forest oak (*Allocasuarina torulosa*), occur in the study area and are common within the dry ridgetop forest community. Glossy black-cockatoo were seen feeding in black she-oak within Ballengarra State Forest and evidence of recent feeding (cracked she-oak cones) were noted approximately 50 metres south of Sancrox Road.

Figure 10 Threatened fauna recorded in the study area during surveys



Greater broad-nosed bat

This species was recorded at Fernbank Creek as well as another survey site via ultrasonic call detection (Anabat).

Green-thighed frog

A population of green-thighed frog was recorded in Rawdon Creek Nature Reserve and Maria River State Forest. In Maria River State Forest, at least 10 frogs were observed and heard calling from vegetation surrounding a flooded pool, indicating that this could be an important breeding site. It is likely that this species occurs at other locations along the study area as well, such as riparian areas associated with Smiths, Pipers and Cooperabung creeks.

Grey-headed flying-fox

This species was recorded at 10 survey locations along the study area by Ecotone, as well as GHD during supplementary surveys. This species is considered a seasonal feeder in the study area from nearby roosting camps at Crescent Head and Port Macquarie

Koala

A koala was sighted crossing the Pacific Highway approximately 200 metres south of Sancrox Road (GHD 2007b). Searches for koala scats and scratches on potential feed trees indicated signs of recent koala activity within Ballengarra State Forest and south of Sancrox Road.

Recent koala records are concentrated north and south of Sancrox Road, Cairncross State Forest and Rawdon Creek Nature Reserve, Ballengarra State Forest, Cooperabung Nature Reserve, Mingaletta Road to Smiths Creek, Kundabung Road to north of Pipers Creek, and Maria River State Forest (DECC 2007).

Little bent-wing bat

The little bent-wing bat was one of the most commonly recorded bat species, being found at 12 sites by Ecotone and again by GHD in supplementary fieldwork. Small numbers of this species may seasonally roost under bridges and culverts along the existing Pacific Highway, with a few individuals noted as roosting in the girder gaps of the south-bound Maria River road bridge. This species was also recorded foraging under Stumpy Creek, Pipers Creek and Smiths Creek bridges. Known breeding caves for this species occur in the Yessabah and Willi Willi caves, west of Kempsey. This species is also known to travel up to 20 kilometres at night to feed.

Masked owl

The masked owl was recorded during spring surveys (September 2006) as road kill at Telegraph Point, just south of the Wilson River. This species is considered particularly vulnerable to vehicle strikes as its preferred foraging habitat occurs along forest edges and into cleared habitats, such as roads, taking prey from the ground.

Osprey

Two individuals of this species were recorded flying over forest just north of Hastings River in November 2005. GHD also recorded this species in the study area during supplementary surveys in November 2007.

Rose-crowned fruit dove

This species was tentatively recorded from calls within the study area by GHD during supplementary surveys in November 2007.

Sooty owl

The sooty owl was recorded where the existing Pacific Highway crosses the Maria River in April 2006. A single bird was recorded responding to call playback. This species is also considered vulnerable to vehicle strike.

Southern myotis

This species was recorded at Maria River bridge by trapping and ultrasonic call detection (Anabat). Probable calls were also detected at a dam near Wharf Road. Another individual was recorded roosting in a drainage hole in the southern culvert at Barrys Creek. A potential roost site was identified at the existing Smiths Creek bridge where the species was recorded foraging in November 2007. GHD also recorded this species during supplementary surveys at the existing Smiths Creek bridge.

Square-tailed kite

Square-tailed kite was recorded foraging near Fernbank Creek, as well as just north of Wilson River at Telegraph Point. Nesting sites have been previously recorded near the existing highway north of Blackmans Point Road in Cairncross State Forest and Rawdon Creek Nature Reserve (Ecotone 2007).

Yellow-bellied glider

This species was identified by calls from the northern area of Ballengarra State Forest.

3.10.2 Invertebrate fauna

Only one threatened invertebrate, the giant dragonfly (*Petalura gigantea*), has been previously recorded in the locality. This species is listed as endangered under the TSC Act and is threatened by declining population size and loss or degradation of wetland habitats.

The giant dragonfly has been recorded from both coastal and upland permanent wetlands from Moss Vale to southern Queensland, but has not been recorded in most areas for many years. Currently, the largest and most viable population is believed to occur in sphagnum swamp areas within Wingecarribee Swamp near Moss Vale. Only one record exists from within the locality of the study area (DECCW Wildlife Atlas). However, the paucity of records for the giant dragonfly in the locality may be more a reflection of the generally low likelihood of encountering individuals given their prolonged underground larval stage (10-20 years) and relatively short conspicuous adult phase, rather than an accurate indication of its presence in the locality.

The giant dragonfly was not specifically targeted during field surveys though habitat assessments identified suitable potential habitat in permanent swamps and bogs in the study area, particularly on the Hastings River and Wilson River floodplains.

No other threatened invertebrates are predicted to occur in the study area.

3.11 Migratory species

Of the 50 migratory species listed under the EPBC Act 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 3-9**.

Table 3-9 Migratory fauna species recorded during field surveys or considered likely to occur in the study area

Common name	Scientific name	TSC Act	EPBC Act
Listed migratory species recorded in the study area			
cattle egret	<i>Ardea ibis</i>		Migratory
black-faced monarch	<i>Monarcha melanopsis</i>		Migratory
Latham's snipe	<i>Gallinago hardwickii</i>		Migratory
osprey	<i>Pandion haliaetus</i>	Vulnerable	Migratory
rufous fantail	<i>Rhipidura rufifrons</i>		Migratory
satin flycatcher	<i>Myiagra cyanoleuca</i>		Migratory
white-bellied sea-eagle	<i>Haliaeetus leucogaster</i>		Migratory
white-throated needletail	<i>Hirundapus caudacutus</i>		Migratory
Listed migratory species that may potentially occur in the study area			
Australian painted snipe	<i>Rostratula australis</i>		Migratory
fork-tailed swift	<i>Apus pacificus</i>		Migratory
great egret	<i>Ardea alba</i>		Migratory
rainbow bee-eater	<i>Merops ornatus</i>		Migratory
regent honeyeater	<i>Xanthomyza phrygia</i>	Endangered	Endangered, Migratory
spectacled monarch	<i>Monarcha trivirgatus</i>		Migratory
swift parrot	<i>Lathamus discolor</i>	Endangered	Endangered, Migratory

3.12 Aquatic habitats

3.12.1 Watercourses and wetlands

The main aquatic habitat features within the study area are the two large rivers, the Hastings River and Wilson River. 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.

