



Transport
Roads & Maritime
Services

OXLEY HIGHWAY TO KEMPSEY PACIFIC HIGHWAY UPGRADE

K2K Fauna Connectivity Report

Date	Status	Revision	Approved by
Report prepared by SMEC Hyder Joint Venture			
19 July 2013	Final		DP&E
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1 INTRODUCTION

The proposed upgrade of the Pacific Highway between the Oxley Highway and Kempsey (the Project) is part of the Pacific Highway Upgrade Program. This program is a joint commitment by the New South Wales (NSW) and Federal Governments to provide a continuous dual carriageway on the Pacific Highway between Hexham (near Newcastle) and the Queensland border. The Project is approximately 37 kilometres in length, from its southern extent, approximately 700 metres north of the Oxley Highway interchange, to its northern connection to the Kempsey Bypass, just south of Kempsey.

As part of the Minister's Conditions of Approval (MCoA) Condition B1 for the Project, dedicated, incidental and combined drainage and fauna crossing measures are required to minimise the barrier effects and habitat fragmentation caused by the Project on native and threatened fauna within the locality.

Table 6.2 in Appendix B of the *Ecological Review of Fauna Crossings in the Ballengarra State Forest* (Roads and Maritime 2011) (hereafter referred to as Table 6.2) stated the requirements for the location and dimensions for fauna crossings. Detailed design development along with subsequent stakeholder consultation required as part of MCoA B2 has resulted in changes to some fauna crossing locations and refinement to dimensions (lengths, heights etc.) of some crossing structures compared with Table 6.2.

This report details the process undertaken during detailed design development to fulfil the requirements as stipulated in the MCoA for fauna passage. This report focuses on the section of the Project between station 24430 metres and station 37600 metres (the Kundabung to Kempsey (K2K) section of the Project). Consultation undertaken to meet MCoA requirements is also detailed.

Appendix A1 provides a summary of the fauna crossing locations, fauna provision requirements, engineering considerations, habitat connectivity and target species for each location. Appendix A2 is an updated version of Table 6.2 focussing on the K2K section, inclusive of refinements based on detailed design development.

Appendix B provides a summary of consultation conducted with regulatory agencies (Environment Protection Authority (EPA) and NSW Department of Primary Industries (DPI) (Fishing and Aquaculture)) regarding fauna crossing requirements.

Appendices C-F provide relevant detailed design drawings developed for fauna culverts, bridges, rope bridges, glider poles and fauna fencing.

1.1 SCOPE

The NSW Minister for Planning approved the Project on 8 February 2012, subject to a number of conditions. This report responds to the Minister's Conditions of Approval (MCoA) (refer Table 1) and Statement of Commitments

(SoC) (refer Table 2) in relation to fauna connectivity for the K2K section of the Project.

Table 1 MCoA relevant to fauna crossings

MCoA No.	Condition	Compliance
B1	The Proponent shall design (and implement) the fauna and waterway crossings identified in Table 6.2 of Appendix B of the document listed under condition A1 (d), at the locations and in accordance with the minimum design principles identified in Table 6.2, unless otherwise agreed by the Director-General.	The waterway crossings identified in Table 6.2 have been applied where feasible during detailed design. This paper provides detail on the crossings as designed; including any changes to that stated in Table 6.2 in order to satisfy this condition (refer Appendix A2).
B2	Investigations into the design of fauna and waterway crossings identified in Table 6.2 of Appendix B of the document listed under condition A1 (d) during detailed design shall be undertaken with the input of a suitably qualified and experienced ecologist and in consultation with the EPA and DPI (Fishing and Aquaculture).	An ecologist has been consulted throughout the design development process. EPA and DPI (Fishing and Aquaculture) have also been consulted through the process. Details are provided in Appendix B.
B3	The proponent shall prepare a report on the final design of fauna and/or waterway crossings identified in Table 6.2 of Appendix B of the document listed under condition A1 (d), where the location of the crossing has changed and/or the crossing does not meet the minimum design principles identified in Table 6.2. The report shall be submitted to the Director General prior to the commencement of construction of the relevant crossing, and shall demonstrate how the new location and/or design would result in acceptable biodiversity outcomes. The report shall clearly identify how the fauna and/or waterway crossing will work in conjunction with complementary fauna exclusion fencing measures to be implemented for the Project. The report shall be accompanied by evidence of consultation with the EPA and DPI (Fishing and Aquaculture) in relation to the suitability of any changes to the location and/or crossing design.	This report. Section 4, Appendix A1, Appendix A2. Section 3.7, Appendix D, Appendix F Appendix B

MCoA No.	Condition	Compliance
B6	The Proponent shall, in consultation with the EPA and DPI (Fishing and Aquaculture), ensure that all waterway crossings are designed and constructed consistent with the principles of the <i>Guidelines for Controlled Activities Watercourse Crossings</i> (Department of Water and Energy, February 2008), <i>Policy and Guidelines for Fish Friendly Waterway Crossings</i> (NSW Fisheries, February 2004) and <i>Policy and Guidelines for the Design and Construction of Bridges, Roads, Causeways, Culverts and Similar Structures</i> (NSW Fisheries 1999). Where multiple cell culverts are proposed for creek crossings, at least one cell shall be provided for fish passage, with an inlet or bed level that mimics creek flows.	All crossings have been designed in accordance with the stated guidelines. There are no culvert crossings of creeks in the Kundabung to Kempsey section of the Project. All have bridge crossings.

Table 2 SoC relevant to fauna crossings

Reference	Commitment	Compliance
F6	Watercourse crossings will be designed to facilitate fish passage where appropriate and in consultation with relevant government agencies.	All crossings have been designed in accordance with the appropriate guidelines. EPA and DPI (Fishing and Aquaculture) have also been consulted through the process. Details are provided in Appendix B.
F17	Culverts and bridges identified in the Environmental Assessment as having a potential role in fauna crossing will be designed to facilitate fauna movements where feasible and reasonable.	All new bridges provide a 3 metre wide fauna path to facilitate fauna movement along the major creek lines.

In the event of an inconsistency between this report and the appendices of this report, or any other plan or strategy, the requirements of this program will prevail.

2 DESIGN DEVELOPMENT

2.1 BACKGROUND AND APPROACH

Seven types of fauna crossing are proposed. These are:

- Culverts that are either dedicated for dry fauna passage, combined drainage and fauna crossings or incidental crossings.
- Culverts that are combined drainage and fish passage or for incidental fish passage.
- Bridge underpasses for terrestrial fauna crossing.

- Bridge underpasses for fish passage.
- Glider poles.
- Rope bridges.

To maximise effectiveness, fauna crossings must be placed in locations where animals naturally approach and cross the highway. The characteristics of the surrounding landscape influence which sections of a highway are crossed, and how often. Barnum (2003) found that the presence of suitable habitat on both sides of the road was the baseline condition required for animals to cross the road on a regular basis and the better the habitat, the higher the frequency of crossings. Intersections of linear guideways such as drainage lines, ridgelines and fencing with highways may support well-defined intensely used crossing zones and is most well-pronounced for drainage lines. Crossings structures are unlikely to be used if they are located where the surrounding landscape does not encourage fauna to approach the road (Barnum 2003).

Chapter 6 of the *Environmental Assessment: Flora and Fauna Working Paper* (GHD September 2011) proposed mitigation measures to address the impacts of habitat fragmentation, terrestrial barrier effects and road mortality impacts on fauna be mitigated in Table 6.2 (underpasses) and Section 6.3.2 (aerial crossings). These mitigation measures included dedicated fauna underpasses, combined drainage/fauna movement culverts (in conjunction with fauna fencing) and aerial fauna crossings. The paper also stated that the number, location and design of fauna crossing structures would be determined at the detailed design phase in consultation with (former) NSW Office of Environment and Heritage (OEH), previously the Department of Environment, Climate Change and Water (DECCW).

A *Supplementary Flora and Fauna Assessment* (GHD, 2011) was undertaken as part of the Submissions Report for the Project. This included revisions to Table 6.2 (underpasses). The Statement of Commitments for the Project was also included in the Submissions Report. The Commitments relevant to fauna crossings are stated in Table 2.

A subsequent Review of fauna crossings in the Ballengarra State Forest report was prepared prior to Project approval which included further revisions to Table 6.2. Ministers Conditions of Approval were issued on 8 February 2012, referencing this report in MCoA A1(d) (refer Table 1).

Since the concept design was approved by the Minister, a number of design refinements to the Project have been proposed to minimise environmental impacts, improve road user safety and/or improve the efficiency of the Project. Some of these design refinements have affected the proposed fauna crossing locations and/or dimensions.

The most significant change to the concept design assessed in the Project EA is an increase in vertical alignment of the Project during detail design of the Kundabung to Kempsey section. This has led to longer batter slopes, resulting in increased length of fauna underpasses in some places. Wherever possible, fauna culverts have been lifted to decrease the length of culverts, where this does not affect line of sight for fauna species. In other cases, culverts have been relocated to positions where batter slopes are shorter.

2.2 CONSULTATION

The location and design of fauna crossings has been developed in consultation with NSW Environment Protection Authority (EPA) and NSW Department of Primary Industries (DPI) (Fishing and Aquaculture). Consultation with EPA included discussions on the proposed locations of dedicated and combined culverts, culverts that will require fauna furniture, and the location of the widened median. DPI (Fishing and Aquaculture) was consulted for the purpose of identifying culverts that will need to provide for fish passage.

A summary of site visits with the Agencies is shown in Table 3. Minutes of the site visits are attached as Appendix B.

Table 3 Summary of Agency site visits

Date	Present	Discussion/focus
7 September 2012	EPA DPI (Fishing and Aquaculture) Roads and Maritime	Fauna crossing structures, including proposed dedicated and combined culvert locations and bridges. Inspected Pipers, Smiths and Barrys Creek. Conducted site visit for whole OH2K Project, with focus on K2K section. Discussion and inspection of proposed widened median area in Cairncross State Forest (Construction Stage 3).
26 October 2012	DPI (Fishing and Aquaculture) Roads and Maritime	Fish passage requirements for those culverts not inspected on 7 September site visit. Particular focus on incidental culverts.
6 December 2012	EPA DPI (Fishing and Aquaculture) Roads and Maritime	Proposed changes at Smiths Creek from three span to four span bridge and removal of culvert C28.3A.
15 February 2013	EPA DPI (Fishing and Aquaculture) Roads and Maritime	Site visit for K2K section only. Fauna crossing structures, including proposed dedicated and combined culvert locations. Discussion on provision of dry passage. Provision of fauna up-stands and low flow passage for combined culverts. Inspection of existing bridge at Stumpy Creek.

Email correspondence was also undertaken through the detailed design period to update the Agencies on issues as they arose. This is also provided in Appendix B.

A further opportunity for comment will be provided to Agencies through review of this report and relevant design drawings. If required, this report and Table 6.2 (Appendix A2) will be updated following consultation.

Specialist advice has also been sought from Kylie Soanes (PhD candidate, University of Melbourne) with regard to glider poles and rope bridges; and Ben Lewis (Lewis Ecological) regarding fauna fencing.

2.3 SITE INVESTIGATIONS DURING DETAILED DESIGN

Site investigations were undertaken during detailed design to identify and verify locations for fauna crossings in the Project area.

An inspection of locations of proposed dedicated and combined culverts was undertaken on 7 September 2012. In attendance was a Hyder ecologist, representatives of Roads and Maritime, representatives of the SMEC Hyder Joint Venture, DPI (Fishing and Aquaculture) and EPA. The site inspection involved identifying potential target species for culverts, identifying culverts that would be required to provide for fish passage, fauna furniture requirements for some culverts and a discussion of monitoring requirements (for the Ecological Monitoring Program).

Requirements for fish passage were investigated by DPI (Fishing and Aquaculture) and Roads and Maritime on 26 October 2012. The site investigation involved an inspection of drainage lines conveyed by culverts beneath the existing Pacific Highway, and determining which of those potentially provide fish passage. Culverts needing to address fish passage requirements were then identified.

Proposed glider pole and rope bridge locations were verified by ecologists during a site investigation on 30 and 31 October 2012. One proposed rope bridge location was also investigated by Roads and Maritime on 30 October.

A further inspection of dedicated and combined fauna culverts was undertaken on 15 February 2013 with representatives of Roads and Maritime, representatives of the SMEC Hyder Joint Venture, DPI (Fishing and Aquaculture) and EPA. The site visit involved inspecting locations of proposed changes to the siting and dimensions of culverts.

2.4 PROJECT STAGING

Due to the Project's length and funding models available, the Project will be essentially delivered in two main sections – from the Oxley Highway to Kundabung (approximately 24 kilometres) and from Kundabung to Kempsey (approximately 14 kilometres). The delivery of these two sections will be undertaken in four stages as shown in Figure 1. These stages are:

- Sancrox Road traffic arrangement.
Construction of this stage commenced in late-2013 through a construct only contract and was opened to traffic in late 2015.
- Kundabung to Kempsey (relevant section to this report).

This stage includes construction of approximately 14 kilometres of dual carriageway, commencing north of Barrys Creek near Kundabung (Station approximate 24,000) and joining the southern end of the Kempsey Bypass at Stumpy Creek (Station 37,800). Construction of this stage commenced in late 2014 and will open to traffic around mid-2017. The Kundabung to Kempsey stage is being facilitated through a construct only contract.

Refer to Figure 2 for the key features of the Kundabung to Kempsey section.

- Oxley Highway to Kundabung.

The Oxley Highway to Kundabung stage includes construction of approximately 24 kilometres of dual carriageway, commencing just north of the intersection of the Pacific Highway with the Oxley Highway in Port Macquarie and finishing north of Barrys Creek near Kundabung (extending from Station 700 to approximate Station 24,000). The Oxley Highway to Kundabung stage also includes a bypass of Telegraph Point and a new alignment across the Hastings River and Wilson River floodplains. Construction of this stage commenced in late-2014 and will open to traffic by the end of 2017. The Oxley Highway to Kundabung stage is being delivered through a design and construct contract.

- Class A to Class M standard.

The Project has been designed inclusive of a four lane Class M (motorway) standard highway. However, due to estimated traffic volumes and availability of funding some sections of the Project will initially be constructed and operated as a Class A (arterial) standard highway. Upgrade of those sections of the Project from Class A to Class M standard will occur when it is warranted by an increase in traffic volumes, and when funding becomes available.

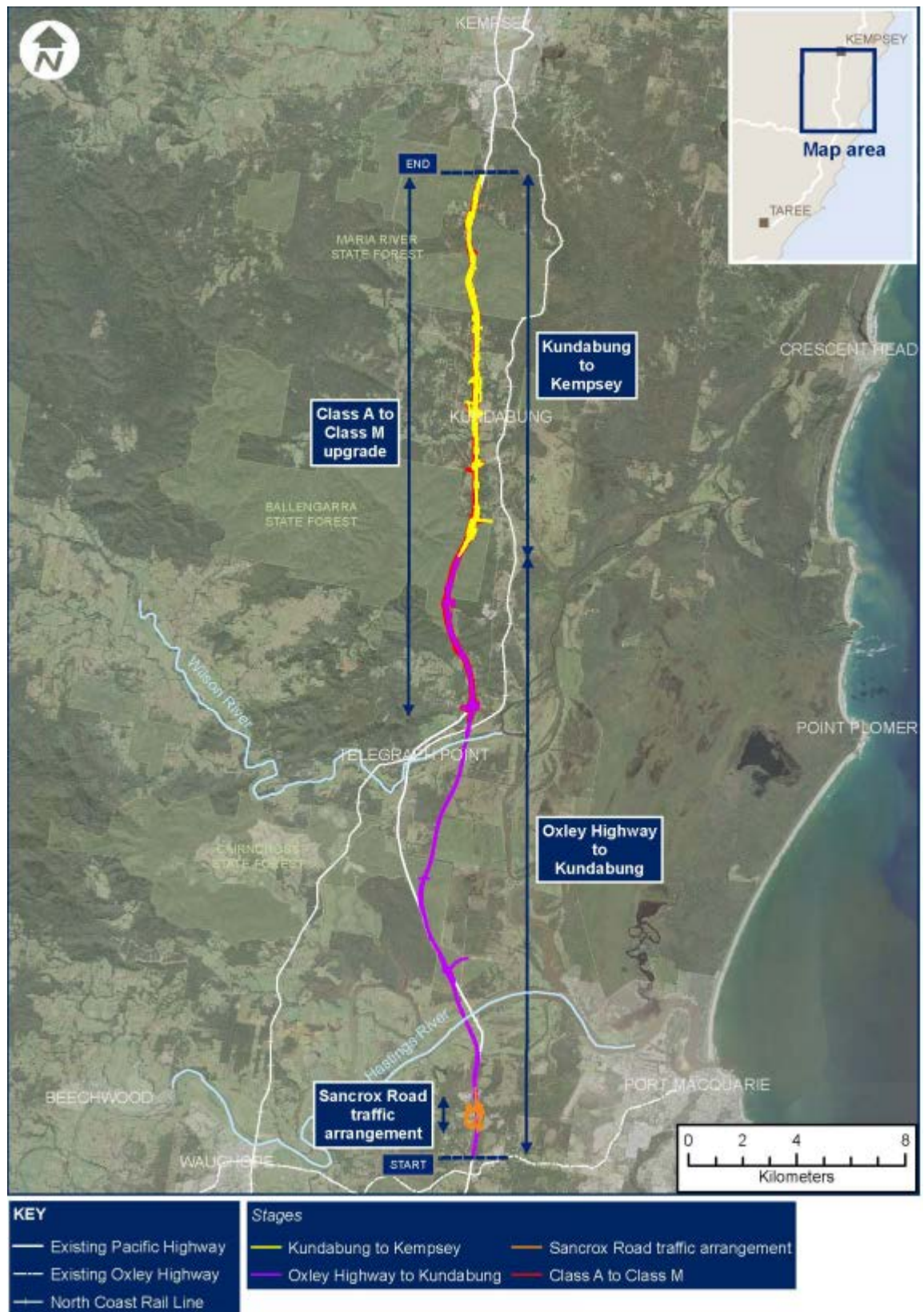


Figure 1 Overview of the Project and proposed staging

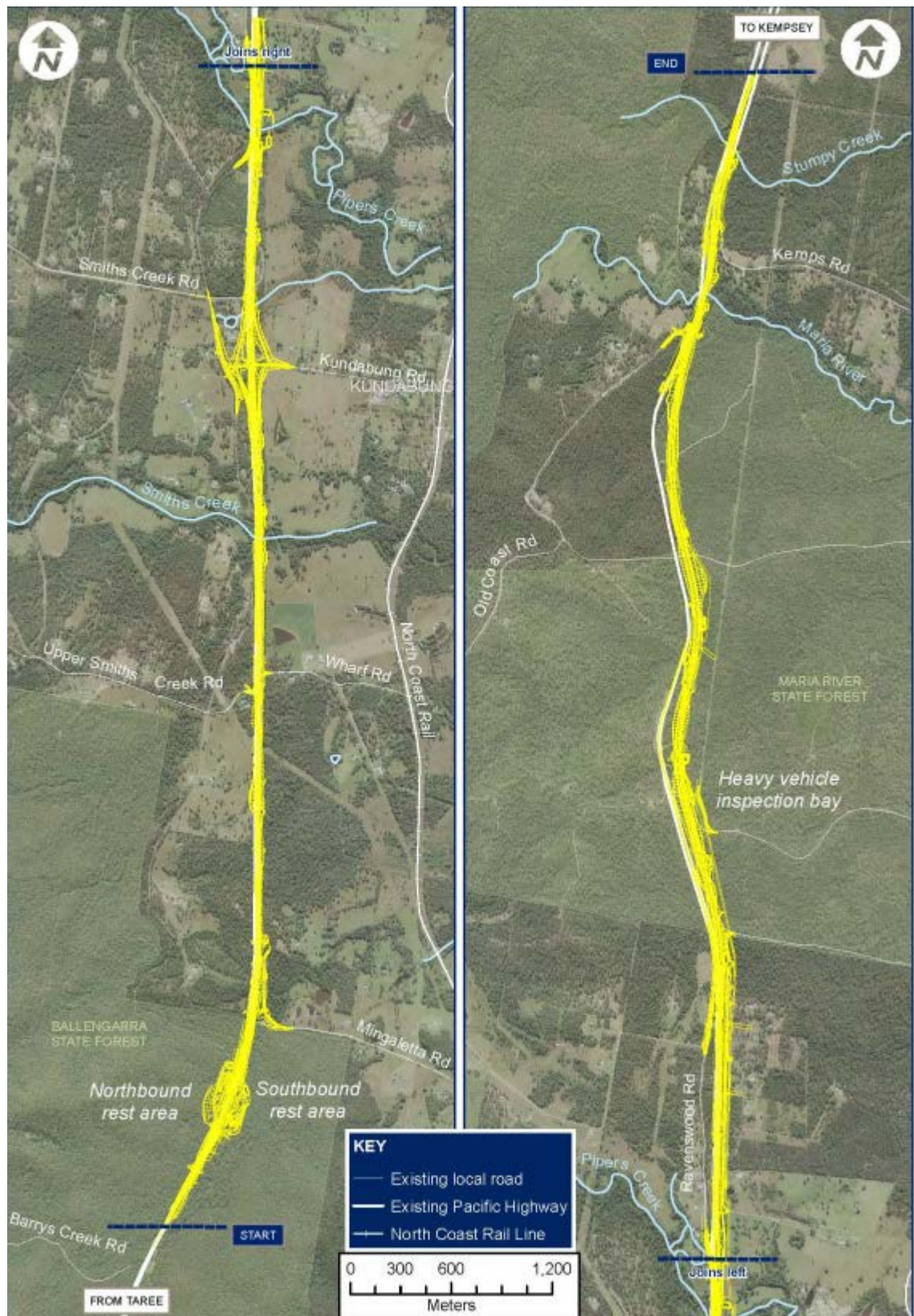


Figure 2 Key features of Kundabung to Kempsey stage

3 FAUNA CROSSINGS

This section describes the types of fauna crossings that have been incorporated into the detailed design for Kundabung to Kempsey.

