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</tbody>
</table>
1. Introduction

Roads and Maritime Services (Roads and Maritime) are upgrading 11.6 km of the Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry (the project). The resulting upgrade will be a four lane divided highway (two lanes in each direction) with median separation. Bypasses of Foxground and Berry are an integral part of the project. An Environmental Assessment (EA), and submissions report, was submitted and approval for the project granted on 22 July 2013, under Part 3A of the Environmental Planning and Assessment Act 1979 which included a suite of mitigation measures designed to reduce the impacts of the project on fauna and habitat connectivity. Condition B3 of the Minister’s Conditions of Approval (CoA) requires Roads and Maritime to design (and implement) the fauna crossings identified in Table 5.1 of Appendix F of the EA, at the locations and in accordance with the minimum design principles identified in Table 5.1, unless otherwise agreed by the Director General. Appendix F of the EA is the terrestrial ecological assessment titled ‘Technical paper: Terrestrial flora and fauna’, prepared by Biosis Research (2012).

Fulton Hogan Construction Pty Ltd (FH) was awarded the contract by Roads and Maritime for the design and construction of the Foxground and Berry bypass by Roads and Maritime in June 2014. This contract includes the design and installation of the fauna crossings.

Fulton Hogan has commissioned this report with reference to CoA B4 and B5, which relate to the design of the fauna crossings. This report provides a review of the fauna crossings identified in Table 5.1 of Appendix F of the EA, and consequently approved by the Minister (CoA B4). It also provides an outline of the final design of fauna crossings where the location of the crossing has changed and/or the crossing does not meet the minimum design principles as outlined in Table 5.1. Furthermore, the report demonstrates how the new location and/or design will result in acceptable biodiversity outcomes and how the fauna crossing will work in conjunction with permanent fauna exclusion fencing (CoA B5).

This report does not cover temporary exclusion fencing to protect identified flora during construction. For details on how potential impacts on ecology will be managed during construction, refer to the Construction Flora and Fauna Management Sub-plan.

For the purposes of this Fauna Crossings Report, the fauna crossing design identified in Table 5.1 of Appendix F of the EA is referred to as the “Approved EA Design” and the final fauna crossing design is referred to as the “Final Design”. Both sets of crossing designs are provided for comparison in this report, plus detailed design in Appendix A for further design detail.

1.1 Minister’s conditions of approval

The CoA relevant to this Fauna Crossings Report are listed in Table 1.1. A cross reference is also included to indicate where the condition is addressed in this Report.
Table 1.1  Minister’s CoA relating to fauna crossings for the project

<table>
<thead>
<tr>
<th>CoA No.</th>
<th>CoA requirement</th>
<th>Fauna Crossings Report reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>B4</td>
<td>Investigations into the design of fauna crossings identified in Table 5.1 of Volume 2 Appendix F of the document listed under condition A1(b) during detailed design, shall be undertaken with the input of a suitably qualified and experienced ecologist and in consultation with OEH and DPI (Fishing and Aquaculture).</td>
<td>This Report Section 1.2</td>
</tr>
<tr>
<td>B5</td>
<td>The Proponent shall prepare a report on the final design of fauna and/or waterway crossings identified in Table 5.1 of Appendix F of the document listed under condition A1(b), where the location of the crossing has changed and/or the crossing does not meet the minimum design principles identified in Table 5.1. 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 OEH and DPI (Fishing and Aquaculture) in relation to the suitability of any changes to the location and/or crossing design.</td>
<td>This Report</td>
</tr>
</tbody>
</table>

1.2 Consultation

Investigations into the Approved EA Design have been undertaken with the input from Senior Ecologists and a Principal Ecologist from Parsons Brinckerhoff, and in consultation with OEH (Biodiversity) and DPI (Fishing and Aquaculture). Following incorporation of their input, OEH and DPI have provided confirmation that the Final Design outcomes are acceptable.

A summary of consultation undertaken to assist with the Final Design and the preparation of this Fauna Crossings Report is provided in Table 1.2.
### Table 1.2 Record of consultation with OEH and DPI (Fishing and Aquaculture)