Wetland areas listed under *State Environmental Planning Policy No. 14 – Coastal Wetlands* occur on Dalhunny Island and the adjacent northern bank of the Wilson River.

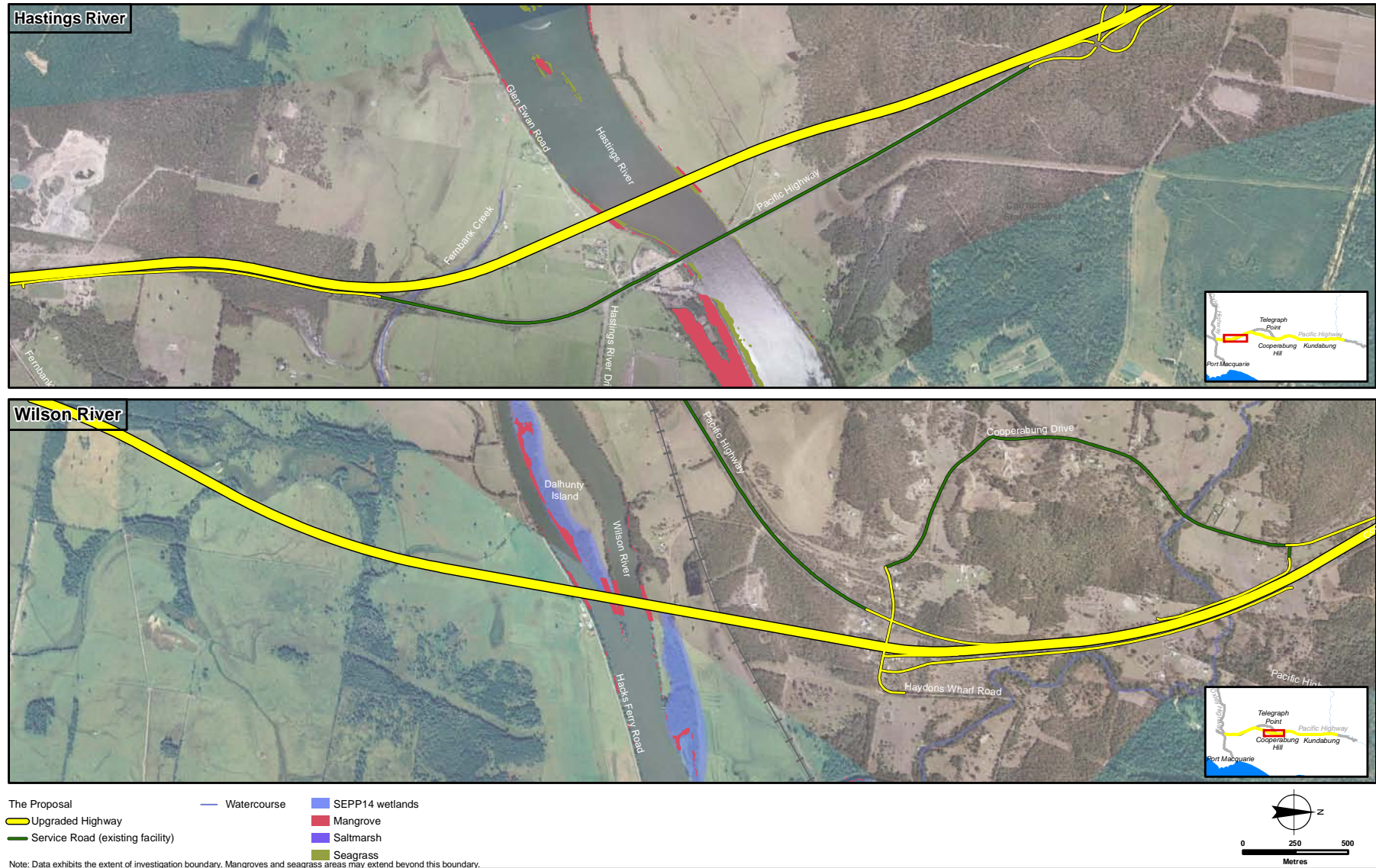
There are also a number of permanent and ephemeral creeks within the study area. There is no clear geomorphological or ecological distinction between creeks and rivers although creeks are generally considered to be intermittent streams and rivers are more or less permanent streams. Most of the streams in the investigation areas are intermittent and comprise a well-defined channel with ponds and riffles. The ponds may retain water for weeks or months, and are therefore important aquatic habitats. While some wetland plants often grow in the ponds, characteristic wetland vegetation is typically sparse or absent on the stream banks, generally being replaced by rainforest species (*Melaleuca* species are also often present).

The main watercourses and State listed wetlands present within the study area are listed in **Table 3-10** and shown in **Figure 11**.

Table 3-10 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 Dalhunny 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 understory 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 11 Aquatic habitats - State listed wetlands, seagrasses, and mangroves



3.12.2 Seagrasses and mangroves

Seagrasses occur within the inter-tidal and sub-tidal zones of estuaries and are a valuable feeding and shelter site for hatchling fish and other aquatic animals, including commercially and recreationally important fish, crustacean and mollusc species. Seagrasses are an important part of the estuarine food chain, and work as a buffer against water currents helping to maintain water quality by reducing nutrient levels and preventing erosion by stabilising sediments (Smith et al., 1997).

Mangroves grow along the shores of many NSW estuaries where they are exposed to regular tidal inundation. Mangroves and mangrove creeks provide important habitat for a range of fish and crab species, as well as birds and other fauna. Mangrove trees provide a valuable food source to many small aquatic animals, being an important link within the aquatic food chain, and also help to maintain water quality by filtering runoff from surrounding landscapes, reducing nutrient loads and silt entering watercourses, as well as stabilising banks and controlling erosion (West et al., 1985).

Seagrasses were recorded within the study area in the Hastings River and extended for over 500 metres in both directions from the study area. Mangroves were recorded within the study area along the banks of both the Hastings and Wilson rivers and on Dalhenty Island. Mangroves were widespread on Dalhenty Island and extended for over 500 metres in both directions from the study area on both Hastings and Wilson rivers. The results of the seagrass and mangrove surveys in the study area are detailed in **Section 3.15**.