3.1 CULVERT UNDERPASSES

The Kundabung to Kempsey section of the Project includes 30 underpasses (with a further seven in Class M), which comprise of:

- Three dedicated fauna culverts.
- 13 combined culverts (a further two in Class M).
- Four bridge crossings over creeks and rivers.
- 10 incidental culverts that may provide for passage of small fauna species (a further five in Class M).

The following classifications of treatments have been applied:

- Type 1 - typical fish, fauna and drainage culvert. Fauna pass up-stand and vertical poles are to be installed on one side of the culvert to establish a link to retain vegetation. Low flow fish passages are to be on alternate side. Where required due to water velocities, fish shelter will be provided. Refer to drawing OH2K-DDN-DR2101-081 in Appendix C for further detail.
- Type 2 - typical drainage and fish passage culvert. Low flow fish passage provided at centre of culvert. Where required due to water velocities, fish shelter to be provided. Refer to drawing OH2K-DDN-DR2101-082 in Appendix C for further detail.
- Type 3 - typical dedicated fauna crossing culvert. Dry fauna passage provided to one in 100 year flood immunity. Refuge poles are to be installed through the culvert. Refer to drawing OH2K-DDN-DR2101-083 in Appendix C for further detail.
- Type 4 - typical combined drainage / fauna crossing culvert. Fauna pass up-stand to be installed on one side of culvert to establish a link to retained vegetation. Refer to drawing OH2K-DDN-DR2101-084 in Appendix C for further detail.

Details of each dedicated, combined and incidental fauna underpass are provided in Appendix A1. The detail provided in Appendix A1 for each culvert underpass includes:

- Reference to relevant detailed design drawings.
- Engineering considerations in development of the design.
- Habitat connectivity considerations.
- Potential fauna species targeting the underpass.
- Dry crossing provisions and fish crossing provisions.

Refinements to culvert underpasses required during detailed design are identified in Table 12 in Chapter 4.

3.1.1 DEDICATED FAUNA UNDERPASSES

Dedicated fauna underpasses (for examples refer Figure 3 and Figure 4) generally comprise of precast concrete cells three metres high and three metre wide that provide for the dry passage of fauna species at a one in 100 year flood immunity. The lengths of the dedicated fauna culverts for the K2K section of the Project range from approximately 47 metres to 49 metres.

Dedicated fauna underpasses will support fauna furniture to encourage the passage of target fauna species. Fauna furniture is described in section 3.3. Target fauna species for dedicated fauna culverts are listed in Appendix A1 and Appendix A2.



Figure 3 Bingis Lane dedicated culvert, Kempsey Bypass (Source: Lewis Ecological Consulting 2012)



Figure 4 Dedicated fauna underpass, Pacific Highway upgrade (Source: RTA 2010)

3.1.2 COMBINED UNDERPASSES

Combined underpasses (for examples refer Figure 5 and Figure 6) are culverts that convey drainage and provide for fauna passage. A 1200 millimetre wide, 100 millimetre high fauna up-stand will be provided within all new combined culverts. Hydrological calculations have shown that all combined culverts where fauna up-stands are included will provide dry passage for at least a one year 72 hour storm event. The fauna up-stands would be temporarily inundated during a one in one year ARI peak flow event.

Combined underpasses generally comprise of precast concrete cells that vary in size in accordance with the required hydrological capacity. Fauna furniture has been provided in some combined culverts (identified in Appendix A2), where hydraulic modelling has assumed a 50 per cent blockage to account for fauna furniture.



Figure 5 Combined fauna underpass culvert with dry cell for fauna passage, Pacific Highway upgrade (Source: RTA 2010)



Figure 6 Combined fauna underpass culvert with shelf for dry passage, Pacific Highway upgrade (Source: RTA 2010)

3.1.3 INCIDENTAL UNDERPASSES

Incidental crossings (Figure 7, Figure 8) are designed for drainage purposes only but may be used by fauna on occasion. They are not designed specifically to facilitate terrestrial fauna movement, but may require provision for fish passage.

The structures are comprised of pipes and box culverts of smaller dimensions than the dedicated and combined use culverts. Due to their smaller size, use would be limited to smaller fauna (small terrestrial mammals, reptiles and frogs) when and if conditions were suitable (for example, when dry for mammals) (GHD, 2010).



Figure 7 Incidental fauna underpass culvert, Pacific Highway upgrade (Source: RTA 2010)



Figure 8 Incidental fauna underpass culvert, Pacific Highway upgrade (Source: RTA 2010)

3.2 BRIDGE UNDERPASSES

Bridge underpasses (for examples refer Figure 9 and Figure 10) have a primary function to facilitate the movement of water, yet also facilitate fauna movement. Bridge underpasses within the K2K section of the Project include Smiths Creek, Pipers Creek, Maria River and Stumpy Creek.



Figure 9 Koala poles under dual carriage bridge, Pacific Highway upgrade (Source: RTA 2010)



Figure 10 Rope bridge under dual carriage bridge, Pacific Highway upgrade (Source: RTA 2010)

All bridge designs provide for minimum fauna connectivity requirements as per Minister's Conditions of Approval B1, B2 and B3. Table 4 identifies the connectivity requirements established by Table 6.2 as referenced in MCoA B1, B2 and B3 and how they are being met by the design for terrestrial fauna connectivity at bridge locations.

New twin bridges are being provided at Smiths and Pipers Creeks. The existing bridge at Pipers Creek will be retained for use as a service road. Both existing bridges are to be retained at Maria River. At Stumpy Creek, the existing southbound bridge is to be retained, with a new northbound bridge constructed.

A three metre wide unhindered fauna path is provided at all new bridges. The retention of existing bridges at Pipers, Maria and Stumpy Creeks prevents the provision of a new 3 metre wide fauna passage at these bridges. At the existing bridges, fauna passage has been integrated with the existing abutment slope and scour protection.

Typical drawings and cross-sections are provided in Appendix D.

No monitoring is proposed as successful fauna passage under bridges has been demonstrated on other projects.

Table 4 Summary of Fauna Connectivity at Bridge Structures

Chainage	Description	Table 6.2 Requirements (Type of Facility)	Existing Connectivity	Proposed Connectivity
28250	Twin bridges-Smiths Creek	At least three metre unhindered fauna passage on both banks.	On edge of sub-regional corridor, riparian vegetation continuous within riparian corridor to east and west	Three metre wide unhindered fauna passage along each bank of the creek. The crossing is located at a level to remain above the 1 in 2 year ARI flood level (RL 4.22 metres). The EA concept design comprised a shorter bridge in combination with an extension to an existing box culvert. A four span bridge layout and removal of the existing culvert has now been adopted which will likely enhance the fauna connectivity at the bridge site.
28250	Existing bridge-Smiths Creek service road	At least three metre unhindered fauna passage on both banks.	Adjacent to sub regional corridor. Connectivity along creek line.	To be demolished due to construction of new 4 span twin bridges. A new service road bridge would be required for Class M design and would be designed as part of Stage 4 of the Project.
30600	Twin bridges-Pipers Creek	At least three metre unhindered fauna passage on both banks.	Riparian vegetation is continuous within riparian corridor to east and west Creek flowing at site visit held on 7 September 2012.	Three metre wide unhindered fauna passage along each bank of the creek. The crossing is located at a level to remain above the 1 in 2 year ARI flood level (RL 8.2 metres).
30600	New bridge- Pipers Creek Service Road (east)	At least three metre unhindered fauna passage on both banks.	Riparian Forest associated with Pipers Creek	This bridge is not required as part of Stage 2 of the Project. Would be designed if required as part of Stage 4 of the Project.

Chainage	Description	Table 6.2 Requirements (Type of Facility)	Existing Connectivity	Proposed Connectivity
30600	Existing bridge-Ravenswood Rd over Pipers Creek		Riparian Forest associated with Pipers Creek	There is insufficient level ground under the existing bridge to provide three metre wide fauna access on the banks of the creek. Additionally, there is insufficient vertical clearance to provide fauna access above the 1 in 2 year ARI flood level. A narrower (one metre minimum) fauna access is proposed at a lower level adjacent to the piers on each side of the creek.
36860	Existing bridges over Maria River	Existing bridges retained.	Riparian forest along creek line connecting to Kumbatine National Park in the west.	Existing connectivity to be retained.
37730	Northbound bridge over Stumpy Creek	At least three metre wide unhindered fauna passage along each bank of the creek.	Existing bridge underpass in regional corridor linking fragmented habitat to west and extensive areas of key habitat in Maria River to east.	Dedicated fauna passage cannot be provided in the form of a bench set above the 1 in 2 year ARI flood level as this would require modification to the existing bridge abutment. Slopes both upstream and downstream. A fauna bench would also reduce the cross section of the waterway, increasing flood levels upstream (afflux). The creek is predominately dry at this location and adequate fauna passage width is provided outside the limits of the creek channel and within the scour protection along dedicated routes.

Chainage	Description	Table 6.2 Requirements (Type of Facility)	Existing Connectivity	Proposed Connectivity
37730	Southbound bridge over Stumpy Creek	At least three metre wide unhindered fauna passage along each bank of the creek for new bridge (Class M). Connectivity suitable if bridge is retained under staged development.	Current (existing) southbound bridge has better connectivity than existing northbound. Existing bridge underpass in regional corridor linking fragmented habitat to west and extensive areas of key habitat in Maria River to east.	The existing bridge is to be retained. Current connectivity provisions will be maintained without modification to existing abutment slopes.
37730	Service Road bridge over Stumpy Creek		Existing bridge underpass in regional corridor linking fragmented habitat to west and extensive areas of key habitat in Maria River to east.	The existing bridge is to be retained. Current connectivity provisions will be maintained.

3.3 FAUNA FURNITURE

Fauna furniture, including logs, hollow logs, ropes, rocks, poles, elevated logs and refuge/escape poles will be installed at selected culverts to encourage fauna passage (for examples refer Figure 11 to Figure 16).

Fauna furniture may protect a species from predators or allow the animal to undertake a staged passage by allowing it to rest on the furniture within the culvert.

Table 5 identifies types of fauna furniture that has been effective in previous projects for a variety of fauna groups (Bond and Jones 2008, Goosem et al 2001, QDMR 2000, LFHJV 2010).

Table 5 Fauna furniture for target species

Target species	Possible fauna furniture
Frogs	Rocks, logs, hollow logs, terracotta tiles, steel pipe and pieces of shade cloth placed throughout the culvert may provide safe passage and refuge from predators. Prefer shorter culverts. Prefer culverts that offer moist passage, eg with a drainage channels or depressed areas that retain water.
Small terrestrial mammals	Hollow logs and rocks provide safe passage and refuge from predators. Where possible, substrate on floor is to be as natural as possible and many include gravel, embedded rocks or mulch, or a roughening of the concrete surface.
Koalas, possums	Poles, rails (interconnected horizontal poles) and refuge poles may encourage arboreal mammals to utilise tunnels, along with refuge from predators. Prefer natural substrate on culvert floor. Prefer large diameter culverts.
Reptiles	Hollow logs, mulch, tiles and rocks place inside the culvert and at entrances provide safe passage and refuge from predators

Fauna furniture is proposed for all dedicated fauna underpasses. In addition, fauna furniture will be installed under some combined culverts and bridges as identified in Appendix A1, Appendix A2 and Appendix C. Locations targeted for monitoring are shown in Table 6.2 in Appendix A2.



Figure 11 Koala rails and refuge poles at dedicated fauna underpass, Oxley Highway (Source: SHJV)



Figure 12 Bingis Lane dedicated culvert, Kempsey Bypass (Source: Lewis Ecological Consulting 2012)



Figure 13 Koala rails in underpass at Sapphire to Woolgoolga Pacific Highway upgrade (Source: RTA 2010)



Figure 14 Koala rails in Boat Harbour Creek combined culvert, Kempsey Bypass (Source: Lewis Ecological Consulting 2012)



Figure 15 Koala using Raleigh West underpass at Boville Pacific Highway upgrade (Source: AMBS 2011)



Figure 16 Koala using refuge pole at underpass entrance, Pacific Highway upgrade (Source: RTA 2010)

3.4 GLIDER POLES

Glider poles are vertical poles placed in the centre median and/or on the road verge and enable launch and landing opportunities, thereby providing connectivity for gliding mammals. General design considerations include:

- Glider poles not be located more than 40 metres apart.
- The glider path slopes downward at 1V:1.84H:

- The glider path should clear the vehicle envelope by at least 2m;
- Cross bars on glider poles must point to the desired landing area;
- Glider poles must include shelter pipes and predator shields to discourage attack from aerial predators; and
- Habitat trees for gliders must be within gliding distance of glider poles for glides in both directions.

Glider poles at three locations across the K2K and OH2Ku stages will be monitored as a requirement of the *Ecological Monitoring Program* (RMS 2016).

Potential glider pole locations were initially identified in Section 6.4.16 of *Upgrading the Pacific Highway – Oxley Highway to Kempsey Environmental Assessment* (Project EA) (GHD 2010). During detailed design, a desktop analysis of mapped habitat types, mapped fauna corridors, vegetation communities and drainage lines was undertaken to confirm the identified locations were suitable. These locations were verified by a site investigation undertaken on 30 and 31 October 2012, in order to determine adjoining vegetation communities, habitat features and take note of other important habitat variables in proximity to proposed glider pole locations.

Two glider pole crossings are proposed in the K2K upgrade at the locations identified in the EA. These are at approximately Station 25190 and Station 25292. The environmental documents also recommended a glider crossing at Station 34100; however at this location placing a pole in the median presented an issue with stopping sight distance, due to the requirement for safety barriers in the median at the pole location. Potential alternative locations were investigated by reviewing fauna movement corridors and Forestry zones. It was deemed acceptable from both an environmental and design perspective to include a third glider pole at approximate Station 35780.

The locations of glider poles are shown in Table 6. Typical drawings are provided in Appendix E and locations are shown on the fauna fencing drawings in Appendix F.

Table 6 Locations of glider poles

Station	Target Species	Details
25100	Squirrel Glider Yellow-bellied Glider	Two pairs of glider poles located within 100 metres of each other. Located in proximity to tributary of Barrys Creek and within Ballengarra State Forest, a mapped Regional fauna movement corridor. Vegetation in this area includes Moist Slopes Forest and Riparian Forest. <u>Habitat</u>: canopy trees 20-25 metres tall to be retained between existing highway and proposed alignment. Large canopy tree to east of proposed alignment. Midstorey of Black She-oak (<i>Allocasuarina littoralis</i>) to 15 metres. Barrys Creek to east of alignment supports permanent standing water.
35780	Squirrel Glider Yellow-bellied Glider	One set of glider poles just north of C35.70 (combined culvert). Located in proximity to rope bridge. Located within the Maria River State Forest and within mapped Regional corridor. <u>Habitat</u>: Scattered emergent eucalypts to 20 metres tall. Canopy of Black She-oak (<i>Allocasuarina littoralis</i>) and White Feather Honeymyrtle (<i>Melaleuca decora</i>) to 12 metres. Several stag trees are located here. Trees to be retained between existing highway and proposed alignment include eucalypts to 12 metres. Drainage line is ephemeral at this location. Groundlayer vegetation is sparse. Some ground timber but no hollow logs.

3.5 ROPE BRIDGES

Rope bridges are rope ladders or netting suspended above the traffic that typically provide for the crossing of arboreal and scansorial (specialised climbing) species. At three locations along the K2K section of the Project rope bridges will be suspended across the highway between poles on each side (refer Table 7). General design considerations include:

- The rope ladder must be constructed of marine grade silver (high UV rating) rope and stainless steel cables.
- The rope bridge must be linked to adjacent glider habitat trees by ropes or ladders tied off onto the support poles and the trees.
- The preferred minimum clearance above the road pavement surface for the rope bridge is 10.6 metres, however this may be varied in consultation with EPA.

Rope bridges at three locations across the K2K and OH2Ku stages will be monitored as a requirement of the *Ecological Monitoring Program* (RMS 2016).

Potential rope bridge locations were initially identified in Section 6.4.16 of the Project EA (GHD 2010). During detailed design, a desktop analysis of mapped habitat types, mapped fauna corridors, vegetation communities and drainage lines was undertaken to confirm the identified locations were suitable. These locations were verified by a site investigation undertaken on 30 and 31 October 2012, in order to determine adjoining vegetation communities, habitat features and take note of other important habitat variables in proximity to proposed rope bridge locations.

Three rope crossings are proposed in the K2K upgrade design at approximate Station 24120; Station 33990 and Station 35700 (refer Table 7). These align with the locations proposed in the EA.

Typical drawings are provided in Appendix E and locations are shown on the fauna fencing drawings in Appendix F.

Table 7 Locations of rope bridges

Station	Target Species	Existing Environment
24100	Squirrel Glider Yellow-bellied Glider	Located in proximity to Barrys Creek and riparian zone, within Ballengarra State Forest and within a mapped Regional fauna movement corridor. Vegetation in this area includes Riparian Forest, Moist Floodplain Closed Forest with Rainforest Elements and Moist Gully Forest. <u>Habitat</u>: canopy trees 25-30 meters tall to be retained between existing highway and proposed alignment. Large canopy tree to east of proposed alignment. Midstorey of regenerating eucalypts to 15 metres. Barrys Creek is ephemeral at this location. Ground-layer vegetation dominated by lantana (<i>Lantana camara</i>).

Station	Target Species	Existing Environment
33990	Squirrel Glider	Located in proximity to combined underpass C34.10
	Yellow-bellied Glider	Located within the Maria River State Forest and within a mapped Regional fauna movement corridor. Vegetation in this area includes Moist Slopes Forest, Moist Gully Forest and Dry Ridge-top Forest. Habitat: canopy trees 20-25 meters tall to be retained between existing highway and proposed alignment. Large canopy tree to east of proposed alignment. Midstorey of regenerating eucalypts and Black She-oak (<i>Allocasuarina littoralis</i>) to 12 metres. Several large habitat trees (DBH>1.2 metres) and good canopy connectivity. Drainage line is ephemeral at this location. Diversity of native ground-layer vegetation.
35700	Squirrel Glider	Located in proximity to combined underpass C35.70.
	Yellow-bellied Glider	Located within the Maria River State Forest, in proximity to an unnamed watercourse and within a mapped Regional fauna movement corridor. Vegetation in this area includes Moist Slopes Forest, Moist Gully Forest and Dry Ridgetop Forest. <u>Habitat</u>: Scattered emergent eucalypts to 20 metres tall. Canopy of Black She-oak (<i>Allocasuarina littoralis</i>) and White Feather Honeymyrtle (<i>Melaleuca decora</i>) to 12 metres. Several stag trees are located here. Trees to be retained between existing highway and proposed alignment include eucalypts to 12 metres. Drainage line is ephemeral at this location. Groundlayer vegetation is sparse. Some ground timber but no hollow logs.

3.6 FISH PASSAGE

The Project EA (GHD 2011) determined that no threatened fish species listed under the *Fisheries Management Act 1994* (FMA Act) or the *Environment Protection and Biodiversity Conservation Act* (EPBC Act) are considered likely to occur in the study area.

Culverts required to provide for fish passage have been identified in consultation with NSW DPI (Fishing and Aquaculture). The provision of appropriate fish passage will allow for the movement of fish from areas upstream of the Project to downstream areas.

An inspection of drainage lines that traverse the Project that potentially support fish passage was undertaken by Roads and Maritime and NSW DPI (Fishing and Aquaculture) on 26 October 2012. Upon the completion of this inspection, it was determined that the culverts identified in Table 8 below will be required to provide for fish passage. Further information regarding the dimensions of these culverts is contained in Appendices A1 and A2 and drawings are provided in Appendices C and D.

Where feasible, low flow channels have been provided to facilitate fish passage through culverts. The locations marked with an asterisk in Table 8 indicate the extension of an existing culvert where there is currently no low flow channel. Provision of a low flow channel at these extensions would actually hinder fish passage, so no channel has been provided.

Table 8 Fish passage requirements

Culvert I.D.	Station.	Fish Passage
C25.44	25440	Class 2
C25.68	25680	Class 3
C26.38	26380	Class 3
C26.81	26780	Class 2
C27.51	27510	Class 3
Smiths Creek Bridge	28250	Class 2
C28.68	28680	Class 2*
C29.60	29600	Class 3*
Pipers Creek bridges	30600	Class 2
Existing Pipers Creek Bridge	30600	Class 2
C34.70	34700	Class 2
C35.70	35700	Class 3

Culvert I.D.	Station.	Fish Passage
C36.40	36400	Class 3
Stumpy Creek Bridge	27730-37790	Class 2

3.6.1 WATERWAY CLASSIFICATION

There are no Class 1 waterways within the K2K section of the Project.

Class 2 requirements

Class 2 waterways are defined as *“Moderate fish habitat. Named permanent or intermittent stream, creek or waterway, with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area”* (Fairfull and Witheridge 2003).

Recommended crossing types over Class 2 waterways include bridges, arch structures, culverts or fords. Culverts that will convey Class 2 waterways should be designed in accordance with "High Flow Design" procedures (Fairfull and Witheridge 2003):

- "High Flow Design" requires that the effective flow area under the waterway crossing should be at least equal to the natural or existing flow area of the channel below the deck/crest level of the crossing.

In addition:

- Where required, new culverts (not including extensions to existing culverts) at Class 2 waterways will be fitted with concrete sills at appropriate spacing to reduce flow velocities and improve conditions for fish passage.