<table>
<thead>
<tr>
<th>Date of consultation</th>
<th>Method of consultation</th>
<th>Agency and contact details</th>
<th>Summary of consultation</th>
</tr>
</thead>
<tbody>
<tr>
<td>18/09/13</td>
<td>Meeting</td>
<td>NSW Department of Primary Industries (Fishing and Aquaculture) (DPI) Trevor Daly (TD) - Fisheries Conservation Manager, South Coast, Aquatic Habitat Protection</td>
<td>Shared fauna underpasses at Ch 12770 and Ch 13320 - TD had no comment and advised that Fulton Hogan should instead consult OEH (Biodiversity).</td>
</tr>
<tr>
<td>03/10/13</td>
<td>Meeting</td>
<td>Office of Environment and Heritage, Department of Premier and Cabinet (OEH) James Dawson - Senior Team Leader, Ecosystems and Threatened Species – Illawarra, and Kylie McClelland - Senior Threatened Species Officer, Ecosystems and Threatened Species-Illawarra</td>
<td>Discussed the fauna crossings provided in the Concept Design during the tender phase.</td>
</tr>
<tr>
<td>20/06/14</td>
<td>Meeting</td>
<td>OEH Kylie McClelland - Senior Threatened Species Officer, Ecosystems and Threatened Species-Illawarra</td>
<td>Reviewed the fauna crossing strategy for the Foxground and Berry bypass project.</td>
</tr>
<tr>
<td>05/09/14</td>
<td>Email</td>
<td>OEH To Kylie McClelland - Senior Threatened Species Officer, Ecosystems and Threatened Species-Illawarra</td>
<td>Fauna Crossings Report provided for review and comment.</td>
</tr>
<tr>
<td>05/09/14</td>
<td>Email</td>
<td>DPI (Fishing and Aquaculture) To Allan Lugg – Regional Manager – Aquatic Ecosystems (South)</td>
<td>Fauna Crossings Report provided for review and comment.</td>
</tr>
<tr>
<td>23/09/2014</td>
<td>Email</td>
<td>DPI (Fishing and Aquaculture) From Allan Lugg – Regional Manager – Aquatic Ecosystems (South)</td>
<td>Allan Lugg indicated that DPI had no concerns with the content of the Fauna Crossing Strategy.</td>
</tr>
<tr>
<td>16/09/2014</td>
<td>Email</td>
<td>OEH From Kylie McClelland - Senior Threatened Species Officer, Ecosystems and Threatened Species-Illawarra</td>
<td>Comments received from OEH on Fauna crossings report.</td>
</tr>
<tr>
<td>09/10/2014</td>
<td>Email</td>
<td>OEH To Kylie McClelland - Senior Threatened Species Officer, Ecosystems and Threatened Species-Illawarra</td>
<td>Clarification and justification for report aspects commented on by OEH, and included an OEH suggested design change to rope bridge at chainage 10700.</td>
</tr>
<tr>
<td>09/10/2014</td>
<td>Email</td>
<td>OEH From Kylie McClelland - Senior Threatened Species Officer, Ecosystems and Threatened Species-Illawarra</td>
<td>Acceptance by OEH of clarification and justification of design modifications proposed for the project.</td>
</tr>
<tr>
<td>18/11/2014</td>
<td>Email</td>
<td>OEH From Kylie McClelland - Senior Threatened Species Officer, Ecosystems and Threatened Species-Illawarra</td>
<td>Acceptance by OEH of clarification and justification of design modification to extend rope bridge under Broughton Creek Bridge No. 2 at chainage 10700.</td>
</tr>
</tbody>
</table>
2. Background

2.1 Review of affected wildlife corridors

Wildlife corridors can be defined as ‘retained and/or restored systems of (linear) habitat which, at a minimum enhances connectivity of wildlife populations and may help them overcome the main consequences of habitat fragmentation’ (Wilson & Lindenmayer 1995). Corridors can provide ecological functions at a variety of spatial and temporal scales from daily foraging movements of individuals, to broad-scale genetic gradients across biogeographical regions.

The Shoalhaven area contains numerous large wildlife corridors that link National Parks and Nature Reserves to other vegetated areas. Importantly, these corridors link coastal vegetation with the vegetation of the escarpment of the Budawang Range and the Southern Tablelands. The wildlife corridor that is of particular concern for the project is the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor (refer Figure 2.1). This corridor is not completely vegetated and uninterrupted physical or structural connectivity is not present between the Seven Mile Beach National Park and the Barren Grounds Nature Reserve. However, smaller patches of vegetation on agricultural land, roadside strips of vegetation, vegetated riparian areas, and scattered paddock trees combine to form a matrix of habitats. This allows for permeability of the landscape for a range of fauna species. As such, functional connectivity is still present within the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor for a range of more mobile species that are somewhat tolerant of disturbance and human presence.

The Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor is composed of smaller corridors that are important for biodiversity on a smaller subregional and local scale including the Toolijooa Ridge – Harley Hill corridor and the Broughton Creek corridor (refer Figure 2.1), both of which will be affected by the project to varying degrees.

In addition to the currently identified wildlife corridors affected by the project, the Southern Rivers Catchment Management Authority (CMA – now Local Land Services or LLS) has identified a broad wildlife corridor which is intended for revegetation. This proposed corridor is located between Broughton Creek Bridge No. 1 and just to the east of Tindalls Lane (refer Figure 2.1). This corridor is also recognised and mapped in the Illawarra Regional Environmental Plan No. 1 (a deemed State Environmental Planning Policy).

The project will affect wildlife corridors and as such mitigation is required to maintain habitat connectivity within the corridors.

2.2 Predicted impacts to the corridors

Habitat fragmentation per se relates to the physical dividing up of once continuous habitats into separate smaller ‘fragments’ (Fahrig 2002) and is a key driver of species loss (Fischer & Lindenmayer 2007). The habitat fragments created by fragmentation tend to be smaller and separated from each other by a matrix of less suitable habitat. The dividing habitat type between fragments is often artificial (i.e. an open farm paddock, roadway or housing) and somewhat less suitable to species remaining within the fragments (Bennett 1990, 1993; Lindenmayer & Fischer 2006; MacNally 1999). Isolation refers to the distance between habitat patches. Habitat patches situated amidst what seems to be an inhospitable landscape have traditionally been considered as ‘islands’ (Knaapen et al. 1992), but we now understand that this theory has limited value in fragmented terrestrial landscapes as land with limited vegetation does not always serve as an impervious barrier to species movement (Kupfer et al. 2006; Prugh et al. 2008). Landscapes should be viewed as functional ecosystems that contain a mix of native vegetation and other components (Fischer et al. 2006; Tscharntke et al. 2012).
Figure 2.1 Location of affected wildlife corridors (Biosis Research 2012).
Indeed, this is recognised in the allocation of the proposed wildlife corridor identified and mapped in the Illawarra Regional Environmental Plan No. 1. While highways are not a completely impervious barrier to fauna movement, they do represent a considerable obstacle to fauna movement and are generally inhospitable as habitat for a range of species.