3.12.3 Saltmarsh

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 2.5 kilometres upstream (by river) from the development footprint on the Hastings River, and approximately 10 kilometres downstream on the Wilson River.

3.12.4 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.

3.12.5 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 description of riparian vegetation along watercourses (including vegetation type, condition and extent) intersected by the Proposal is provided in **Table 3-11** below.

Table 3-11 Vegetation in existing riparian corridors

Name	Vegetation type	Vegetation in existing riparian corridors
Fernbank Creek	Paperbark Swamp Forest (Swamp Oak Floodplain Forest EEC)	<p>Riparian vegetation extends approximately 80 m from the northern bank and 70 m from the southern bank at the proposed crossing and adjoins cleared lands to the north and south of the creekline. The vegetation is in good condition characterised by dense native species and low levels of weeds.</p> <p>Riparian vegetation connectivity is patchy along the creek line to the east and west of the proposed crossing. Regeneration of native vegetation has occurred to within 5 m of the existing creek crossing.</p>
Hastings River	Mangroves (protected aquatic vegetation)	<p>A narrow corridor of riparian vegetation extends approximately 5 m from the northern bank and 5 m from the southern bank at the proposed crossing. The riparian vegetation adjoins cleared lands to the north and south of the River. The vegetation is in very poor condition, and has been largely cleared and invaded by exotic pasture grasses.</p> <p>Riparian vegetation connectivity is patchy along the River to the east and west of the proposed crossing. Little regeneration of native vegetation has occurred within 100 m of the existing creek crossing.</p>
Wilson River	Mangroves and Swamp Oak Forest (Subtropical Coastal Floodplain Forest EEC)	<p>A narrow corridor of riparian vegetation extends approximately 15 m from the northern bank and 15 m from the southern bank at the proposed crossing. The vegetation is in good condition characterised by native species and low levels of weeds. The riparian vegetation adjoins cleared lands to the north and south of the River.</p> <p>Riparian vegetation connectivity is generally continuous as a narrow band along both banks to the east and west of the proposed crossing. Regeneration of native vegetation has occurred within 5 m of the existing crossing.</p>
Cooperabung Creek	Riparian Forest (Swamp Sclerophyll Forest on Coastal Floodplains EEC)	<p>Riparian vegetation extends approximately 25 m from the northern bank and 25 m from the southern bank at the proposed crossing and is contiguous with native vegetation to the north and south of the creekline. The vegetation is in good condition characterised by dense native species and low levels of weeds.</p> <p>Riparian vegetation is continuous along the creek line to the east and west of the proposed crossing. Regeneration of native vegetation has occurred to within 5 m of the existing creek crossing.</p>
Barrys Creek	Moist Floodplain Closed Forest with Rainforest Elements (Swamp Sclerophyll Forest on Coastal Floodplains EEC)	<p>Riparian vegetation extends approximately 50 m from the northern bank and 50 m from the southern bank at the proposed crossing and is contiguous with native vegetation in all directions from the creekline. The vegetation is in good condition characterised by dense native species and low levels of weeds.</p> <p>Regeneration of native vegetation has occurred within 5 m of the existing crossing.</p>

Name	Vegetation type	Vegetation in existing riparian corridors
Smiths Creek	Riparian Forest (Swamp Sclerophyll Forest on Coastal Floodplains EEC)	Riparian vegetation extends approximately 80 m from the northern bank and 80 m from the southern bank at the proposed crossing and is contiguous with native vegetation to the north and south of the creekline. The vegetation is in very good condition characterised by dense native species and low levels of weeds. Riparian vegetation is continuous along the creek line to the east and west of the proposed crossing. Regeneration of native vegetation has occurred to within 5 m of the existing creek crossing.
Pipers Creek	Riparian Forest (Swamp Sclerophyll Forest on Coastal Floodplains EEC)	Riparian vegetation extends approximately 70 m from the northern bank and 20 m from the southern bank at the proposed crossing and is contiguous with native vegetation to the north and south of the creekline. The vegetation is in very good condition characterised by dense native species and low levels of weeds. Riparian vegetation is continuous along the creek line to the east and west of the proposed crossing. Regeneration of native vegetation has occurred to within 5 m of the existing creek crossing.
Maria River	Riparian Forest (Swamp Sclerophyll Forest on Coastal Floodplains EEC)	Riparian vegetation extends approximately 80m from the northern bank and 80 m from the southern bank at the proposed crossing and is contiguous with native vegetation to the north and south of the River. The vegetation is in good condition characterised by dense native species and low levels of weeds. Riparian vegetation is is contiguous with native vegetation east, west and south of Maria River. Regeneration of native vegetation has occurred to within 5 m of the existing creek crossing.
Stumpy Creek	Riparian Forest (Swamp Sclerophyll Forest on Coastal Floodplains EEC)	Riparian vegetation extends approximately 25 m from the northern bank and 25 m from the southern bank at the proposed crossing and is contiguous with native vegetation in all directions. The vegetation is in very good condition characterised by dense native species and low levels of weeds. Riparian vegetation is continuous along the creek line to the east and west of the proposed crossing. Regeneration of native vegetation has occurred to within 5 m of the existing creek crossing.

3.13 Aquatic fauna

3.13.1 Fish survey and habitat assessment results

A total of 2550 fish representing seven species were sampled from the five watercourses sampled, as shown in **Table 3-12**.

Table 3-12 Overall fish catch for each watercourse sampled

Common name	Scientific name	Pipers Creek	Smiths Creek	Fernbank Creek	Cooperabung Creek	Maria River
firetail gudgeon	<i>Hypseleotris galii</i>	101	3	605	9	11
empire gudgeon	<i>Hypseleotris compressa</i>	58	84	3	8	7
striped gudgeon	<i>Gobiomorphus australis</i>	137	161	1	105	65
crimson-spotted rainbowfish	<i>Melanotaenia duboulayi</i>	0	0	0	5	0
long-finned eel	<i>Anguilla reinhardtii</i>	0	0	0	10	0
short-finned eel	<i>Anguilla australis</i>	4	1	26	0	4
gambusia	<i>Gambusia holbrooki</i>	207	3	920	3	11
Total species		5	5	5	6	5

The most abundant species caught across all sites was the introduced *Gambusia holbrooki*, accounting for 45 per cent of the total catch. Three species belonging to the family Eleotridae collectively contributed a further 53 per cent to the overall abundance; the firetail gudgeon (*Hypseleotris galii*), empire gudgeon (*Hypseleotris compressa*) and striped gudgeon (*Gobiomorphus australis*), contributing 29 per cent, 6 per cent and 18 per cent respectively.