Class 3 requirements

Class 3 waterways are defined as *“Minimal fish habitat. Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi - permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats”* (Fairfull and Witheridge 2003).

Recommended crossing types for Class 3 waterways include culverts or fords. Culverts that will convey Class 3 waterways should be designed in accordance with "Low Flow Design" procedures; however, "High Flow Design" (see Class 2 requirements) and "Medium Flow Design" should be given priority where affordable (Fairfull and Witheridge 2003):

- "Medium Flow Design" requires that the effective flow area is to be at least equal to the natural or existing channel flow area below the roof of the culvert. The depth of the deck slab is to be minimised.

- "Low Flow Design" requires that the culvert should be designed to maximise the geometric similarities of the natural channel profile from the bed of the culvert up to a flow depth of 0.5 metres.

In addition, the following requirements have been specified by DPI (Fisheries) (J. Sakker pers. comm) for Class 3 waterways:

- Flow less than 0.5m/s.
- Invert has no head loss.
- Grade to be less than one per cent.

3.7 FAUNA FENCING

Locations and designs of fauna fencing for the Project are provided in Appendix F.

Fauna fencing aims to prevent animals crossing the road surface, thereby reducing incidence of road kill. Fauna fencing is also used to guide animals towards safe fauna crossing structures or passages such as underpasses (refer Figure 17).

Fauna fencing is to be installed where the upgrade passes through State Forests, regional habitat corridors, at least 200 metres either side of fauna underpasses and at additional locations as identified in consultation with EPA.

Three types of fauna fencing will be used:

- Standard floppy-top fauna fencing.
- Frog fencing.
- Phascogale fencing.



Figure 17 Fauna fencing, Oxley Highway (Source: SHJV)

Standard floppy-top fencing

Permanent floppy top fencing will be a heavily galvanised, floppy-top mesh fauna fence. Standard fauna fencing will be installed:

- Where the Project traverses Ballengarra and Maria River State Forests.
- Where the Project traverses regional habitat corridors.

- Between dual carriageway bridges and culverts where there are gaps between structures to prevent fauna accessing the median strip.

The proposed fauna fence height is 1.45 m, with an additional 0.5 metres of 'floppy' overhang angled at 45°, to discourage animals from climbing over the fence from the non-highway side of the fence. The fauna fence elements would be made from heavily galvanised steel that will achieve the durability requirements as discussed in Section 10.

Ground mesh 1.0 metres wide is to be attached to the fauna fence base and laid on the ground on the non-highway side of the fence and pinned to the ground with metal pins to prevent smaller animals passing through gaps at the base of the fence and/or burrowing beneath the fence. Refer standard detail on drawing OH2K-DDN-PW2101-064 in Appendix F.

One-way escape points / drop down structures will be provided at selected locations giving fauna trapped on the highway side of the fence an opportunity to pass through the fence. Drop down structures will generally be ramp structures, some provided at structures, such as culvert wing walls, with a small drop for fauna coming from the roadway to the non-highway side of the fence. Refer to Appendix F for standard detail and Figure 18 for an example of a fauna drop down structure.



Figure 18 Example Fauna Drop Down Structure, Oxley Highway NSW. Left to Right: Compacted earth ramp and corrugated sheet metal tied to mesh fencing (Source: Hyder Consulting)

Typically, the proposed alignment of the fauna fencing runs adjacent to the top or toe of earthworks batters, and does not contain internal angles less than 135 degrees, to reduce the likelihood of fauna being trapped by predators

The proposed fauna fence alignment avoids crossing drains, undulating topography and drainage basins where possible. Fencing terminates 25 metres past the area required to be fenced, with a nominal return at the end of the fencing.

Standard fauna fencing locations are listed in Table 9. Refer to Appendix F for further fauna fencing details.

Table 9 Locations of standard fauna fencing

Station	Fencing purpose	Approximate length
24040-28350	Ballengarra State Forest (includes regional corridor 25400-25300, subregional corridor 27400-28000 and Smiths Creek underbridge)	3.1km, including 100 metres north and south of Smiths Creek
26400	Dedicated fauna culvert F26.40	Minimum 200 metres either side of underpass, on both sides of the alignment
30700	Pipers Creek	350m. Extends 300 metres south (along Rodeo Drive) and 200 metres north of Pipers Creek northbound, 50 metres north and south of Pipers Creek southbound
32670-37600	Maria River State Forest (includes dedicated fauna culverts F33.40 and F34.72, regional corridor 32670-37600)	4.9km. Extends 20 metres south of C32.67 (northbound) and 200 metres south (southbound). Includes 200 metres either side of dedicated culverts, on both sides of the alignment.

Frog fencing

Frog fencing is to be at least 900 millimetres in height and will comprise of neoprene rubber sheeting or fine galvanised steel wire netting mesh (with approx. opening size of 6.5mm), including return of not less 100 millimetre on the ground. It may be stand-alone fencing or may be fitted to standard (floppy top) fauna fencing. This is applicable in areas of known or high potential threatened frog habitat where standard fauna fencing is proposed.

Frog fencing will be installed at areas of known or high potential Giant Barred frog (*Mixophyes iteratus*) and Green-thighed frog (*Litoria brevipalmata*) habitat to direct frogs away from the highway and towards underpasses.

Generally, frog fencing will be affixed to standard fauna fencing, however there may be the opportunity to provide standalone frog fence if additional potential frog habitat is encountered during construction. The frog fence is to be at least 900 millimetres in height, comprising neoprene rubber sheeting or fine galvanised steel wire netting mesh (with approx. opening size of 6.5mm), including a return of not less 100 millimetre on the ground. The fence will include hot dip galvanized sheet metal or powder coated aluminium sheet metal pressed at a 45 degree angle and mounted on a galvanized star picket on the fauna habitat side of the fence.

Frog fencing is required at the following locations (Table 10). Refer to Appendix F for frog fencing details.

Table 10 Locations of frog fencing

Station	Fencing purpose	Approximate length
28175	Smiths Creek (known Giant Barred Frog habitat)	Attach frog fencing treatment to standard fauna fencing for a distance of approximately 100 metres north and 100 metres south of the creek
30750	Pipers Creek (known Giant Barred Frog habitat)	Attach frog fencing treatment to standard fauna fencing: 300 metres south (along Rodeo Drive) and 200 metres north of Pipers Creek northbound, 50 metres north and south of Pipers Creek southbound
36850	Maria River	Attach frog fencing treatment to standard fauna fencing for a distance of approximately 50 metres north and 50 metres south of the creek

Phascogale fencing

Phascogale fencing aims to exclude the Brush-tailed phascogale, and possibly other small terrestrial mammals, from the road corridor and guide species towards fauna crossings. Phascogale fencing will be installed at areas of known or high potential habitat, to direct phascogales away from the highway and towards underpasses.

The threatened Brush-tailed Phascogale (*Phascogale tapoatafa*) was not recorded during surveys undertaken for the EA, but was predicted to occur “in larger tracts of bushland within the study area, including Maria River State Forest” (GHD 2011). The species had been previously recorded in close proximity to the existing Pacific Highway at Station 34000 in Maria River State Forest (in 2001).

Ecological investigations undertaken by Lewis Ecological Services of the proposed alignment in October 2012 identified areas of potential Brush-tailed phascogale (*Phascogale tapoatafa*) encompassing previous records of the species, mapped regional corridors and expanses of native vegetation contained in Maria River State Forest.

Phascogale fencing will be attached to standard fauna fencing. At the base of the standard fauna fencing, a second layer of mesh offset from the first layer of mesh to create maximum opening size of 25 millimetres, or a or fine galvanised steel wire netting mesh (with approx. opening size of 6.5mm) will be installed 200 - 500 millimetres above ground level. Above the second layer of mesh or fine mesh, 600 millimetre high coated steel panels (flat or vertically corrugated) will be affixed to the fauna fencing to prevent fauna climbing the fence to access larger diameter openings.

Phascogale fencing is required at the locations identified in Table 11. Refer to Appendix F for phascogale fencing details.

Table 11 Potential phascogale habitat (LES pers.comm)

Station	Fencing purpose	Approximate length
347200	Maria River State Forest Mapped regional corridor Species has been previously recorded in this area Phascogale habitat associated with low foothills of the Macleay	Attach phascogale fencing treatment to standard fauna fencing 200metres south and north of dedicated fauna culvert F34.72

4 DESIGN REFINEMENTS

The fauna crossing provisions are generally in accordance with Table 6.2. Refinements have been driven by the need to meet drainage functionality and road safety requirements, along with requests to provide appropriate crossing points for target fauna species. Where there has been a change to Table 6.2, consultation with regulators in accordance with the MCoA has been undertaken and this is detailed below in Table 12.

Some changes have been identified to facilitate provision of the future Class M design (refer Section 2.4).

Table 12 Refinements to culvert design relevant to MCoA B1 and Table 6.2 requirements

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
74/C24.43	24430	Incidental box culvert. Dimensions 3 x 1.8 metre, 45.6 metres in length.	Slight increase in length to 47.92 metres. Relocated 11 metres to the south.	Increase in length is due to raised vertical alignment resulting in longer batter slopes. No further opportunity to reduce the length as the culvert is required at this location for drainage. Culvert was relocated 11 meters south where batter slopes are shorter in order to minimise culvert length for fauna movements and provide greater hydraulic function.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).
75/C24.70	24700	Incidental box culvert. Dimensions 3 x 2.4 metre box culvert, 62.4 metres in length.	Increase in length to 82.38 metres.	Increase in length due to raised vertical alignment resulting in longer batter slopes. Change in length/alignment is due changes in design of southbound entry ramp from rest area. No further opportunity to reduce the length as the culvert is required at this location for drainage.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).
C24.71 (Class M)	24650	New culvert.	Two new incidental pipe culverts under local road. Dimensions 1200 millimetre, 27 metres length.	Required for drainage in M Class design, but dimensions potentially allow for use as incidental culvert. Located in key regional corridor and adjacent to Ballengarra State Forest. Opportunities would be sought when designed as part of the Project Stage 4 (Class M upgrade). Will not be constructed as part of the K2K Project.	No consultation to date.

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
76/C25.10	25100	Incidental pipe culvert. Dimensions 1500millimetre diameter, 30 metres length.	Increase in length to 71.18 metres.	Increase in length due to raised vertical alignment resulting in longer batter slopes. Change in length/alignment is due changes in design of northbound entry ramp to rest area. No further opportunity to reduce the length as the culvert is required at this location for drainage.	No consultation to date.
C25.30 (Class M)	25300	N/A	New five cell box culvert under local road. Dimensions 3 x 2.4 metres, 51 metres length.	Revised access arrangement for Mingaletta Road. Required for drainage in M Class design, but dimensions potentially allow for use as combined culvert. Located in key regional corridor and adjacent to Ballengarra State Forest. Opportunities for low flow and dry passage provisions would be sought when designed as part of the Project Stage 4 (Class M upgrade). Will not be constructed as part of the K2K Project.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).
C25.38 (Class M)	25380	N/A	Two new pipe culverts under local road. Dimensions 1200millimetre diameter, 42 metres length.	Required due to design changes to local road for Class M. Required for drainage but dimensions potentially allow for use as incidental culvert. Located in key regional corridor and adjacent to Ballengarra State Forest. Further opportunities would be sought when designed as part of the Project Stage 4 (Class M upgrade). Will not be constructed as part of the K2K Project.	No consultation to date.
78/C25.42	25420	Three incidental box culverts. Dimensions 1500millimetre diameter, 45.6 metres length.	Increased length to 46.73 metres.	Length slightly amended to match final road design. Length remains optimal for fauna passage at <50 metres.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
C25.44	25440	N/A	New five incidental cell box culverts under local road. Dimensions 3 x 2.4 metres, 19.6 metres length.	Required due to design changes to local road. Located on tributary of Barrys Creek within regional corridor and adjacent to Ballengarra State Forest. Required for drainage but dimensions potentially allow for use as incidental culvert. Drainage/fish crossing provided. Concrete sills provided to decrease velocity for fish passage.	No consultation to date.
C25.68	25680	Extend two existing incidental pipe culverts. Dimensions 1800millimetre diameter, 45 metres length.	New pipe culverts (replace existing). Dimensions 1800millimetre diameter, 52.46 metres length.	Existing culverts at drainage line will be replaced for drainage in order to provide greater dry fauna passage through combined box culvert C25.70. Fish passage has been provided by lowering both pipes below ground level, creating a low flow channel.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
C25.70	25700	Combined culvert at station 25700 metres. 3.0 x 2.4 box culvert, 44 metres length.	Slight increase in length to 46.73. Height increased to 2.7 metres.	Length has slightly increased due to increased batter width, but is still <50m, providing optimal fauna line of sight. Width has been changed to 2.7 metres. The original table 6.2 stated a height of 2.4 metres, with a note stating opportunities to increase to 2.7 metres would be sought at detailed design. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand..	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).
C25.74 (Class M)	25740	N/A	New 1500 millimetre pipe culvert under local road, 39 metres length.	Extension of existing culvert under local road. Required for drainage in Class M, but dimensions potentially allow for use as incidental culvert. Located in key regional corridor and adjacent to Ballengarra State Forest. Further opportunities would be sought when designed as part of the Project Stage 4 (Class M upgrade). Will not be constructed as part of the K2K Project.	No consultation to date.

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
81/C25.85	25850	Combined	Changed to two incidental pipe culverts. Dimensions 900 millimetres, length 44 metres.	This has been downgraded from a combined culvert to drainage only (incidental culvert). Fauna passage possible through C25.70 (120 metres to south). Culvert will be set to the existing bed level for low flow fish passage. Skew angle reduced to minimise length as much as possible.	No consultation to date.
83/C26.38	26380	Incidental pipe culvert. Dimensions 1500 millimetre diameter, 81.2 metres length.	Two pipes now proposed with dimensions of 1200 millimetre diameter. Existing will be replaced with a new pipe culvert alongside. Length decreased to 59.78 metres.	Culvert length reduced due to changes to road design. The original design has the culvert extended under the Class M service road. As this service road is not being constructed until Stage 4, the culvert will be constructed at a reduced length during Stage 2. The existing culvert does not meet the durability requirement, will be replaced. The inclusion of a second culvert provides for 100 year flood immunity to fauna culvert C26.40.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).
83F/F26.40	26415	Dedicated box culvert at station 26400. Dimensions 3 x 3 metre, 40.8 metres length.	Increased length to 49.17 metres. Relocated 15 metres to the north to station 26415.	Culvert moved 15 metres to the north to provide one in 100 year flood immunity. Increased length is due to the lowering of the culvert and embankment widening during detailed design. However, length has been kept at <50 metres to provide optimal fauna line of sight. Inlet has also been lowered to improve line of sight for fauna through culvert.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
C26.80 (Class M)	26800	N/A	New pipe culvert under local road. Dimensions 1200 millimetre diameter, 30 metres length.	Required for Class M Concept Design. Required for drainage in Class M, but dimensions potentially allow for use as incidental culvert. Links fragmented vegetation to the east and west. Further opportunities would be sought when designed as part of the Project Stage 4 (Class M upgrade). Will not be constructed as part of the K2K Project.	No consultation to date.
84/C26.78	26780	Combined box culvert. Dimensions 3 x 3 metres, 45.6 metres length.	Slight increase in length to 49 metres. Relocated 2 metres south to align with watercourse on western side.	Culvert length increased due to changes in road geometry. Fish passage provided as well as fauna furniture. 100year flood immunity provided, allowing for 50% blockage due to fauna furniture. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand. Concrete sills provided to decrease velocity for fish passage.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
C27.50 (Class M)	27500	N/A	New combined box culvert under Cooperabung Range Road. Dimensions 3 x 3 metres, 37 metres length.	Required for Class M Concept Design. Required for drainage in Class M, but dimensions potentially allow for use as combined culvert. Located in sub-regional corridor linking extensive areas of key habitat within state forests to east and west. Opportunities for low flow and dry passage provisions would be sought when designed as part of the Project Stage 4 (Class M upgrade). Will not be constructed as part of the K2K Project.	No consultation to date.
86/C27.51	27510	Combined box culvert. Dimensions 3 x 3 metres, 43.2 metres length.	Slight increase in length to 45.5 metres.	Slight increase in length due to raised vertical alignment resulting in longer batter slopes. Length remains <50 metres to provide optimal fauna line of sight through the culvert. Fish passage provided as well as fauna furniture. 100 year flood immunity provided, allowing for 50% blockage due to fauna furniture. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
88	28250	Twin bridges at Smiths Creek, length 35 metres.	Increased length to 54.9 metres and number of spans increased from 3 to 4 and span lengths equalised.	Increased bridge length in order to reduce flood velocities and flood levels. Increased length provides greater opportunity for fauna connectivity and movement along creek embankments. 3 metres unhindered fauna passage on both banks.	EPA/DPI (Fisheries) 7 September and email to DPI/EPA 7 December 2012 (refer to Appendix C).
88 (west)	28250	Bridge – Smiths Creek Service Road	Existing bridge to be demolished.	A new bridge would be required as part of the Class M, and would be designed during Stage 4 of the Project.	EPA/DPI (Fisheries) 7 September 2012 & 15 February 2013 (refer to Appendix C).
88a/C28.30	28300	Combined box culvert. Dimensions 3 x 3 metres, 41 metres length.	Removed as Smiths Creek bridge extended to 4 spans.	Smith's Creek bridge was increased from 3 spans to 4, so this culvert was not required.	EPA/DPI (Fisheries) 7 September 2012 & 6 December 2012 (refer to Appendix C).
89/C28.68	28700	Extension of combined box culvert. Dimensions 2.4 x 2.4 metres, 50 metres length.	Reduced length to 48.56 metres.	Culvert length reduced to match standard culvert unit lengths. Length has been reduced to <50 metres to provide optimal fauna line of sight through the culvert.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
C28.67 (Class M)	28700	N/A	New incidental box culvert under Rodeo Drive, culvert size to match the existing culvert under main alignment. Dimensions 2.4 x 2.4 metres, 24 metres length.	Required for Class M Concept Design. Required for drainage in Class M, but dimensions potentially allow for use as incidental culvert. Links fragmented vegetation to east and west. Further opportunities would be sought when designed as part of the Project Stage 4 (Class M upgrade). Will not be constructed as part of the K2K Project.	No consultation to date.
90/C29.60	29600	Extension of incidental pipe culvert. Dimensions 1500 millimetre diameter, 64 metres length.	Increase in length to 81.85 metres.	Culvert length changed to match road design due to changes with layout at Kundabung Interchange. No further opportunity to reduce the length as the culvert is required at this location for drainage. The dimensions of the combined culvert located 500 metres to the north have been improved to provide better fauna movement opportunities.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
91/C30.10	30100	Combined box culvert. Dimensions 3 x 2.7 metres, 45.6 metres length.	Increase in length to 49 metres. Increased height to 3.0 metres.	Culvert length changed to match road design but is still <50 metres, to provide optimal fauna line of sight through the culvert. The height of the culvert has also been increased from 2.7 metres to 3.0 metres to provide greater line of sight and opportunities for fauna passage. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.	EPA/DPI (Fisheries) 7 September 2012 & 15 February 2013 (refer to Appendix C).
92	30600	Twin bridges at Pipers Creek. Length 41 metres.	Increased length to 44.7 metres.	Increased length to avoid placing of piles in creek. Relocated 50 metres east to avoid sensitive Giant-Barred Frog habitat. Three metre unhindered fauna passage on both banks.	EPA/DPI (Fisheries) 7 September 2012 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
92 (west)	30600	Bridge – Pipers Creek Service road (west). Length 30 metres.	Existing bridge to be retained for use as service road.	Shift in alignment of twin bridges allows retention of existing bridge as service road. Existing fauna movement provisions will be retained.	EPA/DPI (Fisheries) 7 September 2012 (refer to Appendix C).
92 (east)	30600	Bridge – Pipers Creek Service Road (east). Length 41 metres.	Would only need be constructed as part of future Class M.	A new bridge would be required as part of the Class M, and would be designed during Stage 4 of the Project.	EPA/DPI (Fisheries) 7 September 2012 (refer to Appendix C).
94S/C31.1A	31100	Combined box culvert. Dimensions 3.0 x 1.8 meters, 45.6 metres length.	This culvert has been deleted.	This culvert is in close proximity to combined culvert at Station 31900. Required geometry for functionality could not be achieved due to difference in height between the main alignment and the service road. Pipers Creek bridges immediately to the south also provide opportunity for fauna movement.	No consultation to date.