Road construction is known to contribute to habitat fragmentation and isolation due to the linear nature of roads. Field studies suggest that roads can introduce barriers that cut off gene flow between populations by dividing animal populations into fractions on either side of the road (Mader 1984). In the worst case scenario, this situation may occur in the wildlife corridors affected by the project. However, the project is unlikely to result in a large increase to landscape scale fragmentation in the region or locality. The landscape in which the project is situated is already highly fragmented with most vegetation occurring as small fragments in an agricultural setting. Furthermore, the project does not cut through large areas of continuous habitat and will therefore not break apart previously undisturbed habitat patches that contain large populations of species. Contribution of the project to isolation of habitat patches will also be small in terms of the existing distance between habitat patches in the region. Distance between habitat patches will not be increased substantially by the project and the matrix of habitats in the region and locality will remain intact and suitable for the range of fauna species that use the habitats currently.

While a large landscape scale impact is not expected, impacts to local habitat connectivity present along creek lines and roadsides would be the greatest impact from the project. The project will introduce a wider and additional barrier on the Toolijooa Ridge which may affect fauna movements. The project will introduce three new permanent bridge crossings of Broughton Creek, and single bridge crossings of Broughton Mill Creek and Bundewallah Creek. Four temporary bridge crossing structures at Broughton Creek No. 1, 2, 3, and Broughton Mill Creek, will also likely be built for construction access. These creek crossings will result in some local scale fragmentation of vegetated riparian corridors. This small scale localised fragmentation may adversely affect the dispersal of relatively sedentary species such as small mammals, frogs, and reptiles which can lead to crowding effects and increased competition within habitat patches. Larger wide ranging and more mobile species are less likely to be adversely affected. It is those common species that are likely to be present and may suffer from local fragmentation that should be the focus of the mitigation strategy.

### 2.3 Mitigation — Approved EA Design

Mitigation measures will be implemented as part of the Project to maintain connectivity of fauna habitat. The Approved EA Design mitigation measures included dedicated and combined (or dual use) fauna crossing structures. These included “underpasses”, which consist of culverts, bridges and rope crossings and “overpasses” which include rope crossings. The location of fauna crossing structures in the Approved EA Design are illustrated in Figure 2.2.

The aim of these measures was to maintain fauna movements and allow access to habitat located on either side of the project. The permanent fauna exclusion fencing, fauna crossing structures and revegetation corridors locations were selected to achieve the greatest possible connectivity results based on the existing fauna habitat usage, fauna movements and design constraints (Figure 2.2). These connectivity mitigation measures are summarised below.

#### 2.3.1 Fauna underpasses

The Approved EA Design made provision that dedicated and combined underpasses would be constructed to maintain fauna movement and linkages between existing habitats. The design of the fauna underpasses provided in the Terrestrial Flora and Fauna Assessment (Biosis Research 2012) for the project indicates that four box culverts would be provided to serve as fauna underpasses. Two of the culverts would be dedicated to fauna movement only and two would serve as dual drainage and fauna movement. Fauna ‘furniture’ such as raised log railings and refuge poles would also be implemented within the dedicated dry passage part of the culverts to increase habitat.
The four new highway bridges would also act as fauna underpasses. These bridges included three bridges along Broughton Creek and one bridge at Berry, as illustrated in Figure 2.2 spanning both Bundewallah and Broughton Mill Creeks.

Some of the rope bridges were designed to pass underneath the new highway bridges and for the purposes of this report these have been classified as underpasses, while rope bridges located over and adjacent to the highway have been classified as overpasses. A total of five rope bridges have been designed to pass underneath the highway as outlined below in Table 2.1.

The species that the culverts and bridges were targeted to provide connectivity for, included Threatened species such as the Spotted-tailed Quoll, Long-nosed Potoroo, Bush Stone-curlew, and Koala, and more common species including the Brown Antechinus, Bush Rat, Eastern Grey Kangaroo, Swamp Wallaby, Short-beaked Echidna, and Common Wombat. The species that the rope bridges were targeted for, included, Threatened arboreal mammal species including the Yellow-bellied Glider, and more common arboreal species including the Sugar Glider, Feathertail Glider, Common Brushtail Possum, and Common Ringtail Possum.

The location of the fauna underpasses in the Approved EA Design are provided in Table 2.1 and illustrated in Figure 2.2.

