UPGRADING THE PACIFIC HIGHWAY

Woolgoolga to Ballina Planning Alliance

UPGRADING THE PACIFIC HIGHWAY

Woolgoolga to Ballina Upgrade

Supplementary Biodiversity Assessment

FINAL

November 2013

NSW GOVERNMENT Transport Roads & Maritime Services

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3. Design refinements assessment

This chapter describes the design refinements that have been made to the project design from that detailed in the EIS. These design refinements have arisen through the ongoing process of concept design review, consultation, or in response to issues raised during the EIS display. Potential impacts to biodiversity are discussed identifying, where relevant, important ecological values based on desktop and field investigations.

3.1. Background and approach

The design refinements presented in the Submissions/ Preferred Infrastructure Report (SPIR) are described according to main design refinements (18) and minor refinements (11). Each of the design refinements being assessed is detailed in the SPIR (Chapter .

The first stage of the biodiversity assessment involved a desktop review for all 29 design refinements. This review was undertaken using the GIS database, and overlaying the design refinements and reviewing GIS layers including aerial photography and existing biodiversity data such as vegetation community mapping and threatened species records (from database searches and field survey results). The objective of this review was to determine if additional biodiversity impacts beyond that assessed in the EIS may be reasonably expected. It also identified whether there was already sufficient field data from the location to assess any potential change in the impact.

From the desktop review 15 design refinements were identified as requiring further detailed biodiversity assessment. This included six locations where additional targeted field surveys were required and nine locations where the design change could be assessed using existing field data and knowledge gathered for the EIS, but required recalculation of vegetation clearing impacts. These fifteen are assessed in detail in this chapter. The remaining 14 design refinements were found to:

- Occur in heavily modified landscapes that are completely cleared of natural vegetation, such as cane fields and grazed paddocks; or
- Constituted a very minor refinement in the design that is located wholly with the assessed project corridor, (eg inclusion of a new property access) and involves no anticipated quantifiable change in impacts to biodiversity.

The potential impacts at these minor sites were considered negligible and adequately covered by the EIS. Further notes on these design refinements is provided in **Table 3-1,** including where detailed assessment of biodiversity impacts was not considered necessary.

3.2. Assessment method

A list of the 29 design refinements is detailed in Table 3-1 and identifies the scope of works requiring further assessment and assessed in this supplementary report based on a desktop review of the design refinements.

Table 3-1 Design refinements addressed in the biodiversity assessment

No.	Project section	Location	Design refinement	Scope of works	Where addressed (section)
1	1	Eggins Drive	Changed cycleway access (minor)	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
2	1	Eggins Drive	Change design to improve flood immunity at Eggins Drive (minor)	No field survey required as existing data is relevant and sufficient. Further assessment of the proposed flood immunity improvement is provided using existing ecological data gathered for the EIS.	3.3
3	1	Range Road	Revised interchange layout and highway realignment to address safety and environmental issues ie. important population of Quassia sp. Moonee Creek	Detailed field assessment of this change was undertaken. Data used to calculate the changed impacts on vegetation, habitat and threatened species.	3.4
4	1	Dundoo Reach	Changed access (minor)	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
5	1	Grays Road	Changed access (minor)	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
6	2	Lemon Tree Road	Changed access	No field survey required as sufficient information from working paper to assess level of impact.	3.5
7	3	Luthers Road	Changed access	No field assessment required as sufficient information from the working paper to assess the level of impact.	3.6
8	3	Firth Heinz Road	Realignment to avoid a landfill site	Detailed field assessment required due to the known presence of State and Commonwealth listed threatened species and threatened ecological communities.	3.7
9	3	Rest area at Pine Brush	Relocation of rest area	No field survey required as sufficient information from the working paper to assess the level of impact, particularly on the Commonwealth listed *Angophora robur*. Assessment of the design refinement footprint and indirect impacts.	3.8
10	3	Crowleys Road	Realignment to avoid a landfill site	No field survey required as sufficient information from the working paper to assess the level of impact, particularly on the Commonwealth listed *Angophora robur*. Assessment of the design refinement footprint and indirect impacts.	3.9

No.	Project section	Location	Design refinement	Scope of works	Where addressed (section)
11	3	Bondi Hill and Byrons Lane north Tyndale	Changes to property access (minor)	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
12	4	McIntyres Lane	Overpass at McIntyres Lane	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
13	4	Maclean interchange	Changes to interchange at Maclean	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
14	5	Koala Drive	Realignment and formalisation of Koala Drive, Townsend	Detailed field assessment of this change was undertaken. Data used to calculate the changed impacts on vegetation, habitat and threatened species.	3.10
15	5	Yamba Road	Cycleway access	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
16	5	Watts Lane	Changes to local access (minor)	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
17	5	Carrols Lane	Changed access	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
18	6	Iluka Road	Changed access (minor)	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
19	6	Mororo Road	Increased cutting depth	Detailed field assessment of this change was undertaken. Data used to calculate the changed impacts on vegetation, habitat and threatened species.	3.11
20	7	New Italy - Swan Bay Road	Changed access	No field survey required as sufficient information from the working paper to assess the level of impact.	3.12
21	7	Whites Road	Changed access (minor)	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
22	8	Lang Hill	Reduced extent of material borrow site	No field survey required as sufficient information from the working paper to assess the level of impact.	3.13
23	9	Broadwater	Truck access to Macdonald street (minor)	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required
24	9	South of Richmond River	Changes to project boundary (minor)	No field/desktop assessment required as information from the working paper indicates no ecological sensitivity and	No further assessment required

No.	Project section	Location	Design refinement	Scope of works	Where addressed (section)
				maintains the original assessment based on available data.	
25	10	Rest area north of Richmond River.	Relocation of north and southbound rest areas	No field assessment required as sufficient information from the working paper to assess the level of impact. Impact calculations reassessed for the design refinement footprint plus indirect impacts.	3.14
26	10	Borrow sites north of the Richmond River	Two quarries near Old Bagotville Road	Detailed field assessment of this change was undertaken. Data used to calculate the changed impacts on vegetation, habitat and threatened species.	3.15
27	10	Borrow site west of Wardell Road (Lumleys Hill)	Increased extent of material borrow site	No field assessment required as sufficient information from the working paper to assess the level of impact. Impact calculations reassessed for the design refinement footprint plus indirect impacts.	3.16
28	10	Interchange at Wardell	Realignment and new interchange to avoid Pink Underwing Moth habitat	Detailed field assessment of this change was undertaken. Data used to calculate the changed impacts on vegetation, habitat and threatened species.	3.17
29	11	Pimlico	Changes to property access (minor)	No field / desktop assessment required as existing data indicates no ecological sensitivity and EIS assessment remains unchanged.	No further assessment required

3.2.1. Desktop data and information review

Fifteen (15) design refinements were identified for further biodiversity assessment using existing field data and knowledge gathered for the EIS. A range of database sources were used to obtain information on the presence and distribution of threatened ecological communities, threatened species and populations. These databases included:

- The results of the targeted ecological surveys reported in the EIS.
- Atlas of NSW Wildlife Database (OEH 2013)
- NPWS (2002a and 2002b) Threatened Species of the Upper North Coast of New South Wales: (i) Fauna; and (ii) Flora
- Records published in scientific journals, reports and general flora and fauna distribution texts
- Anecdotal reports from authorities and local ecologists / naturalists and local landowners
- National Directory of Important Wetlands
- Road kill records provided by Clarence Valley WIRES and Roads and Maritime
- OEH Threatened Species Profile Search for species population and ecological communities of NSW (accessed online June 2013)
- Protected Matters Search Tool (DotE)

- Species profile and threat databases (OEH and DotE) (accessed online June 2013).

This was used to assess the known or potential presence of ecologically significant features within the areas subject to a refinement of the road design.

The list of threatened species and populations generated from the assessment was critically reviewed for direct relevance to the study area taking into consideration the types of habitats specifically at the design refinement location. Where there was sufficient field and background data, this data was used to quantify loss of vegetation and habitat for threatened species and identify potential direct and indirect impacts to threatened species, populations and communities.

3.2.2. Targeted field survey

Supplementary field surveys were made where there was insufficient field data available at a design refinement location. The following six sites were identified as requiring further targeted field surveys (the number in brackets refers to description in Table 3-1):

- Range Road (3).
- Firth Heinz Road (8).
- Koala Drive (14).
- Mororo Road (19).
- Bagotville Borrow sites (26)
- Interchange at Wardell (28).

Field surveys were conducted during the period 29 January to 15 February 2013 (sites 2, 3, 4) and 1-5 July 2013 (sites 5, 6). The survey at Range Road interchange (site 1) was completed 29-31 August 2012 as part of the detailed design for the Woolgoolga to Glenugie upgrade (Section 1 and 2) and is reported herein as GeoLink (2012). Details of the field methods used across all sites are described below.

Targeted threatened plant surveys and threatened ecological community mapping

As the design refinement footprints are relatively minor in scale, the surveys were able to be conducted using a traverse on foot across the entire design refinement area for each site. The survey involved:

- Ground-truthing existing digital vegetation mapping data (regional and project specific) to confirm and refine vegetation types and mapping within the design refinement area and to identify the type and presence of threatened ecological communities (TSC Act and EBPC Act) if present.
- A targeted search for threatened plant species.
- For the population of Quassia sp. Monee Creek, at Range Road, this involved a direct count of all plants and stems and mapping the extent of the population to document the size and extent of the population.
- As detailed mapping of Lowland rainforest communities and threatened rainforest plant species around Coolgardie Road was completed for the EIS, for the current assessment the additional survey concentrated on areas to the east of the existing Pacific Highway, north and south of Laws Road, Coolgardie.

Threatened fauna habitat usage survey

A threatened fauna habitat usage survey was conducted as part of the general traverse. This involved searching for evidence of habitat use by threatened fauna species including:

- Recording habitat trees and noting the density and structure of fauna habitat including presence of nests, hollow-bearing trees and other microhabitat features.
- The occurrence of specific habitat features appropriate for threatened fauna species known or potentially occurring at the site. Features known to be used by threatened species included hollow-bearing trees, nest trees, watercourses, specific food trees, wetland habitats, leaf litter and caves or other structures suitable for roosting or denning purposes.
- Latrine sites for Spotted-tailed Quoll.
- Regurgitation pellets and nest/roost sites for forest owls.
- Inspection for 'whitewash' and pellets under any potential owl roost sites.
- Chewed cones beneath Allocasuarina/Casuarina trees indicating Glossy Black Cockatoo feeding.
- For the Range Road interchange the habitat usage survey, a systematic survey was conducted using a 50 m grid placed over the study area and using the same search based methods as described above.

This data was incorporated into the project GIS and used to calculate the direct impacts on biodiversity.

Targeted Koala and habitat survey

Survey for Koala was undertaken in accordance with the interim referral guidelines for Koala (DSEWPaC 2012). Specifically, this involved:

- Distance sampling to estimate Koala population size using regularly-spaced transects across the subject site (as per Buckland et al. 2001, Dique et al. 2003, Thomas et al. 2010);
- Spot Assessment Technique faecal pellet surveys to measure Koala habitat use (Phillips and Callahan 2011); and
- Habitat assessment, using the Koala Habitat Atlas habitat value categories (McAlpine et al. 2006) and categories as reported in DECC (2008) (Table 3-2).

A stratified–random survey design was adopted to obtain a representative survey of habitats across each subject site to ascertain the extent of 'habitat critical to the survival of Koala' within the subject site. A set of parameters was recorded along a 100 x 20 metres transect through potentially suitable habitat.

These parameters included:

- Total number of individual trees (>10 centimetre diameter-at-breast-height) of each potential Koala food-tree species (Eucalyptus, Corymbia, Angophora, Lophostemon and Melaleuca), as well as non-food tree species within the transect area.
- An estimate of ground cover.
- Presence/ absence of Koala scat in accordance with the Spot Assessment Technique.

Table 3-2. Koala habitat categories derived from DECC (2008) and McAlpine et al (2006)

Habitat class	Proportion of overstorey tree species		
	Primary food species	Primary and secondary food species	Secondary food species
Primary *	≥ 30 %	or ≥ 50 %	or ≥ 50 %
Secondary	10 < 30 %	or 30 < 50%	or 10 < 50%
Marginal	< 10 %	or < 30 %	or < 10 %
Unsuitable	Scattered trees	Scattered trees	Scattered trees

*equivalent to the class of habitat 'critical to the survival of Koala' in the Interim Referral Advice (DSEWPaC 2012)

Summary of survey effort

A summary of the survey method and effort at the design changes sites is provided in **Table 3-3.**

Table 3-3. Summary of survey methods and effort

Targeted sites	No. of days (time)	Survey methods and effort			
		Flora	Habitat / Koala	Birds	Frogs/reptiles
1	3 (18 person hours)	6 person hours. Random meander traverses	70 habitat plot assessments. Koala: random scat searches between plots	Opportunistic surveys	Opportunistic surveys
2	1 day (6 person hours)	Random meander traverses	1 habitat assessment plot Koala: 1 Koala habitat assessment including SAT sites	20 minutes per 2 hectare	Opportunistic surveys
3	1 day (6 person hours)	Random meander traverses	1 habitat assessment plot Koala: 1 Koala habitat assessment including SAT plot sites	20 minutes per 2 hectare	Opportunistic surveys
4	1 day (6 person hours)	Random meander traverses	3 habitat assessment plots, including Koala habitat assessment and SAT plot sites	20 minutes per 2 hectare	Opportunistic surveys
5	1 day (6.5 hours over 7.3km)	25 vegetation assessments, threatened flora sites and timed random meander traverses	Koala: 3 SAT plot sites – two person minutes per tree to a minimum of 30 trees. 3 Koala habitat assessment	20 minutes per 2 hectare	Ground searches and wetland habitat assessments
6	11 (6.5 hours over 7.3km)	25 vegetation assessments, threatened flora sites and timed random meander traverses	Koala: 4 SAT plot sites - two person minutes per tree to a minimum of 30 trees. 3 Koala habitat assessment	20 minutes per 2 hectare	Ground searches and habitat assessments

3.2.3. Factors considered within the impact assessment

The potential impacts from each design refinement were assessed separately to determine if there is likely to be additional impacts beyond what was assessed in the EIS working paper. The factors considered are consistent with the EIS assessment and included:

- The likely direct loss of vegetation and habitat.
- The likely indirect impacts on vegetation and habitat for threatened flora and fauna species, including edge effects.
- The impact of the change on landscape connectivity, including potential changes to the proposed fauna connectivity structures.
- The direct and indirect impacts on aquatic habitats.

A consistency assessment was undertaken for all assessments of significance for each of the potential species/communities affected by the design changes, and if changes were not consistent, then the assessment was updated and has been provided in Chapter 6.

If any of the design changes necessitated new assessment of significance for any particular species/communities, then this was provided.

3.3. Eggins Drive biodiversity assessment

The assessment of Eggins Drive design refinement to improve flood immunity was undertaken as a desktop assessment. This area was surveyed comprehensively as described in the EIS working paper for Section 1 and 2 and there was sufficient biodiversity information gathered from the previous field investigations that an additional survey was not required.

3.3.1. Design refinement description

Eggins Drive is a local road located in Section 1 from station 0.0 to around station 1.6 where Eggins Drive intersects with Eggins Close. The road is parallel and to the east of the existing Pacific Highway. The design refinement would increase the flood immunity of Eggins Drive to a 100 year ARI flood event. This requires both the raising of the pavement levels and upsizing of drainage structures.

3.3.2. Direct and indirect impacts

Due to the increased in the construction footprint, which would involve the acquisition of vegetated land, the vegetation clearing required at this location was re-assessed. This assessment is detailed in Table 3-4, which also identifies threatened ecological communities found at the site (in bold). There would be additional impacts to around four hectares of vegetation, including 2.9 hectares of threatened ecological communities listed under the TSC Act. No threatened flora species were directly recorded in this location.

Table 3-4 Comparison of impacts between the EIS design and design refinement at Eggins Road

Biometric vegetation types	EIS design (ha)	Design refinement (ha)	Change in vegetation loss (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	0.4	1.1	+0.7
Paperbark swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest - TSC Act)	**1.7**	**2.0**	**+0.3**
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	3.7	4.1	+0.4
Swamp Box swamp forest of the coastal lowlands of the North Coast (TEC, Subtropical Coastal Floodplain Forest - TSC Act)	**1.8**	**2.1**	**+0.3**
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest - TSC Act)	**6.2**	**8.4**	**+2.2**
Swamp Oak swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Oak Floodplain Forest - TSC Act)	**0.9**	**1.0**	**+0.1**
TOTAL	14.7	18.7	+4.0

The dry open forest habitats at this site contain primary and secondary Koala feed-tree species at low densities (<10 per cent of the canopy species) and is considered to be marginal for koalas. Areas of Swamp Mahogany and Swamp Box forest support low densities of primary Koala feed trees. Surveys carried out for the preferred route study recorded 16 scat search sites across Sections 1 and 2 of the project, including the vicinity of Eggins Road (Ecotone 2007). An additional 32 scat search plots were conducted in Sections 1 and 2 for the EIS (2011), followed by an additional 32 plots in the area surveyed in February 2013 and described in Chapter 4 of this report.

The data from the accumulated survey effort for Koala across Section 1 of the project suggests that Koala populations are most likely limited to very low density populations, and any records in this location may be dispersing individuals across the landscape rather than a home range area. The survey data also shows that koalas occur in low densities relative to the amount of habitat available in the locality. There are 8 records of koalas within 10 km of the project reported in the NSW Wildlife Atlas database between 1983 and 2002. Wildlife Atlas records and communication with local residents during field surveys identified that occasional road deaths do occur within the study area. The habitats in Section 1 and 2 are not considered to support an important Koala population.

Arrawarra Creek (465 metres) and Arrawarra Gully (100 metres) are the nearest watercourses to Eggins Drive located around station 0.5. There is potential for uncontrolled run-off to enter these systems via an ephemeral drainage line adjacent to the site. The aquatic habitats here are not suited to the endangered Oxleyan Pygmy Perch as determined by detailed surveys conducted during detailed design (September 2012 and May-June 2013 (GeoLink 2012; ASM 2013). Further targeted frog survey during this period also indicates that the gullies and creeks at this location are only marginal for the Giant Barred Frog (Lewis 2013) and the species was not confirmed.

The design refinement would require the upsizing of culverts to convey cross drainage and this construction has potential for indirect impacts to downstream areas which include the Solitary Islands Marine Park. Appropriate erosion and sedimentation controls would be required during construction of the project to manage indirect impacts of sediment run-off and to prevent turbidity and disturbance on downstream habitat protection zones.

The additional four hectares of vegetation to be cleared would increase potential edge effects on remaining adjacent habitats. This may indirectly result in further weed invasion and increased noise and light levels which may affect the behaviour of threatened fauna. The design refinement may also change fauna movement patterns.

3.3.3. Connectivity for fauna

There are no proposed connectivity structures in this location and this refinement does not change the potential impact on fauna movements or alter a structure proposed. An arboreal crossing structure has been included in the concept design at station 1.5 targeted at Squirrel Glider and Yellow-bellied Glider and potential Brush-tailed Phascogale populations which are all known from Section 1. This structure is at the northern end of Eggins Drive at a further 200 metres north of where this design refinement would occur.

This section of the project between stations 0.0 to 22.0 is noted in the EIS as a potentially important corridor linking Wedding Bells State Forest (west of the existing highway) to the coastal habitats east of the highway. Due to the presence of the existing Eggins Drive and a number of coastal developments around Arrawarra, the connectivity strategy developed for the EIS targeted crossing structures at Station 1.5 (discussed) and Station 2.1 around 200 and 800 metres north of this location respectively. Therefore there are no dedicated or combined fauna structures in the design refinement area that would be affected.

Connectivity for fauna would be as per the EIS design with no change or reduced connectivity as a result of this design refinement.

3.4. Range Road biodiversity assessment

The biodiversity assessment of the Range Road interchange design refinement required additional field survey investigations as previous field investigations yielded insufficient field data.

3.4.1. Design refinement description

Range Road is located in Section 1 of the project from station 8.8 and station 10.4. The design refinement would relocate the Range Road interchange further north from station 8.5 to station 10.0 to improve road safety (refer to Figure 3-1).

The design refinement occurs between station 8.2 and 10.1 and involves changes to the construction footprint in addition to a new intersection design for Range Road including an overpass at station 9.8. The terrain in this location is characterised by moderately steep to low undulating topography between 60 and 120 metres elevation. There are a small number of ephemeral drainage lines within the vicinity of the road some intersected by the existing Pacific Highway.

3.4.2. Survey results

Vegetation communities and threatened flora

The design refinement construction footprint would require an increased area for vegetation clearing east of the existing highway beyond that required by the EIS design. Targeted surveys were undertaken by GeoLink (2012) as per the approach detailed in Section 3.2.2. The vegetation types recorded in the new impact area include dry sclerophyll forest dominated by Blackbutt (*Eucalyptus pilularis*), Needlebark (*Eucalyptus planchoniana*) and Spotted Gum (*Corymbia variegata*). A smaller area of Broad-leaved Paperbark (*Melaleuca quinquenervia*) forest is present along with a small area of moist riparian forest with rainforest elements.

A summary of the vegetation types is shown in Table 3-5 and compares the field survey data and vegetation descriptions to the relevant biometric vegetation type reported in the EIS.

Table 3-5. Plant communities in the vicinity of the Range Road design refinement

Plant community (Geolink 2012)	Equivalent Biometric vegetation type (EIS)
Dry Open Forest (Blackbutt association)	Blackbutt/Tallowwood ridgetop and upper slopes forest
Moist Open Forest (Blackbutt association)	Blackbutt/Tallowwood lower slopes and gully forest
Riparian rainforest (**Lowland Rainforest - TSC Act)**	No equivalent
Modified community– regenerating dry forest	Cleared / modified community
Modified community–mixed exotic/native pasture	Cleared / modified community

Field investigations, as part of the detailed design, identified the presence of the Moonee Quassia (*Quassia sp. Moonee Creek*) within the Section 1 project footprint at station 8.4. Moonee Quassia is a shrub found in north eastern NSW from the Moonee Creek area north of Coffs Harbour to north-east of Grafton. It is listed as endangered under both the EPBC Act and TSC Act. The avoidance measures and impacts to this population are discussed in Section 3.4.3.

Threatened ecological communities

A field-based assessment was conducted for the rainforest community using the criterion for identifying Lowland Rainforest (listed as Critically Endangered under EPBC Act) (Threatened Species Scientific Committee 2011). The method is based on identifying a number of condition thresholds including patch size and plant diversity. This method was conducted within the narrow linear riparian habitat located adjacent to the design refinement area. Detailed methodology and survey results are described in Section 4.2.

The results of the targeted surveys for Lowland Rainforest confirmed the findings of the EIS that the vegetation type at Range Road does not fit the criteria for listing under the EPBC Act. Rather it is listed as Lowland Rainforest in the NSW North Coast listed under the TSC Act.

Fauna habitats

The site and surrounding area was found to contain a variety of habitat resources for fauna including:

- Flowering vegetation, providing a nectar food resource for nectivorous species such as birds and arboreal mammals, insect prey and microchiropteran bats.
- Plant species that produce a fleshy drupe or berry (fruit) and provide suitable (although limited) foraging resources for frugivorous birds and the bats.
- Koala feed trees at low densities consisting of Tallowwood and Grey Gum. Koala scats were found below two trees indicating very low activity and transient use of the area.
- Groundcover, providing shelter and foraging resources for ground-dwelling species.
- Potential habitat for prey of raptors and owls, as part of an extensive area of forested habitat within Newfoundland State Forest locally of similar habitat value.
- Sandstone rock overhangs providing potential roosting sites for microchiropteran bats and shelter for reptiles.
- Eighteen hollow-bearing trees, providing potential habitat for hollow-dependent fauna.
- Four farm and forestry dams, which (to varying degrees) have intact surrounding wetland vegetation that can provide breeding and foraging habitat for amphibians.

Further detailed description of the vegetation and fauna habitats at this site is provided in a separate report titled 'Ecological Assessment for Additional Geotechnical Investigations at Range Road Interchange Woolgoolga to Ballina Pacific Highway Upgrade Woolgoolga to Glenugie Section' (GeoLink 2012). This report has been provided as Appendix D.

Koala habitat

The dry and moist open forest habitats in the design area contain primary and secondary Koala feed tree species at low densities (<10 per cent of the canopy species) and the habitat is considered to be marginal for koalas (Table 3-6). Aged Koala scats were found below two trees indicating very low activity and transient use. Further discussion on impacts is described in Section 3.4.

Table 3-6. Koala habitat trees and categories at Range Road

Vegetation	Koala food tree species	Food tree type*	Proportion of canopy species	Koala habitat category
Dry open forest (Blackbutt association)	Stringybark (*E.tindaliae*)	Supplementary	15%	Marginal
	Tallowwood (*E.microcorys*)	Primary	<10%	
	Grey Gum (*E.propinqua*)	Secondary	<10%	
Moist open forest (Blackbutt association)	Tallowwood (*E.microcorys*)	Primary	5-10%	Marginal
Riparian rainforest	None			Unsuitable
Modified community (regenerating forest)	None			Unsuitable

*Koala Recovery Plan (Appendix 2: Koala feed tree species for the North Coast)

3.4.3. Direct and indirect impacts

Vegetation communities and threatened fauna

Near Range Road, vegetation types are described above and include several dry sclerophyll forests dominated by Blackbutt (*Eucalyptus pilularis*), Needlebark (*Eucalyptus planchoniana*), Spotted Gum (*Corymbia variegata*), Broad-leaved Paperbark (*Melaleuca quinquenervia*) forest and a small area of riparian rainforest. A comparison of the direct vegetation loss between the EIS and the design refinement is shown in Table 3-7, including change to threatened ecological communities (in bold). The design refinement would result in an additional 3.9 hectares of total vegetation clearing compared to the EIS. Clearing for four of the six biometric vegetation types will increase and two of these will decrease (Table 3-7). The design refinement would impact the same quantity of Swamp Sclerophyll Forest compared with the EIS design and an increased clearing of 0.2 hectares of moist riparian forest consistent with Lowland Rainforest (NSW TSC Act-listed only).