Two species of eels were recorded. Short-finned eel (*Anguilla australis*) were recorded from four of the five watercourses sampled. Collectively, the specimens recorded accounted for 1 per cent of the overall abundance. The long-finned eel *Anguilla reinhardtii* was recorded at only one watercourse (Cooperabung Creek) and accounted for less than 1 per cent of the overall abundance. These results are a reflection of the habitat preferred of these species; the long-finned eel prefers running water while the short-finned eel is generally found in more static water bodies.

The crimson-spotted rainbowfish (*Melanotaenia duboulayi*) was only recorded at Cooperabung Creek. Only five specimens were collected, accounting for less than 1 per cent of the overall abundance.

Gambusia was the only non-native species recorded in the five watercourses sampled.

The number of species sampled across four of the five sites was relatively consistent. Cooperabung Creek was the most diverse watercourse with six species recorded. Pipers Creek and Smiths Creek shared the same fish fauna in terms of species composition, as did Fernbank Creek and Maria River.

The fish communities sampled across the five watercourses were relatively consistent. Although the relative abundance of each species varied, there were four species common to all watercourses. These were the firetail gudgeon, empire gudgeon, striped gudgeon and the introduced gambusia.

The fish species recorded are known to be resilient to low dissolved oxygen concentrations, possibly explaining the uniformity observed across sites. Aquatic organisms become stressed when concentrations of dissolved oxygen fall below 6 milligrams per litre (ANZECC 2000) and are likely to further become stressed through diurnal fluctuations of temperature. This is especially compounded in streams of an ephemeral nature, which at times are reduced to a series of isolated pools that are susceptible to stagnation and organic enrichment, particularly where stock access is unrestricted.

It is widely recognised that oxygen concentrations are a factor influencing the composition of freshwater communities because it critically affects the distribution of many species (Connolly *et al.* 2004). The absence of large predatory species such as Australian bass (*Maquaria novemaculeata*), estuary perch (*Maquaria colonorum*) and oxygen-sensitive foraging species such as Australian smelt (*Retropinna semoni*) and common jollytail (*Galaxius maculatus*) suggests that oxygen concentrations may be a significant factor determining the structure of the fish community within the watercourses sampled within the study area.

The ANZECC (2000) trigger values for physical or chemical stress in freshwater lowland rivers in south east Australia are as follows:

- Dissolved oxygen (percentage saturation): lower limit 85 per cent, upper limit 110 per cent.
- pH: lower limit: 6.5, upper limit 8.0.
- Salinity: lower limit 125 microsiemens per centimetre, upper limit 2200 microsiemens per centimetre.
- Turbidity: lower limit 6 nephelometric turbidity units (NTU), upper limit 50 NTU.

The results of the habitat assessment and fish surveys for sampled watercourses in the study area are described in more detail below.

3.13.2 Fernbank Creek

Fernbank Creek was the only watercourse not flowing at the time of the survey. The riparian vegetation was relatively denuded, having been cleared for agriculture. An upstream sample could not be obtained due to the creek being dry. Through visual observations, it was evident that the area is affected by acid sulfate soils. The existing highway does not appear to be limiting the movement of aquatic fauna from one side of the highway to the other.

Fernbank Creek downstream site 1

Fernbank Creek was not flowing at the time of the survey. Situated approximately 2 kilometres downstream of the Proposal, site 1 was characterised by a lowland wetland habitat with an average depth of 1.5 metres. At the widest point, the creek/wetland was approximately 70 metres in width. The site contained an abundance of aquatic vegetation, mostly consisting of water lilies and aquatic sedges. The approximate aquatic vegetation cover was 50 per cent of the total wetland area. On the northern bank, there was limited overhanging vegetation.

The substratum at this site, which was largely anoxic, consisted of 70 per cent mud with approximately 30 per cent silt. Due to the creek being situated in agricultural land, the creek bed was pugged up by cattle and somewhat degraded. There were a limited number of snags to provide structural cover for fish.

The water within Fernbank Creek was not tannic and relatively clear with a turbidity of 12.1 NTU, and a dissolved oxygen content of 4.43 milligrams per litre. The corresponding electrical conductivity was higher than found in previous watercourses, with a value of 878.0 microsiemens per centimetre.

Although the water was not tannic, the pH levels were slightly acidic, with a value of 6.86. When compared with ANZECC trigger values for freshwater lowland rivers in southeast Australia, the water quality variables measured do not exceed the trigger values with the exception of the low dissolved oxygen level.

With its close proximity to tidal estuaries, abundance of aquatic vegetation and the presence of 'wallum' scrubland in the immediate area, this site represents potential habitat for the Oxleyan pygmy perch. However, despite extensive sampling, no specimens were found at this site.

Fernbank Creek downstream site 2

Situated approximately 50 metres downstream of the Proposal, this site was largely open agricultural land, characterised by open plains with pockets of remnant melaleucas. The average depth of this site was 1 metre, with a width of 30 metres.

There was an abundance of aquatic vegetation covering 50 per cent of the total area sampled. However, unlike site 1, there were a large number of snags and large woody debris present, providing valuable instream structural habitat components. The substrata consisted of 100 per cent mud and released methane gas when disturbed, indicating anoxic conditions. Despite this anoxic sediment, the dissolved oxygen levels were higher than other sampled watercourses with a concentration of 5.15 milligrams per litre.

The corresponding pH and electrical conductivity levels were 6.94 and 951 microsiemens per centimetre respectively, with the elevated conductivity levels most likely resulting from the acid sulphate oxidation 50 metres upstream. The water was slightly tannic with a turbidity of 10.2 NTU. The water temperature was 24.3 degrees Celsius. When compared with ANZECC trigger values for freshwater lowland rivers in southeast Australia, the water quality variables measured do not exceed the trigger values with the exception of the dissolved oxygen level.

Similar to site 1, this site represents potential habitat for the Oxleyan pygmy perch, however no specimens were found.