Table 2.1 Locations of recommended fauna underpasses in the Approved EA Design

<table>
<thead>
<tr>
<th>Chainage</th>
<th>Location</th>
<th>Map location</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8450</td>
<td>Toolijooa Ridge</td>
<td>1</td>
<td>Dedicated fauna underpass box culvertcox culvert&lt;br&gt; Fauna furniture, fauna fencing</td>
</tr>
<tr>
<td>9990</td>
<td>Broughton Creek bridge No. 1</td>
<td>4</td>
<td>One connecting rope bridge under new bridge</td>
</tr>
<tr>
<td>9950</td>
<td>Broughton Creek crossing No. 1</td>
<td>3</td>
<td>Bridge (underpass)&lt;br&gt; Scattered hollow logs, supplementary metal pipe tunnels</td>
</tr>
<tr>
<td>10700</td>
<td>Broughton Creek bridge No. 2</td>
<td>6</td>
<td>One rope bridge under new bridge</td>
</tr>
<tr>
<td>10700</td>
<td>Broughton Creek crossing No. 2</td>
<td>5</td>
<td>Bridge (underpass)&lt;br&gt; Scattered hollow logs, supplementary metal pipe tunnels</td>
</tr>
<tr>
<td>11200</td>
<td>Broughton Creek crossing No. 3</td>
<td>7</td>
<td>Bridge (underpass)&lt;br&gt; Scattered hollow logs, supplementary metal pipe tunnels</td>
</tr>
<tr>
<td>11200</td>
<td>Broughton Creek bridge No. 3</td>
<td>9 &amp; 10</td>
<td>Two rope bridges under new bridge</td>
</tr>
<tr>
<td>12770</td>
<td>Princes Highway Western end of the Austral Park Road extension (1,200 m east of Tindalls Lane)</td>
<td>11</td>
<td>Dual use box culvert (one side raised and dry for dedicated fauna passage)&lt;br&gt; Fauna furniture, fauna fencing</td>
</tr>
<tr>
<td>13320</td>
<td>Princes Highway 600 m east of Tindalls Lane</td>
<td>12</td>
<td>Dual use box culvert (one side raised and dry for dedicated fauna passage)&lt;br&gt; Fauna furniture, fauna fencing</td>
</tr>
<tr>
<td>13680</td>
<td>Princes Highway 300 m east of Tindalls Lane</td>
<td>14</td>
<td>Dedicated fauna underpass box culvert&lt;br&gt; Fauna furniture, fauna fencing</td>
</tr>
<tr>
<td>15900</td>
<td>Broughton Mill Creek bridge</td>
<td>17</td>
<td>One rope bridge under new bridge at Broughton Mill Creek</td>
</tr>
<tr>
<td>16250</td>
<td>Bundawallah Creek (Connollys Creek)</td>
<td>18 &amp; 19</td>
<td>Two rope bridges (2 under new bridge at Berry)</td>
</tr>
<tr>
<td>Chainage</td>
<td>Location</td>
<td>Map location</td>
<td>Type</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------</td>
<td>--------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 16000    | Bridge at Berry         | 16           | Bridge (underpass) over Broughton Mill Creek and Bundewallah Creek (Connollys Creek)  
|          |                         |              | Scattered hollow logs, supplementary metal pipe tunnels               |
|          |                         |              | Fauna fencing (western end of bridge, northern side of bridge only)   |
Figure 2.2  Approved EA Design fauna crossing structure locations
Figure 2.2 Approved EA Design fauna crossing structure locations
Figure 2.2 Approved EA Design fauna crossing structure locations

Legend
- Watercourse
- Approved EA road design
- Water body
- Rope bridge adjacent to bridge
- Rope bridge over road
- Fauna fencing
- Rope bridge under bridge
- Dedicated fauna underpass
- Rope bridge over and under bridge
- Bridge (underpass)
- Dual use underpass

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Figure 2.2  Approved EA Design fauna crossing structure locations
Figure 2.2  Approved EA Design fauna crossing structure locations
Figure 2.2  Approved EA Design fauna crossing structure locations

Legend

- Watercourse
- Approved EA road design
- Water body
- Roads
- Crossing location number
- Rope bridge over road
- Rope bridge under bridge
- Rope bridge over and under bridge
- Dedicated fauna underpass
- Bridge (underpass)
- Fauna fencing
- North Street
- Rawlings Lane
- Bundewallah Creek
- Kangaroo Valley Road
- Queen Street
- Edward Street
- Albany Street
- Alexandra Street
- Princes Highway
- Connollys Creek
- Prince Alfred Street
- BERRY
- FOXGROUND

OVERVIEW MAP
2.3.2 Fauna overpasses

The Approved EA Design allowed for rope bridges for arboreal fauna species at all creek crossings. The rope bridges were designed to cross the project over the highway. The Approved EA Design indicates that fauna overpasses would be provided at six locations (refer Table 2.2 and Figure 2.2). In some instances, there was duplication of crossing structures with overpasses and underpasses at the same crossing point.

The species that the fauna overpasses were targeted for, included, Threatened arboreal mammal species including the Yellow-bellied Glider, and more common arboreal species including the Sugar Glider, Feathertail Glider, Common Brushtail Possum, and Common Ringtail Possum.

Table 2.2 Locations of recommended fauna overpasses in the Approved EA Design

<table>
<thead>
<tr>
<th>Chainage</th>
<th>Location</th>
<th>Map location</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8500</td>
<td>Toolijooa Ridge</td>
<td>2</td>
<td>Minimum of three connecting rope bridges (one over existing highway, one over new highway, at least one on south-western side of new highway to nearby stand of vegetation)</td>
</tr>
<tr>
<td>9990</td>
<td>Broughton Creek bridge No. 1</td>
<td>4</td>
<td>Two rope bridges (one over existing highway, one over new bridge)</td>
</tr>
<tr>
<td>10700</td>
<td>Broughton Creek bridge No. 2</td>
<td>6</td>
<td>One rope bridge over new bridge</td>
</tr>
<tr>
<td>11200</td>
<td>Broughton Creek bridge No. 3</td>
<td>8</td>
<td>One rope bridges adjacent to new bridge crossing creek</td>
</tr>
<tr>
<td>13360</td>
<td>Princes Highway about 600 m east of Tindalls Lane</td>
<td>13</td>
<td>One rope bridge over new highway</td>
</tr>
<tr>
<td>13700</td>
<td>Princes highway about 300 m east of Tindalls Lane</td>
<td>15</td>
<td>Minimum of two connecting rope bridges (one over new highway and at least one on northern side of new highway to vegetation)</td>
</tr>
</tbody>
</table>
3. Analysis of the Approved EA Design

Successfully mitigating and managing the predicted environmental impacts of a development or activity is one of the most important parts of the impact assessment process. When mitigation measures are carefully designed and appropriate for ameliorating impacts, environmental degradation can be reduced and/or avoided (Marshall 2001).