Table 3-7 Comparison of impacts between the EIS design and design refinement at Range Road

Biometric vegetation types	EIS design (ha)	Design refinement (ha)	Change in vegetation loss (ha)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast (TEC, Lowland Rainforest - TSC Act)	**0.1**	**0.3**	**+0.2**
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	13.2	17.8	+4.6
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	4.3	3.7	-0.6
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	12.6	11.6	-1.0
Paperbark swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest - TSC Act)	**0.4**	**0.4**	**0.0**
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	4.8	5.5	+0.7
TOTAL	**35.4**	**39.3**	**+3.9**

The design refinement would result in an increase in the direct loss of non-listed dry sclerophyll forests and dominated by Blackbutt (*Eucalyptus pilularis*) (4.6 hectares), and Spotted Gum (*Corymbia henyrii*) and Grey Ironbark (*Eucalyptus siderophloia*) (0.7 hectares).

The design refinement would see an additional 0.5 hectares of habitat directly impacted at this location mainly as dry open Blackbutt forest. The EIS assesses potential impacts to a number of threatened fauna species through the clearing of these dry and moist open forest habitats (Blackbutt association) (Table 3-7). Species predicted to use these forests habitats in the study area include Powerful Owl (*Ninox strenua*), Masked Owl (*Tyto novaehollandiae*), Brush-tailed Phascogale (*Phascogale tapotafa*), Rufous Bettong (*Aepyprymnus rufescens*), Common Planigale (*Planigale maculata*), Squirrel Glider (*Petaurus norfocensis*) and Yellow-bellied Glider (*Petaurus australis*), all vulnerable species under the TSC Act.

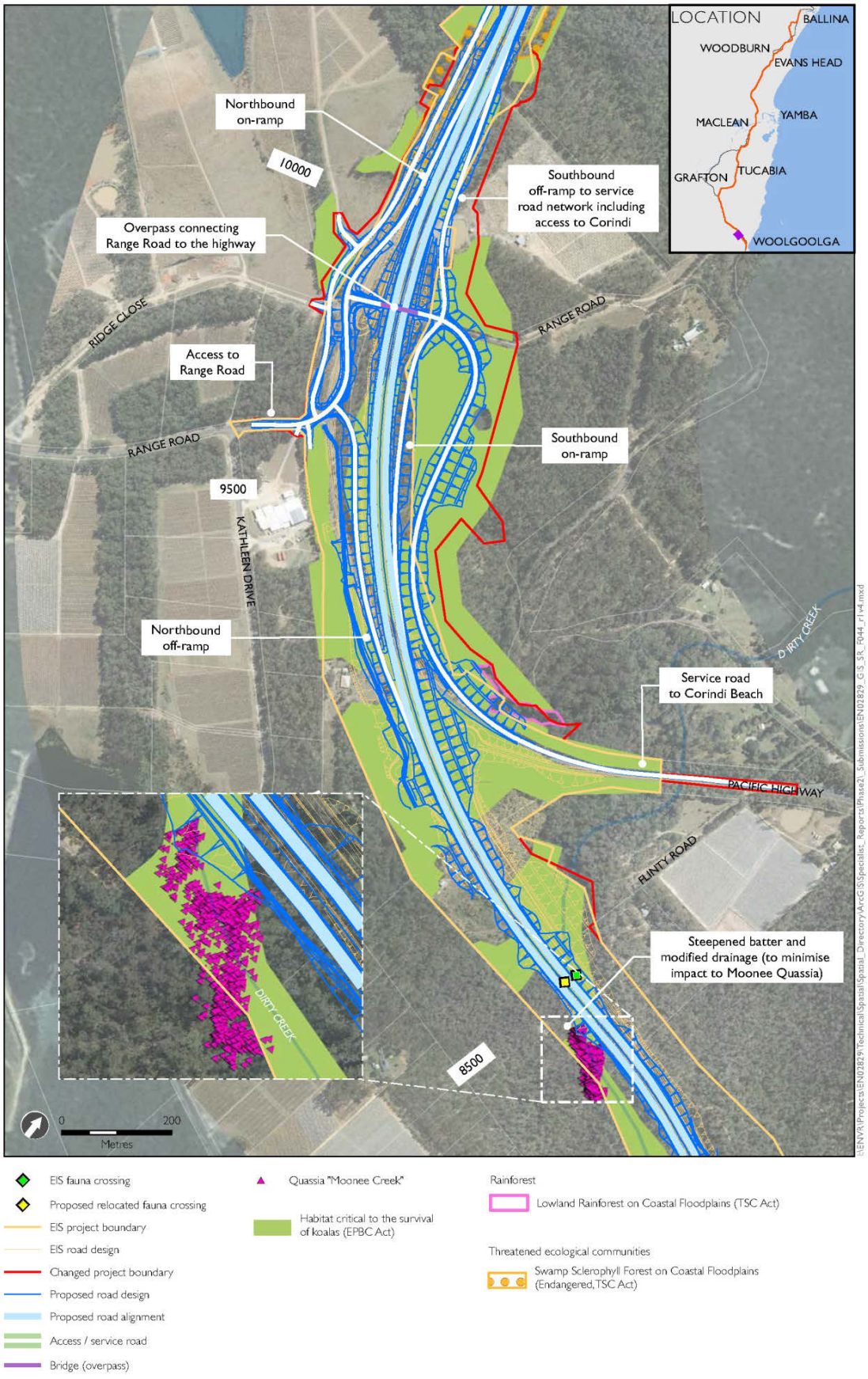

Figure 3-1: Revised design, interchange at Range Road showing ecological values

The design refinement would require an additional 0.5 hectares cleared as potential habitat for these species. However, the site does not contain any prominent habitat features that would not otherwise exist within the adjoining forest system for these species. The vegetation to be removed would provide foraging habitat however, the potential for this vegetation to be used as a significant nesting/roosting site is limited by the paucity of hollow-bearing trees over the size of the habitat or other significant habitat features from the additional vegetation impacted. The additional habitat loss is a relatively minor additional impact to what was reported in the EIS for hollow-dependent fauna. The EIS and this supplementary report conclude the project would have a significant impact for these fauna species in this section.

Threatened fauna moderately likely to occur around Range Road is detailed in Table 3-8.

Table 3-8 Threatened fauna moderately likely to occur around Range Road

Plant community (Geolink 2012)	Biometric vegetation type (EIS)	Threatened fauna with moderate likelihood of occurring
Dry Open Forest (Blackbutt association)	Blackbutt/Tallowwood ridgetop and upper slopes forest	Powerful Owl, Masked Owl, Brush-tailed Phascogale, Rufous Bettong, Koala, Common Planigale, Squirrel Glider, microbats
Moist Open Forest (Blackbutt association)	Blackbutt/Tallowwood lower slopes and gully forest	
Riparian rainforest	No equivalent	Frugivorous birds, Powerful Owl, Giant Barred Frog

The design refinement would impact these species as direct loss of habitat includes food, shelter and breeding resources, potential change in movements of populations, edge effects on remaining habitat adjacent to the project including weed invasion, run-off into the freshwater ephemeral creek, noise and light impacts. Important populations potentially present in project sections 1 and 2, including Brush-tailed Phascogale, Rufous Bettong, Squirrel Glider, and Giant Barred Frog were considered in this assessment.

The design refinement has potential to increase edge effects (noise and light levels, temperature and wind speed) on adjoining habitats given the increased edge area and there is potential for greater run-off impacts to the east of the highway and into adjoining drainage lines.

This increased habitat impact would mostly impact potential foraging habitat and does not alter the results of the assessment of significance prepared for the above mentioned threatened species in the EIS.

Impacts to Giant Barred Frog

The Giant Barred Frog (endangered EPBC Act and TSC Act) was recorded to the east of the design refinement in the small area of riparian rainforest following a period of heavy rainfall in February 2013. The drainage lines in the area are ephemeral with some persistent pools, although considered generally not suitable for the species. The species was reported at Dirty Creek as part of the detailed design surveys for the Woolgoolga to Glenugie project around 370 metres from the design (Lewis 2013). At times of heavy flow the ephemeral creek adjacent to the design refinement boundary would flow directly into Dirty Creek. The Giant Barred Frog encountered here would have been dispersing from the main habitat along Dirty Creek at the time of the survey. The ephemeral creek therefore provides some temporary refuge for this species. The design refinement would therefore directly impact on potential refuge habitat of this species in the form of a small remnant forestry dam and adjacent ephemeral drainage line, which are both only very marginal for this species. Adjacent habitats are to be protected during construction, including the potential downstream impacts to Dirty Creek.

The small area of riparian habitat located to the east of the design has some potential to be used by the Giant Barred Frog as the species was reported in contiguous habitat to the east of the interchange. However, compared to the known habitats of Dirty Creek over 370 metres east, the ephemeral drainage line adjacent to the design is considered of marginal quality for the Giant Barred Frog. The potential frog habitat within the impact area was assessed for this species as part of the supplementary work (refer Section 5.6 and 6.5.4). The habitat within the study area was considered only low value and impacted by high weed abundance (for further details, refer to section 4.5.7).

Aquatic and wetland habitats

Aquatic and wetland habitats are limited to an artificially constructed remnant dam within the design area and ephemeral drainage line on the eastern side of the existing highway as discussed above. No potential habitat for the Oxleyan Pygmy Perch occurs at this location. The design refinement is within less than 20 metres of the ephemeral drainage line and is likely that indirect impacts of sediment run-off would degrade this habitat over the long term if not managed appropriately. This may impact on the condition of the habitat for common non-listed amphibian and fish species.

Impacts to Koala habitat and populations

The site exhibits low level use by koalas, with evidence of two old faecal pellets found from targeted surveys. The habitat was identified previously as marginal for koalas on the basis of two types of known Koala feed tree species present in low density. Surveys undertaken for the preferred route study recorded 16 scat search sites across Sections 1 and 2 (Ecotone 2007). An additional 32 scat search plots were conducted in Sections 1 and 2 for the EIS (2011), followed by an additional 32 plots surveyed in February 2013 and described in Chapter 4 of this report. This included plots specifically positioned along Range Road to the east of the project to assess presence of a Koala population. Scat searches were also conducted at Range Road for the detailed design, as reported in Geolink (2012), and involved a series of plots and random searches between plots.

The data from the accumulated survey effort for Koala across Section 1 of the project indicate Koala populations in the location are most likely limited to transient movements or dispersing individuals across the landscape. The survey data also showed that koalas occur in low densities relative to the amount of habitat available in the locality. There are 8 records of koalas within 10 km of the project reported in the NSW Wildlife Atlas database between 1983 and 2002. Wildlife Atlas records and communication with local residents during field surveys indicated occasional Koala road deaths within the study area. This is consistent with only two scats being found despite the level of survey effort. The study area between Sections 1 and 2 is not considered to support an important Koala population.

The Blackbutt dry open forest includes a low density of the primary feed tree species Tallowwood (*E.microcorys*) and secondary feed tree species Small-fruited Grey Gum (*E.propinqua*) both less than 10% of the canopy species present. The supplementary feed tree species Stringybark (*E.tindaliae*) also occurs at low density. On this basis the project will remove an additional 3.9 hectares of habitat classed as secondary Koala habitat (class B) according to DEC (2008) which is not associated with critical habitat according the DSEWPaC (2011). The remaining habitat loss includes non-Koala habitat, however given the presence of low density Koala populations in this area, this habitat may be used as temporary refuge by dispersing juveniles and there was no evidence of frequent use indicating a portion of the home range of an individual would be impacted.

The indirect impacts of edge effects to Koala habitat may affect the health of potential Koala feed trees in this area and overall vegetation structures and weed abundance.

Connectivity for fauna

The site adjoins Newfoundland State Forest to the north and cleared residential land to the south. Due to the presence of extensive areas of habitat east and west of the highway through this location the need to maintain connectivity was considered in the EIS and a dedicated structure was placed at station 8.5 at the southern end of the design refinement. The structure is 3 x 3 metres and 65 metres in length targeted at Rufous Bettong, Spotted-tailed Quoll and Koala. As the design refinement would see a reduction in the fill requirements between station 8.4 and 8.7 on the eastern side of the upgrade, this would effectively reduce the length of the culvert to less than 50 metres, although the structure would remain.

In addition to remaining consistent with the EIS at station 8.5 with the dedicated structure, the detailed design has added an additional dedicated 3 x 3 metre underpass (50 metres in length) at station 8.8 and also upgraded the incidental structure at station 10.3 to a combined culvert for fauna passage.

The inclusion of fauna connectivity structures as part of the EIS connectivity strategy was avoided around the Range Road interchange itself as the design refine area is unlikely to constitute an important local movement corridor, given the presence of cleared agricultural land on the western side.

Moonee Quassia

Following identification of a population of Moonee Quassia to the west of the alignment at station 8.5, the design refinement was further modified to minimise the impact on the species. The population is located both downslope and upslope of the project and along an ephemeral drainage line that flows to the northeast toward the design. The plants are located where there is a fill batter and drainage works (culvert, headwall and scour protection) in a steep sided gully. The species is known to reproduce vegetatively from suckers and regrow from suckers following disturbance either from buried stems or the root system.

The detailed survey recorded a total of 899 stems of which 35 would be directly impacted (3.9 per cent of the local population) by the project. Also from the design refinement a smaller population was also identified further south and upslope of the known location and outside of the impact area. The total population consists of two clusters approximately 250 metres apart, which are considered to constitute a single population.

The remaining individuals are all within 50 metres of the project, with up to 167 stems within 10 metres of the construction edge. Including potential indirect impacts the project will potentially result in impacts to 22 per cent of the known population in this area comprising 202 stems.

There is potential for further indirect impacts to the remainder of the population, particularly those within 10 metres of the project footprint. Indirect impacts could result from altered exposure and light levels and increased potential for competition from weeds and other flora due to the altered conditions. The Quassia Moonee population would be included within a monitoring program for threatened plants affected by the project and targeted weed management conducted to minimise edge effects. The monitoring and adaptive management program would focus on plants within the edge affected zone.

Recent construction monitoring on a Quassia population has been undertaken on the Sapphire to Woolgoolga Pacific Upgrade (Benchmark 2013). On that project, 15 plants occur in situ within 10 metres of the clearing limit or the road reserve fence. These plants have been monitored for two years during

construction and are found to be resilient to edge effects and persistent (Benchmark 2013). These preliminary results suggest the following (A.Benwell; *pers.comm*):

- The species is relatively hardy and will tolerate increased exposure.
- It can persist in habitat that's been logged as it shoots from suckers underground.
- Plants within a 10 metre edge affected zone are persistent.
- The biggest risk to indirectly impacted Quassia is weed invasion.

3.4.4. Additional mitigation

The proposed physical mitigation measures for the road design adjacent to the Moonee Quassia population include removing batter benching and steepening the fill embankment slope to reduce the batter footprint. It is also proposed to include a drainage swale along the toe of the steeper batter to collect run-off from the batter and direct this to a culvert. Other measures as detailed in the EIS mitigation and management include establishing exclusion zones in construction and weed control in edge affected areas during construction and operation. Other management measures include the aforementioned monitoring of plant health during construction and operation against performance thresholds and, if found necessary, additional weed control. The Threatened Plants Management Plan would provide further detail of these management and control measures.

3.5. Lemon Tree Road biodiversity assessment

The assessment of Lemon Tree Road design refinement was undertaken as a desktop assessment. This area was surveyed comprehensively as described in the EIS working paper for Section 1 and 2 and there was sufficient biodiversity information gathered from the previous field investigations that an additional survey was not required. .

3.5.1. Design refinement description

Lemon Tree Road is a local road in Section 2 of the project. The proposed extension of Lemon Tree Road runs east of the existing Pacific Highway between station 17.4 and station 17.9.

The design has been refined to improve access from the northbound highway carriageway to Lemon Tree Road (under the initial arterial upgrade) and to also improve safety of vehicles exiting the service station, by lengthening the southbound merge lanes onto the highway east of Lemon tree Road.

3.5.2. Direct and indirect impacts

Overall, the design refinement would result in a similar amount / extent of vegetation directly impacted. Table 3-9 compares the vegetation clearing of the EIS design and the design refinement, including the TECs (in bold). The refinement would reduce the amount of clearing as described in the EIS by 0.1 hectares of Swamp Mahogany swamp forest and an increase the loss of 0.1 hectares of dry sclerophyll forest.

Table 3-9 Comparison of impacts between the EIS design and design refinement at Lemon Tree Road

Biometric vegetation types	EIS design (ha)	Design refinement (ha)	Change in vegetation loss (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	0.8	1.2	+0.4
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	8.6	8.3	-0.3
Paperbark swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest – TSC Act)	**0.2**	**0.2**	**0.0**
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest - TSC Act)	**5.0**	**4.9**	**-0.1**
TOTAL	**14.6**	**14.6**	**0.0**

The additional area of Swamp Mahogany swamp forest would provide marginal habitat for Koala where a low density of the primary feed tree *Eucalyptus robusta* would be retained and less area impacted.

The direct loss of vegetation remains as it was in the EIS design. Vegetation clearing and habitat loss would cause indirect impacts such as edge effects in fragmented habitats and invasion of weeds as discussed in the EIS.

3.5.3. Additional mitigation

The management measures included in the EIS and threatened species management plans would apply to the design refinement at Lemon Tree Road. Therefore, no further management measures are needed as a result of this design change during construction and operation.

3.6. Luthers Road biodiversity assessment

The assessment of Luthers Road design refinement to change access from the upgrade was undertaken as a desktop assessment. This area was surveyed comprehensively as described in the EIS working paper for Section 1 and 2 and there was sufficient biodiversity information gathered from the previous field investigations that an additional survey was not required.

3.6.1. Design refinement description

Luthers Road is a local road in section 2 of the project. It runs to the east of the existing Pacific Highway between station 20.5 and station 22.0.

In the interim arterial upgrade, the Pacific Highway intersection with Luthers Road has been relocated south from station 21.5 to station 21.0. In the ultimate motorway standard, the intersection would be upgraded to an overpass, rather than an underpass. The overpass would provide access from the western service road to an access road to the east, connecting with Luthers Road.

3.6.2. Direct and indirect impacts

The design refinement would result in the removal of an additional 0.6 hectares of dry open forest vegetation. Table 3-10 compares the vegetation clearing of the EIS design and the design refinement including TECs (in bold). The additional area of vegetation to be removed comprises dry sclerophyll forest communities dominated by Blackbutt (*Eucalyptus pilularis*) (0.9 hectares) and Needlebark Stringybark (*Eucalyptus planchoniana*) (0.1 hectares). There would be no additional impacts to threatened ecological communities as a result of the design change, there would however be a minor reduction (0.4 ha) in direct impacts to Subtropical Coastal Floodplain Forest.

Table 3-10 Comparison of impacts between the EIS design and design refinement at Luthers Road

Biometric vegetation types	EIS design (ha)	Design refinement (ha)	Change in vegetation loss (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	6.3	7.2	+0.9
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast (TEC, Subtropical Coastal Floodplain Forest - TSC Act)	**0.9**	**0.9**	**0.0**
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	2.4	2.5	+0.1
Paperbark swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest - TSC Act)	**0.2**	**0.2**	**0.0**
Swamp Box swamp forest of the coastal lowlands of the North Coast (TEC, Subtropical Coastal Floodplain Forest - TSC Act)	**4.7**	**4.3**	**-0.4**
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest - TSC Act)	**0.9**	**0.9**	**0.0**
TOTAL	**15.4**	**16.0**	**+0.6**

The existing vegetation surrounding Luthers Road consists of the biometric vegetation type Blackbutt-Bloodwood dry heathy open forest on sandstones of the north coast. This community is not listed as endangered. As detailed in the EIS, the dry open forest provides potential habitat for a range of threatened fauna species assessed including:

- Powerful Owl (*Ninox strenua*) (vulnerable TSC Act).
- Masked Owl (*Tyto novaehollandiae*) (vulnerable TSC Act).
- Brush-tailed Phascogale (*Phascogale tapotafa*) (vulnerable TSC Act).
- Rufous Bettong (*Aepyprymnus rufescens*) (vulnerable TSC Act).
- Common Planigale (*Planigale maculata*) (vulnerable TSC Act).
- Squirrel Glider (*Petaurus norfocensis*) (vulnerable TSC Act).
- Koala (*Phascolarctos cinereus*) (vulnerable TSC Act and EPBC Act).
- Yellow-bellied Glider (*Petaurus australis*) (vulnerable TSC Act).
- Grey-headed Flying-fox (*Pteropus poliocephalus*) (vulnerable TSC Act and EPBC Act).

The EIS reports that a direct loss of habitat, including food, shelter and breeding resources would significantly affect populations of these threatened fauna in project sections 1 and 2, in particular the important populations of Brush-tailed Phascogale, Rufous Bettong and Squirrel Glider found here. This is further exacerbated by the additional loss of potential habitat identified at this location associated with the design refinement. Indirect impacts to threatened fauna were reported as associated with edge effects on remaining habitat adjacent to the project including weed invasion, run-off and noise and light impacts. Edge effects may increase over a slightly larger area associated with the increased clearing, although would be difficult to detect at this scale between the original designs. Edge effects are associated with long-term degradation in the composition and structure of remaining vegetation adjacent to the project. The change is minor and has no change on potential impacts on fauna movements from that described in the EIS. For example movements in this area would already be constrained by the presence of the local road adjacent to the highway. Connectivity structures have been proposed in the EIS further south at Halfway Creek (station 20.7 and 20.8) and linked with exclusion fencing to accommodate this constraint.

The EIS and this supplementary report conclude the project would have a significant impact for these fauna species in this section with the exception of the wide-ranging and highly mobile Grey-headed Flying-fox.

Koala habitat

A Koala plot was done at this location as part of supplementary biodiversity investigations (for further details refer to Chapter 4). The survey confirmed the presence of a dry open forest dominated by Scribbly Gum (*Eucalyptus signata*) at 30 per cent of the canopy species, Bloodwood (*Corymbia gummifera*) at 40 per cent and Red Mahogany (*E. resinifera*) at 25 per cent of the canopy proportion. The habitat is classed as secondary Koala habitat class C and not '*habitat critical to the survival of koalas*' according to the EPBC Act. No evidence of Koala activity was identified during the field investigation, nor were there any records of koalas in the area.

Any direct impacts would include the small change in clearing of dry sclerophyll forest (0.6 ha) which is potential habitat; however, no important populations have been reported in this location. The indirect impacts to this potential Koala habitat would include degradation from edge effects mainly associated with weed invasion as discussed previously.

Connectivity for fauna

The importance of connectivity in this area and potential for indirect impacts on fauna movements was addressed in the EIS connectivity strategy due to the presence of Yuraygir National Park and State Conservation Area and the Wells Crossing Flora Reserve. A review of the structures (combined fauna and drainage function) was made to ensure they were suitable in size and location to target potential use by known populations of Rufous Bettong and Brush-tailed Phascogale. These are described in Table 3-11.

Table 3-11 Combined fauna crossing structures provided in the design refinement area

Station	Name	Structure type	Length (m)	No. cells	Width (m)	Height (m)	Bridge length/ width	Functionality
20.65		Culvert	48	4	3	2.4		Combined
20.71	Halfway Creek	Bridge					50.5 x 11	Combined
20.88		Culvert	43	1	3	2.4		Combined
21.29		Culvert	50	1	3	3		Combined

The detailed design has confirmed that sediment basins in this section have been placed appropriately to avoid disruption to fauna connectivity. However, due to an increase in the area of fill required resulting from this design change, the combined culvert structure at station 20.88 would need to increase to around 60 metres in length, from 43 metres. This increased length may reduce the use of this structure for fauna movements.

3.6.3. Additional mitigation

The management measures included in the EIS would be relevant to manage and mitigate the effects of the design refinement. Therefore, no further management measures are anticipated during construction and operation.

3.7. Firth Heinz Road biodiversity assessment

The assessment of the Firth Heinz Road design refinement was undertaken as a field survey and assessment, as detailed in section 3.2.2. There was insufficient biodiversity information from previous field investigations at this change and additional targeted surveys were required to enable calculation of changed impacts on vegetation, habitat and threatened species.

3.7.1. Design refinement description

Firth Heinz Road is a local road located around station 51.8 in the Pillar Valley around two kilometres to the east of Tucabia in section 3 of the project. The design refinement is a realignment to avoid directly impacting a former landfill site and covers an area from station 50.5 to 53.5. This realignment was considered necessary to avoid contamination risks associated with disturbing this site.

The refinement would move the design of the main alignment slightly west over a length of around three kilometres. At its widest point the alignment would change to around 100 metres west of the previous alignment (refer to Figure 3-2).

3.7.2. Survey results

The remnant vegetation in this location includes three biometric types that are widespread throughout section 3 of the project and the impact from loss of this vegetation was considered in the EIS. These are:

- Spotted Gum-Grey Ironbark Pink Bloodwood open forest.
- Scribbly Gum Needlebark Stringybark heathy open forest.
- Blackbutt/Bloodwood dry heathy open forest on sandstones.

Within the design refinement footprint vegetation in this location is dry sclerophyll forest dominated by Blackbutt (*Eucalyptus pilularis*), Scribbly Gum (*Eucalyptus signata*) and Spotted Gum (*Corymbia variegata*). Small areas of the threatened ecological communities Swamp Sclerophyll Forest, Swamp Oak Floodplain Forest and Subtropical Coastal Floodplain Forest (all endangered on TSC Act) are present at the southern end and the refined project design would directly impact on around 3.5 hectares of TEC at this location.