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
96/C31.90	31900	Combined box culvert. Dimensions 3 x 3 metres, 45.6 metres length.	Increased length of culvert to 65.15 metres. Cell height reduced from 3000 millimetres to 2100 millimetres. Relocated 13 metres north.	The culvert length has increased and the grade has changed due to development of the road alignment and extension under service road. Cell height had to be reduced due to fill height restrictions. No further opportunity to reduce the length as the culvert is required at this location for drainage. Culvert location has shifted to allow the use of existing drainage lines during construction. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
97/C32.35	32350	Combined box culvert. Dimensions 3 x 3 metres, 43.2 metres length.	Increased length to 63.95 metres to extend under service road. Relocated 7 metres south.	Increase in length is due to raised vertical alignment resulting in longer batter slopes. Culvert length also changed to match culvert unit lengths. The culvert has shifted approximately 5 metres to the north to allow construction off the existing drainage lines. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.	EPA/DPI (Fisheries) 7 September 2012 & 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
98/C32.66	32700	Combined box culvert. Dimensions 3 x 3 metres, 43.2 metres length.	Increased length to 67.78 metres. Height reduced to 2.4 metres. Relocated 38 metres north.	Increased length is due to raised vertical alignment resulting in longer batter slopes and culvert continues under local service road. Culvert length also changed to match culvert road design. The culvert location has shifted to the north to allow use of existing drainage lines during construction. The cell height has been reduced from 3000 to 2400 to match the original height of C32.65. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.	EPA/DPI (Fisheries) 7 September 2012 & 15 February 2013 (refer to Appendix C).
C32.67	32700	N/A	New combined box culvert under local road. Dimensions 3 x 2.4 metres, 21 metres length.	Provides access under local road as a continuation of C33.66. A table drain was added in between this culvert and C32.66. A single apron with stone pitching is used to connect this culvert with C32.66, as well as providing safer access for the median drain.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
99/C33.10	33100	Combined box culvert. Dimensions 3 x 3 metres, 45.6 metres length.	Increased length to 56.35 metres. Height increased to 3.3 metres. Relocated 3 metres south.	Increased length due to raised vertical alignment resulting in longer batter slopes. Culvert skew angle changed. The cell height was increased to 3300. This allowed the base slab to be dropped to incorporate 250 millimetre recessed rocks while maintaining the cell height of 3000. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).
100F/F33.40	33400	Dedicated box culvert. Dimensions 3 x 3 metres, 43.2 metres length.	Increased length to 49.19 metres. Relocated 10 metres north.	Increased length due to raised vertical alignment resulting in longer batter slopes. Culvert length also changed to match structural design. 100 year flood immunity provided.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
102/C34.10	34100	Combined box culvert. Dimensions 3 x 3 metres, 48 metres length.	Increased length to 60.21 metres.	Increased length due to raised vertical alignment resulting in longer batter slopes and changed culvert skewed angle. Culvert skewed angle adjusted to reduce length as much as possible. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.	EPA/DPI (Fisheries) 15 February 2013 (refer to Appendix C).
103/F34.72	34700	Dedicated box culvert. Dimensions 3 x 3 metres, 45.6 metres length	Increased length to 47.92 metres.	Slight increase in length, but remains <50 metres to provide optimal line of sight for fauna through the culvert. 1 in 100 year flood immunity provided by separate culverts C34.70 and C34.80.	EPA/DPI (Fisheries) 7 September 2012 & 15 February 2013 (refer to Appendix C).
C34.70	34700	N/A	New three cell incidental box culvert. Dimensions 2.1 x 1.5 metres, 62.7 metres length.	Designed for drainage to ensure dry fauna passage at F34.72, but also provides incidental fauna passage opportunity. Fish passage provided. Concrete sills provided to decrease velocity for fish passage.	EPA/DPI (Fisheries) 7 September 2012 & 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
106/C35.70	35700	Combined box culvert. Dimensions 3 x 3 metres, 40.8 metres length.	Increased length to 50.4 metres.	Increased length due to raised vertical alignment resulting in longer batter slopes. Culvert has been straightened to reduce length as much as possible. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.	EPA/DPI (Fisheries) 7 September 2012 & 15 February 2013 (refer to Appendix C).

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
109/C36.40	36400	Combined box culvert. Dimensions 3 x 3 metres, 57.6 metres length.	Increased length to 66.41 metres.	Increased length due to raised vertical alignment resulting in longer batter slopes. Culvert has been straightened to reduce length as much as possible and align with downstream channel. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.	EPA/DPI (Fisheries) 7 September 2012 & 15 February 2013 (refer to Appendix C).
	36900	Bridge – northbound over Maria River	Existing bridge to be retained. Current connectivity provisions will be maintained.		
	36900	Bridge – southbound over Maria River	Existing bridge to be retained. Current connectivity provisions will be maintained.		
	37730 - 37790	Bridge – northbound over Stumpy Creek	New bridge overall length 36m.		

ID (GHD/Hyder)	Station	Original Table 6.2 Design Requirement	Amendment	Discussion	Stakeholder Consultation
	37730 - 37790	Bridge – southbound over Stumpy Creek	Existing bridge to be retained. Current connectivity provisions will be maintained without modification to existing abutment slopes.		
	37730 - 37790	Bridge – service road over Stumpy Creek.	Existing bridge to be retained. Current connectivity provisions will be maintained.		

5 REFERENCES

- Barnum S., (2003) *Identifying the best locations along highways to provide safe crossing opportunities for wildlife*. Report No. CDOT-DTD-UCD-2003-9. Colorado Department of Transportation Research Branch,
- Bond A., Jones D. (2008) *Temporal trends in use of fauna-friendly underpasses and overpasses*. Wildlife Research. Vol. 25 p103-122.
- Fairfull S and Witheridge G (2003) 'Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings.' NSW Fisheries, Cronulla
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- Mata C., (2003) Effectiveness of wildlife crossing structures and adapted culverts in a highway in northwest Spain. ICOET Proceedings, p265-276
- QDMR(2000). *Fauna sensitive road design. Volume 1- Past and Existing Practices*. Queensland Department of Main Roads, Planning, Design and Environment Division. Brisbane.
- QDMR(2000). *Fauna sensitive road design. Volume 2- Preferred Practices*. Queensland Department of Main Roads, Planning, Design and Environment Division. Brisbane.
- Roads and Maritime (2011) *Ecological Review of Fauna Crossings in the Ballengarra State Forest*.
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APPENDIX A1

FAUNA CROSSING LOCATIONS

Appendix A1 describes the fauna crossings developed for the Project. Details regarding the existing structures, proposed design and fauna habitat considerations for each of the locations are also specified.

Appendix A2 provides an updated version of Table 6.2 that focuses on the K2K section of the Project. Appendix A2 details the requirements associated with MCoA compliance for Conditions B1-B6.

Station: 24430		ID: 74/C24.43																													
Crossing type:	Incidental box culvert																														
Proposed size:	1 cell box culvert, 3000 mm width, 1800 mm height to be installed under the main alignment over a length of 45.6 metres.																														
Drawing reference (s):	OH2K-DDS-SC2105-002_[03], OH2K-DDS-SC2105-003_[03], OH2K-DDS-SC2105-004_[03]																														
Existing provisions:	None																														
Fauna provision requirement:	Incidental fauna crossing.																														
Engineering considerations :	Precast crown units on an in-situ reinforced concrete (RC) base slab cast. Increase in length is due to raised vertical alignment resulting in longer batter slopes. Relocated 11 metres south. HW elevation does not impact on upstream C24.42 (Class M). Overspilling level controlled by cut/fill interface (~RL27). <table><tr><th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr><tr><th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr><tr><td>1.15</td><td>25.56</td><td>4.05</td><td>2.15</td><td>200</td><td>12</td><td>11</td><td>Type A Dissipater</td></tr></table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	1.15	25.56	4.05	2.15	200	12	11	Type A Dissipater
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
1.15	25.56	4.05	2.15	200	12	11	Type A Dissipater																								
Conservation status:	None																														
Habitat connectivity:	Regional corridor linking key habitat to east and west, continuous with climate change corridor to east.																														
Potential species:	Frogs, reptiles, small to medium mammals if dry.																														
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																														
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																														
Furniture:	No																														

Station: 24470	ID: 75/C24.70																								
Crossing type:	Incidental box culvert																								
Proposed size:	1 cell box culvert, 3000 mm width, 2.4 metres in height to be installed under the main alignment over a length of 82.38 m.																								
Drawing reference (s):	OH2K-DDS-SC2105-002_[03], OH2K-DDS-SC2105-003_[03], OH2K-DDS-SC2105-004_[03]																								
Existing provisions:	None																								
Fauna provision requirement:	Incidental fauna crossing.																								
Engineering considerations:	Precast crown units on an in-situ reinforced concrete (RC) base slab cast. Increase in length due to raised vertical alignment resulting in longer batter slopes. Overtopping level controlled by cut/fill interface (approx. RL24.85mAHD). HW elevation does not impact on upstream C24.71 (Class M). <table><tr><th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr><tr><th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr><tr><td>0.70</td><td>21.80</td><td>2.38</td><td>1.42</td><td>200</td><td>-</td><td>-</td><td>Rock lining to D/S culvert</td></tr></table>	Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	0.70	21.80	2.38	1.42	200	-	-	Rock lining to D/S culvert
Headwater		Scour protection (50Yr ARI)																							
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																		
0.70	21.80	2.38	1.42	200	-	-	Rock lining to D/S culvert																		
Conservation status:	None																								
Habitat connectivity:	Regional corridor linking key habitat in Ballengarra State Forest.																								
Potential species:	Frogs, reptiles, small to medium mammals if dry.																								
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																								
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																								
Furniture:	No																								

Station: 25100	ID: 76/C25.10						
Crossing type:	Incidental pipe culvert						
Proposed size:	1 pipe 1500 mm diameter to be installed under the main alignment over a length of 71.18 m.						
Drawing reference (s):	OH2K-DDS-DR2101-413_[02]						
Existing provisions:	None						
Fauna provision requirement:	Incidental fauna crossing.						
Engineering considerations :	Increase in length due to raised vertical alignment resulting in longer batter slopes.						
	<i>Headwater</i>		Scour protection (50Yr ARI)				
	H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)
	2.11	16.73	3.36	1.07	200	10.0	11.7
Conservation status:	None						
Habitat connectivity:	Regional corridor linking key habitat in Ballengarra State Forest.						
Potential species:	Frogs, reptiles, small to medium mammals if dry.						
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.						
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.						
Furniture:	No						

Station:	ID:78/ C25.42																														
25420																															
Crossing type:	Incidental box culvert																														
Proposed size:	1 cell 3000 mm width, 1500 mm in height to be installed under the main alignment over a length of 46.73 m.																														
Drawing reference (s):	OH2K-DDS-SC2105-002_[03], OH2K-DDS-SC2105-003_[03], OH2K-DDS-SC2105-004_[03]																														
Existing provisions:	None																														
Fauna provision requirement:	Incidental fauna crossing.																														
Engineering considerations :	Precast crown units on an in-situ reinforced concrete (RC) base slab cast. Length amended to match final road design. Overspilling level controlled by sag on main alignment (~RL13.477). Backwater from C25.44 ~ 11.28mAHD. <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr> </thead> <tbody> <tr> <td>1.56</td><td>12.05</td><td>3.59</td><td>1.49</td><td>200</td><td>12.0</td><td>11.0</td><td>Type A Dissipator</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	1.56	12.05	3.59	1.49	200	12.0	11.0	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
1.56	12.05	3.59	1.49	200	12.0	11.0	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	Links to fragmented native vegetation to east and west.																														
Potential species:	Frogs, reptiles, small to medium mammals if dry.																														
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																														
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																														
Furniture:	No																														

Station:	ID:C25.44																														
25440																															
Crossing type:	Incidental box culvert																														
Proposed size:	5 cells 3000 mm width, 2400 mm in height to be installed under Mingaletta Road over a length of 19.6 m.																														
Drawing reference (s):	OH2K-DDS-SC2106-002-[03], OH2K-DDS-SC2106-003-[03]																														
Existing provisions:	None																														
Fauna provision requirement:	Incidental fauna crossing.																														
Engineering considerations :	Type 2 arrangement (Drainage/fish crossing). Precast crown units and precast link slabs on an in-situ reinforced concrete (RC) base slab cast. Overtopping level controlled by sag on Mingaletta Road (~RL12.94). 100yr ARI FL~11.77mAHD does not impact hydraulic capacity of C25.42 and C25.30 (Class M only). Embankment will not be overtopped in 100yr ARI. <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr> </thead> <tbody> <tr> <td>1.91</td><td>11.07</td><td>3.63</td><td>1.01</td><td>300</td><td>14.0</td><td>25.0</td><td>Type A Dissipator provided as fish pool</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	1.91	11.07	3.63	1.01	300	14.0	25.0	Type A Dissipator provided as fish pool
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
1.91	11.07	3.63	1.01	300	14.0	25.0	Type A Dissipator provided as fish pool																								
Conservation status:	None																														
Habitat connectivity:	Links to fragmented native vegetation to east and west.																														
Potential species:	Frogs, reptiles, small to medium mammals if dry.																														
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																														
Fish crossing provisions:	Class 2 fish passage is provided via low flow channel. Concrete sills provided to decrease velocity for fish passage.																														
Furniture:	No																														

Station: 25700	ID:C25.70																														
Crossing type:	Combined box culvert																														
Proposed size:	1 cell 3000 mm width, 2700 mm in height to be installed under the main alignment over a length of 45 m.																														
Drawing reference (s):	OH2K-DDS-SC2108-002, OH2K-DDS-SC2108-003																														
Existing provisions:	N/A																														
Fauna provision requirement:	Combined wet and dry crossing.																														
Engineering considerations :	Type 4 arrangement (combined drainage / fauna crossing). Precast crown units on an in-situ reinforced concrete (RC) base slab cast. System analysed based on twin 1800mm RCPs (C25.68) & 3000x2700 RCBC (C25.70). <table><tr><th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr><tr><th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr><tr><td>-</td><td>14.69</td><td>3.07</td><td>0.97</td><td>200</td><td>7</td><td>10</td><td>Rock Transition Apron</td></tr></table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	-	14.69	3.07	0.97	200	7	10	Rock Transition Apron
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
-	14.69	3.07	0.97	200	7	10	Rock Transition Apron																								
Conservation status:	None																														
Habitat connectivity:	Riparian forest, vegetative connectivity to vegetation at C25.74.																														
Potential species:	Frogs, reptiles, small to medium mammals if dry.																														
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																														
Fish crossing provisions:	Not required. No or very limited fish crossing would be available in the event of water flow.																														
Furniture:	No																														

Station:	ID:80/C25.68																														
25680																															
Crossing type:	Incidental pipe culvert																														
Proposed size:	2 pipes 1800 mm diameter to be extended under the main alignment over a length of 45.27 m.																														
Drawing reference (s):																															
Existing provisions:	Existing 2 pipes under alignment																														
Fauna provision requirement:	Incidental fauna crossing.																														
Engineering considerations :	System analysed based on twin 1800mm RCPs (C25.68) & 3000x2700 RCBC (C25.70). Culverts subject to backwater from downstream culvert C25.75 (tailwater = 14.27mAHD). <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr> </thead> <tbody> <tr> <td>2.19</td><td>14.69</td><td>3.44</td><td>0.97</td><td>200</td><td>8.0</td><td>10.5</td><td>Rock Transition Apron</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	2.19	14.69	3.44	0.97	200	8.0	10.5	Rock Transition Apron
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
2.19	14.69	3.44	0.97	200	8.0	10.5	Rock Transition Apron																								
Conservation status:	None																														
Habitat connectivity:	Links fragmented native vegetation to east and west.																														
Potential species:	Koala, possums, spotted-tailed quoll, macropods, small mammals, reptiles and amphibians.																														
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																														
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																														
Furniture:	No																														

Station:	ID:81/C25.85																														
25850																															
Crossing type:	Incidental pipe culvert																														
Proposed size:	2 pipes 900 mm diameter to be installed under the main alignment over a length of 61 m.																														
Drawing reference (s):	OH2K-DDS-DR2101-441_[02]																														
Existing provisions:	N/A																														
Fauna provision requirement:	Incidental fauna crossing.																														
Engineering considerations :	Overtopping level controlled by catchment boundary (~RL16.8mAHD). 100yr bypass to C25.71 approx. 1.25m³/s assuming 30% blockage. Existing drainage downstream is estimated to have 100yr capacity. 100yr FL 14.62mAHD is applied as tail water condition but does not impact 100yr capacity of C25.85. <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr> </thead> <tbody> <tr> <td>2.79</td><td>18.06</td><td>5.58</td><td>2.66</td><td>400</td><td>9.8</td><td>8.3</td><td>Type A Dissipator</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	2.79	18.06	5.58	2.66	400	9.8	8.3	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
2.79	18.06	5.58	2.66	400	9.8	8.3	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	Moist gully forest, vegetative connectivity to vegetation at C25.70.																														
Potential species:	Frogs, reptiles, small mammals if dry.																														
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																														
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																														
Furniture:	No																														

Station:	ID:83/C26.38																														
26380																															
Crossing type:	Incidental pipe culvert																														
Proposed size:	1 pipe 1500 mm diameter to be installed under the main alignment over a length of 54.03 m.																														
Drawing reference (s):	OH2K-DDS-DR2101-446_[02]																														
Existing provisions:	N/A																														
Fauna provision requirement:	Incidental fauna crossing.																														
Engineering considerations :	Overspilling level controlled by existing cut/fill interface (~RL21.75). <table> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr> <tr> <td>1.51</td><td>18.12</td><td>2.87</td><td>0.98</td><td>200</td><td>8.1</td><td>6.9</td><td>Type A Dissipator</td></tr> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	1.51	18.12	2.87	0.98	200	8.1	6.9	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
1.51	18.12	2.87	0.98	200	8.1	6.9	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	Links fragmented native vegetation to east and west.																														
Potential species:	Frogs, reptiles, small mammals if dry.																														
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																														
Fish crossing provisions:	Class 3 fish passage provided via low flow channel.																														
Furniture:	No																														

Station: 26400 ID:83F/C26.40F	
Crossing type:	Dedicated box culvert
Proposed size:	1 cell 3000 mm width, 3000 mm in height to be installed under the main alignment over a length of 49.18 m.
Drawing reference (s):	OH2K-DDS-SC2108-102_[03], OH2K-DDS-SC2108-103_[03]
Existing provisions:	N/A
Fauna provision requirement:	Dedicated fauna crossing.
Engineering considerations:	Type 3 arrangement (dedicated fauna). Precast crown units on an in-situ reinforced concrete (RC) base slab cast. Increased length due to lowering of culvert and embankment widening during detailed design. Culvert Slope 3.06%.
Conservation status:	None
Habitat connectivity:	Links fragmented native vegetation to east and west.
Potential species:	Koala, macropods, spotted-tailed quoll, small mammals, reptiles, amphibians.
Dry crossing provisions:	Dry passage provided with one in 100 year flood immunity.
Fish crossing provisions:	Not required - dry fauna culvert with no drainage function.
Furniture:	Rails and refuge poles for koalas and rocks, hollow logs for quolls.

Station:	ID:84/C26.78																														
26780																															
Crossing type:	Combined box culvert																														
Proposed size:	1 cell 3000 mm width, 3000 mm in height to be installed under the main alignment over a length of 46.73 m.																														
Drawing reference (s):	OH2K-DDS-SC2108-202, OH2K-DDS-SC2108-203																														
Existing provisions:	N/A																														
Fauna provision requirement:	Combined fauna crossing.																														
Engineering considerations :	Type 1 arrangement (fish, fauna and drainage). Precast crown units on an in-situ reinforced concrete (RC) base slab cast. Combined drainage/fauna/fish culvert (Type 1 Arrangement with Fauna furniture). Overspilling level controlled by sag on existing highway (~RL18.85). 100yr water level considered 50% blockage due to fauna furniture. Headwater impact on C26.80 (Class M only). <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr> </thead> <tbody> <tr> <td>1.76</td><td>15.04</td><td>3.39</td><td>1.20</td><td>300</td><td>12.0</td><td>11.0</td><td>Type A Dissipator</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	1.76	15.04	3.39	1.20	300	12.0	11.0	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
1.76	15.04	3.39	1.20	300	12.0	11.0	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	Limited connectivity to west.																														
Potential species:	Koala, macropods, spotted-tailed quoll, small mammals, reptiles, amphibians.																														
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																														
Fish crossing provisions:	Class 2 fish passage available via low flow channel in culvert. Concrete sills provided to decrease velocity for fish passage.																														
Furniture:	Rails and refuge poles for koalas.																														

Station: 27510	ID:C27.51																														
Crossing type:	Combined box culvert																														
Proposed size:	1 cell 3000 mm width, 3000 mm in height to be installed main alignment over a length of 47.94 m.																														
Drawing reference (s):	OH2K-DDS-SC2108-302, OH2K-DDS-SC2108-303																														
Existing provisions:	None																														
Fauna provision requirement:	Combined fauna crossing.																														
Engineering considerations :	Type 1 arrangement (fish, fauna and drainage). Precast crown units on an in-situ reinforced concrete (RC) base slab cast. Combined drainage/fauna/fish culvert (Type 1 Arrangement with fauna furniture). 100yr water level considered 50% blockage due to fauna furniture. Headwater impact on C27.50 (Class M only). <table><tr><th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr><tr><th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr><tr><td>1.64</td><td>10.24</td><td>2.88</td><td>1.00</td><td>300</td><td>12.0</td><td>11.0</td><td>Type A Dissipator</td></tr></table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	1.64	10.24	2.88	1.00	300	12.0	11.0	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
1.64	10.24	2.88	1.00	300	12.0	11.0	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	Sub-regional corridor linking areas of key habitat within state forests to east and west.																														
Potential species:	Koala, macropods, spotted-tailed quoll, small mammals, reptiles, amphibians.																														
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																														
Fish crossing provisions:	Class 3 fish passage provided in low flow channel.																														
Furniture:	Rails and refuge poles for koalas.																														