A major criticism levelled at ecological mitigation is that the measures posed in an impact assessment document often do not give any indication as to their potential effectiveness or feasibility. The reader of the document is often left to wonder whether certain mitigation measures are effective or not and whether the proposed measures are technically possible, operationally possible, and economically viable. To be effective, mitigation measures should be easily transferrable into practice.

A review of the Approved EA Design is provided below to determine the likely effectiveness of the structures for the target species. This review considers whether any refinements or changes to the fauna crossings in the Approved EA Design are warranted for further consideration.

3.1 Best practice mitigation

Roads present a significant barrier to the movement of fauna, disrupting movement patterns ranging from everyday foraging patterns to migration and dispersal movements. This in turn can have a significant impact on population dynamics and long-term viability of local populations. This is in addition to the direct impacts that roads can have on fauna mortality. A number of mitigation measures have been developed and trialled to minimise the impacts of roads on fauna connectivity and mortality, including:

- modifying driver behaviour – e.g. installing road signs warning about wildlife
- modifying the behaviour of the animals – e.g. installing permanent fauna exclusion fencing or landscaping roadside verges
- providing connectivity – e.g. fauna underpasses or rope bridges
- providing escape structures – e.g. Koala netting on concrete median barriers.

While many of these mitigation measures have been demonstrated to be effective, their use will depend on the local environment, the nature of the road and the species of interest.

The Foxground and Berry bypass environment is one of a fragmented rural landscape and therefore requires specific design of the appropriate fauna overpasses and underpasses. Many factors work together to influence the selection of a particular mitigation measure. Adopted standards, legal requirements, public and agency concerns, operational guarantees, and technical restrictions are perhaps the most important. To be successful any mitigation measure must (Marshall 2001):

- directly avoid, reduce or remediate the impact (it is specific)
- work, be technically achievable with available resources, be implemented in a timely manner, and be cost effective (it is feasible)
- resolve issues and minimise controversy (it reduces the significance of the impact)
- achieve the objective of avoiding, reducing or remediying significant adverse effects (it is effective)
be free of controversy to avoid public or political opposition and supported by current scientific evidence (it conforms).

In terms of the criteria listed above, fauna crossing structures are an appropriate choice in this instance to mitigate the impacts to wildlife corridors caused by the project.

Importantly, fauna crossing structures are specific to the target species, they are feasible to construct, the chosen crossing structure types are known to be effective at re-establishing connectivity between habitat patches (see discussion below), and are based on robust scientific evidence.

3.2 Crossing structure types

Two types of fauna crossing structures have been used in the Approved EA Design to mitigate impacts that might be caused by the project: underpasses in the form of culverts and bridges (sometimes with rope bridges underneath), and overpasses in the form of rope bridges. Considering the fauna species that are known to be present within the locality, the crossing structure types chosen as mitigation for the project are generally considered to be appropriate.

There is a growing body of scientific literature supporting the effectiveness of underpasses and overpasses as mitigation measures for road projects. Underpasses (in the form of culverts and bridges) have been shown to be effective mitigation in maintaining habitat connectivity for a range of species and species-groups particularly rodents (Bond & Jones 2008; Hayes & Goldenay 2009) and bandicoots (Hayes & Goldenay 2009; Taylor & Goldenay 2014). However, macropods (e.g. kangaroos and wallabies) have been shown to be more frequent users of overpasses (in this case land bridges) rather than underpasses (in the form of culverts and bridges) (Hayes & Goldenay 2009). Underpasses (in the form of culverts and bridges) are also known to be used by Echidna, Koalas, lizards and birds (Taylor & Goldenay 2003).

The size of an underpass (in the form of culverts and bridges) is an important consideration and large underpasses have been shown to provide crossing opportunities for the greatest number of species, although small animals often show preference for small underpasses, presumably for security from predation (Glista et al. 2009). The size of the underpasses designed for the project should be sufficient to allow movement of all target fauna groups.

Road-crossing structures such as rope bridges have been shown to be the most plausible means available to link remnants to enable inter-patch movement for gliders where there is inadequate road-side tree height (Taylor & Goldenay 2012). This is important for the project due to limited tree height adjacent to the new highway. Native arboreal mammals including gliders and possums have been seen to utilise rope bridges installed across highways (Goldenay et al. 2013; Soanes et al. 2013) and the rope bridges should be appropriate to maintain functional habitat connectivity for gliders and other arboreal mammals in the locality.

The species that the fauna underpasses (in the form of culverts and bridges) are targeted at include Threatened species including the Spotted-tailed Quoll, Long-nosed Potoroo, Bush Stone-curlew, and Koala, and more common species including the Brown Antechinus, Bush Rat, Eastern Grey Kangaroo, Swamp Wallaby, Short-beaked Echidna, and Common Wombat. Such underpasses are known to be effective for common species of small mammals, macropods, Echidna and wombats and these are the species that are most likely to use the underpasses. If present in the area, Threatened species including the Spotted-tailed Quoll, Long-nosed Potoroo, Bush Stone-curlew, and Koala may also utilise the underpasses where they are present. The underpasses (i.e. the culverts and bridges) should be appropriate to maintain a level of functional habitat connectivity for the target species and other species that may utilise the habitats.