The Sandstone Rough-barked Apple (*Angophora robur*) (EPBC Act and TSC Act) was identified in relatively high abundance within and surrounding the design refinement area at station 52.0. A small population of the

threatened *Maundia triglochinoides* (TSC Act) was also identified in a small wetland adjacent to Chaffin Creek.

The design refinement traverses an area of open forest with several large and mature hollow-bearing habitat trees which provide important resources for hollow-dependent fauna. Direct evidence of Glossy-black Cockatoo (*Calyptorhynchus lathami*) (TSC Act) was observed south of Firth Heinz Road in the form of chewed cones (Plate 3-1) within a stand of Black She-oak (*Allocasuarina littoralis*) which is moderately abundant in this area. Several large hollow stags were also observed nearby which support hollows suitable for nesting by Glossy Black-Cockatoo (Plate 3-2) however the presence of a nest site was not determined.

Plate 3-1: Evidence of Glossy Black-Cockatoo chewed *Allocasuarina littoralis* fruits south of Firth Heinz Road

Plate 3-2: Hollow potentially suitable for Glossy Black-Cockatoo nest site, adjoins feeding area

Koala habitat

The Koala feed tree species Swamp Mahogany (*Eucalyptus robusta*) and Tallowwood (*Eucalyptus microcorys*) is present in the design refinement area and the habitat is categorised as potentially suitable for koalas.

3.7.3. Direct and indirect impacts

The vegetation types adjacent to Firth Heinz Road are described in Table 3-12 and show the reduction or avoidance of vegetation types and TECs (in bold) as well as threatened flora species.

Table 3-12 Comparison of impacts between the EIS design and the design refinement (bold represents threatened ecological communities)

Biometric vegetation types	EIS design (ha)	Design refinement (ha)	Change in vegetation loss (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	11.2	14.1	+2.9
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast (TEC, Subtropical Coastal Floodplain Forest TSC Act)	**2.3**	**1.4**	**-0.9**
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	8.5	8.1	-0.4
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	0.4	1.3	+0.9
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest TSC Act)	**0.9**	**1.4**	**+0.5**
Swamp Oak swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Oak Floodplain Forest TSC Act)	**0.2**	**0.7**	**+0.5**
TOTAL	**23.5**	**27**	**+3.5**
Angophora robur (individuals)	313	494	+181
Maundia triglochinoides (ha)	0.1	0	-0.1 ha

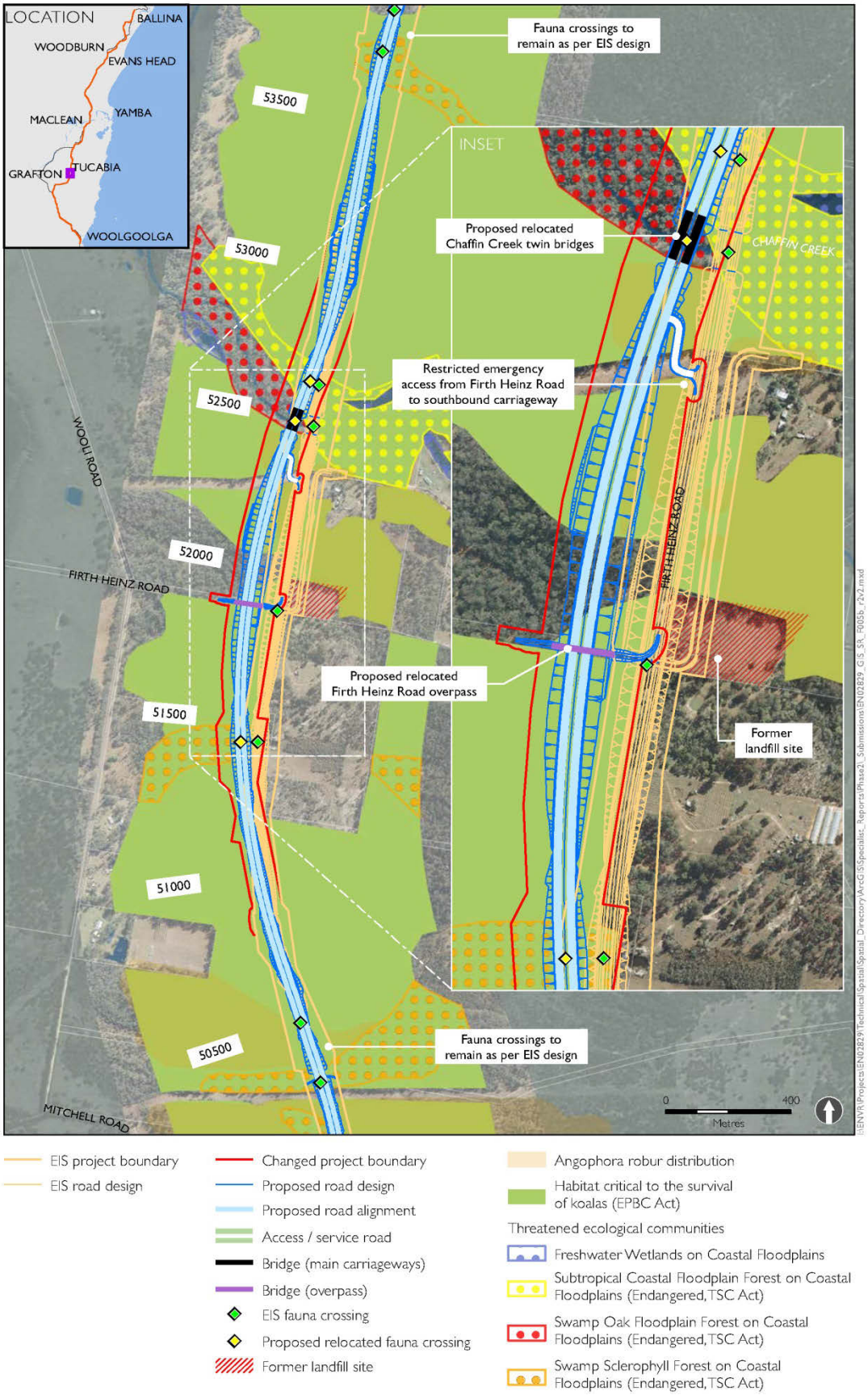

Figure 3-2: Revised design at Firth Heinz Road showing ecological values

The move of the main alignment west would increase in the loss of vegetation and fauna habitat by 3.5 hectares. The design refinement would result in an overall increase in the clearing of threatened ecological communities by 0.1 hectares. The design refinement would reduce the clearing of the threatened ecological community Subtropical Coastal Floodplain Forest (endangered TSC Act). However, it would increase the clearing of Swamp Oak Forest (endangered TSC Act).

The refinement traverses open forest and moist forest habitats and would increase the area of clearing from that assessed in the EIS for the following forest fauna habitats:

- Blackbutt open forest.
- Spotted Gum / Grey Ironbark open forest.
- Swamp Mahogany open forest.
- Swamp Oak forest.

Several additional hollow-bearing trees would be impacted by the design shifts that were not impacted previously. The EIS identifies that this location provides potential habitat for a range of threatened fauna species assessed including:

- Powerful Owl (*Ninox strenua*) (vulnerable TSC Act).
- Masked Owl (*Tyto novaehollandiae*) (vulnerable TSC Act).
- Brush-tailed Phascogale (*Phascogale tapotafa*) (vulnerable TSC Act).
- Rufous Bettong (*Aepyprymnus rufescens*) (vulnerable TSC Act).
- Squirrel Glider (*Petaurus norfocensis*) (vulnerable TSC Act).
- Glossy Black-cockatoo (*Calyptorhynchus lathami*).
- Koala (*Phascolarctos cinereus*) (vulnerable TSC Act and EPBC Act).
- Grey-headed Flying-fox (*Pteropus poliocephalus*) (vulnerable TSC Act and EPBC Act).
- Swift Parrot (Lathamus discolour) (endangered TSC Act and EPBC Act).
- Several threatened microchiropteran bat species, particularly hollow-dependent fauna.

The EIS reports that a direct loss of habitat, including food, shelter and breeding resources would significantly affect populations of these threatened fauna in project section 3, in particular the important populations of Brush-tailed Phascogale, Rufous Bettong and Squirrel Glider found here. This is further exacerbated by the additional loss of 3.5 hectares of potential habitat identified at this location associated with the design refinement. Indirect impacts to threatened fauna were reported as associated with edge effects on remaining habitat adjacent to the project including weed invasion, run-off and noise and light impacts. Edge effects may increase over a slightly larger area associated with the increased clearing, although would be difficult to detect at this scale between the original designs. Edge effects are associated with long-term degradation in the composition and structure of remaining vegetation adjacent to the project.

The design refinement would require an additional 3.5 hectares of native vegetation cleared, which represents potential habitat for the threatened fauna species. This includes a greater impact to primary Koala habitat.

The additional habitat loss, although relatively small would add to the impact that was reported in the EIS for these fauna. The EIS and this supplementary report identify significant impacts for these fauna species for the project already with the exception of the wide-ranging and highly mobile Grey-headed Flying-fox and Swift Parrot. This is particularly relevant for hollow-dependent fauna, and the increase in the number of hollow bearing trees cleared as a result of this design change would reinforce this conclusion.

Allocasuarina species are a critical food resource for Glossy-Black Cockatoo, as are large tree hollows for nesting. The species is reliant on mature forest habitats in the study area for breeding and foraging, although this may occur in both large contiguous remnants and small fragmented forests in modified fragmented landscapes provided food resources are abundant and there is access to large hollow-bearing trees. Pairs may repeatedly use favoured nest trees over multiple breeding seasons and family groups exhibit home range territories and repeated use of the same food trees within their home range. The design change would remove an area of known food resource for the Glossy Black-Cockatoo. It is unknown whether this is a dispersing individual or part of the home range of a local pair. Nonetheless potential nesting hollows (not confirmed) are present and would be impacted. If a breeding pair occupies part of the habitat and/or a nest tree is removed this would likely have a significant impact on a small scale. This species has a low birth rate, with only 1-2 individuals born each and breeding may not occur in all years depending on predation on eggs and other stochastic events. The loss of habitat may lead to reduced breeding success for an established pair and affect recruitment and dispersal on a local scale but unlikely to be significant impact on the regional population. The broader impact on local populations and the region populations also discussed in Chapter 6 of this report.

Impacts on Angophora robur and Maundia triglochinoides

The design refinement would result in an increased impact on listed Sandstone Rough-barked Apple (*Angophora robur*) (vulnerable TSC Act and EPBC Act) from the EIS design. There are two main clusters, one located at the northern end from station 52.0 to 52.4, and one at the southern end at station 50.5. At the southern end impacts remain the same as per the EIS, however for the northern cluster, the design refinement would result in the loss of an additional estimated 181 individual *Angophora robur* trees.

The indirect impacts (edge effects) would be reduced, with the design refinement retaining *Angophora robur* between station 52.0 and 52.3 to the east of the alignment only. Under the EIS design, the patch would have been bisected, with trees on both sides of the highway, increasing potential indirect impacts. Further the design refinement would not require the construction of a new section of Firth Heinz Road, reducing indirect impacts again. *Angophora robur* has been confirmed as occurring within forests but also as isolated paddock trees and in other edge-affected habitats within the project area. Therefore, it would be likely to be somewhat tolerant of edge effects and indirect impacts would not be expected to significantly impact the lifecycle attributes of *Angophora robur*.

Where changed impacts on threatened species have been discussed in this section, these are also addressed in the Assessment of Significance presented in Chapter 4.

The design refinement avoids impacts to a population of the listed *Maundia triglochinoides* (vulnerable TSC Act) on the northern side of Firth Heinz Road (c. 0.1 hectares).

The design refinement would move the road around 40-50 metres further west, avoiding direct impacts to a large pond located on Chaffin Creek. This waterhole was identified as being of high habitat value for fauna, particularly waterfowl and frogs and is also expected to provide important fish habitat. No populations of threatened fish or frogs have been identified at this location. Potential impacts to the waterway are associated with indirect impacts including noise levels and surface run-off. While noise levels at the waterhole would be slightly reduced, potential impacts during construction and operation would remain the same and would not indirectly impact calling birds and amphibians. Surface run-off during both construction and operation would be controlled via sedimentation and water quality basins.

Connectivity for fauna

The importance of connectivity in this area and potential for indirect impacts on fauna was addressed in the EIS connectivity strategy due to the presence of important habitat for threatened fauna. A number of drainage structures were sized accordingly to target potential use by known populations of threatened fauna including the Coastal Emu, Rufous Bettong and Brush-tailed Phascogale. In addition to these structures, a canopy rope structure has been included targeted at Squirrel Glider and potentially Yellow-bellied Glider and Brush-tailed Phascogale. These are described in Table 3-13.

Table 3-13 Combined fauna crossing structures provided in the design refinement area

Station	Name	Structure type	Length (m)	No. cells	Width (m)	Height (m)	Bridge length/ width	Functionality
50.5		Canopy rope	65					Dedicated
51.4		Culvert	62	1	2.4	3.6		Combined
52.4	Chaffin Creek	Bridge					54 x 10.5	Combined
52.6		Culvert	60	6	3.6	2.1		Combined
53.7		Culvert	63	1	3.6	3.6		Combined

At station 50.5 and 53.7 there is no change to the widening of the project footprint, this is the very start and end of the deviation of the alignment to the west, and there would be no change to the structures. At 51.4 and 52.6 the alignment has shifted to the west around 40-60 metres although the width and height of the road remains the same and there would be no change in the design or length of the structure.

The Chaffin Creek bridge at station 52.5 would remain as part of the design refinement but shifted about 60 m to the west. This bridge (54 metres in length) is a combined fauna crossing structure and was raised to 3.6 metre clearance to provide potential Coastal Emu passage. Chaffin Creek is a Class 1 waterway with potential to provide fish habitat. There would be no change in connectivity for aquatic or terrestrial fauna.

As discussed the proposed combined structures for emus in the area over the Firth Heinz Road design change would remain. It is noted that EPA has commented on Emu connectivity structures in section 3 between stations 46.1 and 59.3 which includes the section through the Firth Heinz Road area. These comments are noted and further development of the connectivity strategy, particularly in regards to all identified Emu crossing structures would be developed in consultation with EPA/OEH.

3.7.4. Additional mitigation

There are no additional specific mitigation measures beyond what is reported in the EIS. This includes the identification of important habitat and provided exclusion zones as well as protection of hollow-dependent fauna during clearing works, both of which has direct implications for the Glossy Black-cockatoo.

3.8. Rest area at Pine Brush biodiversity assessment

The assessment of the rest area at Pine Brush relocation design refinement was undertaken as a desktop assessment. There was sufficient biodiversity information gathered from the previous field survey investigations that an additional survey was not required. Impact calculations were reassessed, particularly on the Commonwealth listed *Angophora robur* for the design refinement footprint and included potentially indirectly impacted areas.

3.8.1. Design refinement description

A rest area was included in the EIS design (for both north and southbound traffic), from station 63.3 to 64.3, adjacent to the Pine Brush State Forest (refer Figure 3-4). The design refinement relocates the rest area further south to an area that is mostly within an area to be cleared to allow construction as assessed in the EIS (refer Figure 3-3).

The design refinement would move the rest area around 7.5 kilometres south, to an area located between Bostock Road and Somervale Road (station 55.5 to 56.9). The rest area would consist of a northbound and southbound rest area for light vehicles and heavy vehicles. The project boundary would be increased by around 0.5 hectares, and be around 170 metres wide.

3.8.2. Avoidance measures

The location of any rest area along the alignment has been influenced by a number of functional requirements and consideration of biodiversity and social economic issues. The functional requirements that must be met include: being spaced around 50 kilometres apart and located on or near a crest in the highway. The rest area at Pine Brush needs to be around 50 kilometres north of the Arrawarra rest area. Twenty potential rest area locations between stations 40.0 and 70.0 were reviewed to find a site which met the functional requirements and minimised social and biodiversity impacts. Almost all (20) areas were rejected as potential locations due to the presence of heavy vegetation (including areas of habitat critical to the survival of koalas and threatened flora including *Angophora robur*).

A number of cleared areas were identified (eg at station 40.0 and 63.1). However, these sites were not preferred locations due to sensitive receivers being located in the vicinity of these locations.

The relocated rest area has been sited to meet the functional requirements. While it is also located in a vegetated area, the majority of this area had already been identified for clearing for the construction of the project. As such, this location minimises additional vegetation clearing that is not required for the main alignment. The rest area would also reduce the impact on the Commonwealth listed Sandstone Rough-barked Apple (*Angophora robur*), threatened ecological community vegetation and habitat critical to the survival for Koala. To account for the presence of *Angophora robur* surrounding this area, as part of the rest area design refinement the alignment was also refined within the corridor. Hence while the footprint is larger the impacts to *Angophora robur* were able to be reduced.

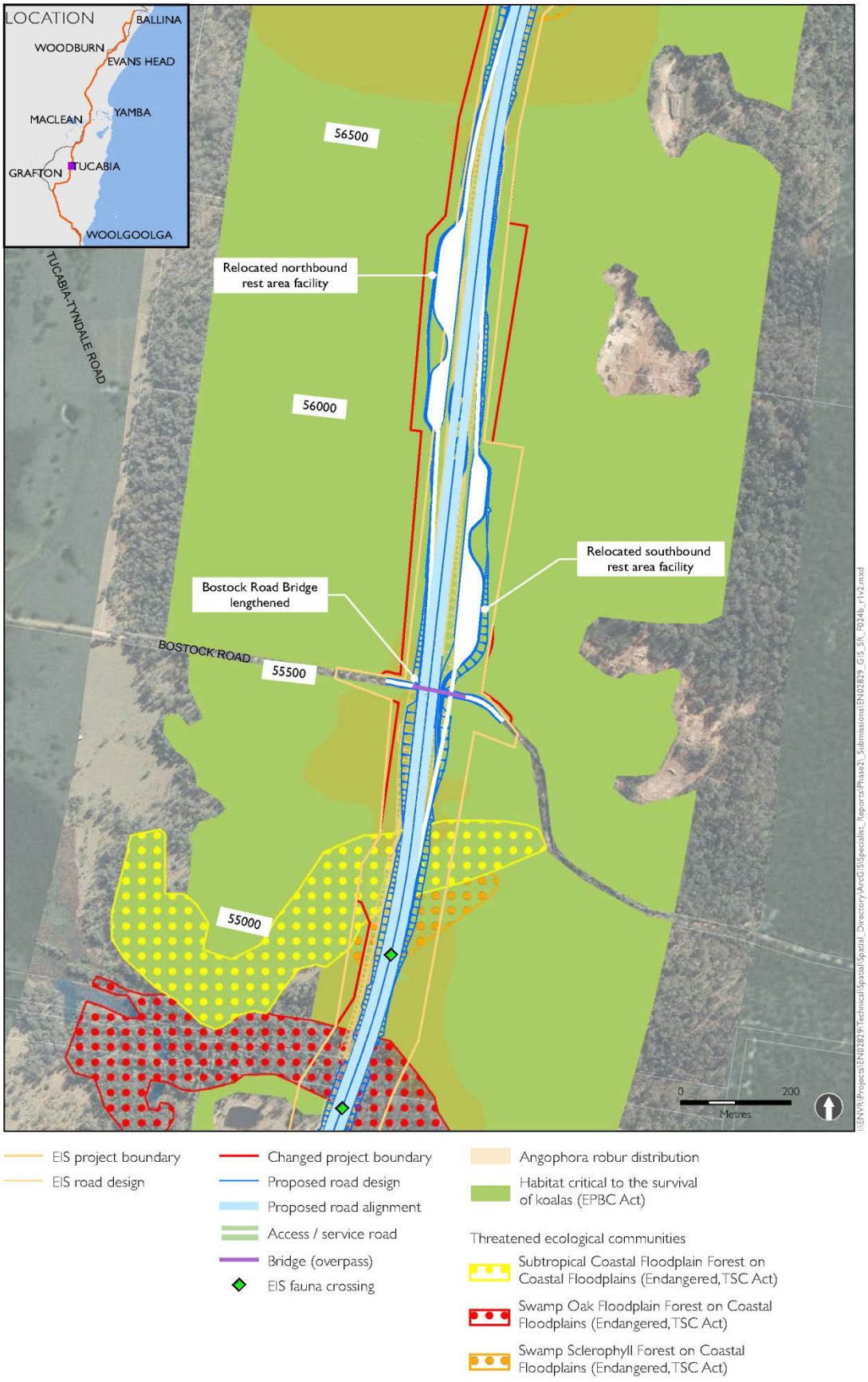

Figure 3-3: Refined rest area at Pine Brush and ecological values

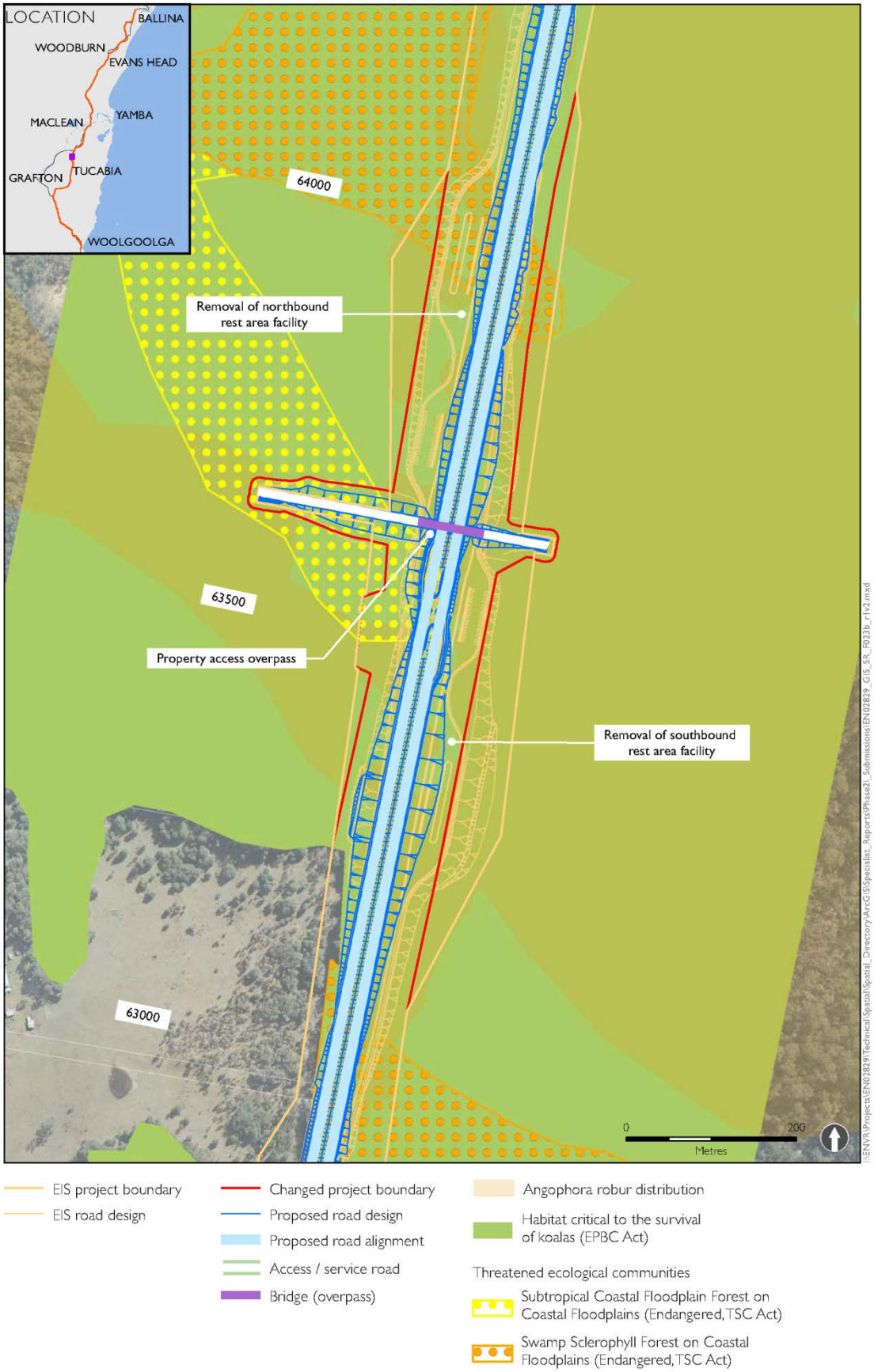

Figure 3-4: EIS rest area location showing ecological values

3.8.3. Direct and indirect impacts

The rest area relocation would see a net improvement in impacts by reducing vegetation clearing by 5.4 hectares (ie reduction of 6.5 hectares from the reduction in footprint at the EIS location and an increase of only 1.1 hectares at the relocated site over the EIS design) (refer **Table 3-14**). Table 3-14 also identifies changes to removal of TECs (in bold) and threatened fauna.

Table 3-14 Comparison of impacts at the locations between the EIS rest area design and PIR rest area design

Biometric vegetation types	EIS rest area location		PIR rest area location	
	With rest area (ha)	Rest area deleted (ha)	Without rest area (ha)	With rest area (ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast (TEC, Subtropical Coastal Floodplain Forest TSC Act)	1.4	1.7 (+0.3)	1.4	1.5 (+0.1)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	-	-	8.3	7.5 (-0.8)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest TSC Act)	5.4	4.0 (-1.4)	0.9	0.9 (0.0)
Swamp Oak swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Oak Floodplain Forest TSC Act)	-	-	1.3	1.1 (-0.2)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	3.1	2.7 (-0.4)	-	-
Turpentine moist open forest of the coastal hills and ranges of the North Coast	12.0	7.0 (-5.0)	8.5	10.5 (+2.0)
TOTAL	21.9 ha	15.4 ha (-6.5)	20.4 ha	21.5 ha (+1.1)
Angophora robur individuals	709	378 (-331)	569	492 (-77)

Note: Brackets indicate a gain or loss of impact area in relation w ith design refinement.