Fernbank Creek fish survey

With 1555 individuals belonging to five families, Fernbank Creek was the most diverse watercourse sampled in terms of number of individuals. The introduced gambusia was the most abundant species, accounting for 59 per cent of the total fish sampled. The abundance of gambusia and sizes ranging from 5 millimetres to 30 millimetres in length indicate that Fernbank Creek supports a viable population of this species.

The firetail gudgeon accounted for a further 38 per cent of fish recorded and were the second most abundant species sampled. The size classes of the firetail gudgeon similarly indicated that the population was viable. Only one specimen of striped gudgeon and three specimens of empire gudgeon were recorded. The low numbers of these species may be due to the high numbers of Gambusia which is known to predate on the eggs and larvae of native fish.

The short-finned eel was the third most abundant species, with 26 individuals.

Despite this site being the most likely habitat for Oxleyan pygmy perch based on known habitat associations, none were found. No creeks in the study area occur within the known distribution ranges for the species.

3.13.3 Cooperabung Creek

Cooperabung Creek was a very different type of habitat compared to the other sampled watercourses. Cooperabung Creek was shallow, fast flowing with defined riffle and pool sections; rock (cobble) substrate and the presence of macrophytes. Access to this site was good with three sites sampled. The existing highway does not appear to be limiting the movement of aquatic fauna from one side of the highway to the other.

Cooperabung Creek downstream site 1

This site was situated amongst partially cleared agricultural land. The creek was approximately 3 metres wide, with an average depth of 0.6 metres. The substrata consisted of 100 per cent cobbles (average diameter 10 centimetres) with scattered macrophytes covering 10 per cent of the reach. The water was not tannic, but was slightly murky with a turbidity of 29.6 NTU. Similar to all watercourses sampled as part of this study, the pH of 6.32 was slightly acidic. The detritus cover of 30 per cent was restricted to the littoral zone, a feature indicative of streams that receive high velocity flows. The dissolved oxygen concentration was much higher than recorded in the other sampled watercourses, with a value of 5.27 milligrams per litre.

The instream habitat was good, with an abundance of snags and undercut banks providing good cover for fish. The riparian strip was relatively intact and consisted of dense rainforest-like species. Over hanging vegetation provided 60 per cent cover. Electrical conductivity was 174.6 microsiemens per centimetre.

The dissolved oxygen and the pH level at this site exceed the ANZECC trigger values for freshwater lowland rivers in southeast Australia.

Cooperabung Creek downstream site 2

This site was slightly more channelised than site 1, with an average depth of 1 metre and a width of 1.5 metres. The flow within this section was good; however, due to its depth it was not flowing as fast as at site 1. The substrata of this section consisted of 60 per cent cobble and 40 per cent clay, with localised sections of silt in areas deeper than 1.5 metres. The riparian zone was not as intact, with intermittent clearings for vehicle crossings. The canopy covered 40 per cent of the area sampled.

The water quality parameters were consistent with site 1, possibly a reflection of the consistent flow within this watercourse. The turbidity was 28.1 NTU with a pH of 6.43 and a dissolved oxygen level of 5.05 milligrams per litre. The electrical conductivity at this site was 175 microsiemens per centimetre.

The dissolved oxygen and the pH level at this site exceed the ANZECC trigger values for freshwater lowland rivers in southeast Australia.

Cooperabung Creek upstream site 1

Located approximately 700 metres upstream of the Pacific Highway, this site was very similar in characteristics to downstream site 1. There was an average width of 3 metres and a depth of 0.6 metres, and the riffle substrata consisted of 100 per cent cobbles (average diameter 10 centimetres). Slightly murky in appearance, the turbidity was 21.2 NTU with a pH of 6.57. The dissolved oxygen concentration was measured at 5.42 milligrams per litre at a temperature of 23.8 degrees Celsius. The electrical conductivity was 161.9 microsiemens per centimetre.

The low dissolved oxygen at this site exceeds the ANZECC trigger values for freshwater lowland rivers in southeast Australia.

Cooperabung Creek fish survey

Cooperabung Creek was the most diverse watercourse sampled in terms of species richness, with 140 individuals belonging to six families. The most abundant species was the striped gudgeon accounting for 36 per cent of the total catch. Individuals of all size classes were represented, indicating a viable population within this system. The maximum and minimum length for this species were 120 millimetres and 16 millimetres respectively, with the majority of individuals occurring between 31 millimetres and 70 millimetres.

Crimson-spotted rainbowfish were collected from this watercourse, accounting for 3 per cent of the overall catch. As only five specimens were collected, it is difficult to determine whether the population is viable, although the presence of this species in this creek and no others during the survey suggests that they may prefer flowing waters. However, it should be noted that this species has also been recorded in still or slow-flowing conditions, particularly around vegetation and snags (McDowall 1996).

The firetail gudgeon sampled ranged in size from 18 millimetres to 35 millimetres, and accounted for 6 per cent of the total catch.

Ten long-finned eels were sampled from this site, ranging from 80 millimetres to 1000 millimetres in length. This size range indicates sufficient connectivity within this system for the reproductive success of this species.

3.13.4 Smiths Creek

Smiths Creek was very similar to Pipers Creek in terms of hydrology and habitat characteristics. Due to issues with upstream access, two sites downstream of the existing Pacific Highway were sampled. Sections of Smiths Creek were extremely deep (greater than 2 metres). The existing highway does not appear to be limiting the movement of aquatic fauna from one side of the highway to the other.

Smiths Creek downstream site 1

Smiths Creek is a medium-sized creek with little flow. The average depth of the area sampled was 1.2 metres; however, there were holes greater than 2 metres in depth. The average width of the creek at this site was 5 metres.

There was an abundance of large woody debris with an approximate detritus cover of 100 per cent over the silt substrate. The sediment discharged methane bubbles when disturbed, indicating anoxic conditions in the substrata. The dissolved oxygen levels at this site were extremely low with a value of 1.86 milligrams per litre.

The water appeared clear but heavily tannic with a corresponding turbidity of 12.1 NTU. The pH at this site was slightly acidic with a value of 6.38. There were localised areas of aquatic vegetation present that included lilies and macrophytes. Floating vegetation covered 10 per cent of the total area sampled, while submerged macrophytes were more prevalent with 40 per cent cover. The riparian vegetation at this site was intact, providing approximately 30 per cent canopy cover.