The species that the fauna overpasses are targeted at include Threatened species including the Yellow-bellied Glider, and more common arboreal species including the Sugar Glider, Common Brushtail Possum, and Common Ringtail Possum. Rope bridges have been shown to be successful in establishing functional connectivity for arboreal mammals and are considered more appropriate in this instance for the Yellow-
bellied Glider than glider poles due to the low height of canopy trees adjacent to the roadway. The species expected to make use of the rope bridges are the Sugar Glider, Common Brushtail Possum, and Common Ringtail Possum as these species are more likely to be present in the roadside habitats. There is some level of duplication with rope bridges proposed under and over the highway at the same locations. The rope bridges over or under the highway alone are considered to be effective for providing functional habitat connectivity for arboreal mammals and duplication of crossing structures at the same location is unnecessary to achieve the outcome of habitat connectivity for arboreal fauna species.

3.3 Location of crossing structures

An obvious requirement for locating fauna crossing structures is that suitable habitat for the target species needs to be present on both sides of the road for wildlife to cross. Regardless of any other factor, a crossing structure will be of little value as a wildlife corridor if it does not connect suitable habitats (Ng et al. 2004). Ideal crossing structure characteristics will be species-specific and results of studies imply that wildlife corridors need to offer sufficient cover and be placed a frequency that corresponds to the spatial scale over which the targeted species move (McDonald & St Clair 2004). Distance to cover is another feature that will differentially affect crossing structure use by various species based on their habitat preferences (McDonald & St Clair 2004). Macropods may utilise crossing structures in open areas away from forest cover due to their preference for foraging in open grassed areas. Smaller ground dwelling mammals and arboreal mammals may only use crossing structures if sufficient vegetation cover is present.

The location of crossing structures has been largely determined based on where the project will affect habitat connectivity. This can be seen in the placement of fauna crossing structures at vegetated riparian zones (i.e. Broughton Creek, Broughton Mill Creek and Bundawallah Creek) and in the most vegetated areas near Tindalls Lane. The culverts near Tindalls Lane were placed in consultation with the Southern Rivers CMA and Berry Landcare to help achieve their long term goal of restoring the ‘escarpment to sea’ corridor.

The general locations of the fauna overpasses are appropriate and will help to reduce the impacts of the project on wildlife corridors. The crossing structures connect patches of vegetation and as such should maintain a level of functional connectivity for arboreal fauna. However, care must be taken to ensure that all crossing structures physically join two patches of vegetation and that vegetation is connected to continuous vegetation (where possible).

3.4 Initial modification considerations

The frequency of crossing structures is considered more than adequate for the number of corridors and level of vegetation cover in the locality, particularly given the site is in a highly modified landscape. The following fauna crossing locations have been initially identified for further consideration of modification, due to individual circumstances that might lead to those crossings not performing effectively to facilitate the crossing of targeted species. Such circumstances primarily related to more detailed design information becoming available post-approval, which may have rendered some proposed crossing locations unpractical. Note the map locations are provided on Figure 2.2.

1. Dedicated fauna underpass at chainage 8450 (map location 1)
2. Joined rope bridges on Toolijooa Ridge at chainage 8500 (map location 2)
3. Rope bridges at chainage 9990 (map location 4)
4. Rope bridges at chainage 10700 (map location 6)
5. Rope bridges at chainage 11200 (map locations 8, 9 & 10)
6. Dual use box culvert at chainage 12770 (map location 11)
7. Rope bridge at chainage 13360 (map location 13)
8. Rope bridges at chainage 13700 (map location 15)
9. Rope bridge at chainage 15900 (map location 17)
10. Rope bridges at chainage 16250 (map locations 18 & 19).

While, the above locations have been focussed on as part of this report, all crossings have been checked to ensure functional outcomes occur in the post-construction environment.
4. Final Design Analysis

4.1 Justification and impacts to biodiversity outcomes

Modification of the fauna crossing structures is needed to ensure that the structure locations and designs are practical and functional and ensure habitat connectivity persists in the long term. The final designs of the fauna crossing structures at each chainage are discussed below in terms of acceptable biodiversity outcomes. Only those where proposed changes are to be made have been discussed below. The summary table in Section 4.2 provides a summary of all final crossing locations and designs. Locations of the Approved EA Design compared to the proposed final locations and designs are shown in Figure 4.1.

4.1.1 Chainage 8450 – Location 1

Proposed change

Delete the dedicated fauna underpass and associated permanent exclusion fencing. Replace with combined fauna passage at chainage 9480 (Map location 1A) and permanent exclusion fencing. The combined fauna passage will be 4m wide x 4.6m high.

Justification

Suitable habitat for the target species needs to be present on both sides of the road for wildlife to cross and this underpass will likely be of little value as a functioning mitigation for impacts to the wildlife corridor as it does not connect suitable habitats. This underpass at chainage 8450 is not located appropriately as it effectively connects two roadways instead of two patches of fauna habitat. Furthermore, the entry and exit points of this underpass will be completely exposed which will further limit the effectiveness of this underpass for species such as small mammals which prefer to move under vegetative cover to avoid predation risk. While the risk of road kill on the proposed local access road and the old Princes Highway will be significantly reduced due to low volume of traffic, the risk is still present and if animals do use the underpass they will be funnelled from one roadway onto another which creates a risk for animals and motorists. While some form of connectivity is better than none, the location and/or design of this underpass should be revised so that the underpass connects two areas of fauna habitat rather than two roadways.