Vegetation and fauna habitat types are homogenous across both locations being dominated by dry sclerophyll open forests comprising Scribbly Gum (*Eucalyptus signata*) and Tallowwood (*Eucalyptus microcorys*). Moist forest habitats also occur and dominated by Turpentine (*Syncarpia glomulifera*) and threatened ecological communities including Swamp Sclerophyll Forest and Swamp Oak Floodplain Forest (endangered TSC Act). The habitat for fauna at both locations has been identified as high to very high value and suited to a range of threatened species in particular Koala and forest dwelling species such as Rufous Bettong and hollow-dependent birds and mammals, including Brush-tailed Phascogale, Squirrel Glider and threatened microbats. The impacts therefore do not vary in terms of the importance of the habitat and types of potential indirect impacts, however the proportion of habitat loss would decrease as per above discussion.

Overall the impacts to threatened ecological communities would be reduced by about 1.2 hectares (refer to **Table 3-13**). The reduction in the loss of known threatened fauna habitat would have a net beneficial outcome, particularly for Squirrel Glider and Brush-tailed Phascogale which were both identified near the EIS design rest area.

The relocated rest area further south has a net beneficial outcome by reducing the impacts in this area on threatened fauna and flora. However, this would not impact on the results of the assessment of significance for the above threatened species or threatened ecological communities.

There are no aquatic habitats, waterways for permanent creeks at this location.

Angophora robur

The rest area was relocated further south from the EIS identified location to reduce the impact on the Commonwealth listed Sandstone Rough-barked Apple (*Angophora robur*). Relocation of the rest area from its northern location sees a net reduction in the direct loss of *A.robur* of an estimated 408 trees. This is achieved from a combination of removing the rest area from the EIS location and refining the alignment at the new location. Despite moving the rest area to a known area of *Angophora robur* habitat near Bostock Road the relocated rest area would still have a reduced impact of an estimated 77 trees from the EIS design at that location.

The design refinement has the same indirect impacts assessed for the EIS and includes edge effects for threatened fauna and flora habitat. However there would be a reduction in potential edge effects on the habitat for *Angophora robur* north of Pine Brush State Forest.

Connectivity for fauna

Both the former and the new rest area location have been identified as important areas for east-west fauna movements for a range of ground-dwelling and arboreal fauna, including the Coastal Emu. It is possible that the southern location, which is adjacent to Chaffin Creek and Chaffin Swamp, is more important for Emu movements then the previous northern location. As the relocated rest area design has been sited on a crest there are no dedicated or combined crossing fauna crossing structures at this location. The nearest combined structures are two raised bridges located at Champion Creek bridge (station 57.0) and unnamed tributary at station 54.7. These structures would not be changed as a result of the relocation of the rest area. The presence of the rest area at this location would influence decisions regarding provisional measures for emus crossing points if these are required in the future.

Bostock and Somervale roads north and south of the rest area are bridges over the highway and provide only incidental fauna passage, but are not targeted as fauna structures. The need for provisional measures for emus, if required may identify these as potential crossing structures with modification although this option is not assessed at present.

3.8.4. Additional mitigation

There are no additional specific mitigation measures beyond what is reported in the EIS and threatened species management plans.

3.9. Crowleys Road biodiversity assessment

The assessment of Crowleys Road design refinement was undertaken as a desktop assessment. There was sufficient biodiversity information gathered from the previous field investigations that an additional survey was not required. Impact calculations were reassessed, particularly on the Commonwealth listed *Angophora robur* for the design refinement footprint and included potentially indirectly impacted areas.

3.9.1. Design refinement description

Crowleys Road is a local road located in the northern part of section 3, around three kilometres south of Tyndale. It provides property access either side of the highway at station 64.9. The design refinement would realign the highway from station 64.9 to station 66.0 to avoid the former landfill (potential disturbance to contaminated land). The highway would realign to the east of the initial arterial upgrade and relocate the highway overpass to the south and west. The design refinement and ecological values is shown as Figure 3-5.

3.9.2. Survey results

The design refinement is a small deviation from the original design; however the area is within a known area of habitat for *Angophora robur* and several threatened fauna species as discussed in the EIS, including Brush-tailed Phascogale, Rufous Bettong and Squirrel Glider.

The vegetation in this area consists of Tallowwood *(Eucalyptus microcorys*) dominated forest, with minor disturbance, but in relatively good condition. The forest has a moderately diverse understory, low-moderate weed abundance and hollow-bearing trees. Other common tree species in the area include Pink Bloodwood (*Corymbia intermedia*) and the threatened Sandstone Rough-barked Apple (*Angophora robur*). Some areas of disturbed vegetation are present where the former landfill was located comprising dense regrowth of Black She-oak (*Allocasuarina littoralis*) and Eucalypt species.

Tallowwood is a primary Koala feed tree and evidence of Koala has been observed nearby adjacent to Tucabia Road. A range of other threatened fauna is likely to use the habitats within this area.

3.9.3. Direct and indirect impacts

The vegetation types adjacent to Crowleys Road are described in Table 3-15. The design refinement would result in a total reduction of 0.8 hectares of remnant vegetation clearing, including a reduction of 0.4 hectares for Subtropical Coastal Floodplain Forest TEC.

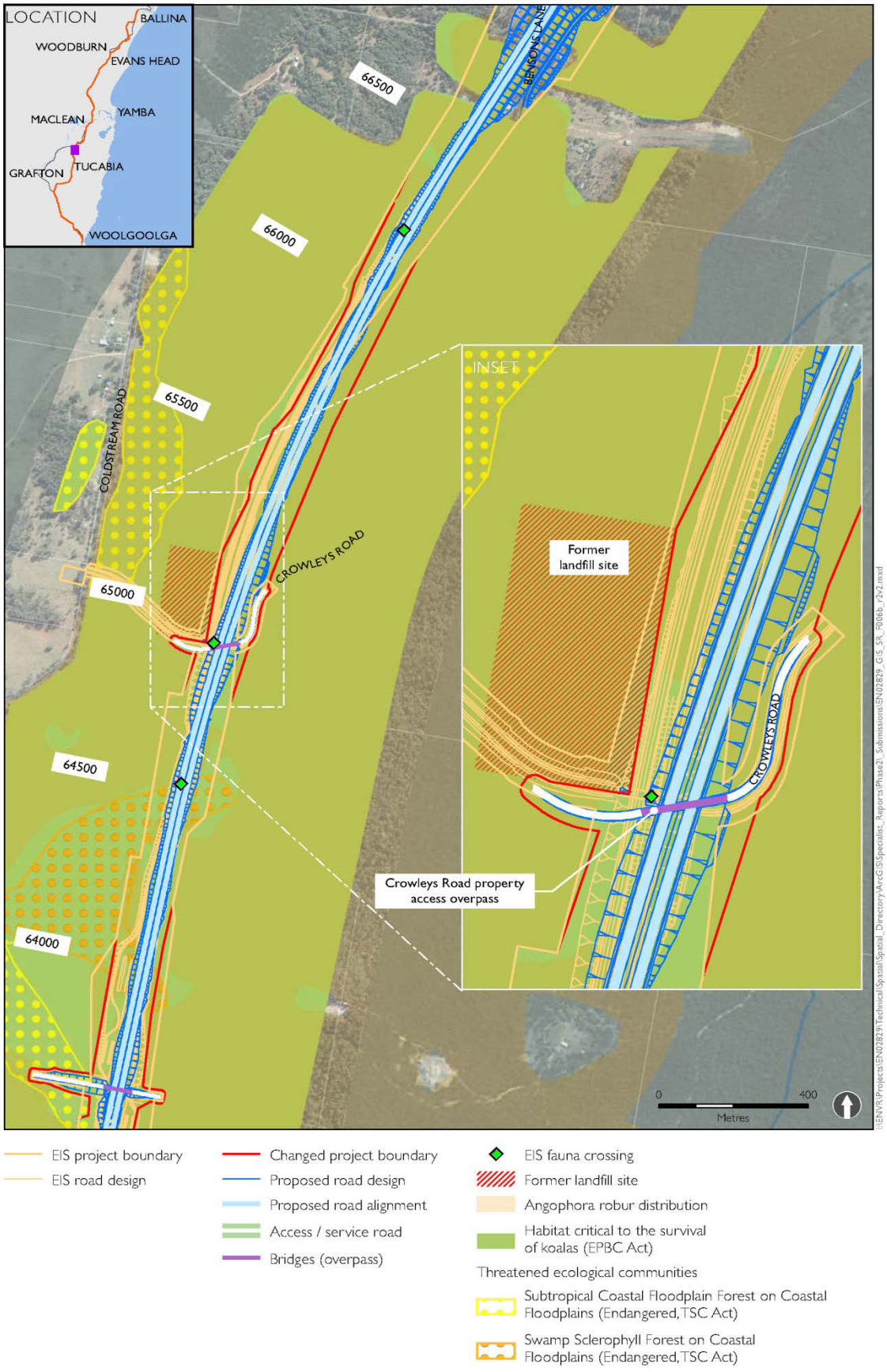

Figure 3-5: Revised design at Crowleys Road and ecological values

Table 3-15 Comparison of impacts between the EIS design and Crowley Road design refinement

Biometric vegetation types	EIS design (ha)	Design refinement (ha)	Change in vegetation loss (ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast (TEC, Subtropical Coastal Floodplain Forest - TSC Act)	**0.4**	**0**	**-0.4**
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest - TSC Act)	**0.5**	**0.5**	**0.0**
Tallowwood dry grassy forest of the far northern ranges of the North Coast	17.9	17.5	-0.4
TOTAL	**18.8**	**18.0**	**-0.8**
Angophora robur individuals	866	877	+11

The design refinement is a minor adjustment to the alignment to the east over a distance of around 1.8 kilometres. At its widest distance the alignment would be shifted around 60 metres east of the EIS design. The design refinement would cross the same terrain and vegetation / habitat types to those assessed in the EIS. This refinement would result in a small reduction (0.8 hectares) of vegetation loss (refer to **Table 3.15**). This comprises dry sclerophyll forest dominated by Tallowwood (*Eucalyptus microcorys*), and threatened ecological communities Swamp Sclerophyll Forest and Subtropical Coastal Floodplain Forest (endangered TSC Act).

As detailed in the EIS, this location provides potential habitat for a range of threatened fauna species assessed including:

- Powerful Owl (*Ninox strenua*) (vulnerable TSC Act).
- Masked Owl (*Tyto novaehollandiae*) (vulnerable TSC Act).
- Brush-tailed Phascogale (*Phascogale tapotafa*) (vulnerable TSC Act).
- Rufous Bettong (*Aepyprymnus rufescens*) (vulnerable TSC Act).
- Squirrel Glider (*Petaurus norfocensis*) (vulnerable TSC Act).
- Glossy Black-cockatoo (*Calyptorhynchus lathami*)
- Koala (*Phascolarctos cinereus*) (vulnerable TSC Act and EPBC Act).
- Grey-headed Flying-fox (*Pteropus poliocephalus*) (vulnerable TSC Act and EPBC Act).
- Swift Parrot (*Lathamus discolour*) (endangered TSC Act and EPBC Act)
- Several threatened microchiropteran bat species, particularly hollow-dependent fauna.

The design refinement is relocating the main alignment through habitat with a better condition than the EIS design. The EIS reports that a direct loss of this habitat, including food, shelter and breeding resources would affect the viability of local populations, with the exception of the Grey-headed Flying-fox and Swift Parrot which are wide-ranging and highly mobile species capable of accessing resources over large areas of the range. Indirect impacts to threatened fauna would include potential change in movements of populations, and create edge effects on remaining habitat adjacent to the project including weed invasion, run-off and

noise and light impacts. Increased edge effects would also degrade the composition and structure of remaining vegetation.

The design refinement would reduce clearing of potential habitats for these species by 0.8 hectares. The EIS and this supplementary report identify significant impacts for these fauna species for the project already with the exception of the wide-ranging and highly mobile Grey-headed Flying-fox. The impacts to threatened fauna are not expected to change from that reported in the EIS and conclusions of the assessment of significance on these species are not altered by this design refinement.

Impacts to Angophora robur

The threatened flora species Sandstone Rough-barked Apple (*Angophora robur*) (EPBC Act and TSC Act) occurs in relatively high abundance through this area and the design refinement would result in an additional impact on around 11 individuals (refer to Table 3-15).

Connectivity for fauna

There are no proposed connectivity structures in this location and this refinement does not change the potential impact on fauna movements or alter a structure proposed. There is a combined Emu underpass structure located at Station 64.5 which is 400 metres south of Crowleys Road. Crowleys Road would be built as an overpass over the highway and is not expected to provide a fauna connectivity function.

Indirect impacts

The indirect impacts would likely to include potential weed invasion in edge areas as assessed in the EIS. The edge ratio would not increase. As there is a reduction in vegetation clearing, there would be a decreased level of indirect impacts such as edge effects and reduced the penetration of weeds into native habitats. Noise and light levels and changes in temperature and wind speed would still remain and indirectly impact remaining habitats.

3.9.4. Additional mitigation

There are no additional specific mitigation measures beyond what is reported in the EIS and threatened species management plans.

3.10. Koala Drive biodiversity assessment

The assessment of the Koala Drive design refinement was undertaken as a field survey assessment. There was insufficient biodiversity information from previous field investigations and required additional targeted surveys to calculate changed impacts on vegetation, habitat and threatened ecological communities.

3.10.1. Design refinement description

Koala Drive is located around 1.5 kilometres north of Townsend, adjacent to the Yaegl Nature Reserve within Section 5 of the project. The design refinement provides formalised access along Koala Drive under the twin highway bridges shown in Figure 3-6.

3.10.2. Survey results

Koala Drive is an unsealed property access road that connects Yaegl Nature Reserve with the Maclean Pinnacle. Targeted surveys were undertaken in February 2013 and are detailed in Section 3.2.2. It is currently preserved as an informal reserve (crown land) via a road underpass. It is likely that the existing underpass in this location is used by fauna. Vegetation in the low-lying Yaegl Reserve is dominated by the threatened ecological community Swamp Sclerophyll Forest (TSC Act) and would not be impacted by the proposed design refinement. The vegetation on the western side of the road is on an isolated hill and contains a high diversity of tree species, mainly Tallowwood (*Eucalyptus microcorys*) and Grey Ironbark (*Eucalyptus siderophloia*) with several other eucalypt species. There is a high density of weeds in the lower slope area adjacent to the exiting access track and the existing Pacific Highway.

The crown lands to the west of and beyond the design refinement support a diverse canopy of dry sclerophyll species. The understorey is diverse and includes in some areas a dense mid-storey of rainforest trees, and also a high floristic diversity including a diversity of grasses, ferns, forbs and shrubs. Dense thickets of *Lantana camara* are represented in parts. Dominant canopy species include Tallowwood (*Eucalyptus microcorys*), Narrow-leaved White Mahogany (*Eucalyptus acmenoides*), Pink Bloodwood (*Corymbia intermedia*), Small-fruited Grey Gum (*Eucalyptus propinqua*), Brush Box (*Lophostemon confertus*), and Grey Ironbark (*Eucalyptus siderophloia*) (Plate 3-3).

Higher condition areas occur on the steeper elevated western portions of Maclean Pinnacle which are outside of the site area and include a diversity of native understorey plants including Tree Heath (*Trochocarpa laurina*), Banana Bush (*Tabernaemontana pandacaqui*), Coffee Bush (Breynia oblongifolia), Hairy Psychotria (*Psychotria loniceroides*), Rasp Fern (*Doodia aspera*), Settlers Twine (*Gymnostachys anceps*), Lawyer Vine (*Smilax australis*) and Scrambling Lily (*Geitonoplesium cymosum*).

Portions of the lower slopes adjacent to the existing Pacific Highway appear to have been subject to disturbance and allowed to regenerate comprising a dense canopy of Southern Salwood (*Acacia disparrima*) and in some areas Coastal Cypress Pine (*Callitris columellaris*), with a dense understorey of *Lantana camara* and thickets of rainforest trees and shrubs in the gullies (Plate 3-4).

Plate 3-3. Good condition vegetation on steeper, elevated western portions to the west of Koala Drive upslope from the highway

Plate 3-4. Lower condition vegetation on lower slopes with a dense cover of *Lantana camara* and small patches of rainforest trees

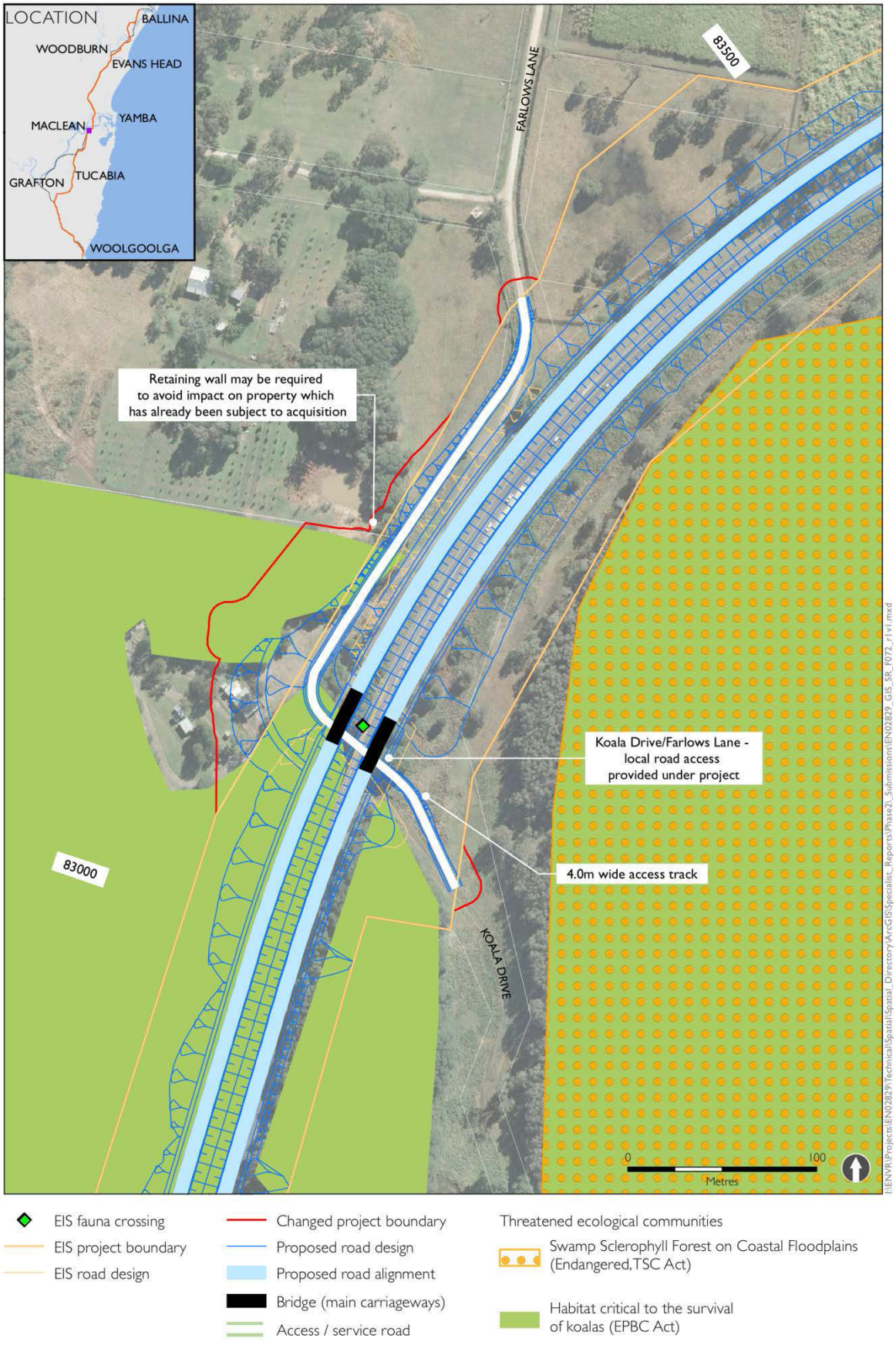

Figure 3-6: Revised design to the Koala Drive access showing ecological values

Koala habitat

The primary feed tree species Tallowwood (*Eucalyptus microcorys*) is present at greater than 30 per cent of the canopy species in the slopes associated with the crown land to the west of Koala Drive. Additionally, the secondary feed tree species Small-fruited Grey Gum (*E.propinqua*) was also present at densities below 10 per cent. This habitat is classed as primary habitat for koalas and equivalent to the class of habitat 'critical to the survival of Koala' in the interim referral advice (DSEWPaC 2012).This habitat is in contrast with the swamp sclerophyll habitat to the east of the highway which has no Koala tree species present.

Dedicated searches for koalas were conducted on both sides of the highway in this location including much of the crown lands to the west within the identified primary habitat. From a total of 15 plots, no evidence of koalas was reported at this location. A review of regional data included the NSW Wildlife Atlas and the Clarence Valley WIRES wildlife rescue database. There are reported 31 historical records of koalas within a 10 kilometre radius of the site, Clarence Valley Council (2010) report on Koala populations on the northern part of the LGA at Ashby, Woombah and Iluka and low density populations in the southern and eastern parts of the LGA. These important populations are all located on the opposite side of the Clarence River to the Koala Drive site and the river would provide a barrier to movements such that they are not expected to occur around Maclean. koalas are expected to be absent in this small area of the project, despite the name of the road.

3.10.3. Direct and indirect impacts

The design refinement would only result in a minor additional vegetation impact of 0.1 hectares of remnant dry sclerophyll forest dominated by a mixed canopy including Tallowwood (*Eucalyptus microcorys*) with a disturbed understorey and high weed density, mainly Lantana (*Lantana camara*) along edge effected habitat. The change would reduce the impact on the listed Swamp Sclerophyll Forest (endangered TSC Act) at this location by 0.02 hectares.

Habitat value for fauna is limited by the degree of weed abundance and disturbance and location of the site adjacent to the existing highway. The project would pass over Koala Drive, via twin-bridges around 30 metres long. This bridge crossing and underpass would provide a 30 metre combined access and fauna crossing, enabling vehicle access and connectivity to adjoining areas of Yaegl Nature Reserve and crown land to the west. This combined bridge/fauna underpass is existing at this location and presented in the EIS. This design refinement would retain the underpass structure. The road underpass is a local road only designed to provide access for NPWS to Yaegl Nature Reserve and therefore is expected to have low use.

The design refinement does occur in an area identified as a wildlife black spot, associated with east-west movements of other fauna across the highway between the two reserves. This is mostly common species including Swamp Wallaby and Red-necked Wallaby which commonly use both reserves. There is no evidence of koalas at this location. The refinement would alter the current suitability of this underpass location to act as an effective fauna movement corridor, and further design refinement is required to reduce the size of the cut or vehicle access.

A large cutting is required to the west of the highway and is likely to alter the approach and exit from the underpass on the western side reducing its effectiveness for fauna. However the structure itself is an improvement in fauna connectivity from the existing smaller design and remains critical given the known wildlife roadkill hotspot at this point of the highway. An additional change the design will require additional

land as part of the project and is unlikely to be warranted provided additional mitigation is implemented as discussed below.

3.10.4. Additional mitigation

Additional mitigation would be required here and comprise appropriate revegetation of the batter slope to make it attractive for fauna and is considered feasible measure of retaining the current use of the structure.

3.11. Mororo Road biodiversity assessment

The assessment of the Mororo Road design refinement was undertaken as a field assessment. There was insufficient biodiversity information from previous field investigations at this change and additional targeted surveys were required to enable calculation of changed impacts on vegetation, habitat and threatened species.

3.11.1. Design refinement description

The design refinement at Mororo Road (station 97.4 and 98.9) has increased the cutting extent at Mororo Road to improve the material balance for construction at this location. The design refinement is adjacent to the Bundjalung National Park The design refinement shown in Figure 3-7 consists of:

- A deepening of the road cutting either side of the project between stations 97.4 and 98.9 to a design level between 10 metres to 30 metres AHD.
- A move of the project boundary of around 50-100 metres to the west for a 650 metre length.
- No change to the eastern project boundary, but an increase in the area to be disturbed within the boundary.