Station: 28250 ID:88	
Crossing type:	Twin bridges – Smiths Creek
Proposed size:	4 span twin bridges, 54.88 metres length.
Drawing reference (s):	OH2K-DDS-SB2102-005, OH2K-DDS-SB2102-070, OH2K-DDS-SB2102-071
Existing provisions:	N/A – new bridges
Fauna provision requirement:	3 metres unhindered fauna passage above the 2 year ARI flood level
Engineering considerations:	Twin bridges are designed to AS5100 Bridge Design. Design traffic loading consists of SM1600 and HLP400 design vehicles, with the HLP vehicle located centrally between the traffic lanes ($\pm 1.0\text{m}$) on the bridge deck. Previous three span arrangements have now been replaced with a four span bridge due to results from flood modelling.
Conservation status:	None
Habitat connectivity:	On edge of sub-regional corridor, riparian vegetation continuous within riparian corridor to east and west.
Potential species:	Koala, macropods, spotted-tailed quoll, small to medium mammals, reptiles, amphibians.
Dry crossing provisions:	Dry passage provided via 3 metre wide fauna paths above 2 year ARI flood level on both banks.
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

Station: 28250 ID:88 (west)	
Crossing type:	Bridge – Smiths Creek Service Road
Proposed size:	Existing bridge to be demolished. New bridge only required under Class M (Stage 4) arrangement.
Drawing reference (s):	OH2K-DDN-SB2108-005
Existing provisions:	Existing passage under bridge
Fauna provision requirement:	At least 3 metres unhindered fauna passage on both banks.
Engineering considerations:	N/A
Conservation status:	None
Habitat connectivity:	Adjacent to sub regional corridor.
Potential species:	Koala, macropods, spotted-tailed quoll, small to medium mammals, reptiles, amphibians.
Dry crossing provisions:	Dry passage will be available for terrestrial fauna on both banks as per existing provisions.
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

Station: 28680	ID:89/C28.68																														
Crossing type:	Combined box culvert																														
Proposed size:	3 cells 2400 mm diameter, 2400 mm in height to be extended under main alignment over a length of 47.74 m.																														
Drawing reference (s):	OH2K-DDS-SC2107-102, OH2K-DDS-SC2107-103																														
Existing provisions:	Existing culvert to be extended.																														
Fauna provision requirement:	Combined fauna crossing.																														
Engineering considerations :	Type 4 arrangement (combined drainage / fauna crossing). Extensions consist of precast crown units and precast link slabs on an in-situ reinforced concrete (RC) base slab cast. The interface between the existing culvert crown units and the new crown units includes a cast-in-situ transition structure to accommodate the geometrical differences between the two structures. Catchment to this culvert is estimated conservatively. Overspilling level is controlled by catchment boundary (~7.2mAHD). Flood water exceed this ponding level will overspill to Smiths creek via channel. <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr> </thead> <tbody> <tr> <td>2.44</td><td>7.12</td><td>4.12</td><td>1.26</td><td>300</td><td>13.0</td><td>11.0</td><td>Type A Dissipator</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	2.44	7.12	4.12	1.26	300	13.0	11.0	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
2.44	7.12	4.12	1.26	300	13.0	11.0	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	Links fragmented vegetation to east and west.																														
Potential species:	Koala, macropods, small mammals, reptiles, amphibians.																														
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																														
Fish crossing provisions:	Class 2 fish passage provided as per existing culvert arrangement, no low flow passage due to extension of existing culverts at ground level.																														
Furniture:	No																														

Station:	ID:90/C29.60																														
29600																															
Crossing type:	Incidental pipe culvert																														
Proposed size:	4 cells 1500 mm diameter to be installed under main alignment over a length of 81.85 m.																														
Drawing reference (s):	OH2K-DDS-SC2107-202, OH2K-DDS-SC2107-203																														
Existing provisions:	Existing 4 cell culvert to be extended.																														
Fauna provision requirement:	Incidental fauna crossing.																														
Engineering considerations :	Both upstream and downstream extensions consist of precast crown units on an in-situ reinforced concrete (RC) base slab cast. The interface between the existing culvert crown units and the new crown units includes a cast-in-situ transition structure to accommodate the geometrical differences between the two structures. Assume subject to tail water from future C29.62 (Class M) ~ RL11.65. Overspilling level controlled by sag on Cooperabung Rd (~RL13.00). <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr> </thead> <tbody> <tr> <td>2.11</td><td>12.22</td><td>3.54</td><td>1.29</td><td>300</td><td>9.0</td><td>11.0</td><td>Type A Dissipator provided as fish pool</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	2.11	12.22	3.54	1.29	300	9.0	11.0	Type A Dissipator provided as fish pool
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
2.11	12.22	3.54	1.29	300	9.0	11.0	Type A Dissipator provided as fish pool																								
Conservation status:	None																														
Habitat connectivity:	Limited connectivity: small fragments of vegetation, large cleared areas.																														
Potential species:	Frogs, reptiles, small mammals if dry.																														
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																														
Fish crossing provisions:	Class 3 fish passage provided as per existing culvert arrangement, no low flow passage due to extension of existing culverts at ground level.																														
Furniture:	No																														

Station: 30100	ID:91/C30.10																														
Crossing type:	Combined box culvert																														
Proposed size:	1 cell 3000 mm width, 3000 mm in height to be installed under main alignment over a length of 51.45 m.																														
Drawing reference (s):	OH2K-DDS-SC2108-401 to 409																														
Existing provisions:	None																														
Fauna provision requirement:	Combined fauna crossing.																														
Engineering considerations :	Type 4 arrangement (combined drainage / fauna crossing). Precast crown units on an in-situ reinforced concrete (RC) base slab cast. Fauna furniture not required. Tail water level of C30.10 from C30.11 (Class M only - RL11.01mAHD). Overtopping level controlled by catchment boundary (approx. 13mAHD). <table><tr><th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr><tr><th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Apron Type</th></tr><tr><td>0.99</td><td>10.59</td><td>2.47</td><td>1.24</td><td>200</td><td>9.0</td><td>11.0</td><td>Riprap Apron</td></tr></table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type	0.99	10.59	2.47	1.24	200	9.0	11.0	Riprap Apron
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Apron Type																								
0.99	10.59	2.47	1.24	200	9.0	11.0	Riprap Apron																								
Conservation status:	None																														
Habitat connectivity:	Links fragmented vegetation to east and west. Supports standing water and aquatic vegetation.																														
Potential species:	Frogs, reptiles, small mammals if dry.																														
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																														
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																														
Furniture:	No																														

Station: 30600 ID:92	
Crossing type:	Twin bridges
Proposed size:	Twin bridge of length 41 metres to be installed over Pipers Creek.
Drawing reference (s):	OH2K-DDS-SB2103-005_[04], OH2K-DDS-SB2103-070_[03], OH2K-DDS-SB2103-071_[03]
Existing provisions:	N/A – new bridges
Fauna provision requirement:	Underbridge crossing.
Engineering considerations:	Designed to AS5100 Bridge Design. Design traffic loading consists of SM1600 and HLP400 design vehicles, with the HLP vehicle located centrally between the faces of the traffic barriers ($\pm 1.0\text{m}$). Skewed span arrangement is influenced by the location of the internal pier supports and has been selected to ensure the internal piers are located outside the assumed natural creek channel based upon the current available survey data.
Conservation status:	None
Habitat connectivity:	Riparian vegetation is continuous within riparian corridor to east and west.
Potential species:	Koala, spotted-tailed quoll, small medium and larger mammals, macropods, birds, reptiles, amphibians.
Dry crossing provisions:	Fauna passage under the new bridges comprises of a minimum 3 metre wide unhindered dry fauna passage along each bank of the creek. The crossing is located at a level to remain above the 1 in 2 year ARI flood level (RL 8.2m).
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

Station: 30600 ID:92 (west)	
Crossing type:	Existing bridge
Proposed size:	Existing Ravenswood Rd bridge over Pipers Creek over a length of 30 m.
Drawing reference (s):	OH2K-DDS-SB2104-005_[03], OH2K-DDS-SB2104-010_[02], OH2K-DDS-SB2104-011_[02]
Existing provisions:	Dry fauna passage and fish crossing provisions under existing bridge.
Fauna provision requirement:	As per existing.
Engineering considerations:	N/A
Conservation status:	None
Habitat connectivity:	Riparian Forest associated with Pipers Creek
Potential species:	Koala, spotted-tailed quoll, small medium and larger mammals, macropods, birds, reptiles, amphibians.
Dry crossing provisions:	There is insufficient level ground under the existing bridge to provide a 3 metre wide fauna access on the banks of the creek. Additionally, there is insufficient vertical clearance to provide fauna access above the 1 in 2 year ARI flood level. The existing (1.0 metres minimum) fauna access is proposed at a lower level beside each pier.
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

Station: 30600 ID:92 (east)	
Crossing type:	Bridge
Proposed size:	New service road bridge over Pipers Creek over a length of 41 m.
Drawing reference (s):	Only required under a Class M (Stage 4 arrangement).
Existing provisions:	N/A
Fauna provision requirement:	N/A
Engineering considerations:	N/A
Conservation status:	None
Habitat connectivity:	Riparian Forest associated with Pipers Creek
Potential species:	Koala, spotted-tailed quoll, small medium and larger mammals, macropods, birds, reptiles, amphibians.
Dry crossing provisions:	A 3000mm wide fauna access paths provided along each bank. The crossing is located at a level to remain above the observed normal high water mark.
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

Station: 31900	ID:96/C31.90																															
Crossing type:	Combined box culvert																															
Proposed size:	1 cell 3000 mm width, 2100 mm to be installed under main alignment over a length of 65.15 m.																															
Drawing reference (s):	OH2K-DDN-SC2104-002, OH2K-DDN-SC2104-003																															
Existing provisions:	N/A																															
Fauna provision requirement:	Combined fauna crossing.																															
Engineering considerations :	Type 4 arrangement (combined drainage / fauna crossing). The culvert consists of precast crown units on an in-situ reinforced concrete (RC) base slab cast on a 50 mm thick blinding layer. Cell height reduced due to fill height restrictions. Combined drainage/fauna culvert extended across local road and culvert C31.91 deleted. <table><tr><th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr><tr><th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Scour Protection Type</th></tr><tr><td>0.58</td><td>19.53</td><td>3.47</td><td>2.87</td><td>150</td><td>12.0</td><td>11.0</td><td>Type A Dissipator</td></tr></table>								Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type	0.58	19.53	3.47	2.87	150	12.0	11.0	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																														
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type																									
0.58	19.53	3.47	2.87	150	12.0	11.0	Type A Dissipator																									
Conservation status:	None																															
Habitat connectivity:	In regional corridor linking extensive areas of key habitat in Maria River and Ballengarra State Forests																															
Potential species:	Koala, macropods, small mammals, reptiles, amphibians.																															
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																															
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																															
Furniture:	No																															

Station: ID:97/C32.35 32350																									
Crossing type:	Combined box culvert																								
Proposed size:	1 cell 3000 mm width, 3000 mm height to be installed under main alignment over a length of 63.95 m.																								
Drawing reference (s):	OH2K-DDN-SC2104-102, OH2K-DDN-SC2104-103																								
Existing provisions:	N/A																								
Fauna provision requirement:	Combined fauna crossing.																								
Engineering considerations :	Type 4 arrangement (combined drainage / fauna crossing). Precast crown units on an in-situ reinforced concrete (RC) base slab cast on a 50 mm thick blinding layer. <table><tr><th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr><tr><th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Scour Protection Type</th></tr><tr><td>0.80</td><td>20.95</td><td>2.18</td><td>1.13</td><td>150</td><td>10.0</td><td>14.0</td><td>Rock Transition Apron</td></tr></table>	Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type	0.80	20.95	2.18	1.13	150	10.0	14.0	Rock Transition Apron
Headwater		Scour protection (50Yr ARI)																							
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type																		
0.80	20.95	2.18	1.13	150	10.0	14.0	Rock Transition Apron																		
Conservation status:	None																								
Habitat connectivity:	In regional corridor linking extensive areas of key habitat in Maria River and Ballengarra State Forests																								
Potential species:	Koala, macropods, small mammals, reptiles, amphibians.																								
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																								
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																								
Furniture:	No																								

Station:	ID:C32.66																														
32700																															
Crossing type:	Combined box culvert																														
Proposed size:	1 cell 3000 mm width, 2400 mm in height under main alignment over a length of 67.78 m.																														
Drawing reference (s):	OH2K-DDN-SC2104-202, OH2K-DDN-SC2104-203																														
Existing provisions:	N/A																														
Fauna provision requirement:	Combined fauna crossing.																														
Engineering considerations :	Type 4 arrangement (combined drainage / fauna crossing). Precast crown units on an in-situ reinforced concrete (RC) base slab cast on a 50 mm thick blinding layer. <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Scour Protection Type</th></tr> </thead> <tbody> <tr> <td>0.96</td><td>23.46</td><td>4.05</td><td>2.46</td><td>-</td><td>-</td><td>-</td><td>Rock pitched concrete slab between cuverts.</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type	0.96	23.46	4.05	2.46	-	-	-	Rock pitched concrete slab between cuverts.
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type																								
0.96	23.46	4.05	2.46	-	-	-	Rock pitched concrete slab between cuverts.																								
Conservation status:	None																														
Habitat connectivity:	In regional corridor linking extensive areas of key habitat in Maria River and Ballengarra State Forests																														
Potential species:	Koala, possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians.																														
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																														
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																														
Furniture:	Rails and refuge poles for Koalas.																														

Station:	ID:C32.67																														
32700																															
Crossing type:	Combined box culvert																														
Proposed size:	1 cell 3000 mm width, 2400 mm in height under local road over a length of 19.67 m.																														
Drawing reference (s):	OH2K-DDN-SC2104-402, OH2K-DDN-SC2104-403																														
Existing provisions:	N/A																														
Fauna provision requirement:	Combined fauna crossing.																														
Engineering considerations :	Type 4 arrangement (combined drainage / fauna crossing). Precast crown units on an in-situ reinforced concrete (RC) base slab cast on a 50 mm thick blinding layer. <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Scour Protection Type</th></tr> </thead> <tbody> <tr> <td>0.77</td><td>21.95</td><td>3.60</td><td>1.97</td><td>150</td><td>12.0</td><td>11.0</td><td>Type A Dissipator</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type	0.77	21.95	3.60	1.97	150	12.0	11.0	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type																								
0.77	21.95	3.60	1.97	150	12.0	11.0	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	In regional corridor linking extensive areas of key habitat in Maria River and Ballengarra State Forests																														
Potential species:	Koala, possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians.																														
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																														
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																														
Furniture:	Rails and refuge poles for Koalas.																														

Station:	ID:99/C33.10																														
33100																															
Crossing type:	Combined box culvert																														
Proposed size:	1 cell 3000 mm width, 3000 mm in height under main alignment over a length of 56.35 m.																														
Drawing reference (s):	OH2K-DDN-SC2104-502, OH2K-DDN-SC2104-503																														
Existing provisions:	N/A																														
Fauna provision requirement:	Combined fauna crossing.																														
Engineering considerations :	Type 4 arrangement (combined drainage / fauna crossing). Precast crown units on an in-situ reinforced concrete (RC) base slab cast on a 50 mm thick blinding layer. Height increased to allow for rock pitching on the base slab and maintain 3 metres height for fauna requirement. <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Scour Protection Type</th></tr> </thead> <tbody> <tr> <td>0.74</td><td>31.33</td><td>2.97</td><td>2.48</td><td>150</td><td>9.0</td><td>12.1</td><td>Type A Dissipator</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type	0.74	31.33	2.97	2.48	150	9.0	12.1	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type																								
0.74	31.33	2.97	2.48	150	9.0	12.1	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	In regional corridor linking extensive areas of key habitat in Maria River																														
Potential species:	Koala, possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog.																														
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																														
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																														
Furniture:	Rails and refuge poles for Koalas.																														

Station: 33400 ID:100F/F33.40	
Crossing type:	Dedicated fauna culvert
Proposed size:	1 cell 3000 mm width, 3000 mm in height under main alignment over a length of 49.19 m.
Drawing reference (s):	OH2K-DDN-SC2105-002, OH2K-DDN-SC2105-003
Existing provisions:	N/A
Fauna provision requirement:	Dedicated fauna crossing.
Engineering considerations:	Type 3 arrangement (dedicated fauna). Increased length due to raised vertical alignment resulting in longer batter slopes. Precast crown units on an in-situ reinforced concrete (RC) base slab cast. Culvert Inlet is above the 100Yr ARI HW of the adjacent culvert C33.30. Culvert Slope 0.61%.
Conservation status:	Maria River State Forest
Habitat connectivity:	Maria River State Forest
Potential species:	Koala, possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog.
Dry crossing provisions:	Permanent dry passage provided with one in 100 year flood immunity.
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.
Furniture:	Rails and refuge poles for Koalas.

Station: 34100	ID:102/C34.10																															
Crossing type:	Combined box culvert																															
Proposed size:	1 cell 3000 mm width, 3000 mm in height under main alignment over a length of 60.21 m.																															
Drawing reference (s):	OH2K-DDN-SC2105-102, OH2K-DDN-SC2105-103																															
Existing provisions:	N/A																															
Fauna provision requirement:	Combined fauna crossing.																															
Engineering considerations :	Type 4 arrangement (combined drainage / fauna crossing). Increased length due to raised vertical alignment resulting in longer batter slopes and changed culvert skewed angle. Precast crown units on an in-situ reinforced concrete (RC) base slab cast. <table><tr><th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr><tr><th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Scour Protection Type</th></tr><tr><td>1.03</td><td>44.03</td><td>4.70</td><td>2.91</td><td>150</td><td>12.0</td><td>11.0</td><td>Type A Dissipator</td></tr></table>								Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type	1.03	44.03	4.70	2.91	150	12.0	11.0	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																														
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type																									
1.03	44.03	4.70	2.91	150	12.0	11.0	Type A Dissipator																									
Conservation status:	None																															
Habitat connectivity:	Key regional corridor																															
Potential species:	Koala, possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog.																															
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																															
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.																															
Furniture:	Rails and refuge poles for Koalas.																															

Station: 34700 ID:103/F34.72	
Crossing type:	Dedicated fauna culvert
Proposed size:	1 cell 3000 mm width, 3000 mm in height under main alignment over a length of 47.92 m.
Drawing reference (s):	OH2K-DDN-SC2105-202, OH2K-DDN-SC2105-203
Existing provisions:	N/A
Fauna provision requirement:	Dedicated fauna crossing.
Engineering considerations:	Type 3 arrangement (dedicated fauna). Precast crown units on an in-situ reinforced concrete (RC) base slab cast. Culvert Inlet is above the 100Yr ARI HW of the adjacent culvert C34.70. Culvert Slope 2.29%.
Conservation status:	None
Habitat connectivity:	Moist Gully Forest Maria River National Park Key regional corridor
Potential species:	Koala, possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog.
Dry crossing provisions:	Permanent dry passage provided with one in 100 year flood immunity.
Fish crossing provisions:	None or very limited fish crossing would be available in the event of water flow.
Furniture:	Rails and refuge poles (koalas) Rocks, logs, hollow logs (frogs) Rocks, hollow logs (quolls)

Station: 34700	ID:C34.70																														
Crossing type:	Incidental box culvert																														
Proposed size:	3 cells 2100 mm width, 1500 mm in height under main alignment over a length of 62.70 m.																														
Drawing reference (s):	OH2K-DDN-SC2106-002, OH2K-DDN-SC2106-003																														
Existing provisions:	None																														
Fauna provision requirement:	Downgraded from combined to incidental culvert due to proximity to F34.72.																														
Engineering considerations :	Type 2 arrangement (Drainage/fish crossing) Precast crown units on an in-situ reinforced concrete (RC) base slab cast. This culvert will receive approximately 1.68 bypass flow from culvert C34.80, total flow 30.36. Both C34.70 and C 34.80 discharge to same water course downstream. <table><tr><th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr><tr><th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Scour Protection Type</th></tr><tr><td>2.53</td><td>32.73</td><td>2.99</td><td>0.85</td><td>300</td><td>8.4</td><td>11.9</td><td>Type A Dissipator</td></tr></table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type	2.53	32.73	2.99	0.85	300	8.4	11.9	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type																								
2.53	32.73	2.99	0.85	300	8.4	11.9	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	In regional corridor linking extensive areas of key habitat in Maria River																														
Potential species:	Frogs, reptiles, small mammals if dry.																														
Dry crossing provisions:	No dedicated dry passage - dry passage only available for terrestrial fauna during dry periods.																														
Fish crossing provisions:	Class 2 fish passage provided in low flow channel. Concrete sills provided to decrease velocity for fish passage.																														
Furniture:	No																														

Station:	ID:106/C35.70 35700																														
Crossing type:	Combined box culvert																														
Proposed size:	1 cell 3000 mm width, 3000 mm in height under main alignment over a length of 50.40 m.																														
Drawing reference (s):	OH2K-DDN-SC2105-302, OH2K-DDN-SC2105-303																														
Existing provisions:	N/A																														
Fauna provision requirement:	Combined fauna crossing.																														
Engineering considerations :	Type 1 arrangement (combined drainage/fauna/ fish culvert). Precast crown units on an in-situ reinforced concrete (RC) base slab cast. <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Scour Protection Type</th></tr> </thead> <tbody> <tr> <td>1.32</td><td>34.57</td><td>2.90</td><td>1.19</td><td>200</td><td>12.0</td><td>11.0</td><td>Type A Dissipator</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type	1.32	34.57	2.90	1.19	200	12.0	11.0	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type																								
1.32	34.57	2.90	1.19	200	12.0	11.0	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	Moist Gully Forest Maria River National Park Key regional corridor																														
Potential species:	Koala, possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog.																														
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																														
Fish crossing provisions:	Class 3 fish passage provided in low flow channel.																														
Furniture:	Rails and refuge poles (koalas)																														