The dedicated fauna underpass in the vicinity of Toolijooa Ridge is appropriate in principle, but the current location of the underpass (Map location 1) represents a potential hazard to both motorists and fauna on the existing Princes Highway. The Approved EA Design would funnel fauna directly onto the existing Princes Highway to the south and fauna would need to cross the Princes Highway to gain access to the underpass from the north. It is recommended to delete the dedicated fauna underpass and fauna exclusion fencing from this location, and relocate the crossing.

Prior to removing the fauna underpass at chainage 8450 and instead providing fauna passage at chainage 9480 (1030m away), several other options closer to chainage 8450 were investigated. However, these were not pursued due to terrain constraints. More specifically, the large cutting between Toolijooa ridge and chainage 9480 precludes the installation of a fauna underpass.

As constrained terrain prohibits relocation of the underpass in this specific area, Parsons Brinckerhoff determined that it was appropriate to delete the approved EA dedicated fauna underpass, and associated fauna exclusion fencing, and relocate fauna exclusion fencing to the property access underpass at chainage 9480 (Map location 1A) so that fauna will be encouraged to cross the new highway in a location safer for motorists and fauna alike.
Following evaluation of the options at several chainages, with the input of the Ecologist, it was determined that providing fauna passage at chainage 9480 was the most appropriate option considering the abovementioned constraints in terms of: fauna safety; motorist safety; and terrain.

Fauna exclusion fencing is proposed at the same location to strategically direct fauna crossing to a location that is safer for motorists and fauna. Traffic use of the combined fauna passage is expected to be infrequent as this road will only provide access to two dwellings, thereby reducing likely conflicts between fauna and traffic.

**Expected impact on biodiversity outcomes**

The constraining terrain means that there are no other suitable alternative in the locality for a dedicated fauna underpass. It is expected that the proposed revised combined underpass scenario will still provide good connectivity for ground fauna in the locality, particularly for the target species. There may be a slight increase in conflict due to a low-use road being present; however it is considered that the potential for conflict is low, due to likely minimal traffic use of the crossing.

### 4.1.2 Chainage 8500 – Location 2

**Proposed change**

Realign the three proposed connecting rope bridges

**Justification**

The design (joined rope bridges) on Toolijooa Ridge at chainage 8500 (Map location 2) extends to vegetation on the southern side of the new highway that will be removed for construction of the local property access road and highway road cuttings. In addition, further clearing may occur in the future for residential development at chainage 8550, thereby increasing distance between habitat patches. The rope bridge at chainage 8500 therefore requires modification so that it extends to an isolated island of vegetation to the east of the Approved EA Design location. The distance between habitat patches will not be increased substantially by this modification, in light of the reduced practical functionality of the original rope bridge provided in the Approved EA Design.

**Expected impact on biodiversity outcomes**

Realigning the rope bridge will result in the same biodiversity outcomes as the Approved EA Design as no change to connectivity would occur from this modification. The moving of the rope bridge due to the removal of vegetation in the rope bridge's Approved EA Design location as a consequence of project design constraints is supported. The new location of the rope bridge to the east of the original position is also supported, because it will achieve the same connectivity within the project boundary at the Approved EA Design.

### 4.1.3 Chainage 9990 – Location 4

**Proposed change**

Retain the rope bridges over the existing highway and under Broughton Creek bridge No. 1. Delete the rope bridge over Broughton Creek bridge No. 1.

**Justification**

The rope bridge over the Broughton Creek bridge No. 1 duplicates the connectivity provided by the other two proposed rope bridges.
Expected impact on biodiversity outcomes

Deletion of the rope bridge over the new Broughton Creek bridge No. 1 (Map location 4) should not result in any appreciable effects on habitat connectivity in these areas as one rope bridge crossing the highway at this site will be retained. The single rope bridge crossing the highway should be sufficient to retain functional habitat connectivity for arboreal fauna (including gliders) and the rope bridge under the bridge (3.0m high), will provide a level of protection from predation that would be absent without rope bridges crossing the highway. These changes will result in acceptable biodiversity outcomes. While gliders and possums do display a reluctance to come to the ground and do not regularly use underpasses that lack attractive features (Abson & Lawrence 2003) the rope bridge to be provided under the new bridge at Broughton Creek No. 1 is quite different to an underpass such as a culvert. Importantly, the scientific literature shows that gliders and possums will use rope bridges under highways. A study of rope crossings under bridges over creek lines on the Pacific Highway indicated that these structures will be used by a diverse group of arboreal mammal species including Sugar Glider Feathertail Glider, Common Ringtail Possum, and the Common Brushtail Possum (Goldingay et al. 2013).

4.1.4 Chainage 10700 – Location 6

Proposed change

Retain the rope bridge under Broughton Creek bridge No. 2, plus add an intermediate pole to ensure practical height as advised by OEH. Delete the rope bridge over Broughton Creek bridge No. 2

Justification

The rope bridge over the Broughton Creek bridge No. 2 duplicates the connectivity provided by the other proposed rope bridge.

An intermediate pole will be provided under Broughton Creek bridge No. 2 to provide a minimum rope bridge height of approximately 2.5m, an increase from the original proposed height of 1.7m.

Expected impact on biodiversity outcomes

Only one rope bridge across the new highway is required for fauna connectivity, Parsons Brinckerhoff supports the removal of the rope bridge (over) at this location. The change should not result in any appreciable effects on habitat connectivity in these areas as one rope bridge crossing the highway at this site will be retained. The single rope bridge crossing the highway should be sufficient to retain functional habitat connectivity for arboreal fauna (including gliders) and the rope bridge under the bridge, will provide a level of protection from predation that would be absent without rope bridges crossing the highway. This change will result in acceptable biodiversity outcomes.