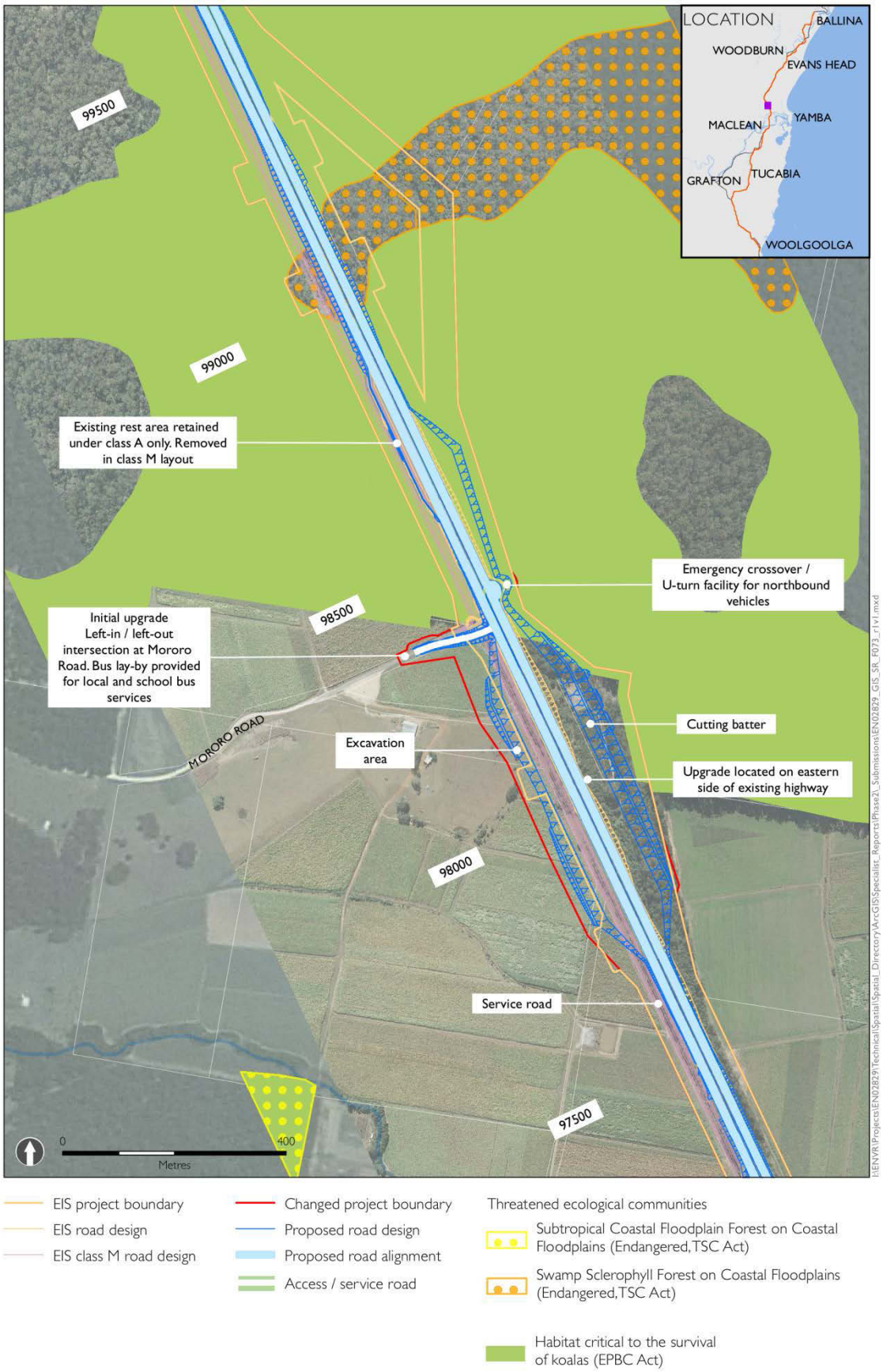

Figure 3-7: Revised design at Mororo Road showing ecological values

3.11.2. Survey results

The vegetation of the eastern side consists of both remnant and regrowth open forest. As this area is located within the existing road reserve, an old alignment of the Pacific Highway traverses parallel to the existing highway. Several parts of the old pavement are still present with some covered with regrowth native forest and weeds and associated with old cut and fill batters, including a former large ancillary site which is dominated with weeds. Regrowth over the old road exists as smaller vegetation and no large or mature trees are present.

Remnant mature forest occurs outside the boundaries of the old road particularly at the northern end of the design refinement and continues to the north. The vegetation within the cutting consists of a dry open forest dominated by Spotted Gum (*Corymbia variegata*) and Blackbutt (*Eucalyptus pilularis*) with Bloodwood (*Corymbia intermedia*) and Brush Box (*Lophostemon suaveolens*) in wetter areas. The understorey is disturbed wherever former clearing has occurred along the road reserve with dense areas of *Lantana camara* and exotic grasses. No threatened flora species or threatened ecological communities occur in this location.

The habitat within the road reserve is considered marginal for threatened fauna species which may include Brush-tailed Phascogale, threatened microbats, large forest owls and Squirrel Glider. A low density of Tallowwood (*Eucalyptus microcorys*) occurs along the length of the proposed cutting however no evidence of Koala activity was noted at this site. The condition of the habitat increases with further distance from the road reserve and continues to the east into the higher quality habitats associated with Bundjalung National Park. Areas adjacent to the highway within the impact area are notably degraded or reduced in quality and exhibit a high diversity and abundance of weeds in the mid and understorey. In particular there is extensive disturbance from around station 98.2 associated with a former road construction compound and storage area.

3.11.3. Direct and indirect impacts

The design refinement involves widening the cut batter within the current road reserve situated between the existing highway and the boundary of Bundjalung National Park on the eastern side of the project corridor (Figure 3-7). The fill batter would be widened on the western side which is cropping land (sugar cane) with minimal value for flora and fauna and no conservation significant biota.

As a result of the widened footprint on the eastern side, additional impacts to native vegetation would occur (refer Table 3-16) compared to the clearing boundary assessed in the EIS. The vegetation to be impacted consists of both remnant and regrowth dry open sclerophyll forest and no Threatened Ecological Communities or threatened species populations will be impacted, hence these are not shown on the map.

Table 3-16 Comparison of impacts between the EIS design and the design refinement at Mororo Road

Biometric vegetation types	EIS design (ha)	Design refinement (ha)	Change in vegetation loss (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	1.2	2.7	+1.5
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	1.7	0.8	-0.9
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	2.8	6.2	+3.4
TOTAL	**5.7**	**9.7**	**+4.0**

The design refinement in this location would result in a broader footprint impacting a larger area of remnant and regenerating vegetation than the EIS design (around 4.0 hectares). This consists of widespread vegetation types commonly recorded throughout this location and no communities listed under the EPBC Act or TSC Act. No threatened plant species were identified from the field surveys. The condition of the habitat in this location varies from poor to moderate and exhibits a high weed density particularly along edge areas of the old and existing highway.

There is moderate potential for threatened fauna to occur including forest dwelling species such as large forest owls, microchiropteran bats, Squirrel Glider, and Brush-tailed Phascogale. These species may be impacted only through the loss of foraging habitat as there is a lack of mature habitat here including hollow-bearing trees which were not found during the survey. The increase in the cut area would involve an increase in the amount of clearing of native vegetation at this site as described. The impact area does not contain any prominent habitat features or plant species that would not otherwise exist within the adjoining forest system or indeed a better represented outside the design area. The vegetation that would be removed would provide limited foraging habitat for a small range of fauna, though the potential for this vegetation be used as significant nesting/roosting sites is limited by the absence of hollow-bearing trees or other significant habitat features within the clearing areas.

Connectivity for fauna

An important east-west regional wildlife corridor occurs to the north of this location linking Bundjalung National Park on the east across the existing highway to Mororo State Forest and continuing west and north. The design refinement is located at the southern end and mostly outside of this large corridor. Indeed from south of station 98.5, the land on the western side of the cutting is cleared farm land (refer Figure 3-7). For this reason no fauna connectivity structures have been located here and the design refinement does not impact on fauna connectivity structures or fauna connectivity in general, given the lack of habitat on the western side. There is a dedicated underpass to the north of the design refinement at station 99.7 to connect Mororo State Forest with Bundjalung National Park and within the identified regional corridor. Fauna connectivity would not be significantly compromised with this proposed design refinement, given the location of the refinement is outside of the large east-west vegetated corridor.

There would be minimal impact to fauna connectivity and regional and local wildlife corridors and no change to the location of proposed crossing structures.

Koala habitat

Potential Koala habitat in this location is associated with the Grey gum - Grey Ironbark open forest habitat and determined by the presence of Small-fruited Grey Gum (*Eucalyptus propinqua*) listed as a secondary food tree species for the North Coast region (DECC 2008). A dedicated search for koalas or use of the habitat by koalas was conducted along the length of the cutting within the road reserve. No evidence of koalas was reported within the road reserve. Higher quality habitat for koalas was noted to the east and north east of the road reserve within Bundjalung National Park. The area to be impacted is considered to have low value for koalas.

3.11.4. Additional mitigation

There are no additional specific mitigation measures beyond what is reported in the EIS and threatened species management plans.

3.12. New Italy-Swan Bay Road biodiversity assessment

The assessment of New Italy-Swan Bay Road design refinement was undertaken as a desktop assessment. There was sufficient biodiversity information gathered from the previous field investigations that an additional survey was not required. Impact calculations were reassessed, with considerations given to the threatened NSW listed *Melaleuca irbyana*, in particular.

3.12.1. Design refinement description

New Italy-Swan Bay Road is located in the section of the project between Devils Pulpit to Trustums Hill (Section 7).

The design refinement would alter the access arrangements to New Italy-Swan Bay Road under both the interim arterial upgrade and the ultimate motorway upgrade. The design refinement would be situated within the project boundary as proposed in the EIS, with a reduction in the project boundary at the corner of New Italy- Swan Bay Road. However, this change is situated on cleared land. The design refinement is shown as Figure 3-8.

3.12.2. Direct and indirect impacts

The design refinement at this site is minor in scale and associated with a refinement to the intersection design and access/egress points to New Italy-Swan Bay Road. The design refinement is confined to the EIS clearing boundary. Impacts would be to a narrow linear strip of vegetation currently positioned between the existing highway and an adjacent service road to the west. As a result there would be no additional impacts to vegetation, fauna habitat or threatened ecological communities beyond what was assessed in the EIS.

An important population of the threatened Weeping Paperbark (*Melaleuca irbyana)* (vulnerable species TSC Act) was identified in the EIS and occurs to the south of this location and impacts have not altered from those assessed in the EIS. Specific details on this population area described in the EIS include quantifying the impact on the population and direct and indirect impacts.

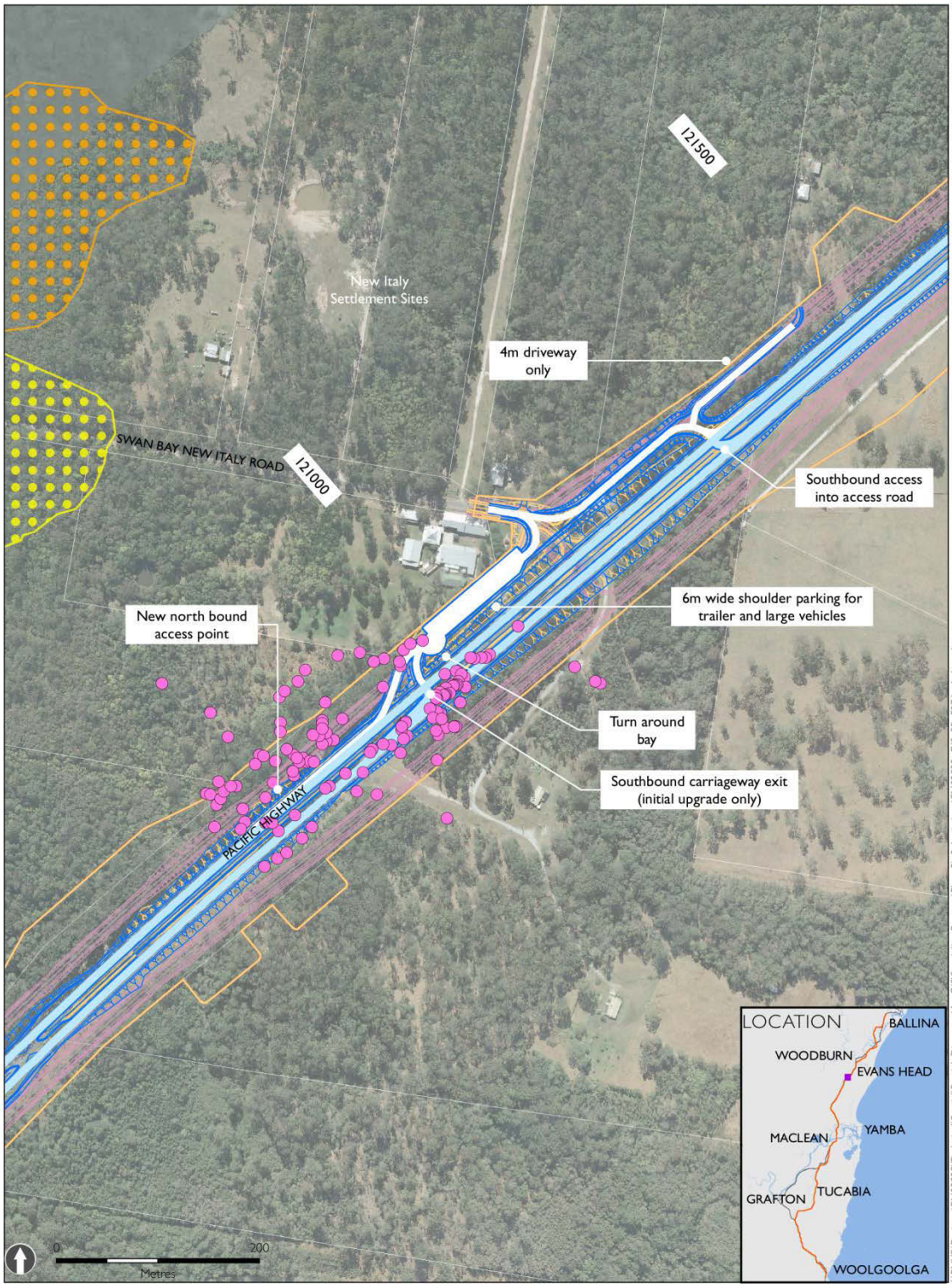

Figure 3-8: Revised design at New Italy-Swan Bay Road showing ecological values

The areas impacted and discussed in the EIS include narrow linear portions of remnant habitat positioned along the road reserve that are currently impacted through edge effects and fragmentation. Because of this position in the landscape they provide limited value for threatened flora and fauna particularly in comparison to surrounding areas of habitat to the east and west at distance from the highway.

Indirect impacts associated with weeds, altered light levels and noise would penetrate further into the retained habitat and associated with the proposed refinement. This would mostly occur over an area of 600 metres (station 125.9 to 126.5). The habitat in this location is dominated by wet sclerophyll forest (Red Mahogany open forest of the coastal lowlands on the North Coast).

The EIS reports that a direct loss of this habitat, including food, shelter and breeding resources is likely in this area, as with surrounding areas, however the project also reports that impacts are expected to be less where the existing highway is duplicated as at this location, opposed to where new deviations occur. This is because the edge habitats being impacts here are expected to have only marginal habitat value for the assessed threatened fauna particularly for wide-ranging and highly mobile species such as Grey-headed Flying-fox and Swift Parrot, Little Lorikeet and threatened microchiropteran bats. These species are capable of accessing resources over large areas and would not be dependent on habitats along the exiting edge of the highway. Indirect impacts to threatened fauna would include potential change in movements of populations, edge effects on remaining habitat adjacent to the project including weed invasion, run-off and noise and light impacts and these were considered in the EIS. Increased edge effects would also degrade the composition and structure of remaining vegetation.

The design refinement would see a similar impact on vegetation in terms of size and location by 0.8 hectares. The EIS and this supplementary report identify significant impacts for many of these fauna species for the project already with the exception of the wide-ranging and highly mobile Grey-headed Flying-fox. The impacts to threatened fauna are not expected to change from that reported in the EIS and conclusions of the assessment of significance on these species are not altered by this design refinement.

Connectivity for fauna

In general, given the design in this location is a duplication of the existing highway, it provides limited opportunity for fauna connectivity. Much of the habitat on the western side of the highway has been previously cleared for hobby farming with the exception of a patch between 125.9 and 126.5. This vegetation extends to the east and west of the highway and may provide a local wildlife corridor. There is currently a 60 metres wide mown strip adjacent to the existing highway occurring across the length of this corridor. Fauna that get across the highway would also have to cross this clearing. The proposed new service road would be placed in this mown strip and therefore would not involve vegetation clearing, but would result in a further barrier for fauna crossing at this location.

3.12.3. Additional mitigation

The mitigation measures outlined in the EIS are directly applicable to both the EIS design and the design refinement in this location, as there would be no further impacts on *Melaleuca irbyana* which is located south of this position. Measures at this site would include identifying exclusion zones and conducting pre-clearing surveys and fauna rescue during clearing to ensure the protection or rescue of any hollow dependent fauna species. There are no additional specific mitigation measures beyond what is reported in the EIS and threatened species management plans.

3.13. Lang Hill biodiversity assessment

The assessment of Lang Hill design refinement was undertaken as a desktop assessment. There was sufficient biodiversity information gathered from the previous field investigations that an additional survey was not required. Impact calculations reassessed for the design refinement footprint to consider impacts on the Commonwealth listed Oxleyan Pygmy Perch.

3.13.1. Design refinement description

Lang Hill is the locality for a major source of material (borrow site) for the project, providing around 300,000 cubic metres of earthworks. The refined area of the borrow site would be located around 250 metres to the north of the project. The design refinement includes:

- An area of excavation and disturbance that is reduced by over half.
- A reduction in the quantity of material sourced from the site from around 530,000 cubic metres to 300,000 cubic metres.
- Site restoration, where reasonable and feasible, to include the rehabilitation and landscaping of the site using permanent stockpiling of surplus material.

3.13.2. Survey results

Lang Hill is located near Broadwater National Park and a number of surrounding waterways have been identified as critical habitat for the Oxleyan Pygmy Perch (DPI 2010). Targeted surveys were conducted for the EIS within the creek area crossed by the project alignment which is south of the excavation area (station 134.6). The Oxleyan Pygmy Perch was confirmed near the project corridor where the habitat is in better condition than further north towards the excavation area. The condition of the creek immediately adjacent to the excavation area is considered poor, being impacted by uncontrolled access by cattle, leading to heavy trampling, siltation and potential pollution from cattle dung (Plate 5). Based on the present condition it is unlikely that Oxleyan Pygmy Perch extend into this disturbed area of habitat adjoining Lang Hill. South of the project corridor, the waterway is of better condition where it continues through densely vegetated habitat fenced off from cattle. This was the area where Oxleyan Pygmy Perch were recorded during surveys.

3.13.3. Direct and indirect impacts

The design refinement at Lang Hill would remove a small isolated remnant of open forest; comprising scattered low number of trees and a completely modified and grazed understorey (refer Figure 3-9). The disturbed remnant is dominated by Grey Gum (*Eucalyptus propinqua*), Pink Bloodwood (*Corymbia intermedia*) and Northern Grey Ironbark (*E.siderophloia*). The habitat was assessed as providing some value for wide-ranging fauna species not dependent on habitat connectivity given the isolated nature of the habitat. There are some larger, mature trees which would provide temporary refuge or food and shelter for nectarivores such as the Grey-headed Flying-fox or wide ranging nectarivores and insectivores including lorikeets and insectivorous bats. The habitat may also be used by species such as the Masked Owl which have adapted to hunting in modified landscapes. The direct and indirect impacts on terrestrial flora and fauna species would be adequately covered in the EIS and not change between the EIS design and the design refinement.

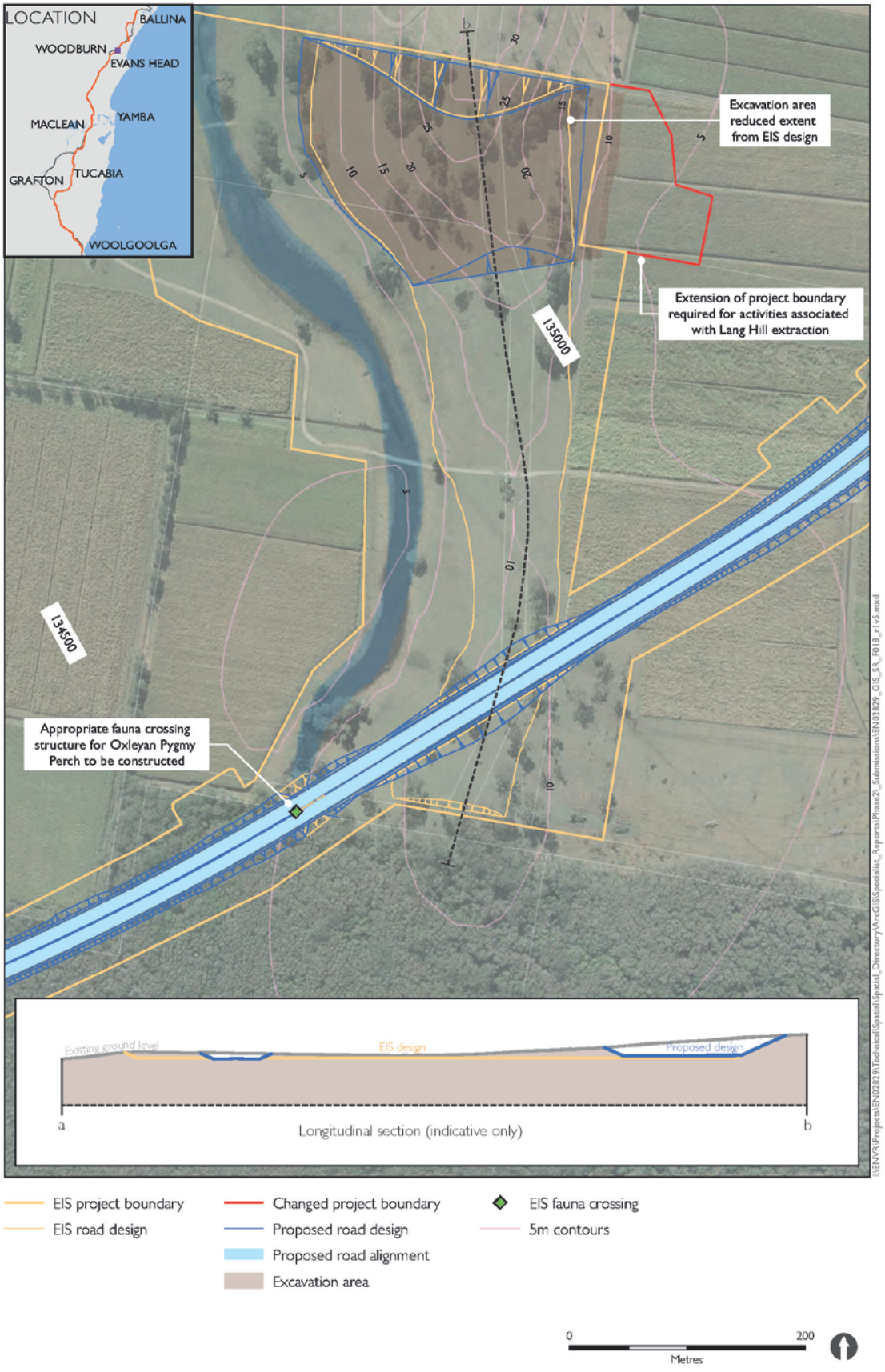

Figure 3-9: Revised excavation design at Lang Hill

There are no impacts to threatened ecological communities or threatened flora species in this location.

By reducing the area of the borrow site from the design in the EIS, the new design would restrict ground disturbance works to the northern end of the site. This is a significant reduction in area and minimises the potential impact on known habitat for Oxleyan Pygmy Perch to the west of the site.

Aquatic and wetland habitat

The portion of the waterway adjacent to the Lang Hill borrow site is considered unlikely habitat or only very marginal for the Oxleyan Pygmy Perch, despite the species known presence further upstream. This is because the waterway adjacent to the hill is heavily impacted by a long history of unrestricted cattle access into the water and past removal of riparian vegetation, resulting in poor water quality and a complete lack of riparian vegetation. The proposed excavation area of Lang Hill is to the east of the creek line and adjacent to the poor quality habitat (refer Figure 3-9). At its nearest location the excavation area is located between 50 to 60 metres east of the waterway and buffered by a wide flat area of cleared pasture land (Plate 3-5). Access to the site would be from the east only, with material haulage not undertaken across the existing crossing over this waterway to further minimise potential impacts to fish habitat.

There would be no direct impacts on potential habitat of the Oxleyan Pygmy Perch as a result of the excavation of material at Lang Hill. Potential impacts to the waterway are associated with indirect impacts including noise levels and surface run-off. Surface run-off during both construction and operation would be controlled via sedimentation and water quality basins.

The waterway is believed to be at least partially fed by groundwater sources, and the interruption of the groundwater table could adversely affect the waterway. The excavation would intersect the local groundwater table, however, as the cutting would not be deeper than the level of the stream bed (4.5m AHD versus 1.5m AHD), the site would not induce groundwater flow away from the waterway and result in reduction in low flow conditions.

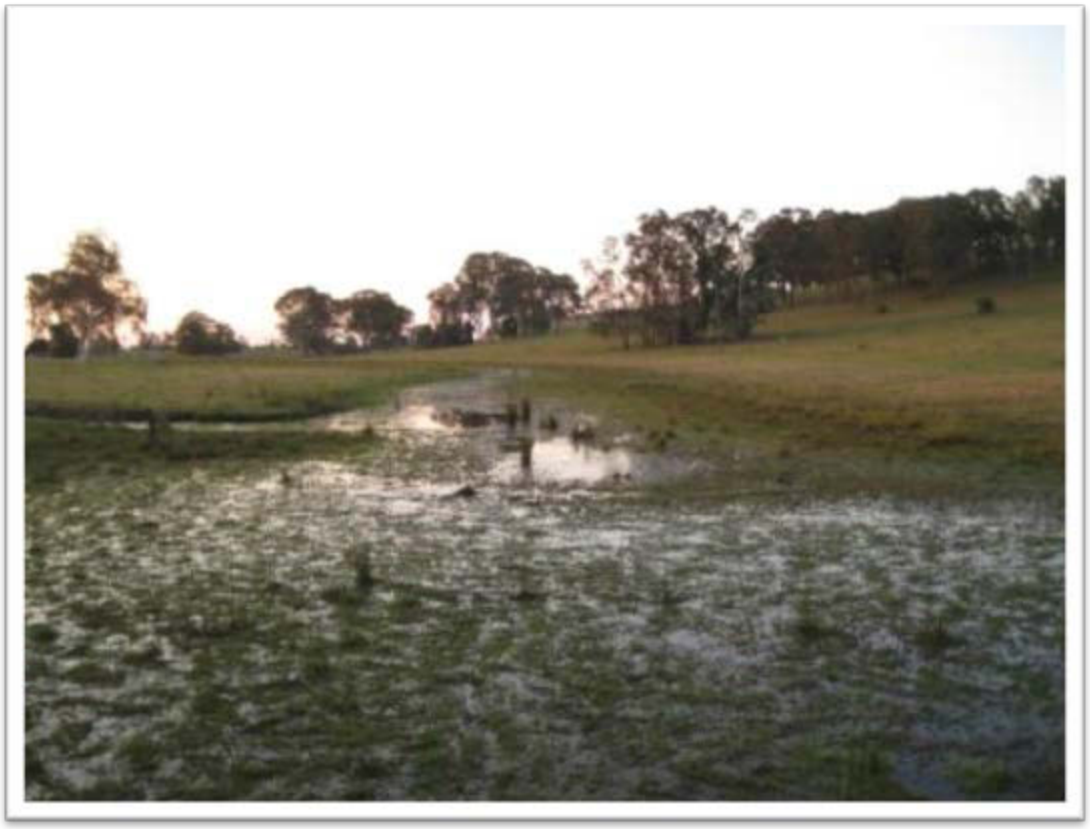

Plate 3-5. Disturbed creek habitat at the Lang Hill site shows buffer area to the right of the photo downslope from the hill.