Both dissolved oxygen and the pH level at this site exceed the ANZECC trigger values for freshwater lowland rivers in southeast Australia.

The vegetation primarily comprised rainforest species, thus not fitting the 'wallow' habitat requirements for Oxleyan pygmy perch or the requirements for eastern freshwater cod.

Smiths Creek downstream site 2

The average width of Smiths Creek at site 2 was 4 metres, with an average depth of 0.7 metres. Because of the relatively shallow depth of this site, it was able to be more extensively sampled using active methods.

The sediment (including a 100 per cent detritus layer) was largely anoxic with a corresponding dissolved oxygen content of 1.69 milligrams per litre. Within this site was an abundance of snags and large woody debris providing valuable habitat for fish. Unlike site 1, an oily surface film was present, further suggesting anoxic conditions.

Although there was no submerged aquatic vegetation at this site, there was an abundance of overhanging vegetation providing 90 per cent canopy cover and an important source of organic input into the system. The substrata at this site consisted of 90 per cent silt with 10 per cent clay. Overhanging banks and dense vegetation in the littoral zone provided an abundance of structural habitat for fish.

The water appeared slightly murky and heavily tannic with a corresponding turbidity of 32.3 NTU and pH of 7.07. The electrical conductivity was 273 microsiemens per centimetre. When compared with ANZECC trigger values for freshwater lowland rivers in southeast Australia, the water quality variables measured do not exceed the trigger values with the exception of the low dissolved oxygen level.

Smiths Creek fish survey

Smiths Creek contained 252 individuals belonging to five families. The striped gudgeon was the most dominant species sampled with 161 individuals accounting for 63 per cent of the total fish recorded. Fish ranged in length from 10 millimetres to 104 millimetres, with the majority of specimens between the 35 millimetres and 51 millimetres size class. Although large adult specimens were present, the majority of fish caught were juvenile, suggesting that the lower reach of Smiths Creek is possibly a collection sink for juveniles that have drifted downstream as larvae.

This high abundance of striped gudgeon could possibly explain the relatively low abundance of gambusia, which only contributed 1 per cent to the overall abundance. Gambusia are a key component of the striped gudgeon's diet.

The second most abundant species was the empire gudgeon, contributing a further 33 per cent (83 individuals) to the overall abundance. The size distribution recorded indicates that a population consisting of two distinct generations exists within Smiths Creek. The first generation consisting of juvenile specimens ranged from 16 millimetres to 34 millimetres in length and the second consisting of adult specimens, ranging from 36 millimetres to 51 millimetres in length. Another likely explanation is sexual segregation; however, as fish sex was not recorded, further investigation into this scenario is not possible.

Three firetail gudgeons were sampled, suggesting the creekline provides only marginal habitat for this species.

Young eels enter freshwater during spring and summer, penetrating the upper reaches of rivers, creeks and wetlands (McDowall 1996). The presence of a short-finned eel elver suggests that despite the lack of flow, there is sufficient connectivity in the system to facilitate eel migration from the sea.

3.13.5 Pipers Creek

At the time of the survey, there was very little flow running through Pipers Creek. Generally, the water was very tannic with extremely low oxygen levels. Sections of the creek were relatively deep (greater than 2 metres), making sampling somewhat difficult. As a result, only two sites downstream of the existing Pacific Highway could be sampled. Upstream of the Pacific Highway was deemed unsafe to sample due to sheer banks, deep water and limited access. The existing highway does not appear to be limiting the movement of aquatic fauna from one side of the highway to the other.

Pipers Creek downstream site 1

Downstream site 1 was approximately 20 metres in width at its widest point. With a depth greater than 2 metres, this site formed an open wetland-type habitat with an abundance of submerged (70 per cent cover) and emergent (20 per cent cover) aquatic vegetation. Situated along the northern bank, there was an abundance of overhanging vegetation providing an important source of large woody debris and fine organic matter. The substratum consisted of 80 per cent silt and 20 per cent clay, with an approximate detritus cover of 60 per cent. The southern bank was relatively denuded of riparian vegetation. Methane bubbled from the sediment upon disruption, indicating anoxic conditions in the substrata.

The dissolved oxygen levels within this waterhole were extremely low with a value of 1.65 mg/L at a temperature of 23.1 degrees Celsius. The electrical conductivity for this site was 184 microsiemens per centimetre.

The water within this waterhole was heavily tannic with a turbidity of 31.4 NTU, and slightly acidic with a pH of 6.5, providing potential conditions favourable for Oxleyan pygmy perch. However, the riparian vegetation type does not fit the 'wallum' habitat type indicative of this species' preferred habitat. When compared with ANZECC trigger values for freshwater lowland rivers in southeast Australia, the water quality variables measured do not exceed the trigger values for physical or chemical stress, with the exception of the low dissolved oxygen level.

Due to the low dissolved oxygen concentrations and the location of this site outside the natural range of the eastern freshwater cod, this species presence in this watercourse is very unlikely.

Pipers Creek downstream site 2

Situated approximately 300 metres downstream of the existing Pacific Highway, this site was characterised by steep banks and thick detritus cover (100 per cent) on a silt substrata. The sediment was highly anoxic with methane bubbles discharged when disturbed. Pipers Creek at this site was relatively channelised with an average width of 4 metres and the presence of many large holes deeper than 2 metres. The average depth sampled was approximately 1.2 metres.

There was no aquatic vegetation, either submergent or emergent, at this site. However, the riparian zone was intact, providing a canopy cover of 80 per cent. The vegetation was primarily comprised of lowland rainforest species (for example, lilly pilly), thus not fitting the 'wallum' habitat requirements for Oxleyan pygmy perch.

Similar to site 1, the water was tannic with a turbidity of 23.1 NTU. The dissolved oxygen was slightly higher with a value of 1.84 milligrams per litre and a pH level of 6.36. The electrical conductivity was 184 microsiemens per centimetre.

Both dissolved oxygen and the pH level at this site exceed the ANZECC trigger values for freshwater lowland rivers in southeast Australia.

Pipers Creek fish survey

507 individuals from five families were sampled from Pipers Creek. *Gambusia* was the dominant species, with 207 individuals accounting for 40 per cent of the total abundance. The length distribution of *Gambusia* ranged from 5 millimetres to 39 millimetres, indicating that the population within this creek is viable, having undergone a period of recent recruitment. This was also the case with the firetail and empire gudgeons that contributed a further 31 per cent combined, with respective values of 20 per cent and 11 per cent.