Station:	ID:109/C36.40																														
36400																															
Crossing type:	Combined box culvert																														
Proposed size:	1 cell 3000 mm width, 3000 mm in height under main alignment over a length of 66.41 m.																														
Drawing reference (s):	OH2K-DDN-SC2105-402, OH2K-DDN-SC2105-403																														
Existing provisions:	N/A																														
Fauna provision requirement:	Combined fauna crossing.																														
Engineering considerations :	Type 1 arrangement (combined drainage/fauna/ fish culvert). Increased length due to raised vertical alignment resulting in longer batter slopes. Culvert has been straightened to reduce length as much as possible. <table border="1"> <thead> <tr> <th colspan="2">Headwater</th><th colspan="6">Scour protection (50Yr ARI)</th></tr> <tr> <th>H (m)</th><th>Level (mAHD)</th><th>V (m/s)</th><th>Froude Number</th><th>Rock Size (mm)</th><th>Apron Length (m)</th><th>Apron Width (m)</th><th>Scour Protection Type</th></tr> </thead> <tbody> <tr> <td>-11.25</td><td>14.75</td><td>3.36</td><td>1.20</td><td>300</td><td>12.0</td><td>11.0</td><td>Type A Dissipator</td></tr> </tbody> </table>							Headwater		Scour protection (50Yr ARI)						H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type	-11.25	14.75	3.36	1.20	300	12.0	11.0	Type A Dissipator
Headwater		Scour protection (50Yr ARI)																													
H (m)	Level (mAHD)	V (m/s)	Froude Number	Rock Size (mm)	Apron Length (m)	Apron Width (m)	Scour Protection Type																								
-11.25	14.75	3.36	1.20	300	12.0	11.0	Type A Dissipator																								
Conservation status:	None																														
Habitat connectivity:	Moist Gully Forest Adjacent to key regional corridor Maria River National Park Continuous vegetation to east and west of alignment																														
Potential species:	Koala, possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog.																														
Dry crossing provisions:	An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event. Further increases to the height of the fauna up-stand would result in corresponding decreases in overall height between the roof of the culvert and the surface of the fauna up-stand.																														
Fish crossing provisions:	Class 3 fish passage via low flow channel.																														
Furniture:	Rails and refuge poles (koalas)																														

Station: 36900 ID: N/A	
Crossing type:	Bridge – existing northbound bridge over Maria River
Proposed size:	Existing
Drawing reference (s):	N/A
Existing provisions:	Existing bridge over Maria River
Fauna provision requirement:	Existing provisions.
Engineering considerations:	The existing bridge is to be retained. Current connectivity provisions will be maintained.
Conservation status:	None
Habitat connectivity:	In regional corridor linking Maria River State Forest and Kalateenee State Forest.
Potential species:	Koala, spotted-tailed quoll, macropods, small to medium mammals, reptiles, amphibians (such as Giant Barred Frog).
Dry crossing provisions:	Current dry passage connectivity provisions will be maintained.
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

Station: 36900 ID: N/A	
Crossing type:	Bridge – existing southbound bridge over Maria River
Proposed size:	Existing
Drawing reference (s):	N/A
Existing provisions:	Existing bridge over Maria River
Fauna provision requirement:	Existing provisions.
Engineering considerations:	The existing bridge is to be retained. Current connectivity provisions will be maintained.
Conservation status:	None
Habitat connectivity:	In regional corridor linking Maria River State Forest and Kalateenee State Forest.
Potential species:	Koala, spotted-tailed quoll, macropods, small to medium mammals, reptiles, amphibians (such as Giant Barred Frog).
Dry crossing provisions:	Current dry passage connectivity provisions will be maintained.
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

Station: 37790 ID: N/A	
Crossing type:	Bridge - Northbound Bridge over Stumpy Creek
Proposed size:	New bridge with a length of 36 m.
Drawing reference (s):	OH2K-DDN-SB2101-005_[04], OH2K-DDN-SB2101-067_[04], OH2K-DDN-SB2101-068_[04]
Existing provisions:	Existing twin bridges over Stumpy Creek.
Fauna provision requirement:	Under bridge crossing - 3 metre wide unhindered fauna passage along each bank of the creek
Engineering considerations:	Provision of a raised benched fauna passage above 2 year flood level across the project corridor would require modification to the existing bridge abutment details. A fauna bench would also reduce waterway cross section increasing flood levels upstream.
Conservation status:	None
Habitat connectivity:	In regional corridor linking fragmented habitat to west and extensive areas of key habitat in Maria River to east
Potential species:	Koala, spotted-tailed quoll, macropods, small to medium mammals, reptiles, amphibians possibly Green-thighed frog.
Dry crossing provisions:	Dry passage will be available for terrestrial fauna. A 3 metre wide unhindered fauna passage along each bank of the creek is provided.
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

Station: 37790 ID: N/A	
Crossing type:	Bridge – existing Southbound Bridge over Stumpy Creek
Proposed size:	Existing
Drawing reference (s):	OH2K-DDN-SB2103-005_[03]
Existing provisions:	Existing bridges over Stumpy Creek.
Fauna provision requirement:	Existing provisions.
Engineering considerations:	The existing bridge is to be retained. Current connectivity provisions will be maintained.
Conservation status:	None
Habitat connectivity:	In regional corridor linking fragmented habitat to west and extensive areas of key habitat in Maria River to east
Potential species:	Koala, spotted-tailed quoll, macropods, small to medium mammals, reptiles, amphibians possibly Green-thighed frog.
Dry crossing provisions:	Current dry passage connectivity provisions will be maintained.
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

Station: 37790 ID: N/A	
Crossing type:	Bridge – existing service road over Stumpy Creek
Proposed size:	Existing
Drawing reference (s):	OH2K-DDN-SB2108-005_[02], OH2K-DDN-SB2108-010_[01]
Existing provisions:	Existing service road over Stumpy Creek.
Fauna provision requirement:	Existing provisions.
Engineering considerations:	The existing bridge is to be retained. Current connectivity provisions will be maintained.
Conservation status:	None
Habitat connectivity:	In regional corridor linking fragmented habitat to west and extensive areas of key habitat in Maria River to east
Potential species:	Koala, spotted-tailed quoll, macropods, small to medium mammals, reptiles, amphibians possibly Green-thighed frog.
Dry crossing provisions:	Current dry passage connectivity provisions will be maintained.
Fish crossing provisions:	Class 2 fish passage under bridge.
Furniture:	No

APPENDIX A2

REVISED TABLE 6.2

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
-	C24.42	24420	Incidental	2	1.05	-	-	22	(Frogs, reptiles, small to medium mammals if dry)	Regional corridor linking key habitat to east and west, continuous with climate change corridor to east	No issue	N/A	No	No	No	Class M
74	C24.43	24430	Incidental	1	3	1.8	45.6	48	(Frogs, reptiles, small to medium mammals if dry)	Regional corridor linking key habitat to east and west, continuous with climate change corridor to east	Slight increase in length.	Increase in length is due to raised vertical alignment resulting in longer batter slopes. No further opportunity to reduce the length as the culvert is required at this location for drainage. Culvert was relocated 11 meters south where batter slopes are shorter in order to minimise culvert length for fauna movements and provide greater hydraulic function.	No. Insufficient culvert height to accommodati on furniture.	No. Proposed to monitor culvert 73, located 500m to the south.	No	DDS
75	C24.70	24700	Incidental	1	3	2.4	62.4	82	(Frogs and reptiles, small to medium mammals if dry)	Regional corridor linking key habitat in Ballengarra State Forest	Increase in length	Increase in length due to raised vertical alignment resulting in longer batter slopes. Change in length/alignment is due changes in design of southbound entry ramp from rest area. No further opportunity to reduce the length as the culvert is required at this location for drainage.	No	No	No	DDS

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
-	C24.71	24650	Incidental	2	1.2	-	-	27	(Frogs and reptiles, small to medium mammals if dry)	Regional corridor linking key habitat in Ballengarra State Forest	New culvert.	Required for drainage, but dimensions allow for use as incidental culvert.	No	No	No	Class M
76	C25.10	25100	Incidental	1	1.5	-	30	71	(Frogs and reptiles, small to medium mammals if dry)	Regional corridor linking key habitat in Ballengarra State Forest	Increased length	Increase in length due to raised vertical alignment resulting in longer batter slopes. Change in length/alignment is due changes in design of northbound entry ramp to rest area. No further opportunity to reduce the length as the culvert is required at this location for drainage.	No	No	No	DDS
-	C25.30	25300	Incidental	5	3	2.4	-	51	(Frogs and reptiles, small to medium mammals if dry)	Regional corridor linking key habitat in Ballengarra State Forest	New culvert.	Revised access arrangement for Mingaletta Road. Required for drainage in M Class design, but dimensions potentially allow for use as combined culvert.	No	No	No	Class M

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
-	C25.38	25380	Incidental	2	1.2	-	-	41.5	(Frogs and reptiles, small to medium mammals if dry)	Regional corridor linking key habitat in Ballengarra State Forest	New culverts	Required due to design changes to local road for Class M. Required for drainage but dimensions potentially allow for use as incidental culvert.	No	No	No	Class M
78	C25.42	25420	Incidental	1	3	1.5	45.6	47	(Frogs and reptiles, small to medium mammals if dry)	Links fragmented native vegetation to east and west	Increased length	Length extended slightly due to changes in road design. Length remains optimal for fauna passage at <50 metres.	No	No	No	DDS
-	C25.44	25440	Incidental	5	3	2.4	-	19.5	(Frogs, reptiles, small mammals if dry)	Links fragmented native vegetation to east and west	New culvert	Required due to design changes to local road. Required for drainage but dimensions potentially allow for use as incidental culvert.	No	No	Yes Class 2 Concrete sills included	DDS

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
80	C25.70	25700	Combined	1	3	2.7	44	47	(Frogs, reptiles, small mammals if dry)	Riparian forest, vegetative connectivity to vegetation at C25.74.	Slight increase in length	Length has slightly increased due to increased batter width, but is still <50m, providing optimal fauna line of sight. Width has been changed to 2.7 metres. The original table 6.2 stated a height of 2.4 metres, with a note stating opportunities to increase to 2.7 metres would be sought at detailed design. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	No	No. Dedicated culvert 83F is located 750m to north.	No	DDS
80	C25.68	25680	Incidental	2	1.8	-	45	52	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles and amphibians)	Links fragmented native vegetation to east and west	To be replaced rather than extended	Existing culverts at drainage line will be replaced for drainage in order to provide greater dry fauna passage through combined box culvert C25.70. Fish passage has been provided by lowering both pipes below ground level, creating a low flow channel.	No	No	No	DDS

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
-	C25.74	25740	Incidental	1	1.5	-	-	39	(possums, spotted-tailed quoll, macropods, small mammals, reptiles and amphibians)	Links fragmented native vegetation to east and west	New culvert	Extension of existing culvert under local road. Required for drainage in Class M, but dimensions potentially allow for use as incidental culvert.	No	No	No	Class M
81	C25.85	25850	Incidental	2	0.9	-	44	44	(Frogs, reptiles, small mammals if dry)	Moist gully forest, vegetative connectivity to vegetation at C25.70.	This has been downgraded from a combined culvert to drainage only (incidental culvert).	Fauna passage possible through C25.70 (120m to south). Culvert will be set to the existing bed level for low flow fish passage. Skew angle reduced to minimise length as much as possible.	No	No. Incidental fauna crossing.	No	DDS
83X	C26.38	26380	Incidental	1	1.5	-	81.2	60	(Frogs, reptiles, small mammals if dry)	Links fragmented native vegetation to east and west	Decreased length	Culvert length reduced due to changes to road design. The original design has the culvert extended under the Class M service road. As this service road is not being constructed until Stage 4, the culvert will be constructed at a reduced length during Stage 2.	No	No	Yes Class 3	DDS

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
83F	F26.40	26400	Dedicated	1	3	3	40.8	49.17	Koala (macropods , spotted-tailed quoll, small mammals, reptiles, amphibians)	Links fragmented native vegetation to east and west	Increased length	Culvert moved 15 metres to the north to provide one in 100 year flood immunity. Increased length is due to the lowering of the culvert and embankment widening during detailed design. However, length has been kept at <50 metres to provide optimal fauna line of sight. Inlet has also been lowered to improve line of sight for fauna through culvert.	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)	Yes. Dedicated fauna crossing.	No	DDS
-	C26.80	26800	Incidental	1	1.2	-	-	30	(spotted-tailed quoll, small mammals, reptiles, amphibians)	Links fragmented native vegetation to east and west	New culvert	Required for Class M Concept Design. Required for drainage in Class M, but dimensions potentially allow for use as incidental culvert.	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)	Yes. Dedicated fauna crossing.	No	Class M

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
84	C26.78	26780	Combined	1	3	3	45.6	49	Koala (macropods , spotted-tailed quoll, small mammals, reptiles, amphibians)	Limited connectivity to west	Increased length	Culvert length increased due to changes in road geometry. Fish passage provided as well as fauna furniture. 100year flood immunity provided, allowing for 50% blockage due to fauna furniture. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	Rails and refuge poles (koalas)	No. Dedicated culvert 83F is located 300m to the south.	Yes Class 2 Concrete sills included	DDS
-	C27.50	27500	Combined	1	3	3	-	37	Koala (macropods , spotted-tailed quoll, small mammals, reptiles, amphibians)	Sub-regional corridor linking extensive areas of key habitat within state forests to east and west.	New combined culvert	Required for Class M Concept Design. Required for drainage in Class M, but dimensions potentially allow for use as combined culvert.	Rails and refuge poles (koalas)	No. Culvert is located in sub-regional corridor. No vegetation has been retained on eastern side of alignment	No	Class M

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
86	C27.51	27510	Combined	1	3	3	43.2	45.5	Koala (macropods , spotted-tailed quoll, small mammals, reptiles, amphibians)	Sub-regional corridor linking extensive areas of key habitat within state forests to east and west.	Slight increase in length.	Slight increase in length due to raised vertical alignment resulting in longer batter slopes. Length remains <50 metres to provide optimal fauna line of sight through the culvert. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	Rails and refuge poles (koalas)	No. Culvert is located in sub-regional corridor. No vegetation has been retained on eastern side of alignment	Yes Class 3	DDS
88	-	28250	Twin bridges-Smiths Creek	-	-	-	Overall length: 35	Overall length: 55	(Koala, macropods, spotted-tailed quoll, small to medium mammals, reptiles, amphibians)	On edge of sub-regional corridor, riparian vegetation continuous within riparian corridor to east and west	Increased length. Change from 3 spans to 4 spans.	At least 3m unhindered fauna passage on both banks. Increased bridge length in order to reduce flood velocities and flood levels. Increased length provides greater opportunity for fauna connectivity and movement along creek embankments.	No	No. Successful fauna passage under bridges has been demonstrated on other projects.	Yes Class 2	DDS

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
88 (west)	-	28250	Bridge-Smiths Creek service road	-	-	-	Overall length: 35	Overall length: 35	(Koala, macropods, spotted-tailed quoll, small to medium mammals, reptiles, amphibians)	Adjacent to sub regional corridor	Existing bridge to be demolished	A new bridge would be required as part of the Class M, and would be designed during Stage 4 of the Project.	No	No.	Yes Class 2	Class M
89	C28.68	28680	Combined	3	2.4	2.4	50	48	(Koala, macropods, small mammals, reptiles, amphibians)	Links fragmented vegetation to east and west	Reduced length	Extension of existing culvert. Culvert length reduced to match standard culvert unit lengths. Length has been reduced to <50 metres to provide optimal fauna line of sight through the culvert.	No	No. Culvert is located in fragmented landscape, little vegetation has been retained in this area	Yes Class 2	DDS
-	C28.67	28700	Incidental	1	2.4	24	-	24	(small to mammals, reptiles, amphibians)	Links fragmented vegetation to east and west	New culvert	Required for Class M Concept Design. Required for drainage in Class M, but dimensions potentially allow for use as incidental culvert.	No	No	No	Class M
90	C29.60	29600	Incidental	4	1.5	1.5	21.6	82	(Frogs, reptiles, small mammals if dry)	Limited connectivity: small fragments of vegetation, large cleared areas	Increased length	Extension of existing culverts. Culvert length changed to match road design due to changes with layout at Kundabung Interchange. No further opportunity to reduce the length as the culvert is required at this location for drainage. The dimensions of the combined culvert located 500 metres to the north have been improved to provide better fauna movement opportunities.	No	No	Yes Class 3	DDS

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
91	C30.10	30100	Combined	1	3	3	45.6	49	(Frogs, reptiles, small mammals if dry)	Links fragmented vegetation to east and west Supports standing water and aquatic vegetation	Increase length, increased height	Culvert length changed to match road design but is still <50 metres, to provide optimal fauna line of sight through the culvert. The height of the culvert has also been increased from 2.7 metres to 3.0 metres to provide greater line of sight and opportunities for fauna passage. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	No	No. Culvert is located in fragmented landscape, little vegetation has been retained in this area	No	DDS
92	-	30600	Twin bridges- Pipers Creek	-	-	-	Overall length: 41	Overall length: 44.7	(Koala, spotted-tailed quoll, small medium and larger mammals, macropods, birds, reptiles, amphibians)	Riparian vegetation is continuous within riparian corridor to east and west Creek flowing at site visit 7/9/12	Increased length, sensitive habitat	At least 3m unhindered fauna passage on both banks. Increased length to avoid placing of piles in creek. Relocated 50 metres east to avoid sensitive Giant-Barred Frog habitat.	No	No. Successful fauna passage under bridges has been demonstrated on other projects.	Yes Class 2	DDS

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
92 (west)	-	30600	Existing Bridge-Pipers Creek service road	-	-	-	Overall length:30	Overall length:30	(Koala, spotted-tailed quoll, small medium and larger mammals, macropods, birds, reptiles, amphibians)	Riparian Forest associated with Pipers Creek	No issue	Shift in alignment of twin bridges allows retention of existing bridge as service road. Existing fauna movement provisions will be retained.	No	No. Successful fauna passage under bridges has been demonstrated on other projects.	Yes Class 2	DDS
92 (east)	-	30600	Bridge-Pipers Creek access road	-	-	-	Overall length: 41	Overall length: 41	(Koala, spotted-tailed quoll, small medium and larger mammals, macropods, birds, reptiles, amphibians)	Riparian Forest associated with Pipers Creek	No issue	A new bridge would be required as part of the Class M, and would be designed during Stage 4 of the Project.	No	No. Successful fauna passage under bridges has been demonstrated on other projects.	Yes Class 2	Class M

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
96	C31.90	31900	Combined	1	3	2.1	45.6	65	Koala (macropods , small mammals, reptiles, amphibians)	In regional corridor linking extensive areas of key habitat in Maria River and Ballengarra State Forests	Increased length, reduced height, and relocated 13 metres north.	The culvert length has increased and the grade has changed due to development of the road alignment and extension under service road. Cell height had to be reduced due to fill height restrictions. No further opportunity to reduce the length as the culvert is required at this location for drainage. Culvert location has shifted to allow the use of existing drainage lines during construction. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	No	No Located in regional corridor, however, surrounding landscape is modified by farm land and roads. Fragmented connectivity of vegetation adjoining culverts with larger patches of vegetation to east and west.	No	DDN

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
97	C32.35	32350	Combined	1	3	3	43.2	64	Koala (macropods , small mammals, reptiles, amphibians)	In regional corridor linking extensive areas of key habitat in Maria River and Ballengarra State Forests	Increased length, relocated 7 metres south	Increase in length is due to raised vertical alignment resulting in longer batter slopes. Culvert length also changed to match culvert unit lengths. Gap for light included. The culvert has shifted approximately 5 metres to the north to allow construction off the existing drainage lines. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	No	Yes. Use to measure successful crossing rates in this long culvert (66m) Located in regional corridor, however, surrounding landscape is modified by farm land and roads. Fragmented connectivity of vegetation adjoining culverts with larger patches of vegetation to east and west.	No	DDN

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
98	C32.66	32700	Combined	1	3	2.4	40.8	66	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians)	In regional corridor linking extensive areas of key habitat in Maria River and Ballengarra State Forests Relatively dry passage at site inspection (7/9/12)	Increased length, reduced height, and relocated 38 metres north.	Increased length is due to raised vertical alignment resulting in longer batter slopes and culvert continues under local service road. Culvert length also changed to match culvert road design. The culvert location has shifted to the north to allow use of existing drainage lines during construction. The cell height has been reduced from 3000 to 2400 to match the original height of C32.65. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	Rails and refuge poles (koalas)	No. Dedicated fauna culvert 100F is located 700m to north Located in regional corridor, however, surround landscape is modified by farm land and roads. Fragmented connectivity of vegetation adjoining culverts with larger patches of vegetation to east and west.	No	DDN
-	32.67	32700	Combined	1	3	2.4	-	21	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians)	In regional corridor linking extensive areas of key habitat in Maria River and Ballengarra State Forests	New combined culvert	Provides access under local road as a continuation of C33.66. A table drain was added in between this culvert and C32.66. A single apron with stone pitching is used to connect this culvert with C32.66, as well as providing safer access for the median drain.	Rails and refuge poles (koalas)	No. Dedicated fauna culvert 100F is located 700m to north	No	DDN

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
99	C33.10	33100	Combined	1	3	3	45.6	57	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog)	In regional corridor linking extensive areas of key habitat in Maria River	Increased length, increased height, relocated 3 metres south	Increased length due to raised vertical alignment resulting in longer batter slopes. Culvert skew angle changed. The cell height was increased to 3300. This allowed the base slab to be dropped to incorporate 250 millimetre recessed rocks while maintaining the cell height of 3000. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	Rails and refuge poles (koalas)	No. Dedicated fauna culvert 100F is located 300m to north	No	DDN
100F	F33.40	33400	Dedicated	1	3	3	43.2	49	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog)	Maria River State Forest	Increased length, relocated 10 metres north	Increased length due to raised vertical alignment resulting in longer batter slopes. Culvert length also changed to match structural design. 100 year flood immunity provided.	Rails and refuge poles (koalas)	Yes. Dedicated fauna crossing.	No	DDN