3.13.4. Additional mitigation

An environmental management work statement (EMWS) has been developed for the site. This EMWS has established procedures and controls to avoid impacts to the waterway. Procedures and controls include:

- Excavation of the site would be undertaken in a number of stages with consideration of the sensitivity of the site including the adjacent waterway. The staging has been designed to minimise the risk of impacts to the waterway.
- The staged approach would minimise the area of the site exposed at one time and ensure that any run-off drains away from the waterway or is captured on-site.
- A large sedimentation basin would be situated to the east of the site to capture site runoff and avoid spilling into the waterway discussed. Water in the sedimentation basin would not be released to the waterway, but rather, sprayed onto adjoining Roads and Maritime owned land.
- A diversion drain would be established to the north of the site to divert clean water around the site.
- Silt fencing would be established to the east of the waterway to capture any sediment.
- All controls would be subject to ongoing monitoring and maintenance throughout the use of the site.

The site would be backfilled with available surplus material from the project and revegetated following use during construction.

The creekline on the property should be fenced off and allowed to regenerate to improve the condition of the habitat for Oxleyan Pygmy Perch.

3.14. Rest area north of Richmond River biodiversity assessment

The assessment of Richmond River (rest area) design refinement was undertaken as a desktop assessment. There was sufficient biodiversity information gathered from the previous field investigations and survey of adjacent quarries (refer 3.15) that an additional survey was not required. Impact calculations reassessed for the design refinement and included potentially indirectly impacted areas.

3.14.1. Design refinement description

The proposed rest area is located near Old Bagotville Road in Section 10 of the project (refer to Figure 3-10). The southbound rest area has been relocated from stations 147.3 to 148.3, to north of Old Bagotville Road between stations 149.1 to 149.6. The northbound rest area has been shifted slightly north to stations 148.0 to 148.2.The rest area designs now excludes the heavy vehicle checking station previously provided.

A new dedicated fauna land bridge has been provided at station 147.6 targeted primarily at koalas and recognising the important Koala population in the Wardell Bagotville area.

3.14.2. Avoidance measures

The relocation of the south bound rest area north would effectively reduce impacts on biodiversity by reducing the need for vegetation clearing and providing improved opportunities for fauna connectivity east and west of the project which in this location that has been identified as a critical movement area for fauna, particularly the Koala population in this area (discussed further in Section 5.5 of this report). These opportunities will be assisted by the inclusion of a new dedicated fauna land bridge (station 147.6) and strategic revegetation of a number of currently cleared areas on Roads and Maritime owned land. Habitat revegetation would occur on the west side of the land bridge at station 147.6, also on the eastern side at station 147.8 and east and west of the proposed underpass structure at 148.6.

The new southbound rest area would be placed in cleared land where it formerly occurred in an area of mixed clearing and remnant vegetation and therefore a reduced area of clearing is required. The northbound rest area will remain in the area identified by the EIS with a slight move where there is minimal vegetation and is located on the edge of an existing quarry. There will be minimal loss of vegetation here above the assessed rest area design.

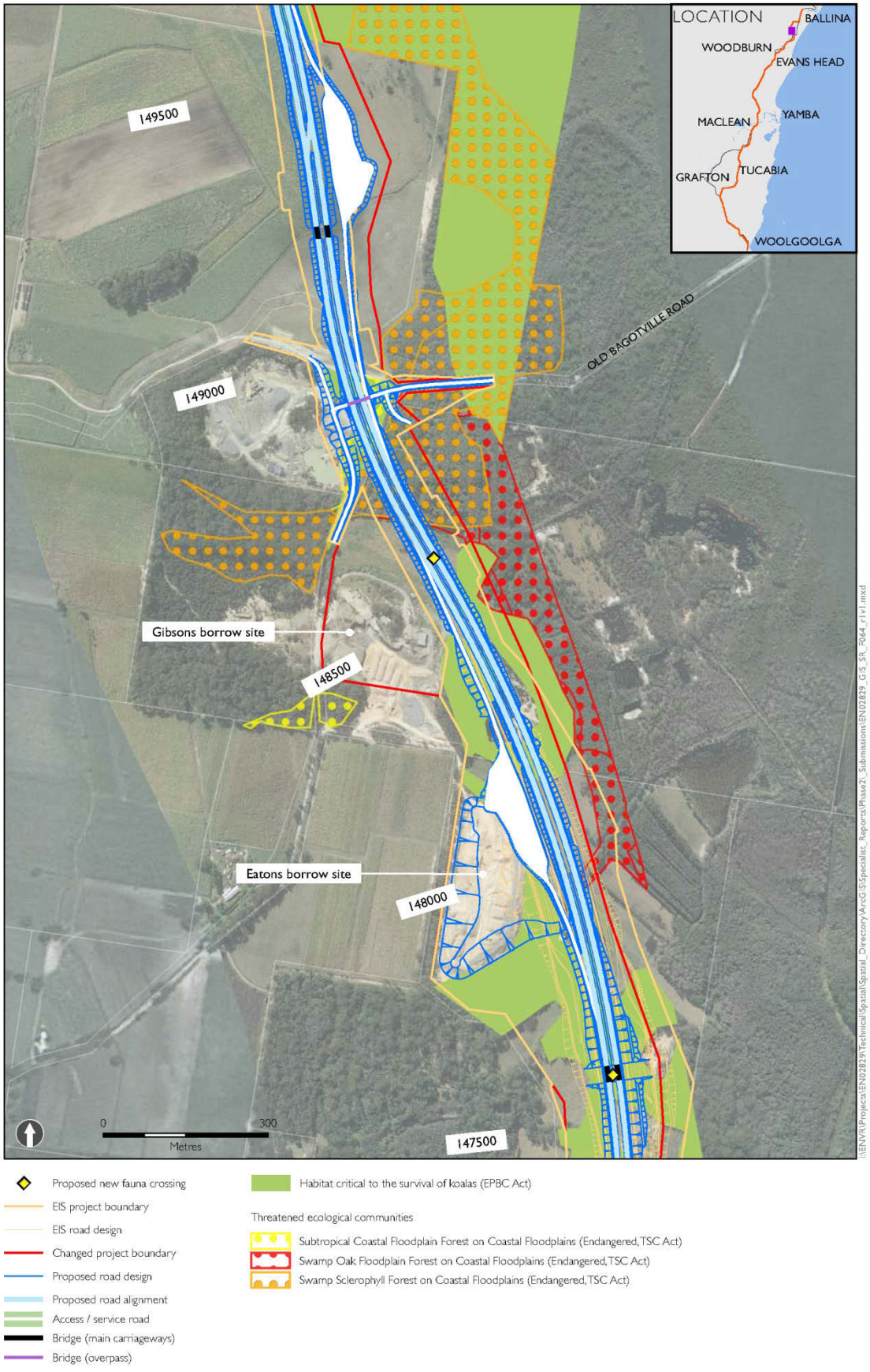

Figure 3-10: Revised rest area design north of Richmond River showing ecological values

3.14.3. Direct and indirect impacts

The design refinement for the rest area at Bagotville was shifted to the north of its original location, and includes a smaller of vegetation and habitat being impacted (-6.2 hectares) than the original location through the narrowing of the footprint and the south bound rest area itself has been deliberately placed in an existing cleared paddock. The vegetation types present in the clearing area are listed in Table 3-17 along with a comparison of the area of impact between the concept design and the design refinement. The area of impact to threatened ecological communities would remain the same or would decrease (refer to Table 3-17).

Table 3-17 Comparison of impacts between the EIS design and the relocation of the rest area

Biometric vegetation types	Concept design (ha)	Design refinement (ha)	Change in vegetation loss (ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	20.2	15.5	-4.7
Coastal floodplain sedgelands, rushlands, and forblands (EEC, Freshwater Wetlands - TSC Act)	0.5	0.2	-0.3
Coastal heath on sands of the North Coast	1.8	1.9	+0.1
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast (EEC, Subtropical Coastal Floodplain Forest - TSC Act)	0.8	0.8	0.0
Paperbark swamp forest of the coastal lowlands of the North Coast (EEC, Swamp Sclerophyll Forest - TSC Act)	2.3	1.5	-0.8
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast (EEC, Swamp Sclerophyll Forest - TSC Act)	0.1	0.1	0.0
Swamp Oak swamp forest of the coastal lowlands of the North Coast (EEC, Swamp Oak Floodplain Forest - TSC Act)	0.6	0.2	-0.4
Tallowwood dry grassy forest of the far northern ranges of the North Coast	0.6	0.5	-0.1
TOTAL	26.9	20.7	-6.2

The reduction in vegetation clearing includes approximate 0.1 hectares of habitat for koalas identified as habitat critical to the survival of Koala, according to DSEWPaC (2012) also defined as secondary Koala habitat according to DECC (2008) which would be avoided. The supplementary Koala surveys in this location are described in more detail and Chapter 5 and explain that the habitat from the Richmond River to Bagotville and Coolgardie contains an important Koala population which is a source population for other Koala populations west of this area on the Alstonville plateau and Blackall Range. The area is important for Koala movements which are acknowledged by this design refinement.

There would be a small increase (0.1 hectares) in the area of Coastal heath on sand habitat for Long-nosed Potoroo being removed. However this species could use a diversity of dry sclerophyll forest habitats in this location and is expected to also benefit from the overall reduction in habitat loss resulting from the design refinement.

No threatened flora species have been recorded in the design refinement area.

There would be an overall reduction in the area of vegetation to be cleared. The net benefit associated with the design refinement is in the shifting of the rest area out of a fauna corridor connecting Wardell heathlands to the west towards Bagotville. This would see a reduction in indirect impacts and benefit species such as Koala and Long-nosed Potoroo. To further offset impacts in this area a dedicated land overpass has been included at station 147.6. This structure was not included in the concept design and would contribute to the maintenance of wildlife movements in this important area for biodiversity.

3.14.4. Additional mitigation

The design has incorporated a new fauna land bridge at station 147.6 to facilitate connectivity for Koala, Long-nosed Potoroo and other fauna. There are no additional measures required.

3.15. Borrow sites north of the Richmond River biodiversity assessment

There are two quarries near Old Bagotville Road adjacent to the project corridor now included for a source of material for the project. The two quarry sites are located on the west side of the highway south west of Old Bagotville Road between station 147.8 and 148.8 and are covered by an approved Development Application (DA). The intent is to retain any further excavation works on these properties within the approved DA footprint.

3.15.1. Direct and indirect impacts

A site inspection was conducted for the two quarries, which currently are cleared of vegetation and have existing access from Bagotville Road. The survey identified that both sites are cleared of vegetation and contain only modified and disturbed areas, including access roads and dams. However there are areas of remnant vegetation around the perimeters of one of the quarries which would be directly impacted by the proposed extraction of material. This will comprise the removal of around 0.8 hectares of disturbed Blackbutt grassy open forest of the lower Clarence Valley of the North Coast, which has been identified as habitat critical to the survival of Koala, according to DSEWPaC (2012) also defined as secondary Koala habitat according to DECC (2008). No evidence of Koala activity was recorded at this small patch adjacent to the quarry works.

3.16. Borrow site west of Wardell (Lumley's Hill) biodiversity assessment

The assessment of Wardell Road design refinement was undertaken as a desktop assessment. There was sufficient biodiversity information gathered from the previous field investigations that an additional survey was not required. Impact calculations reassessed for the design refinement and included potentially indirectly impacted areas.

3.16.1. Design refinement description

A borrow site on Hillside Lane in Section 10 (Station 152.5) would be established for the project, to provide construction fill material. The borrow site would be increased to source an additional 287,000 cubic metres from the site, extending the site a further 170 metres north to around 1.83 hectares (refer to Figure 3-11).

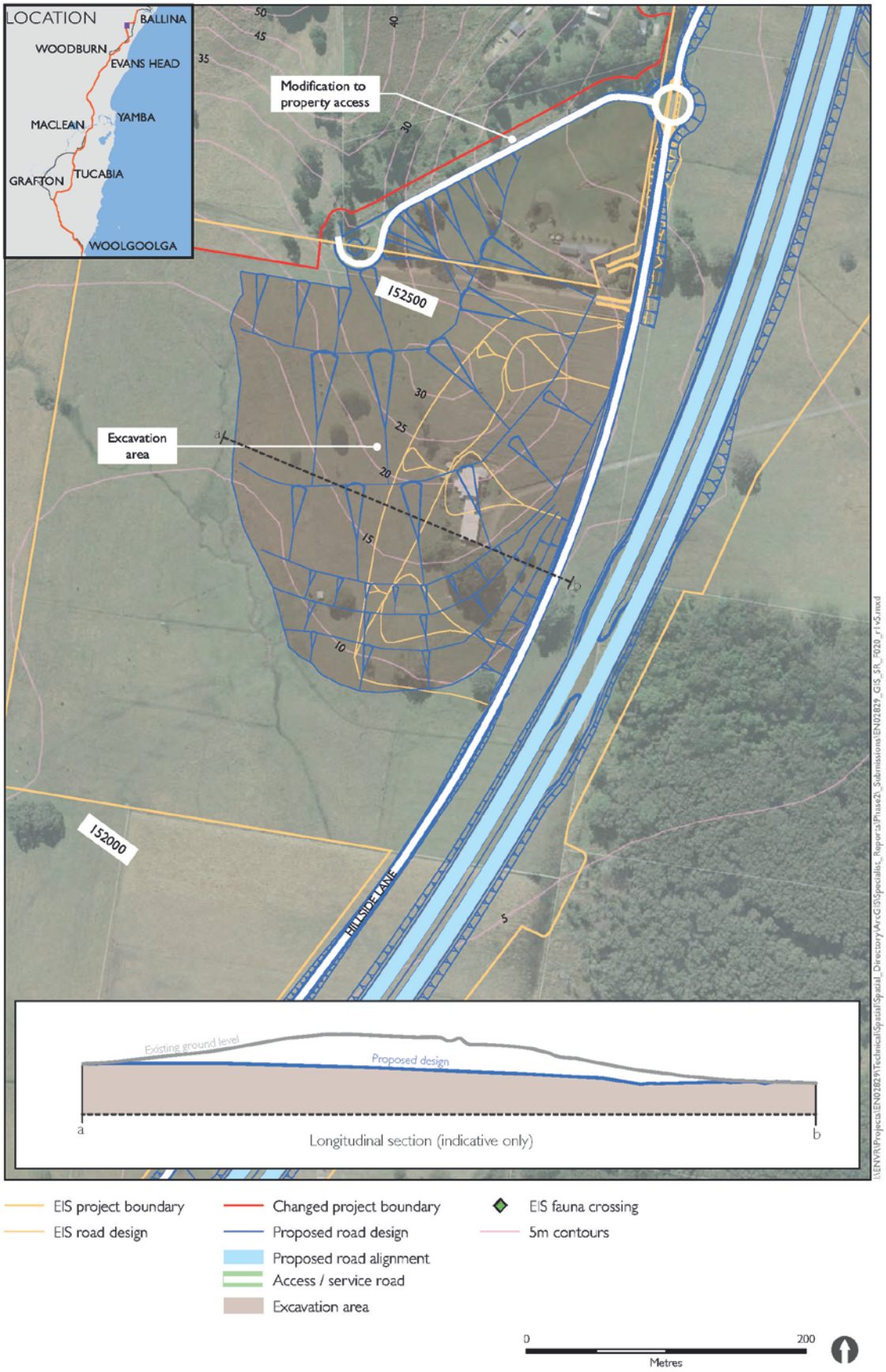

Figure 3-11: Borrow site west of Wardell

3.16.2. Direct and indirect impacts

The property occurs in cleared farmland with scattered remnant paddock trees, mostly Stringybark (*Eucalyptus acmenoides*) and the introduced and invasive Camphor Laurel (Figure 3-11). Of the scattered low density trees, a single mature tree is hollow-bearing and provides potential nesting habitat for birds and microchiropteran bats, including a number if threatened species. The tree would need to be felled for the borrow site extension. This habitat tree may provide potential roosting or nesting habitat for several hollow-dependent fauna species. These could include several threatened microchiropteran bats and a small range of threatened birds such as the Little Lorikeet and Masked Owl.

Associated with the scattering of trees is also a potential food resource for nectivorous fauna in the form of seasonally available blossom, and again this is of greatest value to wide-ranging and highly mobile species such as the Grey-headed Flying-fox, Little Lorikeet and Swift Parrot.

The design refinement would only have a minimal change in impact from the EIS design. The site is located in cleared land with a lack of permanent freshwater aquatic habitat at the site. As such, no indirect impacts are expected or additional impacts to connectivity for fauna.

3.16.3. Additional mitigation

There are no additional specific mitigation measures beyond what is reported in the EIS and threatened species management plans.

3.17. Interchange at Wardell biodiversity assessment

The assessment of the interchange at Wardell design refinement required additional field survey. Targeted surveys were required to calculate changed impacts on vegetation, habitat and threatened species and ecological communities.

3.17.1. Design refinement description

The design refinement would relocate the highway alignment south and east between station 155.4 and 159.5 (refer to Figure 3-12 to Figure 3-14). The interchange at Wardell would also be modified, with key changes consisting of:

- Relocation of the western roundabout 50 metres east.
- Relocation of the eastern roundabout 200 metres north-east, providing access to/from the southbound carriageway and access to the service road and local road network (allowing removal of the third roundabout).
- Minor realignment of the overpass and access between Coolgardie Road and the existing Pacific Highway.
- Realignment of on-ramps and off-ramps.
- New access into Kays Road from the existing Pacific Highway (around station 157.2).
- Provision of a narrow median to minimise the project footprint with widening to a potential future third lane undertaken on the outside shoulder of each northbound and southbound carriageway (subject a separate approval).
- Relocation of a dedicated fauna land bridge to 100 metres further east, to station 156.1.

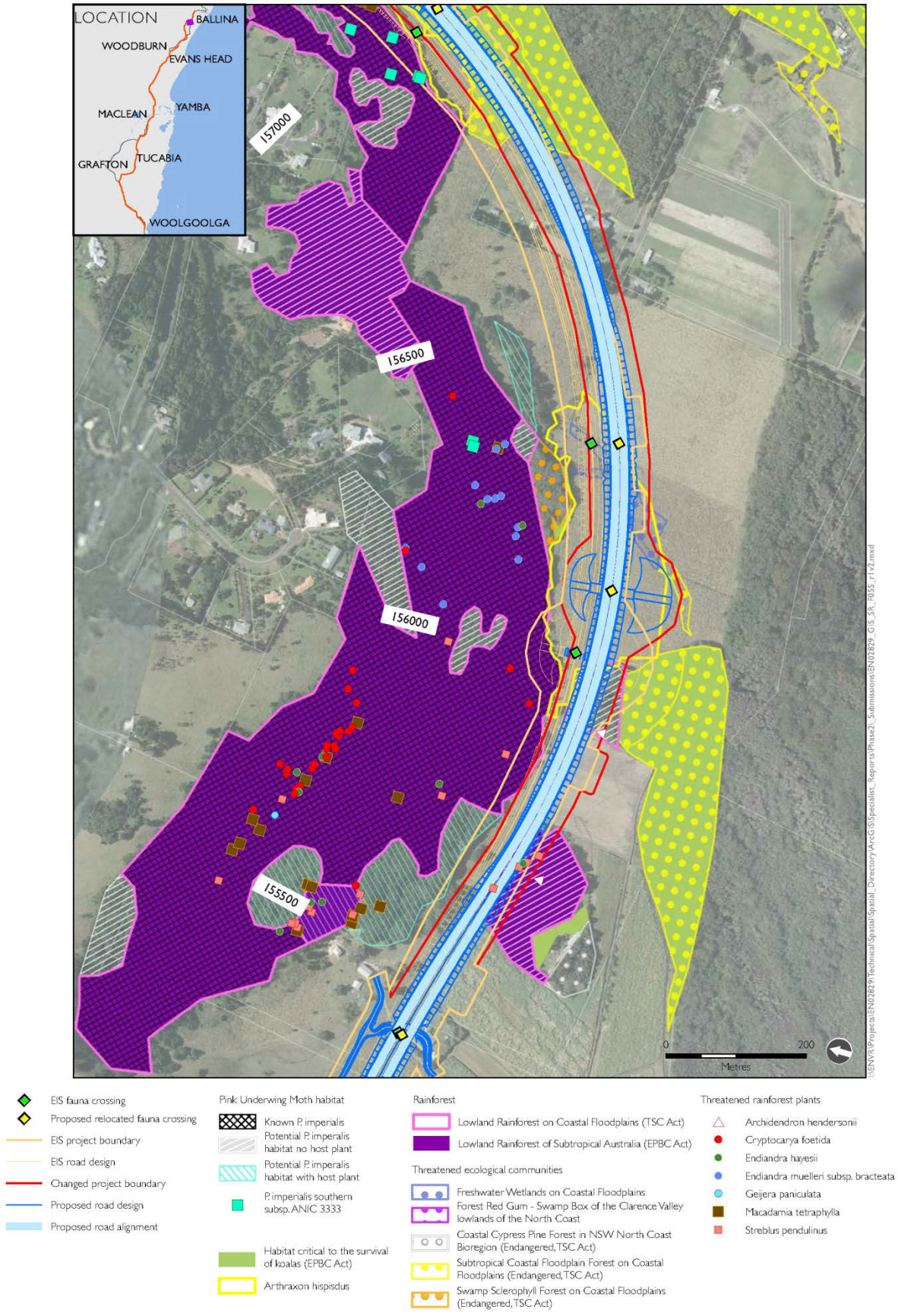

Figure 3-12: Revised interchange at Wardell (station 154.5 to157.0)

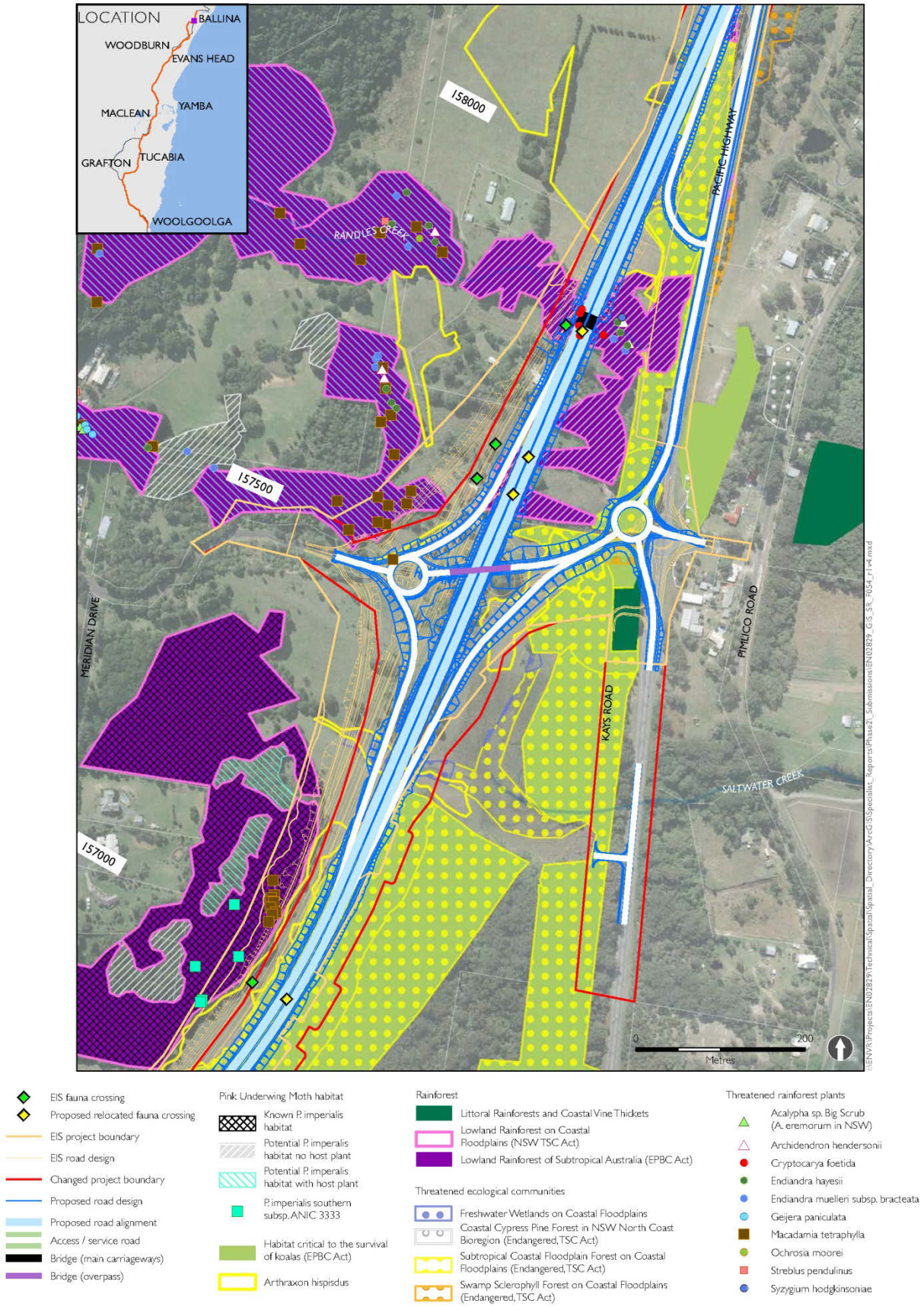

Figure 3-13: Revised interchange at Wardell (station 156.5 to 158.5)