Striped gudgeon ranged in size from 41 millimetres to 70 millimetres, with the majority of the specimens belonging to the 26 millimetres to 46 millimetres size class. The distinct lack of large individuals (greater than 46 millimetres) suggests that the population is a sink for juveniles washed down from the upper reaches of the catchment. Striped gudgeon was the second most abundant species sampled from this site, accounting for 27 per cent of the fish recorded.

Short-finned eels were recorded. The presence of an elver indicated that recent recruitment has occurred in the system.

3.13.6 Maria River

Access to this site was extremely limited due to the dense rainforest-like vegetation and sheer banks flanking each side of the river. At the time of the survey there were fast flows down the Maria River due to heavy rain the night before, resulting in higher water levels than would normally be expected. However, sampling still recorded species that would be expected to occur in this habitat, and the heavy rain is unlikely to have impacted on the diversity of species recorded. The existing highway does not appear to be limiting the movement of aquatic fauna from one side of the highway to the other.

Maria River downstream site 1

The riparian vegetation at this site was intact, providing 100 per cent canopy cover. However, despite this, there was a lack of instream aquatic vegetation. The substrata at this site comprised 90 per cent clay, 10 per cent silt and a thick detritus layer of 100 per cent. There was a number of large snags and woody debris providing an abundance of cover for aquatic fauna. Similarly, undercut banks were present, providing valuable refuge for fish during periods of high flow. Due to the heavy rain experienced prior to sampling, the water was relatively turbid with a value of 56.0 NTU.

The main river channel was 1.5 metres wide with an average depth of 1.2 metres. At this site were a number of holes greater than 1.5 metres in depth. The dissolved oxygen content at this site was 5.82 milligrams per litre at 22 degrees Celsius, with an electrical conductivity of 160 microsiemens per centimetre. The pH was rather acidic with a value of 5.94.

The dissolved oxygen, turbidity and the pH level at this site exceed the ANZECC trigger values for freshwater lowland rivers in southeast Australia.

Despite the acidic nature of the water, this site is considered unlikely habitat for Oxleyan pygmy perch given the lack of instream vegetation and the presence of rainforest-like vegetation on the riparian strip.

Maria River downstream site 2

Site 2 was situated amongst dense rainforest-like vegetation providing 100 per cent cover. The river at this location was approximately 2 metres wide with an average depth 1.2 metres. The site was characterised by a lack of instream aquatic vegetation, with a substrata of 90 per cent clay, 10 per cent silt and a thick detritus layer of 100 per cent that bubbled methane when disturbed. The dissolved oxygen level was 2.08 milligrams per litre with a turbidity of 84.1 NTU. The electrical conductivity was measured at 160 microsiemens per centimetre with a pH value of 5.94.

The dissolved oxygen, turbidity and the pH level at this site exceed the ANZECC trigger values for freshwater lowland rivers in southeast Australia.

Maria River fish survey

A total of 98 fish belonging to five families were sampled from the Maria River. The striped gudgeon was the most dominant species sampled, with 65 individuals accounting for 66 per cent of the total fish sampled. Ranging in length from 21 millimetres to 90 millimetres, the full size range with large breeding adults and juveniles suggests that this species completes a full lifecycle at this location. However, similar to other sampled sites, the majority of fish caught were juvenile.

The second most abundant species sampled from this watercourse were gambusia, the firetail gudgeon and the empire gudgeon, representing 22 per cent of the fish recorded.

Four short-finned eels were sampled from this site, with all specimens under 300 millimetres in length.

3.13.7 Stumpy Creek

The study area was extended to include Stumpy Creek after the aquatic assessments were completed. An aquatic habitat assessment would be undertaken at Stumpy Creek, with the results incorporated into the Submissions Report.

3.14 Threatened aquatic species

3.14.1 Threatened aquatic plants

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 FM Act have been previously recorded in the locality. No threatened aquatic plants are expected to occur in the Proposal footprint based on absence of suitable habitat types (marine habitat for algae).

3.14.2 Threatened fish

No threatened fish species listed under the FM Act 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 daemeli*), 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 FM Act 1994 and the EPBC Act, could occur in the locality based on habitat preferences (**Appendix B**). 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 FM Act or the EPBC Act are considered likely to occur in the study area.

Oxleyan pygmy perch

No records of the Oxleyan pygmy perch were found in the BioNet database for the study area. The study area is located beyond the southern limit of the currently known distribution of the Oxleyan pygmy perch. Broad-scale surveys undertaken by DII to establish the distributional limits of the species have been unable to locate Oxleyan pygmy perch south of Yuraygir National Park. This is well outside the study area, approximately 42 kilometres north of Coffs Harbour. However, based on the habitat requirements for the Oxleyan pygmy perch identified by DII, it was considered that the study area may provide potential habitat and the Oxleyan pygmy perch was targeted during the aquatic field surveys.

The Oxleyan pygmy perch occurs in coastal banksia-dominated heath or 'wallum' habitats containing freshwater lakes, creeks and wetlands (Allen, Midgley and Allen 2003). The pH levels within these habitats usually range from 5.9-7.2 and the water tends to be organically stained (McDowall 1996). This species is generally restricted to waters of low conductivity (less than 330 microsiemens per centimetre) and low flow environments (less than 0.3 metres per second) (Knight 2000).

The Oxleyan pygmy perch usually inhabits waters with a high proportion of aquatic plant cover, ie between 60-80 per cent (DPI, 2005). Plant cover usually consists of various aquatic macrophytes, including stands of emergent sedges (*Lepironia articulata*, *Gahnia sp.* and *Juncus sp.*), beds of submerged sedges (*Eleocharis ochrostachys*) and growths of *Nymphaea sp.*, *Chara sp.* and *Utricularia sp.* (DPI, 2005). In northern NSW, the broad-leaved paperbark (*Melaleuca quinquenervia*) occurred at 80 per cent of the sites where the Oxleyan pygmy perch was present, and assemblages of native riparian vegetation and aquatic macrophytes were found in association with the fish at many of the sites (Knight 2000). Although the water quality parameters for Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River share the common attributes of the chemical characteristics required for the Oxleyan pygmy perch habitats, the study found that these streams lack the aquatic vegetative cover and 'wallum' banksia/melaleuca riparian habitat critical for the presence of this species.