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
102	C34.10	34100	Combined	1	3	3	48	60	Koala (spotted-tailed quoll, possums, small-medium macropods, small mammals, reptiles, amphibians possibly Green-thighed frog)	Key regional corridor	Increased length	Increased length due to raised vertical alignment resulting in longer batter slopes and changed culvert skewed angle. Culvert skewed angle adjusted to reduce length as much as possible. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	Rails and refuge poles (koalas)	No. Dedicated fauna culvert 103 is located 600m to north in the same regional corridor.	No	DDN
103	F34.72	34700	Dedicated	1	3	3	45.6	48	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog)	Moist Gully Forest Maria River National Park Key regional corridor	Increased length	Slight increase in length, but remains <50 metres to provide optimal line of sight for fauna through the culvert. 1 in 100 year flood immunity provided by separate culverts C34.70 and C34.80.	Rails and refuge poles (koalas) Rocks, logs, hollow logs (frogs) Rocks, hollow logs (quolls)	No. Fauna may attempt passage through adjoining drainage culvert. Monitoring C34.72 will not capture those animals	No	DDN
-	C34.70	34700	Incidental	3	2.1	1.5	-	63	(Frogs, reptiles, small mammals if dry)	In regional corridor linking extensive areas of key habitat in Maria River	New culvert	Designed for drainage to ensure dry fauna passage at F34.72, but also provides incidental fauna passage opportunity.	No	No	Yes Class 2 Concrete sills included	DDN

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
106	C35.70	35700	Combined	1	3	3	40.8	50	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog)	Moist Gully Forest Maria River National Park Key regional corridor	Increased length	Increased length due to raised vertical alignment resulting in longer batter slopes. Culvert has been straightened to reduce length as much as possible. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	Rails and refuge poles (koalas)	No. Dedicated fauna culvert 103 is located 1km to south in the same regional corridor.	Yes Class 3	DDN

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
109	C36.40	36400	Combined	1	3	3	57.6	66	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog and giant barred frog)	Moist Gully Forest Adjacent to key regional corridor Maria River National Park Continuous vegetation to east and west of alignment	Increased length	Increased length due to raised vertical alignment resulting in longer batter slopes. Culvert has been straightened to reduce length as much as possible and align with downstream channel. An up-stand 1200 millimetres wide and 100 millimetres high will be provided which allows dry fauna passage for the majority of the year during a 72 hour storm event. The up-stand would be temporarily inundated during a one in one year peak flow event.	Rails and refuge poles (koalas)	Yes. Located in expanse of vegetation continuous with Maria River State Forest, Kumbatine National Park and regional corridor.	Yes Class 3	DDN

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
-	-	37730-37790	North bound bridge over Stumpy Creek	-	-	-	Overall length: 36	Overall length: 36	(Koala, spotted-tailed quoll, macropods, small to medium mammals, reptiles, amphibians possibly Green-thighed frog)	In regional corridor linking fragmented habitat to west and extensive areas of key habitat in Maria River to east	No issue	Dedicated fauna passage cannot be provided in the form of a bench set above the 1 in 2 year ARI flood level as this would require modification to the existing bridge abutment. Slopes both upstream and downstream. A fauna bench would also reduce the cross section of the waterway, increasing flood levels upstream (afflux). The creek is predominately dry at this location and adequate fauna passage width is provided outside the limits of the creek channel and within the scour protection along dedicated routes.	No	No	Yes Class 3	DDN
		37730-37790	South bound bridge over Stumpy Creek	-	-	-	Overall length: 31	Overall length: 31	(Koala, spotted-tailed quoll, macropods, small to medium mammals, reptiles, amphibians possibly Green-thighed frog)	In regional corridor linking fragmented habitat to west and extensive areas of key habitat in Maria River to east	No issue	The existing bridge is to be retained. Current connectivity provisions will be maintained without modification to existing abutment slopes.	No	No	Yes Class 3	DDN

Culvert I.D. (GHD)	Culvert I.D. (SHJV)	Stn.	Crossing type	Cells	Diameter (m)	Height (m)	Length (m) (OEH approved)	Revised length (m) (SHJV)	Target species (other species that may use crossing)	Habitat	Issue	Resolution/Comment	Fauna furniture	Potential monitoring location?	Fish Passage (J. Sakker pers. comm)	Stage
		37730-37790	Service Rd bridge over Stumpy Creek (existing)	-	-	-	Overall length: 27	Overall length: 27	(Koala, spotted-tailed quoll, macropods, small to medium mammals, reptiles, amphibians possibly Green-thighed frog)	In regional corridor linking fragmented habitat to west and extensive areas of key habitat in Maria River to east	No issue	The existing bridge is to be retained. Current connectivity provisions will be maintained.	No	No	Yes Class 3	DDN

APPENDIX B

CONSULTATION WITH EPA AND NSW DPI

DARLINGTON Aleesha K

From: Robert Donohoe [Robert.Donohoe@epa.nsw.gov.au]
Sent: Wednesday, 3 July 2013 4:14 PM
To: DARLINGTON Aleesha K
Cc: Craig Harre; LAWRENCE Scott B
Subject: RE: Oxley Highway to Kempsey documents

Hi Aleesha,

Have reviewed the amended K2K Connectivity Report (Table 6.2), taking particular note of the agency consultation detailed at Appendix B and can confirm that the EPA has no further comments in regard the K2K Connectivity Report.

I'll get back to you tomorrow morning on the below fauna/nest box management plans and also confirm our position on the OH2Ku RMS responses to avoid any further delay on your submission of this document to Planning

If you have any concerns please don't hesitate to contact me to discuss.

Regards

Rob

Robert Donohoe
Coordinator - Pacific Highway Team
NSW Environment Protection Authority
Ph: (02) 6640 2518 | Fax: (02) 6640 2539
[REDACTED]
Email: Robert.Donohoe@epa.nsw.gov.au

Page 1 of 2

DARLINGTON Aleesha K

From: james.sakker@dpi.nsw.gov.au
Sent: Monday, 15 April 2013 2:34 PM
To: jdeath@manidiroberts.com.au
Cc: DARLINGTON Aleesha K; Craig Harre; Kate Wiggins; DALLEY Steve; marcus.riches@dpi.nsw.gov.au
Subject: Re: Detailed Fauna Connectivity Report - K2K

Hi Jesse

Thanks for supplying the report for comment.
I would just like this paragraph amended to show that both Class 2 & 3 waterways should have these requirements and where these requirements (particularly grade) cannot be met that measures such as sills be installed in consultation with NSW DPI Fisheries. Below is the original paragraph and then I have included my suggested revised paragraph in section 3.6. A general comment is that sills are to overcome grade issues in culverts as well as velocity in table 12.
One final point, the bridge designs at Smiths Creek and Pipers Creek appear to have some conflict as to whether the bridge piles are in the creek (in normal flow) or not as one part of the drawing shows them not in the creek and another part shows them in the creek. Obviously our stated preference is for bridge piles not be located in the normal flow section of the channel. Can you please clarify this.

In addition, the following requirements have been specified by DPI (Fisheries) (J. Sakker pers. comm) for Class 3 waterways:

- ✍ Flow less than 0.5m/s.
- ✍ Invert has no head loss.
- ✍ Grade to be less than one per cent.
- ✍ Culverts will be provided with dissipater pool at the downstream outlet.

In addition, the following requirements have been specified by DPI (Fisheries) (J. Sakker pers. comm) for Class 2 & 3 waterways:

- ✍ Low flow less than 0.5m/s and preferably less than 0.3m/s.
- ✍ Invert has no head loss. To ensure fish passage there should be no chutes or waterfalls at either end of the culvert and any scour protection should provide a channel for fish passage.
- ✍ Grade to be less than one per cent and where grades are steeper for notched sills to be installed at a suitable spacing to provide a continuous series of pools through the culvert. The sills to be designed and installed in consultation with NSW DPI Fisheries
- ✍ Culverts will be provided with dissipater pool at the downstream outlet.

I think this makes it a little bit clearer. Often these details will come out at the 85% design stage and i'm happy to work with the design team to get the best outcome.
regards James

James Sakker Conservation Manager (Pacific Highway Upgrade) Department of Primary Industries NSW (NSW DPI) 1243 Bruxner Highway Wollongbar NSW 2477
[REDACTED]
james.sakker@industry.nsw.gov.au

DARLINGTON Aleesha K

From: james.sakker@dpi.nsw.gov.au
Sent: Wednesday, 27 February 2013 5:11 PM
To: Jesse Death
Cc: DARLINGTON Aleesha K; COOK Andrew; Craig Harre; DALLEY Steve
Subject: Re: Kundabung to Kempsey - Fish passage design detail

Thanks Jesse
 That is acceptable to NSW DPI.
 regard james

James Sakker Conservation Manager (Pacific Highway Upgrade) Department of Primary Industries NSW (NSW DPI) 1243 Bruxner Highway Wollongbar NSW 2477

james.sakker@industry.nsw.gov.au

-----Jesse Death <jdeath@manidisroberts.com.au> wrote: -----

To: "james.sakker@dpi.nsw.gov.au" <james.sakker@dpi.nsw.gov.au>
 From: Jesse Death <jdeath@manidisroberts.com.au>
 Date: 02/27/2013 04:38PM
 Cc: Aleesha Darlington <Aleesha.Darlington@rms.nsw.gov.au>, Andrew Cook <Andrew.COOK@rms.nsw.gov.au>, Craig Harre <Craig.Harre@epa.nsw.gov.au>, Steve Dalley <Steve.Dalley@rms.nsw.gov.au>
 Subject: Re: Kundabung to Kempsey - Fish passage design detail

Hi James,

Thanks for the feedback below. As per our discussion today could you please confirm (via email is fine) your acceptance of the following with regard to RMS's approach to fish passage design in relation to velocities:

- No sills in pipe culverts given various engineering, constructability and OHS constraints.
- No sills in culverts that are to be extended (and thereby required to meet the design / grade / velocity of the existing structures).
- Where low flow channels exist in new (not extended) culverts proposed at class 3 waterway locations a rock check design at alternate five metre intervals is agreed as reasonable and feasible.
- Where low flow channels exist in new (not extended) culverts proposed at class 2 waterway locations sills would be included. Indicatively (subject to detail of the design), the sills would be 200mm high and would be 'notched' on alternate sides. Sills would be spaced within the culvert based on culvert grade such that there is no dry areas between the sills (ie a pool is formed between the sills and the pool is deeper at the 'outlet' end than the 'inlet' end).

In a review of the design the above approach means that of the nine instances in the K2K section where culverts are proposed at fish passage locations, sills would be constructed at three of them. The three locations are all class 2 waterways and the subject culverts are C25.44, C26.78 and C34.70.

Regards

Jesse Death
 Senior Executive – Environment
 Manidis Roberts

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From: <james.sakker@dpi.nsw.gov.au>
Date: Tue, 26 Feb 2013 10:16:25 +1100
To: Manidis Roberts <jdeath@manidisroberts.com.au>
Cc: Aleesha Darlington <Aleesha.Darlington@rms.nsw.gov.au>, Andrew Cook <Andrew.COOK@rms.nsw.gov.au>
Subject: Re: FW: Kundabung to Kempsey - Fish passage design detail

Hi Jesse

My apologies for not responding earlier. As can be seen from the table provided culvert velocities are too high to provide fish passage.

My suggestion is to explore the feasibility of installing sills throughout the low flow (fish passage) culverts at appropriate spacings to provide permanent pools through the culverts, and to break up the velocity into appropriate short lengths to provide some fish passage.

Although not optimal this solution has been applied at Cutty Creek on the Herons Creek upgrade and also at 2 locations on the Coopemook to Herons Creek upgrade where the velocities and grades are similar to those described in Andrews email.

I've attached a photo to give you an idea of what I mean. The spacings of the sills are according to the grade of the culvert ie steeper grade means more closer spaced sills. The sills are notched to allow for low flow and to enable fish to make short burst speed climbs into the next pool.

I can provide more detail of treatment that have been previously conducted.

regards james

James Sakker Conservation Manager (Pacific Highway Upgrade) Department of Primary Industries NSW (NSW DPI) 1243 Bruxner Highway Wollongbar NSW 2477

0410 100061 02 92489247

4/07/2013

james.sakker@industry.nsw.gov.au

From: Jesse Death <jdeath@manidiroberts.com.au>
 To: "James Sakker@dpi.nsw.gov.au" <james.sakker@dpi.nsw.gov.au>
 Cc: Andrew Cook <Andrew.COOK@rms.nsw.gov.au>, Aleesha Darlington <Aleesha.Darlington@rms.nsw.gov.au>
 Date: 26/02/2013 09:50 AM
 Subject: FW: Kundabung to Kempsey - Fish passage design detail

James,

As discussed, please see below the email from Andrew Cook last December (attachments also included). Given the Kundabung to Kempsey section is a construct only contract RMS is wanting to close out on all requirements / issues. As such if you could please consider Andrew's email below and respond (via email is fine) that would be great.

Regards

Jesse Death
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From: COOK Andrew
Sent: Wednesday, 19 December 2012 12:56 PM
To: james.sakker@dpi.nsw.gov.au
Cc: WOOD Peter G; DALLEY Steve; DARLINGTON Aleesha K; LAWRENCE Scott B; WOODS Mark; OH2K - Kate Wiggins
Subject: Kundabung to Kempsey - Fish passage design detail

James,

Following on from our site inspection on Friday 26 October, the SMEC Hyder JV has reviewed the waterway designs for the Kundabung to Kempsey construct only section against the fish passage requirements determined onsite.

Please find attached:

- 2 Summary sheets of the culvert design features, discussion against fish passage requirements and recommended treatments.
- 2 An example of the low flow fish passage design with fish shelter detail highlighted.
- 2 Plans showing culvert locations.

Could you please review the above and provide any comment on the recommended treatments.

If required, RMS would be happy to organise another onsite inspection to further discuss fish passage requirements. This can be arranged through Aleesha Darlington early in the New Year.

Regards,

Andrew



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4/07/2013

These meeting notes reflect discussions held on 15 February 2013 between RMS, EPA, DPI and SHJV representatives (attendees identified below). These notes capture discussions from the pre site visit meeting at the Kempsey Bypass Alliance meeting room as well as discussions held on-site during the site visit.

Attendees:

James Sakker (JS) – DPI	Craig Harre (CH) – EPA
Steve Dalley (SD) – RMS	Aleesha Darlington (AD) – RMS
Mike Murphy (MM) – RMS	Kate Wiggins (KW) – SHJV
Jesse Death (JD) – RMS	

Pre site visit meeting

The meeting pre site visit included discussion on the following:

- Discussed Staging approach to the Project and indicative timing for stages.
- Identified that the focus of this meeting / site visit would be for the Kundabung to Kempsey (K2K) section of the project and that for the Oxley Highway to Kundabung section further consultation would occur during detail design development.
- Discussed Commonwealth (EPBC Act) process. The Project is a controlled action and recognition that there would be conditional approval from SEWPaC (referral information is now online).
- Recognised that this will be one of the first controlled action projects since listing of Koala on EPBC Act list of species (potential for SEWPaC conditions to target further requirements for this species).
- EPA suggested review of the Port of Hastings Council Koala Plan of Management (which was done by RMS in the preparation of referral documentation).
- Identified / detailed how previous EPA and DPI (Fisheries) comments have been addressed in the latest design.
- Specific discussion on siting of glider poles / rope bridges. EPA suggest review forestry management zones (FMZs) that are not identified for logging (ie zones 1-3) prior to relocating these structures. The FMZs reflect buffers to particular geographic features (including drainage lines / waterways). Fauna movement will be typically along these areas and siting of crossing structures to consider these zones. There is a challenge in optimizing the location of these poles between cut/fill line to gain maximum pole height which would require a greater distance to drainage /waterlines which may be the predominant movement corridor.
- EPA to review FMZs relative to proposed glider pole / rope bridge crossing locations through / near State Forest land.
- EPA identified culverts through Maria State Forest as key for fauna movement. EPA have requested that the drawings or supporting information provide detail of the 'typical' flows / hydrology at culverts. Key is to understanding the extent of flow through (how wet) combined or incidental culverts.
- DPI (Fisheries) expressed overall satisfaction with the design. One area identified on the site visit that requires review from DPI perspective is at station 25.70 where review of fish passage required.

- Both EPA and DPI expressed overall satisfaction with bridge designs for the K2K section.

Site visit notes – general

The following relates to the K2K section of the Project:

Comment	SHJV response
Both EPA and DPI expressed overall satisfaction with bridge designs. EPA noted that planning of vegetation within the fauna path under bridges should be removed (but keep water loving sedges in other areas under the bridge structures where possible).	Noted. Vegetation has been removed from dedicated fauna paths under bridges.
DPI expressed overall satisfaction with culvert designs for the K2K section.	Noted.
EPA identified that culvert design drawings should reflect a 'typical' hydrological flow environment (EPA need to understand how dry / wet the culverts will be 'day to day' given dry passage is key for most target fauna).	All dedicated culverts will provide one in 100 year flood immunity. Combined culverts where fauna upstands are included will provide dry passage for all but the one year peak flow event.
EPA have requested flows for a 1 in 2 year 'event' be illustrated on culvert drawings if possible.	Hydraulic flows will be shown on future culvert drawings.
For combined culverts EPA questioned why fauna upstands are limited to 900mm wide. EPA has requested that these fauna upstands be as wide as possible.	Flood immunity was modelled with a 1200 millimetre, 100mm high up-stand. The increased width did not affect the hydraulic function of the culverts. A 1200mm wide upstand will be provided at all new combined culverts which allow dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event.
In combined culverts identified for fish passage DPI has agreed that to facilitate widening of fauna upstands within culverts it is reasonable that low flow channels do not require 2:1 batters. DPI agreed that fish passage components through these culverts could have vertical walls. Fish shelter (alternating through the culvert) should be retained but design adjusted to reflect vertical 'wall' design of low flow passage.	Batter slopes have been reduced from 2:1 to 1:1. Concrete sills are to be provided at culverts C25.44, C26.78, C34.70 to decrease velocities for fish passage.
In general, the Detailed K2K Fauna Crossing Report should provide further detail regarding restrictions to achieving the full three-metre by three-metre culvert dimensions – especially for 'combined' culverts.	Further detail added to the report to provide rationale as to culvert dimensions.

For glider pole typical designs – EPA request that RMS review use of ‘foot pegs’ on the poles as they are a hazard to gliders.	Foot pegs on glider poles would be located on the 'back' side of the pole and not facing the glide path. This is in line with what was provided for the Kempsey Bypass project.
EPA to provide feedback on ‘typicals’ for fauna furniture design.	Noted.

Site visit notes – specific locations

Location	Detail	SHJV response
C36.40	- DPI agree that low flow can have vertical batters to accommodate wider fauna upstand. - EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred).	- Batter slopes have been reduced from 2:1 to 1:1. - Flood immunity was modelled with a 1200 millimetre, 100mm high up-stand. The increased width did not affect the hydraulic function of the culverts. - A 1200mm wide upstand will be provided at all new combined culverts which allow dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event. - A separate hydraulic assessment carried out for one year 72 hours (3 day) storm, the results show the up-stand will be dry for majority of the culverts.
C35.70	- DPI agree that low flow can have vertical batters to accommodate wider fauna upstand. - EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred).	- Batter slopes have been reduced from 2:1 to 1:1. - A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40).
F34.72	- EPA query hydrological environment for ‘typical’ environment and in 1 in 2 year event. - EPA assume no fauna upstand identified because is dedicated (dry) fauna culvert.	1 in 100 year flood immunity provided by separate drainage culverts C34.70 and C34.80. - Upstand inclusion was an error.
C34.70	No comments	Concrete sills are to be provided to decrease velocities for fish

Location	Detail	SHJV response
		passage
C34.10	EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred).	A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40).
F33.40	No comments	
C33.10	EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred).	A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40).

Location	Detail	SHJV response
C32.67 / C32.66	• Confirm no light wells as generate noise and deter fauna movement. • Can further information be provided around constraints that limit culvert height to 2375. • EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred). • The C32.66 outlet / C32.67 inlet area function as a 'habitat view' area and be appropriately landscaped with water loving flora species to encourage fauna movement.	• Light wells have been removed. Opportunities for the inclusion of vegetation at these locations will be looked at during detailed landscape design. • Limited fill cover to road alignment has restricted the height to 2400mm. • A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40). • The approaches to culverts to be used for fauna passage will be the subject of later detail design to be captured in the landscape package to ensure requirements are met regarding attracting fauna to the crossing. Comments are noted and will be passed on to the landscape team.
C32.35	• EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred).	• A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40).
C31.90	• EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred).	• A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40).
C30.10	• EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred).	• A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40).
C29.60	• JV to confirm 'low flow' / fish passage design at this location given this is class 3 fish passage. Current design has 4 x box culverts all at same invert level.	• Class 3 fish passage provided as per existing culvert arrangement. Low flow passage cannot be accommodated due to extension of existing culverts that are at

Location	Detail	SHJV response
		ground level.
C28.68	- Existing 3 x box culverts and proposed extensions to these are all at the same invert level. Can the invert level of one of the culverts be reduced to generate a 'low flow' culvert (this is a class 2 fish passage area)? This would also benefit fauna movement as other two culverts would be 'dry'. - Can further information be provided around constraints that limit culvert heights to 2375.	- Class 2 fish passage provided as per existing culvert arrangement. Low flow passage cannot be accommodated due to extension of existing culverts that are at ground level. - Limited fill cover to road alignment has restricted the height to 2400mm.
C27.51	- DPI agree that low flow can have vertical batters to accommodate wider fauna upstand. - EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred). Key area as this is identified as a sub-regional fauna movement corridor.	- Batter slopes have been reduced from 2:1 to 1:1. - A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40).
C26.78	- DPI agree that low flow can have vertical batters to accommodate wider fauna upstand. - EPA query hydrological implications and impact on culvert height of wider fauna upstand (wider fauna upstand preferred).	- Batter slopes have been reduced from 2:1 to 1:1. Concrete sills are to be provided to decrease velocities for fish passage - A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40).
F26.40 / C26.38	- F26.40 drawing includes reference to a fauna upstand. Assume this is incorrect as this is a dedicated fauna culvert and would be dry all the time. - For fauna movement purposes, smaller rolled rock is preferred as the treatment for scour protection at inlet and outlet to all combined / dedicated culverts.	- Upstand inclusion was an error. - The culvert has been moved 15 metres to the north to provide one in 100 year flood immunity. - Culvert length has been kept at <50 metres to provide optimal fauna line of sight. Inlet has also been lowered to improve line of sight for fauna through culvert. - No scour protection would be provided at dedicated culverts. The approaches to culverts to be used for fauna passage will be the subject of later detail design to be captured in the landscape package to ensure requirements are met regarding attracting fauna to the crossing. Comments are

Location	Detail	SHJV response
		noted and will be passed on to the landscape team. The use of smaller rock as scour protection for combined culverts is noted. Proposed sizes of rock is 200-300 mm.
C25.70	- EPA and DPI question location of culvert (based on need to redirect watercourse). Current approach at this location is that the three x 1800cm pipe culverts would be removed and a new combined culvert included roughly 7-10 metres to the north of the three 1800cm culverts. - RMS to consider opportunity to provide fish passage at pipe culvert location (as low flow) and retain combined culvert at current location. - C25.70 is 3930cm wide and 2675cm high. EPA seek further information around constraints that limit culvert height to 2675.	- The three existing pipe culverts will be removed and replaced with two 1800mm pipe culverts in order to provide greater dry fauna passage through combined box culvert C25.70. - Fish passage has been provided by lowering both pipes below ground level, creating a low flow channel. - Height has been changed to 2.7 metres. The original table 6.2 stated a height of 2.4 metres, with a note stating opportunities to increase to 2.7 metres would be sought at detailed design. Width is 3.0 metres as per table 6.2. No opportunities to increase the height further due to lack of adequate fill cover to the road alignment. - A 1200 millimetre up-stand will be provided which allows dry fauna passage for the majority of the year. The up-stand would be temporarily inundated during a one year peak flow event (see response to C36.40).
C25.42 / C25.30 / C24.70 / C24.43	Limited focus on these culverts and general acceptance of approach / design.	Concrete sills are to be provided at culvert C25.44 to decrease velocities for fish passage.