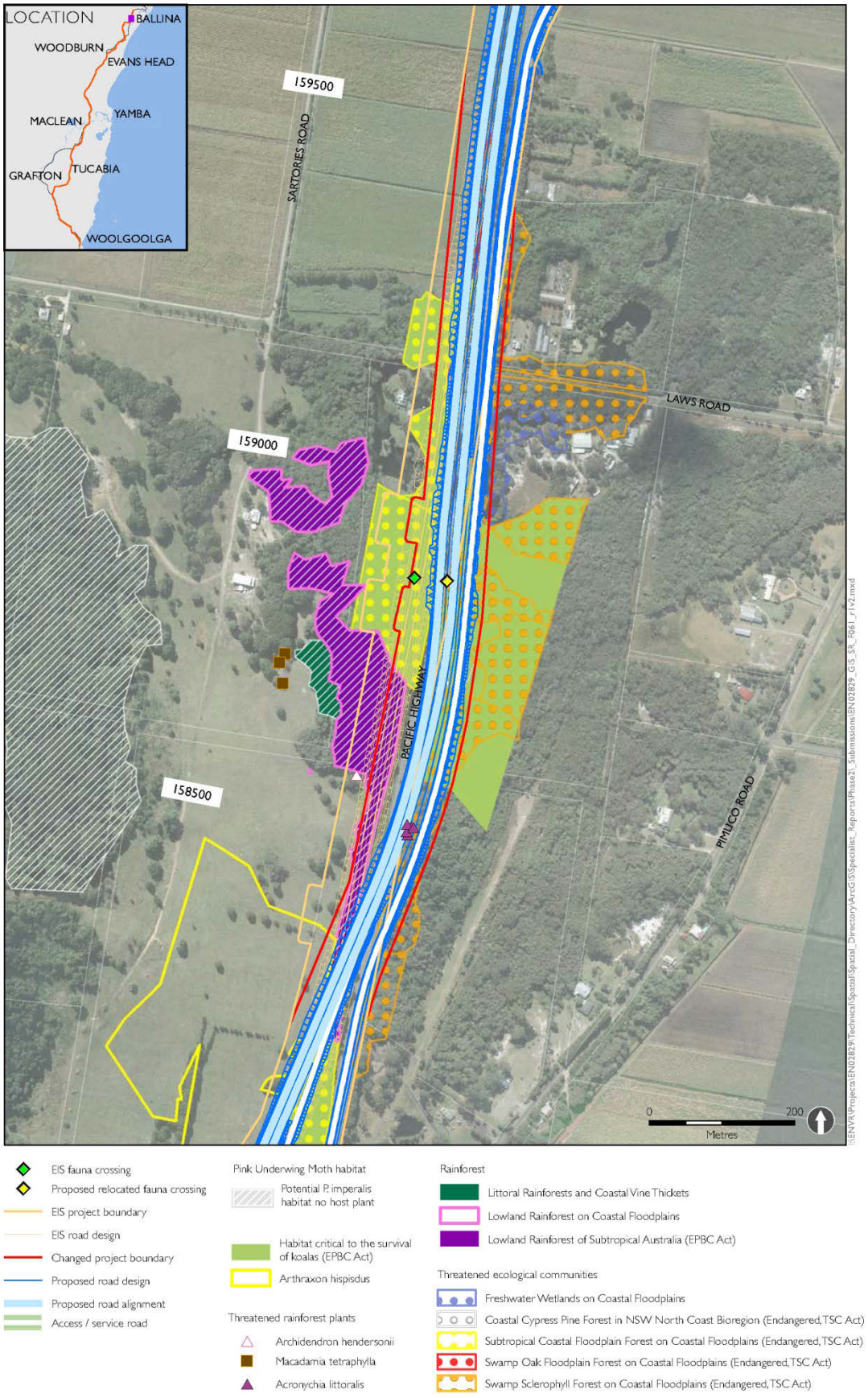

Figure 3-14: Revised interchange at Wardell (station 158.0 to 159.5)

3.17.2. Avoidance measures

This design refinement has been proposed to avoid impacts to known habitat of the Pink Underwing Moth (*Phyllodes imperialis* southern subsp) (listed as endangered on the EPBC Act) and to minimise impacts on potential habitat (breeding and non-breeding) for this species. The refinement to the layout of the interchange has been modified to also minimise impacts to the extent possible on listed lowland rainforest patches, a number of rainforest threatened plants and littoral rainforest patches (EPBC Act and TSC Act).

However, relocation of the alignment east to avoid the lowland rainforest has resulted in as slight increase in impact on other EPBC Act listed species, including habitat critical to the survival of the Koala and a threatened plant species *Acronychia littoralis*.

The design refinement has narrowed the median. However, should the highway be upgraded to six lanes in the future, by widening on the outside of the corridor, there would still be no direct impact to lowland rainforest and known or potential habitat for the Pink Underwing Moth.

The EIS identified two patches of littoral rainforest. The EIS design impacted on one of these patches at station 162.8 (around 0.2 hectares), an isolated fragmented on low condition rainforest that is situated adjacent to the existing highway within the road reserve. Through this section, the design has sought to maximise the use of the existing road reserve in order to tie-in seamlessly with the adjoin Ballina bypass project. The required tie-in at this location has meant the littoral rainforest patch could not be avoided. The supplementary surveys undertaken for this design refinement recorded an additional low condition patch of littoral rainforest (around 0.2 hectares) south of Coolgardie Road, located between the existing highway and Kays Road with a small power easement at the northern end. As a result, the interchange at Wardell was then further refined to minimise, to the greatest extent possible, impacts to this patch of critically endangered vegetation community.

3.17.3. Survey results

The design refinement resulted in the need to shift the alignment east of the existing Pacific Highway for a distance of around 200 metres (between station 158.3 and 159.5) and up to 30 metres east of the edge of the existing highway. These areas had not been targeted previously in EIS surveys and so an additional survey was conducted in February 2013 and July 2013 (refer to Section 3.2.2). The results are described in the following sections.

3.17.4. Direct and indirect impacts

Pink Underwing Moth

The project design, as displayed in the EIS would directly impact on 6.4 hectares of known and potential habitat for the Pink Underwing Moth. The design refinement has reduced the direct impact on known habitat and potential breeding habitat for the species (ie from 1.2 hectares down to zero) and the complete avoidance of direct impacts to the host plant of the moth (*Carronia multisepalea*). The design refinement has reduced the impact to 2.5 hectares of potential habitat (no host plant) (Table 3-18).

The road alignment between station 154.0 and 158.0 is aligned to follow the foothills of a low basalt escarpment. Vegetation to the west of the road within the escarpment is dominated by rainforest. To the east of the project, vegetation is mostly low-lying, eucalypt dominated swamp forest. The road design assessed in the EIS had been aligned to traverse the cleared land as much as possible in between these two native

vegetation blocks, with the rainforest habitat of the Pink Underwing Moth positioned upslope to the west. This design refinement also utilises this cleared corridor although it is now relocated slightly further into the eucalypt dominated swamp forest and away from the rainforest communities.

Due to the presence of the existing cleared habitat there is an existing edge affected zone along the edge of the rainforest habitat occupied by the moth. This is appears in the form of a denser understorey, more open canopy in parts and presence of weeds, mostly Camphor Laurel and Lantana, although these weeds also occur throughout the rainforest patches. There are no impacts from run-off at the site due to the slope of the site and the fact that cleared is downslope although grazing impacts are evident in part of the rainforest inhabited by the moth. Despite the existing edge impacts the host plant and eggs and larvae of the Pink Underwing Moth were located within the edge zones.

The presence of the highway would contribute to indirect impacts at the current edge affected zone although it may be difficult to distinguish these from the existing impacts where weed invasion is concerned. However altered night-time lights (traffic and street lighting) and noise will be new impacts that may negatively impact on the species. There is no published research on the effects of lights on the Pink Underwing Moth. However, while any lights are likely to disrupt normal adult moth activity for a range of common species lights are not particularly attractive to species of Phyllodes moths (Dr Don Sands, *pers.comm*). Other artificial light sources, such as car headlights are not expected to pose a significant threat to the moth, as these are transient rather than fixed. The design refinement has shifted the alignment further east near Coolgardie Road to minimise potential impacts from lighting to the habitat of the Pink Underwing Moth. In addition, lighting has been designed out for the ramps associated with the interchange at Wardell.

Currently there is limited potential for dispersal of the species, which favours dense shaded canopy and given its large size, it is susceptible to air movements (wind) restricting its dispersal capability over cleared land. Given that the majority of the habitat of the moth occurs to the west of the project, impacts from habitat fragmentation and loss of connectivity are not expected. While the presence of the road corridor and traffic may inhibit movements of the moth, there are currently limited opportunities for dispersal to the east, due to the absence of preferred habitat, with the exception of a patch of potential habitat (non-breeding) that would become fragmented to the east of the highway on the northern side of the Wardell Interchange (Station 157.0). The area of habitat isolated by the project would be expected to provide only marginal non-breeding habitat for the moth and possible temporary refuge area during dispersal. Dispersal is likely to occur to the north and west of the project and may be associated with gullies in Randles Creek (Dr Don Sands, *pers.comm*).

Table 3-18 Comparison of direct impacts for habitat on the Pink Underwing Moth

Habitat for Pink Underwing Moth	EIS design	Design refinement
Known habitat (PUM confirmed)	1.2 ha	0.0 ha
Potential habitat (non-breeding; no host plant present)	4.7 ha	2.5 ha
Potential habitat (breeding; host plant present)	0.5 ha	0.0 ha
Total	**6.4 ha**	**2.5 ha**

Rainforest communities

Lowland rainforest

The EIS project design would have impacted on 10.3 hectares of Lowland Rainforest, listed as endangered on the TSC Act, of which 5.8 hectares is consistent with the Commonwealth listed threatened ecological community on the EPBC Act. Adoption of the design refinement would reduce this direct impact to 2.5 hectares (TSC Act listed) in sections 10 and 11, of which 2.0 hectares meets the criteria for listing on the EPBC Act.

As described for the Pink Underwing Moth, the project has been positioned to traverse the cleared land as much as possible in between the rainforest habitat areas, with much of the rainforest positioned upslope and to the west. Due to the presence of existing cleared habitat there is an existing edge affected zone along the edge of the rainforest. Indirect impacts to this edge affected zone could occur through the potential for weed invasion, particularly Camphor Laurel. This situation reflects what is currently occurring as this rainforest patch is currently exposed all along the edge adjoining the cleared agricultural areas. Mitigation measures proposed to reduce these impacts are described below. Indirect impacts from surface run-off are expected to be minimal and as the road would drain away from the rainforest areas.

A small area of rainforest (around 6.5 hectares) located between station 157.7 and 157.9 would be dissected by the highway north of the Wardell interchange, creating an isolated fragment on the eastern side of the highway and between the road and the existing highway (Figure 3-13). This area was recorded as a lower condition area of rainforest, due to its position on the floodplain and the abundance of weeds and low native flora species diversity associated with a long history of edge effects. The fragmented patch and residual area to the west of the project occur on alluvial soil, not basalt, and would be subject to future edge effects over a distance of around 300 metres which may impact on their long-term integrity in the edge zone. The design refinement would not increase the impact of fragmentation that was identified in the EIS.

Littoral rainforest

The supplementary biodiversity surveys identified a patch of littoral rainforest south of Coolgardie Road, between the existing highway and Kays Road. This patch meets the criteria given in the EPBC Act listing advice for the Littoral Rainforests and Coastal Vine Thickets of Eastern Australia having more than 30 per cent of the canopy composed of indicator species from the North Coast region. The entire patch is currently positioned adjacent to the highway and a local road. A power easement at the northern end of the population impacts the condition of the vegetation and there are a high proportion of weeds.

The design refinement was further modified to minimise impacts to this patch to the greatest extent possible. However, a small section of around 50m^2 at the northern end would be directly impacted. As such, the design refinement would change the project impact to littoral rainforest by 0.03 hectares over the EIS design (Table 3-19) (taking the total project impact on littoral rainforest to 0.23 hectares). The design refinement is expected to have minimal net increase in edge effects on littoral rainforest beyond what is already occurring as all impacted areas of littoral rainforest are currently positioned along the edge of the existing Pacific Highway.

Table 3-19 Comparison of direct impacts on rainforest communities at Coolgardie interchange

Item	EPBC Act	TSC Act	EIS design	Design refinement
Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions	-	Endangered	10.3 hectares	2.2 hectares
Lowland Rainforest of Subtropical Australia	Critically endangered	-	5.8 hectares	2.0 hectares
Littoral Rainforest (TSC Act) Littoral Rainforest and Coastal Vine Thickets of Eastern Australia (EPBC Act)	Critically endangered	Endangered	0.0 hectares	0.23 hectares

Other vegetation communities

The objective of the design refinement was to avoid and minimise the direct and indirect impacts to the Pink Underwing Moth habitat and to the critically endangered Lowland Rainforest community that were affected in the EIS design. This was achieved, although noting that there would be a slight increase in the direct impacts to other state listed TECs of around 2.3 hectares and of other non-listed vegetation types of around 0.9 hectares (Table 3-20), some of which is habitat critical for the survival of koalas. Much of this increase would occur to the east of the existing Pacific Highway between stations 158.3 and 159.5 and is associated with existing, edge affected vegetation. The indirect impacts on this vegetation and impacts on Koala habitat are described below.

Table 3-20 Comparison of impacts on biometric vegetation types at interchange at Wardell

Biometric vegetation types	EIS design	Design refinement	Change (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	0.1	0.04	-0.06
Coast Cypress Pine shrubby open forest of the North Coast Bioregion (TEC, Coastal Cypress Pine Forest – TSC Act)	**0.1**	**0.2**	**+0.1**
Coastal floodplain sedgelands, rushlands, and forblands (TEC, Freshwater Wetlands - TSC Act)	**0.6**	**0.7**	**+0.1**
Coastal heath on sands of the North Coast	0.0	0.2	+0.2
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	0.2	0.5	+0.3
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast (TEC, Subtropical Coastal Floodplain Forest - TSC Act)	**7.5**	**6.5**	**-1.0**
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	**0.5**	**0.0**	**-0.5**
Paperbark swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest - TSC Act)	**0.0**	**1.4**	**+1.4**
Red Mahogany open forest of the coastal lowlands of the North Coast	0.0	0.5	+0.5
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Sclerophyll Forest - TSC Act)	**0.1**	**1.8**	**+1.7**
Swamp Oak swamp forest of the coastal lowlands of the North Coast (TEC, Swamp Oak Floodplain Forest - TSC Act)	**0.3**	**0.3**	**0.0**
Tuckeroo - Riberry - Yellow Tulipwood littoral rainforest of the North Coast	**0.0**	**0.03**	**+0.03**
White Booyong - Fig subtropical rainforest of the North Coast	**6.0**	**2.6**	**-3.4**
TOTAL	15.4 (ha)	14.67 (ha)	-0.63 (ha)

Threatened flora

As a result of the reduction in direct impacts on rainforest communities, the design refinement would result in a similar reduction in the direct impacts on several threatened rainforest flora species (Table 3-21). The most evident of these would be a significantly reduced impact on the vulnerable species *Macadamia tetraphylla* (EPBC Act and TSC Act) from a loss of 37 plants reported in the EIS to only 1 plant in the design refinement. Similarly, there would be no direct loss of the vulnerable *Archidendron hendersonii* (TSC Act), where as previously the EIS design reported an impact to six plants.

Indirect impacts could result from plants being retained in situ and subject to new edge effects. This would include altered exposure to wind and light and increased potential for competition from weeds and other flora. Potential indirect impacts to Lowland Rainforest could include:

- Weed invasion.
- Increased light and exposure (drying).
- Decreased humidity.
- Altered hydrology and increased nutrients which could result in weed (and/or pathogen) invasion, particularly Camphor Laurel.
- Fragmentation.
- Polluted surface water runoff.
- Dust impacts during construction

In section 10, the project has avoided to the greatest extent possible, areas of rainforest and has targeted cleared areas. These cleared areas adjoin remnant Lowland Rainforest, and as such, the areas that could be subject to indirect impacts from the project are already subject to edge effects. Indirect impacts to previously unaffected areas would be limited to the three patches directly impacted where new edges would be created. To manage the potential for edge effects mitigation measures include landscaping with rainforest flora adjacent to impacted rainforest patches, sedimentation and erosion control and weed management.

Further discussion of impacts on the threatened flora species and the changed Assessment of Significance is provided in Chapter 6.

Table 3-21 Comparison of direct impacts for threatened rainforest flora species

Species	EPBC Act	TSC Act	EIS design	Design refinement
Archidendron hendersonii		Vulnerable	6 individuals	0 individuals
Macadamia tetraphylla	Vulnerable	Vulnerable	37 individuals	1 individual
Arthraxon hispidus	Vulnerable	Vulnerable	10.4 hectares	5.5 hectares
Cryptocarya foetida	Vulnerable	Vulnerable	13 individuals	13 individuals
Endiandra hayesii	Vulnerable	Vulnerable	5 individuals	5 individuals
Geijera peniculata		Endangered	0 individuals	0 individuals
Ochrosia moorei	Endangered	Endangered	0 individuals	0 individuals
Acronychia littoralis	Endangered	Endangered	0 individuals	1 individual
Streblus pendulinus	Endangered		0 individuals (not assessed in EIS as recently listed)	16 individuals

There would be an increased direct impact on *Streblus pendulinus* (Endangered EPBC Act) and *Acronychia littoralis*. *Acronychia littoralis* was found in a small area on the eastern edge of the existing highway north of Coolgardie Road (station 158.5). This consisted of a stand of *Acronychia* sp. that was apparently entirely clonal (estimated 125 stems from the one parent plant). The foliage resembled *Acronychia oblongifolia,* although the oil dots, venation and smell of the crushed leaves were indicative of *Acronychia littoralis*. A published paper on the genetics of *A.littoralis* shows that there is two forms (A1 and A2), one of which is a hybrid between *A. oblongifolia* and *A. imperforata* (Rosetto 2005). Sterile clonal stands of *A. oblongifolia* that bear fruit without fertile seeds are known (A. Benwell *pers. comm*.). At the time of survey the plant was sterile, so diagnostic fruits were not available to assist identification and genetic tests have not been undertaken.

Therefore, it is unclear if this clonal stand of Acronychia sp. is a form of *A. littoralis* descended from an *A. oblongifolia* hybrid or a sterile form of *A. oblongifolia* s. str. As a precautionary measure this plant is considered as the listed A. littoralis. As noted in the table above only one *Acronychia* sp would be impacted by the design refinement.

The design refinement would see a reduction of around 48 per cent in the loss of known habitat area for Hairy Joint Grass (*Arthraxon hispidus*) (vulnerable EPBC Act and TSC Act). This is calculated as area of habitat rather than individual plants for this grass species which is difficult to quantify in the field.

The degree of indirect impacts for threatened plants would not change between the design refinement and the EIS design. This is because the road alignment has only shifted slightly and the potential edge effects associated with weeds and run-off would be similar between designs and relate to increased potential for weeds. For rainforest species located on the higher elevated areas upslope and to the west of the alignment, such as *Macadamia tetraphylla*, run-off impacts as a result of the project are not an issue, although potential for increased weed invasion remains prevalent.

Threatened fauna

Two small artificially modified freshwater ponds occur on the eastern side of the existing highway, immediately south of Laws Road at station 159.1. These ponds provide potential habitat for the Oxleyan Pygmy Perch (*Nannoperca oxleyana*) as noted by the low pH of around 3.5 and still water with dense riparian vegetation and macrophytes. A targeted survey was conducted in these ponds in August 2013, which did not record the species at this site. This habitat has been modified previously through dredging and excavation and this may reduce the suitability for the species. In addition, in NSW Oxleyan Pygmy Perch has only been recorded between Broadwater and Red Rock to the south of the Richmond River (DPI 2010). However, given the habitat is suitable for the species, the assessment considered it as potential habitat. These freshwater habitats, which extend outside the design refinement to the east also provide potential habitat for the threatened Green-thighed Frog (*Litoria brevipalmata*) and Wallum Sedge Frog (*Litoria olongburensis*) and Wallum Froglet (*Crinia tinnula*). The latter species was confirmed here in habitats that occur north and south of Laws Road, in shallow flooded depressions between stations 158.9 and 159.4 (Plate 3-7, 3-8 and 3-9). Suitable habitat for this species is limited along the edges of the road and is better represented with further distance from the road edge.

The design refinement would involve construction on the immediate eastern side of the existing highway rather than the western side as formerly proposed. The highway would extent around 25-30 metres east beyond the existing footprint and directly impact on several small areas of the potential freshwater habitat. The presence of potential habitat is not restricted to the construction area and does extend into the adjoining lands out to 250-300 metres from the highway such that potential habitat remains well outside the construction area for these species. A suitably large area of potential habitat would remain post-construction for these threatened fish and frog species such that viable populations are expected to remain. There is potential for indirect impacts on these remaining habitats associated with run-off from the road and weed invasion. However, these impacts have already been occurring in this location due to the presence of the existing highway and do not appear to be significantly impacting on the habitat condition. Appropriate treatment and storage of surface run-off during construction and operation is required prior to discharging into the remaining aquatic habitats east of the highway.

Plate 3-7, Plate 3-8 and Plate 3-9. Freshwater habitats eastern side of existing highway and north and south of Laws Road (station 159.1)

Koala habitat

The low-lying eucalypt forest habitats occurring east of the highway and north and south of Laws Road between station 158.2 and 159.4 comprise a mix of swamp forest and open forest habitats and provide potential habitat for koalas. This is due to the presence of the primary Koala feed trees, Swamp Mahogany (*Eucalyptus robusta*) and Tallowwood (*E.microcorys*) and the secondary feed tree species Red Mahogany (*Eucalyptus resinifera*) (DECC 2008). Swamp Mahogany occurs at greater than 30 per cent of the canopy cover present over several areas indicating primary habitat for koalas (refer DECC 2009). Evidence of Koala activity was recorded immediately south of Laws Road on the eastern side of the existing highway at station 159.1. The habitat at this location is consistent with 'habitat critical to the survival of koalas' as per the Commonwealths interim advice (DSEWPaC 2012).

The design refinement would result in an increase in direct impact on Koala habitat from 7.8 hectares for the EIS design to 9.3 hectares. This 1.5 hectare increase occurs over a narrow linear strip along the existing Pacific Highway and would impact on current edge affected habitats located north and south of Laws Road which would have only marginal value for the local Koala population due to a lower condition and its position adjacent to the highway. Larger areas of habitat would remain adjacent to these locations. There would be a further small direct loss south of the interchange between station 156.7 and 157.2. The remaining areas of Koala habitat along the edge of the new highway footprint in this location would be subject to new edge effects, particularly noise and weeds.

Connectivity for fauna

The fauna overpass presented in the EIS at station 156.0 (described as 'North Wardell Fauna Bridge') (Plate 3-10) is important for regional connectivity. The overpass targeted a range of fauna including the Koala and Long-nosed Potoroo and rainforest fauna. It is also expected to be used for dispersal by koalas from source populations at Wardell and Bagotville in the east to populations on the Alstonville plateau and Blackall Range to the west. The design width of this structure has remained the same as the EIS however the structure has been placed further east by around 100 metres to minimise the need to clear rainforest habitat at its former location and known and potential habitat of the Pink Underwing Moth.

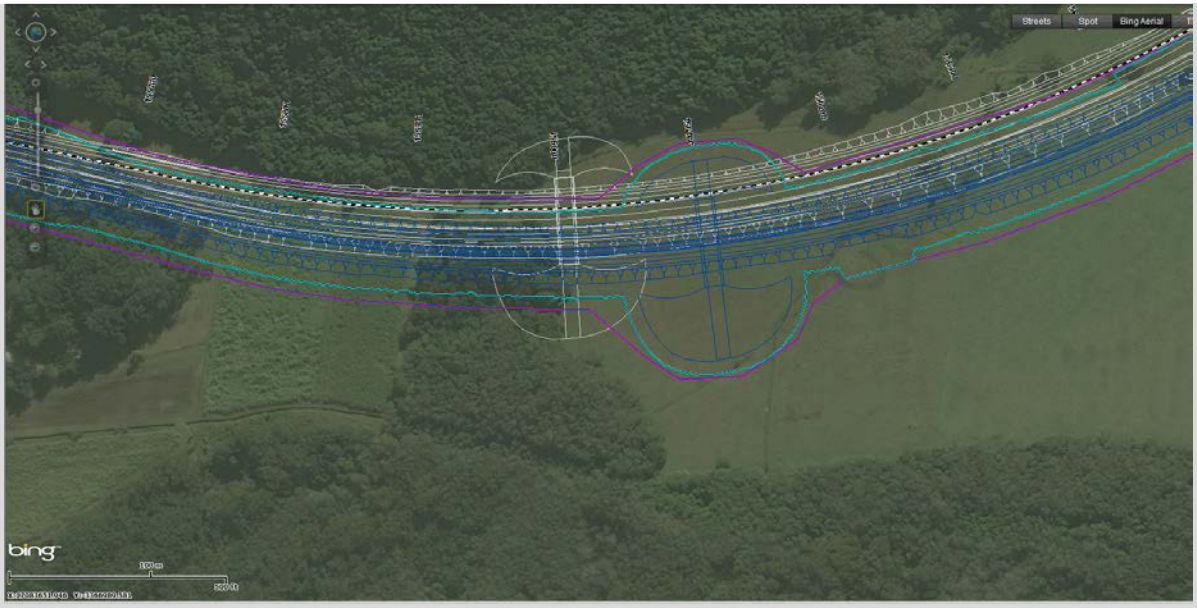

Plate 3-10. Concept design image showing slight shift east of the fauna overpass to avoid impacts to rainforest habitat

This movement is not expected to alter the effectiveness of the structure because it would remain in an important north-south regional link in the landscape. However the change would place the structure further away from the edge of natural vegetation previously located at the approaches the bridge. As the structure would be located on land acquired by Roads and Maritime for the project, it is proposed to revegetate the approaches to the land bridge as a key mitigation measure. The structure and revegetation measures would be monitored as part of the project biodiversity monitoring programs to monitor its effectiveness and implement additional revegetation or maintenance, if required.