The only creek sampled that fitted all facets of the typical Oxleyan pygmy perch habitat was Fernbank Creek and it would be considered likely habitat for this species based on known habitat associations. However, Fernbank Creek contains an abundant population of gambusia, and therefore the likelihood of a co-existing population of Oxleyan pygmy perch is somewhat diminished. Gambusia is competitive and combines high environmental tolerance with flexible feeding and habitat needs and could compete with native species for food and other resources. Gambusia has been linked to the worldwide decline of many endemic fish species. They are now regarded as a pest in Australian waters.

While there is little information about the impacts of gambusia on Oxleyan pygmy perch, their aggression and ability to survive and compete for food in habitats native to Oxleyan pygmy perch suggests that their presence has been detrimental. Intentionally introducing other fish into areas outside their natural range (such as to enhance recreational fishing opportunities) may also have negative impacts on Oxleyan pygmy perch because the species have not co-evolved. Furthermore, no creeks in the study area occur within the known natural distribution of Oxleyan pygmy perch.

It is highly unlikely that the watercourses studied present potential habitat for this species.

Eastern freshwater cod

The habitats of the five watercourses sampled did not equate with the habitat requirements of the eastern freshwater cod. This species prefers clear rocky streams (McDowall 1996) and rivers with slow flow and an abundance of instream cover including rocks, timber or tussocks (Rowland 1996). Recent research indicates that it is associated with deeper parts of the river near cover, especially around rocky islands and large boulders in faster-flowing sections. As with related species, large woody debris may provide shelter and important spawning sites (Eastern Cod Recovery Plan 1999). Unfortunately, the habitat requirements of the various life history stages are largely unknown; however, it is likely that, as with similar species (ie *Maccullochella peelii*), seasonal fluctuations in water level and changes in water temperature act as environmental cues for spawning and migration.

The watercourses surveyed are not within the known natural distribution of the eastern freshwater cod. It is highly unlikely that the watercourses studied present potential habitat for this species.

3.15 Protected aquatic species

Mangroves and seagrasses, which are listed as protected marine vegetation under the FM Act, occur in the study area and are shown in **Figure 11**. 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 under the FM Act but do not occur within the study area (DII 2010).

Seagrasses

Seagrass beds were present on both the north and south banks of the Hastings River. The seagrass bed 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). These areas of seagrass provide potential habitat for some species of syngnathiformes (seahorses, seadragons, pipefish, pipehorses, ghostpipefish and seamoths), which are protected species under the FM Act.

The seagrass beds located in the Hastings River would be intersected by the proposed twin bridges.

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 Dalhenty Island and would be intersected by the proposed twin bridges across each river. The mangrove forests surveyed were generally a mixed assemblage of both grey mangroves and river mangroves. The density and species assemblage of mangroves are outlined in **Table 3-13**.

Table 3-13 Mangrove species assemblages and densities

Site	Approximate density	Species
Hastings River south	10 plants per 20 m ²	River Mangroves and Grey Mangroves
Hastings River north	5 plant per 20 m ²	River Mangroves and Grey Mangroves
Wilson River south	1 plant per 20 m ²	River Mangroves
Wilson River north	5 plant per 20 m ²	River Mangroves and Grey Mangroves
Dalhenty Island south	10 plants per 20 m ²	River Mangroves and Grey Mangroves
Dalhenty Island north	10 plants per 20 m ²	River Mangroves and Grey Mangroves

3.16 Listed wetlands

3.16.1 State listed wetlands

There are two wetlands listed under *State Environmental Planning Policy No. 14 – Coastal Wetlands* within the study area. Wetland 484f is located on Dalhenty Island within the Wilson River and wetland 484e is located on the adjacent northern bank of the river (as shown in **Figure 11**). Extensive areas of State listed wetlands are also located to the east and smaller areas to the west of the study area.

The State listed wetlands on Dalhenty 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. The freshwater wetland is 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.

A review of the *State Environmental Planning Policy No. 14 – Coastal Wetlands* wetland boundaries in the study area (Adam *et al.* 1985) was undertaken by HWR Ecological (2006) using aerial photography interpretation and descriptive data from ground surveys. Based on the results of the review, the boundaries of the State listed wetlands were revised. The revised boundary included some areas of wetland excluded in the original mapping but overall the wetlands were not as extensive as indicated in Adam (*et al.* 1985).

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.

3.16.2 Nationally important wetlands

There are no wetlands of national importance as listed on the directory of important wetlands within the study area. Limeburners Creek Nature Reserve, which is listed as a nationally important wetland, occupies an extensive coastal area to the east of the study area.

3.16.3 Internationally significant wetlands

There are no wetlands of international importance (Ramsar wetlands) within or in the immediate proximity of the study area.

3.17 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.

Groundwater dependent ecological communities vary in their dependence on groundwater, from ecosystems that are totally dependent whereby the ecosystem would suffer from a minor change to groundwater conditions, to ecosystems that make limited or opportunistic use of groundwater (Sinclair Knight Merz 2001). It can be difficult to determine whether and to what extent a particular ecosystem is groundwater dependent in the absence of targeted investigations. Often it is inferred by the presence, at least occasionally, of groundwater in the vicinity of the root zone, but this is not definitive. Even when targeted investigations are undertaken, these may not differentiate between an obligate use of groundwater (where its absence will have a severe negative impact) and a facultative use (where its absence will not have a severe effect) (Eamus *et al.* 2006). Based on these limitations, the following discussion of potential effects on groundwater dependent ecological communities is qualified by the lack of information on which ecosystems are actually groundwater dependent and on the degree of such dependence.

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, those that are considered to have potential as groundwater dependent ecological communities are discussed in **Table 3-13**. All of the eight discussed 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 remember that groundwater dependence is only inferred in the absence of observational or experimental data.

Table 3-14 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

Vegetation community	Occurrence within study area	Likely groundwater influence	Likely groundwater dependence
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
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

Vegetation community	Occurrence within study area	Likely groundwater influence	Likely groundwater dependence
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 slopes 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

All of these communities occur as small remnant patches along the corridor (see **Figure 5a** to **Figure 5f**), but some are much more extensive outside the study area, mostly associated with the floodplains of the Hastings, Wilson and Maria rivers. The likely groundwater dependence is based on categories outlined in Hatton and Evans (1998).

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