OH2K - Kate Wiggins

From: Chris Sheen <Chris.Sheen@epa.nsw.gov.au>
Sent: Monday, 10 December 2012 4:10 PM
To: COOK Andrew; james.sakker@dpi.nsw.gov.au
Cc: Craig Harre; Robert Donohoe; WOOD Peter G; DALLEY Steve; POLLARD Greg J; LAWRENCE Scott B; OH2K - Kate Wiggins; OH2K - Irene Scott; OH2K - Paul Hunter
Subject: RE: OH2K - Smiths Creek bridge design change

Good afternoon Andrew

EPA agrees that the email below captured discussions noted at the inspection of Smiths Creek on Friday the 7/12/2012.

Please respond to the additional EPA requests below:

- EPA seeks guarantee that the scour protection and or pier construction, will not impact on the 3mtre fauna passage.
- EPA requests to review and comment on the work method statement during its development by the bridge construction contractor.

Regards

Chris Sheen
Regional Operations Officer - North Branch |
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From: COOK Andrew [mailto:Andrew.COOK@rms.nsw.gov.au]
Sent: Friday, 7 December 2012 11:42 AM
To: james.sakker@dpi.nsw.gov.au; Sheen Chris
Cc: Harre Craig; Donohoe Robert; WOOD Peter G; DALLEY Steve; POLLARD Greg J; LAWRENCE Scott B; OH2K - Kate Wiggins; OH2K - Irene Scott; OH2K - Paul Hunter
Subject: OH2K - Smiths Creek bridge design change

James, Chris

Thanks again for meeting onsite yesterday to discuss the design change to Smiths Creek bridge.

As discussed, RMS and the SHJV have undertaken further detailed design investigation into the Smiths Creek bridge regarding flood performance. The original design included replacement of the existing highway bridge with twin 3 span bridges providing an overall bridge length of approximately 45 m and extension of the existing twin cell box culvert. Following recent flood model optioneering, it was determined that this design only minimally meets flood performance requirements and exhibits some undesirable high flow velocities. An alternative design has been proposed to extend the bridge using a 4 span arrangement with an overall bridge length of approximately 55 m, whilst deleting the culvert. This design provides improved hydraulic performance, simplifies constructability and eliminates the risk associated with extending and retaining the culvert that is over 80 years old.

The adoption of the proposed alternative design and deletion of the culvert does result in the removal of a combined fauna/drainage underpass listed in Table 6.2 (reference id 88a/C28.3A). However, it is considered that this will be offset by the inclusion of the additional span and increase in overall length of the bridge by 10 m. Additionally, the alternative design would also require infilling of the flood overflow channel upstream of the culvert and reclamation of the existing waterway under the location of the twin bridges.

Please find below a record of discussions from the site inspection regarding the above:

- Generally accept the design change and adoption of the 4 span arrangement.
- The existing bridge and location of piers have resulted in excessive scouring and pooling when compared to the channel of Smiths Creek immediately up and downstream.
- No objection to reclaim the waterway up to the southern side of pier 1 and northern side of pier 2.
- No objection to creek realignment between and under the bridges to rectify existing pooling and scouring and re-establish the creek channel similar to that up and downstream.
- Ensure all piers are suitably armoured with scour protection.
- No objection to the infilling of the flood overflow channel upstream of the culvert.
- Suitable landscaping treatments are to be incorporated on reclaimed land and under span 3. This should include species such as Lomandra.
- Offsetting the combined fauna/drainage underpass with an additional span regarding fauna passage was accepted.
- Ensure that there is a minimum of 3 m from the fauna path to the bottom of the soffit.
- The fauna path is to incorporate smaller diameter rock and be rolled in/compacted similar to that provided on Kempsey Bypass.
- Weed management during and following completion of construction is recommended.
- DPI (Fisheries) is to be consulted further regarding snag management (a number of snags were identified immediately downstream of the existing bridge and in vicinity of new southbound bridge).

I have attached the design plans showing the proposed alternative design and photos from yesterday's inspection.

Could you please confirm the above and provide any additional comment as necessary.

Please do not hesitate to contact me should you wish to discuss further.

Regards,
Andrew



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MINUTES

Issue date Wednesday 12th September 2012

Subject Agency Workshop and Site Inspection

Reference AAD0006-OH2K-M-02 Agency Workshop and Site Inspection Minutes

Client Roads and Maritime Services

Distribution Peter Wood (PW) Shane Higgins (SH)
Irwin Perring (IP) Laura Worthington (LW)
Belinda Bock (BB) Kate Wiggins (KW)
Ben Lewis (BL) Jessica Hedge (JH)
Craig Harre (CH)
James Sakker (JS)

Minutes are outlined below from the site visit with EPA and Fisheries Agencies on Friday 7th September.

Ref #	Discussion	Actions	Response
1.	C36.40 - Highlight that the culvert has been shortened. EPA noted that the reduced length of the culvert is a good outcome. The length of the culvert is 51m reduced from 57.6m. - Culvert is ephemeral and relatively dry. EPA recommended the culvert to be flat and not undulating like other culverts because of the flows.	Provide flat culvert with rails for Koalas	Flat culvert with rails provided in design.
2.	C35.70 - Culvert is longer by 8m (still below the 50m length) - Target species is koala - Fauna fencing each side at combined and dedicated fauna culverts - Incorporate a low flow section for frog	- BL to send to PW sketch/photo of past project that used horizontal brackets for koalas – 14/9/12 - Flood modelling – SH to confirm suitable for koala rails in culverts proposed for furniture – end Sept 12 - Fencing discussed to be	Flood modelling was undertaken for all culverts where furniture was proposed. Fauna fencing is being provided either side of

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Ref #	Discussion	Actions	Response
	passage	installed either side of culvert within State Forest. EPA suggested installing three vertical poles with brackets against the edge of the culvert for fauna furniture dependant on whether flood modelling will prohibit furniture or not.	fauna culverts and within State Forests. Options have been looked at for fauna furniture and typical drawings provided with two vertical poles.
3.	F34.72 - Culvert shortened by 1m - Avoid dedicated being a flood mitigation option - Consider passage by phascogale - Noted that Culverts 34.70, 34.72 and 34.80 are about 100m apart. - EPA recommended to avoid having dedicated and combined culverts close to each other. EPA prefers to keep mulch in culverts. Dedicated culverts need to remain dry. - EPA recommended keeping culvert 34.72; and considering culvert 35.70 as incidental rather than combined to provide savings and good outcome. - EPA noted that 50m maximum culvert length is not ideal if increases in vertical fill height are too high. Recommended case-by-case consideration of height and length and noted that best outcomes are	- KW to determine why is there combined (F34.72 & C34.70) and dedicated culverts so close – 14/9/12 - SH to determine if combined be made to only hydrology and reduce size of C35.70 and note savings that is made through reducing culvert size – 14/9/12 - PW and IP to check drainage drawings for clarity on whether culvert 34.70 can be change to incidental. - KW to review lowering the dedicated culvert for fauna sightline. Noted that the potential increase in length – 14/9/12	Culvert 34.70 has been reduced to a drainage only 3 cell box culvert with dimensions 2100 (w) x 1500 (h) Culvert 34.72 remains a dedicated fauna culvert. Culvert lifted in order to reduce length. Sight lines maintained without the need for lowering as this would have cause further increases to culvert length.

Ref #	Discussion	Actions	Response
	achieved with mulch and if elevation is close to ground level. DPI advised that an arch structure is a good compromise to a bridge or a culvert when there is a steep grade as this keeps the pool riffle sequence and there is a larger aptitude for light and fauna, etc to pass through footings either side of the creek instead of having creek diversions.		
4.	C32.66 - Increased length by 6m - Relatively dry passage with a large catchment. - Culverts are staggered slightly with only one break between the service road. - EPA suggested further survey and ground truthing of zonation, resources and potential habitat.	KW to consider rehabilitation of adjoining vegetation to provide refuge for small fauna – 14/9/12	A detailed landscape plan has been developed by the JV and includes revegetation of areas adjoining culverts.
5.	General: Gliders	- Paper on Gliders effectiveness of crossing and zoning to be provided to SHJV by CH – 21/9/12 - KW to organise detailed survey for proposed locations - KW to look into proposed furniture at Maria River – 21/9/12 - SHJV to consider gap crossing of gliders at Maria River. BL confirm Yellow-bellied Gliders currently denning on the eastern side of the	Detailed glider survey was undertaken by the JV in the vicinity of proposed glider poles. The JV investigated putting glider poles in this vicinity, but there were issues with sight distance due to having to place a pole in the median. The JV is looking for an alternative location.

Ref #	Discussion	Actions	Response
		highway.	
6.	C32.35 - Pavement reuse in this section will need to be monitored for road kills. - EPA advised that koalas are known to go through suitable fragmented habitat but need to verify presence in this area.		An ecological monitoring program has been developed by the JV for the project. This will be implemented by RMS.
7.	Pipers Creek - Proposed location for monitoring. But no requirement for monitoring fauna crossings under bridges, as fauna passage under bridges has been demonstrated on other highways - Identified as a good location for quoll habitat due to presence of hollows and waterways. - Wet creek identified - Identified that sediment basins would be located in this area - No microbats identified inhabiting the bridge. - Ben Lewis discussed monitoring of Giant Barred Frog (GBF). - EPA advised to confirm locations of GBF at Barries, Pipers and Smiths Creeks and to assess their likelihood of survival.	- EPA recommended to Install frog fencing for Giant Barred Frog - Check EA for presence of Quoll in this area	Frog fencing has been provided in this vicinity. A Giant Barred Frog Management Strategy is being developed as part of the FFMP. This area was identified as potential quoll habitat in the EA, but no there have been no recordings to date.
8.	C30.10 Noted that there is not sufficient road cover	- KW to correct table and change to size being 2.7m x 2.7m – 14/9/12 - KW to look into	Table has been revised. Following further design,

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Ref #	Discussion	Actions	Response
	to increase culvert height - Fence (fauna) on either side of culvert only on main carriageway(not on service road), and along habitat the adjoins main alignment - Culvert to be low flow for fish passage (30% of width of culvert should be lowered) and a fauna ledge to be provided. - Culvert exits onto adjacent service road level, no need to extend culvert under service road - Supports stand water and aquatic vegetation. - DPI suggested a low flow channel with fauna passage either side as a better outcome for smaller channels than laminar flow. Try to match existing stream widths. - DPI/EPA suggested multiple cells preferred with outer cells dry; or if single celled then DPI prefers a low flow channel rather than ledges. - DPI also suggested as a general principle to provide a low flow channel rather than ledges. - EPA advised to consider increasing width for fish passage and adding 2-3m for fauna aswell. SH prefers width not to exceed existing	increasing the width to 3.7m to allow enough room for fauna and fish – 14/9/12 SHJV to investigate installing fencing 100m either side of culvert to prevent fauna access to motorway.	the height of the culvert did not need to be reduced. The culvert is a 3 metre x 3 metre. Fauna fencing is provided at each fauna culvert for a length of 200 metres.

Ref #	Discussion	Actions	Response
	channel.		
9.	C28.3B - Was thought to be a 1 cell overflow box culvert; actually 2 cells - Originals 1930s culverts have been extended on both sides in ~1970s. - Scuppers around 30mm diameter noted, BL advised microbats can access scuppers about a minimum diameter of 25mm.		These culverts will now be demolished as an additional span has been added to the bridge.
10.	Smiths Creek - Scour issues on abutments - Proposed location for monitoring. But no requirement for monitoring fauna crossings under bridges, as fauna passage under bridges has been demonstrated on other highways - Class 2 waterway		Design development of the flood model resulted in a design change with a 4 span bridge being adopted in place of the 3 span bridge plus culvert extension. Overall a more open a clear fauna passage results with a reduction in scouring action. Construction of the twin bridges will require a temporary rock platform to be placed across the creek to allow safe demolition and construction of the existing and new twin bridges respectively. It is proposed this platform would be extended to the east of the bridge site to carry construction traffic north and south along the site.
11.	Barrys Creek If existing culverts are to be retained, dedicated fauna culverts will be installed on either	SH to investigate option to retain existing culvert under the future SB carriageway, construct a bridge over the future NB – 12/9/12	Existing culverts are to be demolished and replaced with twin bridges.

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Ref #	Discussion	Actions	Response
	side. - All options (retain culverts/new bridge/arch structure) will require some realignment of the creek - Class 2 waterway - Existing culverts support microbat roosting habitat (<i>Miniopterus sp.</i>) - No need to provide koala crossing structures but should consider furniture for phascogales. - Agencies prefer bridge option subject to RMS consideration. - EPA advised fauna furniture not required here as good habitat available for refuge. - Possible Heritage Bridge found in vicinity.		Detailed fencing has not been designed for Barrys Creek as this is now part of the D&C section. Heritage investigations have been undertaken for the old Barrys Creek bridge. This will be directly impacted by the alignment.
12.	F22.32 - Combined culverts either side of the dedicated culvert - Investigate providing extra width under Yarrabee Rd underbridge bridge for fauna crossing - Review the history and decisions around why the dedicated culvert relocated and increased and send to Craig. - The poor condition of existing culverts would mean no intention to retain structure	- KW to investigate reducing size of combined to possibly 1.4mx1.4m and retain dedicated at large size 3.0mx3.6m – 14/9/12 - KW to review the history and decisions around why the dedicated culvert relocated and increased and send to CH – 14/9/12	Dedicated culvert to be retained and size increased to 3.6x3.6. Combined culvert downsized to incidental 750mm pipe culvert. Extra width for fauna passage provided under Yarrabee Rd overbridge.
13.	C22.18 - Set combined culvert at bed level. - Noted that Culvert is	KW to confirm reasoning behind resizing from 3x3 to 3.6x3.6 – KW 14/9/12	Combined culvert in close vicinity to dedicated culvert. Insufficient fill height did not allow 3.6x3.6 culvert at this

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Ref #	Discussion	Actions	Response
	85m long because it is in a large fill area; and it is being investigated why culvert has changed to a drainage culvert only.		location. Dedicated culvert relocated closer and increased in size. C22.18 downsized to 1500mm pipe culvert. Change in location from 22323 to 22300 has facilitated an increase in size to 3.6x3.6.
14.	F20.54A		
15.	General: Farmed Dams Try to avoid where possible but they can be impacted in required	JS to send protocol to PW/IP regarding decommissioning any farmed dams along the alignment – 21/9/12	
16.	F11.67, C11.14 and Median Widening - Staggered arrangement of combined culverts - Shortened from EA - Through design refinement and the addition of glider poles to the median widening area, a reduced footprint could be achieved. - EA identified that yellow-bellied gliders were heard (not sighted) and squirrel gliders are likely to be in the area. Limited abundance of hollow-bearing trees in widened median may mean a low density of resident gliders - Take a conservative approach to glider distances and tree options, to provide opportunities to fauna - Opportunity to also match glider poles to a specific tree to promote use. Glider	- KW to check dates and locations of glider records – 21/9/12 - Check DBH of trees in median against DBH of trees where they haven't been logged (eg along existing pacific highway), and compare heights and crown diameters. Need trees to median to grow in height, not in crown diameter. An increase in	Additional glider surveys have been undertaken through the widened median section. Surveys of tree heights through the proposed area and close to the road have been undertaken. Findings from additional investigations are detailed in the revised Widened Median report.

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Ref #	Discussion	Actions	Response
	poles should be paired with similar height trees eg 20m pole with 20-25m tree. • There needs to be confidence that trees will grow to expected heights. • Drainage, fencing etc issues have not yet been considered in detail. If these details are to be left to detailed design stage, then adequate allowance (eg clearing width) • needs to be made to ensure that detailed design can construct these options. • Provision of details and specifications (e.g. batters 2:1) around the median widening option, need to be determines and prepared as a constraints program for the D&C contractors • Assume 4-5m launch pad from the truck of the tree (ie gliders may launch from branch 5 m from tree trunk. This may reduce clearing width somewhat). Review tree heights to allow for this. • Noted that greater than 30m is not appealing to gliders to attempt the launch. Theoretical 40m, but this might not be practical. Noted that structures larger than 26m are hard to get and have longevity issues, they also must be wholly and not partially treated.	crown cover may reduce the gap crossing distance so this needs to be considered/compared. • SH to investigate reducing the size, narrowing the embankment height and consider other constraints – 21/9/12 • SH to check the vertical constraints. Is the flood modelling driving the vertical alignment? – 21/9/12 • PW to discuss issue of retaining large trees and process to ensure that this happens.	

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Ref #	Discussion	Actions	Response
	• C11.08 constraints associated with embankment. Koalas have been recorded crossing via 1.8m tall culverts- a reduced culvert height may reduce batter slopes, resulting in a narrower alignment. • Check the vertical constraints. Is the flood modelling driving the vertical alignment? • Flag with State Forests that large trees, especially tagged trees, should not be logged. NB. There are more suitable glide trees than are currently tagged- suitable trees were only tagged at ~10m intervals . • Note that widened medians are most beneficial to gliders. The impacts of a larger footprint may adversely affect a range of species- we need to be sure that a widened median in this location is feasible. If not, rope bridges/glider poles will be used to mitigate impacts on gliders. There is no point in supplementing a widened median with glider poles if trees are never going to be tall enough to facilitate safe glides. • General limit on the availability of glider poles at between 23-26.0 metres. After this they generally become subject to		

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Ref #	Discussion	Actions	Response
	availability issues. • Crossings must be two-way. • If a widened median in this area is considered not feasible then poles and rope crossings would be considered. Noted that EPA would prefer a widened median if feasible, need to confirm presence of habitat and gliders. Further ground truthing to be done. Now is the preferred time to action any additional MCoA survey requirements.		
17.	C2.60 • Extension of culvert to 90m from EA • Update table; currently 4 cells at 1.8m height. 3 wet, 1 dry. • Class 2-3 waterway/	• JH requested one wet cell and cell lowered for low flow. SH to investigate option – 21/9/12	This can be accommodated and will be investigated further at detailed design.
18.	F1.62 • Culvert reduced as far as possible	• SH to assess relocating dedicated crossing to where batter slopes are shorted, to reduce culvert length	Culvert moved to minimise length and to maintain minimum cover to road level.
19.	F1.02 • Culvert lifted – check to see about lowering for fauna • Investigate Option to relocate the dedicated culvert to a better location (possibly out of large fill area.)	• KW to review options to lower for Fauna moving culvert to be 300mm above the ground and check sight distances for fauna on cross-sections. Option to extend fauna furniture to entice fauna closer to the culvert opening – 21/9/12	Further options for lowering will be investigated during detailed design.

Ref #	Discussion	Actions	Response
20.	General: - Guidelines and principles have been developed for Woolgoolga to Ballina project. - Project needs to identify standard culvert x section and design based on proposed purpose and location.	- KW to investigate resizing combined culverts when in close vicinity of a dedicated fauna culvert – 21/9/12 - CH to send through typical fauna culvert designs and principles from W2B – 21/9/12	Opportunities to resize combined culverts have been considered through the detailed design process for the K2K section. This will need to also be considered by the D&C contractor.

APPENDIX C

FAUNA CULVERT DETAILED DESIGN DRAWINGS

Available on request as they do not comply with accessibility requirements (WCAG 2.0).

APPENDIX D

BRIDGE DETAILED DESIGN DRAWINGS

Available on request as they do not comply with accessibility requirements (WCAG 2.0).

APPENDIX E

ROPE BRIDGE AND GLIDER POLE DETAILED DESIGN DRAWINGS

Available on request as they do not comply with accessibility requirements (WCAG 2.0).

APPENDIX F

FAUNA FENCING DETAILED DESIGN DRAWINGS

Available on request as they do not comply with accessibility requirements (WCAG 2.0).