3.17.5. Additional mitigation

In addition to the mitigation measures discussed in the EIS, further mitigation is required for the design refinement. This applies for the Koala, potential habitat for threatened frogs and Oxleyan Pygmy Perch and the Pink Underwing Moth, as well as the fauna overpass. The additional measures are as follows:

- As lighting is required on the western roundabout at Coolgardie Road, further measures to reduce light spill would be considered during detailed design which may include using deflection shields around the lights and using a UV light, with the view of reducing UV light emissions. These measures are detailed in the Threatened Invertebrates Management Plan.

- The detailed design would need to consider appropriate capture and storage of run-off on the eastern side of the existing Pacific Highway between station 158.2 and 159.4. This is to protect remaining *in situ* aquatic habitats located to the east of the highway on private property north and south of Laws Road.
- The Rainforest and Threatened Rainforest Plants Management Plan also apply to the *Acronychia littoralis* identified at station 158.5 on the eastern side of the existing highway. Measures would include assessing the feasibility of translocating threatened species as part of the broad project offsetting and revegetation measures.
- Roads and Maritime owned land surrounding the proposed dedicated overpass at station 156.0 would be revegetated following completion of construction of the structure to provide a vegetated corridor. The site has been identified as an ancillary site and so revegetation would occur post-construction.
- A combined (drainage and fauna movement) culvert at station 157.1 located south of the interchange has potential to be upsized. This culvert links an area of known Koala habitat to the east of the upgrade that was formerly isolated from the EIS design. The detailed design should investigate up-sizing this structure to a minimum 2.4 metres in height (currently 1.2 metres and constrained by low fill height) and linked with Koala fencing. This would provide a net benefit to koalas at this location and offset the small increase in habitat loss for the design refinement.

3.18. Summary and cumulative impacts

A summary and the cumulative impacts of the assessed design refinements are presented in Table 3-18. This table discusses direct and indirect impacts on listed and non-listed vegetation communities, threatened species, habitat fragmentation, connectivity and aquatic impacts. The inclusion of the design refinements to the overall project would result in the following:

- A reduction in the direct impacts on threatened ecological communities by 4.6 hectares and in habitat critical to survival of koalas by 8.0 hectares.
- An increase in the direct impacts on non-listed vegetation communities by 2.7 hectares.
- There would be a net benefit by relocating the rest area south of Pine Brush State Forest in section 3 through a decrease in loss of habitat for threatened flora and fauna, including avoiding clearing of around 408 *Angophora robur* trees.
- The increase in the Mororo cutting would involve an increase in the amount of clearing of native vegetation at this site, as would the change in the intersection design at Range Road. Neither site contains any prominent habitat features or plant species that would not otherwise exist within the adjoining forest system. The vegetation to be removed could provide foraging habitat for a range of fauna. However, the potential for this vegetation to be used as significant nesting/roosting sites is limited by the absence of hollow-bearing trees or other significant habitat features within the clearing areas. There would be minimal impact to fauna connectivity and regional and local wildlife corridors and no change to the location of proposed crossing structures.
- The refinement at Koala Drive would improve on the current combined drainage fauna underpass structure at this location however the placement of a large embankment on the western side of the underpass may see a change to the functionality of this structure impacting on an important link between Yaegl Nature Reserve and informal reserves to the west. Targeted revegetation of the batter is required and would improve this situation.

- The design refinement at Firth Heinz Road in section 3 would have an overall minor increase in the clearing of threatened ecological communities, however would increase the clearing of the threatened *Angophora robur* by around 181 trees and increase impacts on the habitat of threatened forest fauna known to occur in this location.
- The design refinement at the Interchange at Wardell would have a net benefit through the significant reduction in clearing of listed rainforest communities and habitat of the endangered Pink Underwing Moth. It would also reduce clearing for three threatened plant species. However, increased impacts would result for a small area of Koala habitat, and non-listed vegetation communities.
- The change in the rest area north of the Richmond River would see a significant reduction in clearing of potential habitat for Koala and long-nosed potoroo and a significant improvement in connectivity through the inclusion of a dedicated land bridge in this location.

Where changed impacts on threatened species have been discussed these are also addressed in the Assessment of Significance presented in Chapter 4. The scale of these changes and the overall net reductions in impacts on threatened species, potential habitat for threatened species and listed threatened ecological communities suggests that the impacts of the combined design refinements are not significant.

The mitigation measures outlined in the EIS for biodiversity follow the Roads and Maritime guidelines for protection of biodiversity during pre-clearing and construction are applicable to these design refinement areas. Where further mitigation is required, this has been reported for each relevant design refinement.

Table 3-22 Summary and cumulative biodiversity impact from the assessed design refinements

Project section	Design refinement	Changed impacts to TECs (ha)	Changed impacts to non-listed vegetation/habitat *	Direct impacts to threatened species	Changed impacts to Koala habitat	Impacts to connectivity	Fragmentation impacts	Aquatic and wetland impacts
1	Eggins Road	+2.9 hectares	+1.1 hectares	Potential increased to low density Koala population Section 1	+2.2 hectares	No change	No change	No change
2	Range Road	+0.2 hectares	+3.7 hectares	Potential impact on habitat of Giant Barred Frog	No change	No change	No change	Minor increase, mitigation proposed
2	Lemon Tree Road	-0.1 hectares	+0.1 hectares	No change	No change	No change	No change	No change
2	Luthers Road	-0.4 hectares	+1.0 hectare	No change	No change	No change	No change	No change
3	Firth Heinz Road	+0.1 hectares	+3.4 hectares	Additional 181 Angophora robur impacted. Habitat for threatened hollow-dependent fauna and foraging habitat for Glossy Black Cockatoo. Reduce impact on Maundia triglochinoides population by 0.1 hectares	-0.4 hectares	No change	Alignment shift results in less impacts from fragmentation of Angophora robur population then the original alignment.	No change
3	Crowleys Road	-0.4 hectares	-0.4 hectares	Additional 11 Angophora robur. Reduced impact on potential Koala habitat for low density population in Section 3	-0.8 hectares	No change	No change	No change
3	Tucabia (rest area)	-1.2 hectares	-4.2 hectares	Reduced the impact on the Angophora robur population by 408 individuals.	-1.5 hectares	No change	No change	No change
4	Koala Drive	-0.02 hectares	+0.1 hectares	No change	No change	Improvement with further mitigation	No change	No change

Project section	Design refinement	Changed impacts to TECs (ha)	Changed impacts to non-listed vegetation/habitat *	Direct impacts to threatened species	Changed impacts to Koala habitat	Impacts to connectivity	Fragmentation impacts	Aquatic and wetland impacts
5	Mororo Road	No change	+4.0 hectares	Moderate potential for threatened fauna to occur however condition of the habitat varies from poor to moderate.	-0.9 hectares	No change	No change	No change
7	Swan Bay Road New Italy	No change	No change	No change	No change	No change	No change	No change
8	Lang Hill	No change	No change	Not expected, mitigation proposed expected to alleviate potential impacts to habitat for Oxleyan Pygmy Perch near this site	No change	No change	No change	Not expected
8-9	Lang Hill to Broadwater	No change	No change	Not expected, net improvement in structure / connectivity for fish and potentially Oxleyan Pygmy Perch	No change	Not expected, net improvement in structure / connectivity for fish and potentially Oxleyan Pygmy Perch	No change	Not expected
10	West of Wardell Road	No change	No change	With the loss of one additional tree the proposed design refinement would have minimal change in impact from the EIS design in this location.	No change	N/A	No change	No change
10	Rest area north of Richmond River	-1.5 hectares	-4.7 hectares	Reduction in clearing of habitat by 6.2 ha and significant improvement in fauna connectivity	-0.1 hectares	No, additional structure added and moving of rest area away from fauna corridor an improvement	Net improvement	No change
10	Two quarries	No change	No change	No change	No change	No change	No change	No change

Project section	Design refinement	Changed impacts to TECs (ha)	Changed impacts to non-listed vegetation/habitat *	Direct impacts to threatened species	Changed impacts to Koala habitat	Impacts to connectivity	Fragmentation impacts	Aquatic and wetland impacts
10	Interchange at Wardell	-10.3 hectares of listed rainforest communities +2.3 hectares of other TECs	+0.9 hectares	Reduced impact on habitat of Pink Underwing Moth Reduced impact on rainforest communities Reduced impact for 3 threatened plants Increased impact for 2 threatened plants and potentially threatened fauna	+1.5 hectares	Not expected, land bridge shifted by 100 m	No change	No change
All	**Combined total**	**-8.4 hectares**	**+5.0 hectares**		**0 hectares**			

*this includes impacts to habitat for threatened fauna

4. Critical review and scope of supplementary assessment

This chapter presents the objectives of the supplementary biodiversity assessment, and the methodology used in undertaking the review.

4.1. Background and objectives

As part of the ongoing assessment and design process for the project, the biodiversity assessment presented in the EIS (Working paper – Biodiversity) was critically reviewed to ensure completeness. The review focused on three key areas:

- Survey effort for threatened species: The Commonwealth Department of the Environment and NSW Department of Planning and Infrastructure requested a critical review of the survey effort in relation to key threatened species (listed under the EPBC Act or TSC Act). In the EIS, these species and communities are considered to be significantly impacted by the project. Supplementary surveys were undertaken, and these are documented in Chapter 5.
- Impact assessment on threatened species, populations and communities: The Assessments of Significance in the EIS were reviewed to incorporate any additional findings from supplementary surveys, to assess changes in impact as a result of design refinements, to examine the suitability of the assessments for grouped species. The supplementary assessment also included proposed ancillary facility sites that were not assessed in the EIS. The supplementary assessment is documented in Chapter 6.
- Effectiveness of the proposed mitigation strategy: The adequacy and effectiveness of the mitigation measures proposed in the EIS were reviewed, specifically for those species that would be significantly impacted by the project. The supplementary mitigation measures are documented in Chapter 7 and in the threatened species management plans, which are appended to this report.

The methodology involved in the review is presented in the following sections.

4.2. Survey effort

A critical review was undertaken of the survey effort of key threatened species (listed under the EPBC Act or TSC Act). The objectives of the critical review were to:

- Identify gaps in survey effort for key species, considering the stratification of habitats and areas surveyed and the season or timing of the initial surveys (refer to section 4.2.1 and 4.2.2 for further information).
- Include new species listings, new survey criteria released since commencement of the study and survey guidelines (DEC, 2004) not addressed previously.
- Consider where potential habitat (vegetation types) of a threatened species identified in the Working paper – Biodiversity was not subject to survey for that species.
- Consider how the information gathered would inform the impact assessment and decision making process, particularly the measures proposed for addressing connectivity impacts.

The critical review identified each species separately, providing a brief explanation of any gaps in survey effort and whether or not further survey was required. Further survey requirements were divided into two categories:

- Surveys required to inform project assessment to more accurately identify the impact of the project on the species.
- Surveys that would be more appropriate to be undertaken post-approval during detailed design, as there is sufficient information to support the conclusions of the impact assessment in the EIS.

4.2.1. Stratification

As part of the critical review, a spatial analysis of the initial threatened species survey locations was undertaken to identify any survey gaps. The spatial analysis examined mapped vegetation along the entire project. For further targeted surveys as part of this supplementary assessment, the habitats in the study area were stratified initially by elevation and soil type, considering the presence of clay soils, alluvial soils and sandstone-derived soils. Vegetation structure (forest, woodland, heath, modified) was then considered along with floristics (according to Biometric vegetation types). Floristics were based on the initial vegetation types mapped in the preferred route studies, as the BioMetric classification was not completed until the EIS process.

The vegetation and habitat strata were overlaid with the field data for flora and fauna survey locations considered in the Working paper – Biodiversity. Gaps were identified where a particular Biometric vegetation type appeared under-represented in the sampling effort for targeted species or a particular location was under-surveyed. This post-survey stratification and review process allowed a clear indication of the extent and location of potential habitat versus that which was surveyed for targeted species. Any gaps identified in the critical review were subsequently addressed in an additional survey, and the results of the survey are detailed in Chapter 5. Any change in impact assessment for that species is described in Chapter 6.

4.2.2. Timing

The timing of surveys undertaken prior to the EIS between 2006 and 2009 were analysed to determine any issues or gaps. This review indicated that these surveys were generally undertaken in dry periods associated with drought conditions, although some surveys were conducted during cooler seasonal periods. The need to undertake further surveys in more favourable wetter conditions was originally identified during preparation of the EIS and surveys to meet this gap were conducted for the EIS (between 2010 and 2012). These surveys targeted species that favour wetlands or ephemeral drainage lines, as well as summer-flowering and cryptic plant species. This follow-up review (which was part of the critical review) identified further survey gaps for water-dependent threatened flora species, such as *Maundia triglochinoides*, and some fauna such as the Giant Barred Frog. Surveys to complete these gaps were subsequently conducted as part of this supplementary investigation and are detailed in Chapter 5.

4.2.3. Outcomes and scope of work

A precautionary approach was taken in the EIS in assuming species presence where there was suitable habitat. The results of the critical review indicated that, in general, the majority of threatened species and ecological communities expected to occur in the study area were surveyed with sufficient sampling effort and appropriate timing to identify potential impacts and adequately inform the biodiversity assessment in the EIS, particularly Commonwealth listed species. Some gaps were identified and further surveys were undertaken as part of this supplementary biodiversity assessment (refer to Table 4-1). The methods and results of supplementary surveys are provided in Chapter 5.

While a precautionary approach was taken in the EIS, in assuming species presence where there was suitable habitat, the supplementary assessment has clearly established the actual locations of threatened species (and/or populations), particularly threatened flora. This provides a high level of confidence in the ecology assessment.

For several key threatened flora and fauna species, additional targeted surveys are also planned to be undertaken prior to construction to document the status of populations and provide baseline data to determine the effectiveness of impact mitigation measures. The methods and timing of these surveys are documented in separate threatened species management plans prepared for this project and described in Chapter 7.

Table 4-1 Additional survey effort identified from the critical review

Key issue	Scope of work	Where addressed
Lowland Rainforest of Subtropical Australia (Critically Endangered under the EPBC Act)	Address the new survey criteria for Lowland Rainforest of Subtropical Australia (Critically Endangered EPBC Act) by conducting targeted plot based surveys. This is to identify the Commonwealth listed community as opposed to the State listed community. Surveys undertaken in rainforest patches in sections 2, 3 and 10, which were previously surveyed under State criteria.	Section 5.1
Littoral Rainforest and coastal vine thickets of eastern Australia	Targeted survey near design refinements in section 10 and 11 to accurately identify the extent of this community and distinguish from Lowland Rainforest. Survey northern parts of Section 9 on sandy soils where this community may occur.	Section 5.1
Minor spatial gaps in vegetation community mapping	Address spatial gaps in vegetation community identification and mapping in selected areas in project sections 1 and 2. Conduct targeted surveys and mapping.	Section 5.1
Survey effort for threatened rainforest flora	Re-survey (previously surveyed) all potential rainforest habitats for threatened rainforest species and populations. Surveys were undertaken over a wider area beyond the road corridor to identify local population densities and extent.	Section 5.2
Survey effort for select threatened flora (non-rainforest)	Address the spatial and temporal gaps in survey effort for select threatened plant species. In particular, surveys targeted under-surveyed locations in project sections 1 and 2 for cryptic flora species dependent on suitable conditions.	Section 5.3
Survey during sub-optimal season or dry conditions	Re-survey cryptic flora and moisture dependent threatened flora species across all relevant sections, with a particular focus on wetter habitats.	Section 5.3
Broader surveys for the endangered Pink Underwing Moth	Targeted surveys to identify the distribution and abundance of the Pink Underwing Moth and identify the extent and condition of habitat for this species within and adjoining project sections 10 and 11.	Section 5.4

Key issue	Scope of work	Where addressed
Koala habitat mapping to address the interim referral advice under the EPBC Act.	Address the *Interim Koala referral advice for proponents* (DSEWPaC 2012) with respect to classifying Koala habitat and identifying important Koala populations.	Section 5.5
Survey effort for Giant Barred Frog	Survey of the Giant Barred Frog in sections 1 and 2 due to spatial gaps and further details on the extent and condition of habitat for this species in sections 1–2 and 6–8.	Section 5.6
Survey effort for Oxleyan Pygmy Perch	Survey of the Oxleyan Pygmy Perch in section 1 to 2 was done during dry periods and further surveys are required to confirm the predictions of this species.	Section 5.7

4.3. Impact assessment

The objectives of the critical review of the impact assessment were to:

- Consider how the information gathered from supplementary surveys would inform the impact assessment process.
- If applicable, revise the 'likelihood of occurrence' assessment for threatened species, considering any new survey information, and identify any species that may not have been assessed previously.
- Consider the assessment of significance carried out for groupings of species with similar ecological requirements and whether or not it adequately assessed the potential impacts of the project.
- Review and update the assessment of significance for key species to account for design refinements or new information gathered from supplementary surveys. This would reflect changed impacts, including increases or decreases in impacts.

4.3.1. Scope of work

The scope of work that flowed from the review of the impact assessment is presented in Table 4-2

Table 4-2 Review of impact assessment and required amendments

Key issue	Scope of work	Where addressed
Lowland rainforest and Littoral rainforest communities (critically endangered EPBC Act and endangered TSC Act) listings	Update assessment of significance due to reduced impacts resulting from the design change at Wardell interchange.	Section 6.2.1, 6.2.2
Threatened Ecological Communities (endangered TSC Act)	Update assessment of significance due to various design changes and to incorporate supplementary surveys	Section 6.2.3, 6.2.4, 6.2.5, 6.2.6, 6.2.7
Threatened rainforest flora	Update assessment of significance due to reduced impacts resulting from the design change at Wardell interchange. Also needed to account for changed population size as determined by broader supplementary surveys.	Section 6.3

Key issue	Scope of work	Where addressed
Threatened flora (non-rainforest)	Update assessment of significance due to various design changes and to incorporate results from supplementary surveys, particularly Quassia sp Moonee Creek	Section 6.4
Square-stemmed Olax (*Olax angulata*) (vulnerable EPBC Act and TSC Act	Commonwealth Assessment of Significance to be provided, where not previously.	Section 6.4.6
Pink Underwing Moth (endangered EPBC Act and TSC Act) and Atlas Rainforest Ground Beetle (vulnerable TSC Act)	Update assessment of significance due to reduced impacts resulting from the design change at Wardell interchange.	Sections 6.5.1 and 6.5.2
Koala (vulnerable EPBC Act and TSC Act)	Update assessment of significance due to changed impacts resulting from design refinements, additional survey information and additional mitigation.	Section 6.5.3
Giant Barred Frog (endangered EPBC Act and TSC Act)	Update assessment of significance to include information from supplementary surveys and habitat mapping, and predicted occurrence of the species in Section 3.	Section 6.5.4
Oxleyan Pygmy Perch (endangered EPBC Act and TSC Act)	Review impact assessment to account for proposed design refinement at Lang Hill and additional information on proposed mitigation measures	Section 3.13 and Section 6.5.5
Common Planigale (vulnerable TSC Act)	Review the Assessment of Significance to acknowledge that the species is widespread but uncommon throughout the northern rivers region and has been recorded in a diversity of habitat conditions. In the absence of certainty surrounding the impacts on this species, the precautionary principle would be adopted.	Section 6.5.6
Glossy Black Cockatoo (vulnerable TSC Act)	Review the Assessment of Significance conclusion considering the extent and magnitude of the impact including clearing of potential nest trees and feed trees.	Section 6.5.7
Three-toed Snake Tooth Skink (vulnerable EPBC Act and TSC Act)	Provide additional information in relation to survey effort for the species to justify the assessment of significance.	Section 6.5.8
White-crowned Snake (vulnerable TSC Act)	Prepare an Assessment of Significance given potential habitat and past records.	Section 6.5.9
Varied Sittella (vulnerable TSC Act)	Undertake further Assessment of Significance for this species. The species was not assessed despite being known within a 5 kilometre radius of the study area and the presence of suitable habitat. The species was identified in the preferred route studies prior to listing in the TSC Act. The further Assessment of Significance to be included in the woodland bird assessment.	Section 6.5.10
Eastern Pygmy Possum (vulnerable TSC Act)	Revise the Assessment of Significance to further consider the magnitude of clearing by the project against the small home range of the species.	Section 6.5.11
Green-thighed Frog (vulnerable TSC Act)	Clarify the assessment for this species (as incorrectly reported as a non-significant impact in Chapter 6) to confirm that a significant impact is likely	Section 6.5.12
Wetland and migratory bird species	Review Assessment of Significance, assessing species separately, or grouped according to their occupancy of microhabitats. The Assessment of Significance currently groups and assesses species with distinct taxonomic, behavioural and ecological differences as one group. Impact assessment conclusions would be further qualified for each of the identified threatened and migratory wetland species against the assertion of significant residual impacts project-	Section 6.5.13-6.5.18

Key issue	Scope of work	Where addressed
	wide.	
Rainforest birds	Review Assessment of Significance, assessing species separately, or grouped according to their occupancy of microhabitats. The Assessment of Significance currently groups and assesses species with distinct taxonomic, behavioural and ecological differences as one group.	Section 6.5.19-6.5.21
Rufous Bettong and Brush-tailed Phascogale (vulnerable TSC Act)	Provide additional mapping along the project to identify the spatial distribution of potential habitat for these species and proposed targeted connectivity measures	Section 6.5.22
Green and Golden Bell Frog (endangered EPBC Act and TSC Act)	Provide additional information in relation to survey effort for the species to justify the assessment of significance.	Section 6.5.23
New Holland Mouse (vulnerable EPBC Act)	Prepare an Assessment of Significance given potential habitat and past records.	6.5.25
Groundwater impacts at cut sites	Provide a detailed analysis of the location of cuttings (high risk areas for groundwater) and impacts to threatened species, groundwater dependent ecosystems and the Oxleyan Pygmy Perch	Section 6.6

4.4. Mitigation strategy

The objectives of the critical review of mitigation measures were based on the following guidelines:

- Detail the species-specific mitigation measures proposed for threatened biota.
- Consider if the mitigation strategy targets key threatened species and communities and is sufficient to determine the likely effectiveness of the measures proposed.
- Consider how the information gathered from the supplementary surveys would inform the connectivity and mitigation measures proposed for koalas.
- Provide a critical review of the connectivity structures proposed in relation to spatial gaps along the project and assessment of vegetation gaps.

4.4.1. Species-specific mitigation measures

The Working paper – Biodiversity presented a mitigation framework that included a biodiversity connectivity strategy. The connectivity strategy provided broadscale mitigation measures for terrestrial and aquatic flora and fauna to inform the project Flora and Fauna Management Plan. The strategy also provided the framework for developing a series of Threatened Species Management Plans to document species-specific and site-specific mitigation measures and a monitoring and adaptive management approach.

Given the need to understand species-specific measures as part of the project approval assessment, agencies requested the development and inclusion of plans of management for specified species.

These have progressed to a series of Threatened Species Management Plans as follows:

- Rainforest Communities and Threatened Rainforest Plants Management Plan.
- Threatened Plant Species (non-rainforest) Management Plan.
- Koala Management Plan.

- Threatened Invertebrates Management Plan.
- Threatened Mammals Management Plan.
- Threatened Gliders Management Plan.
- Threatened Frogs Management Plan.
- Coastal Emu Management Plan.
- Threatened Fish Management Plan.

These plans present in detail the proposed specific mitigation and monitoring measures for key species and specific locations during the different stages of construction and operation. The plans outline proposed methods for monitoring the effectiveness of these mitigation measures and implementing corrective actions as part of an adaptive management process. This would particularly apply where there is uncertainty around the effectiveness of measures.

Each plan was reviewed by an independent expert specialising in the target species or groups. The recommendations of each review are provided in the respective plan, and the plans would be updated to reflect these recommendations. A summary of the species-specific mitigation measures in these plans is provided in **Section 7.1**.

4.4.2. Review of connectivity strategy

- The review addressed three issues relating to the effectiveness of the proposed connectivity mitigation measures:
- The likely effectiveness of mitigation measures for the Koala considering the results of supplementary surveys.
- The location of proposed connectivity structures and whether any currently lacked significant vegetation that would make the connectivity structure perform poorly.
- The number of structures in known fauna corridors and whether a lack of structures at a particular location would reduce the effectiveness of the connectivity strategy.
- The results of this review and further recommendations are provided in **Section 7.2**.

4.4.3. Effectiveness of mitigation measures

The Working paper – Biodiversity reported on the effectiveness of fauna crossing measures (underpasses, overpasses and arboreal structures) based on a review of published studies on other highway upgrades. Further work has since been undertaken, and the range of mitigation measures has been expanded. These measures are provided in **Section 7.3** together with information on their effectiveness based on experience at other road construction projects, including recent Roads and Maritime monitoring results.