4.1.5 Chainage 11200 – Locations 8, 9 & 10

Proposed change

Realign three rope bridges.

Justification

Rope bridges being retained, just realigned to avoid clash with new bridge piers.

Expected impact on biodiversity outcomes

No change is expected as same ecological function will be retained.
4.1.6 Chainage 12770 – Location 11

Proposed change

Replace dual use fauna crossing structure with a combined bridge structure at chainage 12815.

Justification

Detailed design outcomes means that in this location, a small bridge crossing is preferred by Fulton Hogan.

Expected impact on biodiversity outcomes

The proposed combined bridge and removal of the proposed dual use box culvert underpass at chainage 12770 (Map location 11) will result in a benefit to habitat connectivity in the area and acceptable biodiversity outcomes. The bridge will allow for greater fauna movement under a larger area of road than the original culvert underpass. This design change will be beneficial for habitat connectivity. The proposed bridge is designed to integrate with permanent fauna exclusion fencing associated with this section of the road, so that fauna are encouraged to cross the new highway in a safe location. This change will result in acceptable biodiversity outcomes.

4.1.7 Chainage 13360 – Location 13

Proposed change

Relocate single rope bridge in the same vicinity.

Justification

Better alignment with remnant vegetation than original design.

Expected impact on biodiversity outcomes

At chainage 13360 (Map location 13) there is a modified rope bridge over the new highway. This is supported in principle, although there is a paucity of vegetation connectivity on the southern end of the rope bridge. Vegetation on the southern side of the new highway is currently reduced to a linear strip by the Princes Highway and is surrounded by open country, which does not represent part of a corridor for arboreal mammals. Although both the Approved EA Design and the Final Design will adequately maintain connectivity within the project boundary, pre-project connectivity was not significant and neither design will increase connectivity beyond the boundary of the project.

4.1.8 Chainage 13700 – Location 15

Proposed change

Delete northern rope bridge.

Justification

Similar functional design with a single rope bridge to ensure rope bridge anchor block footings remain within the project boundary and avoid clash with the eastern gas pipeline and associated easement.
Expected impact on biodiversity outcomes

This will not diminish the rope bridge functionality significantly. A reduction in the length of the rope bridge at its northern end to avoid the eastern gas pipeline and associated easement is not considered likely to diminish the integrity of the connectivity facilitated by the rope bridge at this location.

4.1.9 Chainage 15900 – Location 17

Proposed change

Replace single rope bridge with two rope bridges.

Justification

Two rope bridges provided to avoid bridge piers and for better alignment with riparian vegetation.

Expected impact on biodiversity outcomes

This will allow for improved biodiversity outcomes for fauna traversing the corridor associated with Broughton Mill Creek as greater clearance away from bridge piers will be provided.

4.1.10 Chainage 16250 - Locations 18 & 19

Proposed change

Delete western rope bridge under the new Berry bridge.

Justification

Two rope bridges under the new bridge are not required – a single rope bridge is sufficient. This was suggested on page F-67 in the Terrestrial Flora and Fauna Assessment (Biosis Research 2012).

Expected impact on biodiversity outcomes

Parsons Brinckerhoff supports the deletion of the western most rope bridge associated with the Berry Bridge crossing of Bundewallah Creek (Map location 19). Vegetation occurring along Bundewallah and Connollys Creek, which joins Bundewallah Creek to the north of the proposed bridge is continuous and represents a corridor for arboreal fauna movements that would be broken by the new highway. Therefore provision of a rope bridge is considered important for the continuation of fauna passage along the corridors represented by vegetation along both of these creeks. The reduction of two rope bridges to a single rope bridge associated with Bundewallah Creek (Map location 18), as suggested on page F-67 in the Terrestrial Flora and Fauna Assessment (Biosis Research 2012), will be sufficient as only one bridge will be required to provide movements for local fauna. This change will result in acceptable biodiversity outcomes as functional connectivity will be maintained along Bundewallah Creek.
4.2 Design detail and rationale summary

While retaining most of the original design from the Approved EA Design, several modifications to crossing locations and design are proposed. Such changes have been proposed due to issues associated with implementing the crossings in the Approved EA Design as a result of updated detailed design understanding. This new design information has meant that in some cases the recommended locations of crossings, or crossing structure type, are not practical. In other cases, terrain constraints and issues such as crossing duplication have arisen, as outlined in Section 4.1.

Parsons Brinckerhoff has worked with Fulton Hogan to review all crossing structures in order to provide an ecological evaluation of the entire final fauna crossing strategy for the project. This does not consider any other mitigation measures that might be implemented for the project; it focuses purely on the fauna crossings, including permanent fauna exclusion fencing measures only.

For ease of reference, the changes to the Approved EA Design are outlined in Table 4.1 below, including cross-reference to revised crossing locations provided in Figure 4.1. It is noted that the changes to the Approved EA Design (addition/deletion/realignment etc.) result in the Final Design. A detailed set of design figures showing the Final Design is provided in Appendix A.
Table 4.1 Comparison of Approved EA Design with the Final Design

<table>
<thead>
<tr>
<th>Chainage and location in Approved EA Design</th>
<th>Map location</th>
<th>Approved EA Design</th>
<th>Changes to the Approved EA Design</th>
<th>Will the new location and/or design result in acceptable biodiversity outcomes?</th>
</tr>
</thead>
<tbody>
<tr>
<td>8450 Toolijooa Ridge</td>
<td>1</td>
<td>Dedicated fauna underpass box culvert Fauna furniture, fauna fencing</td>
<td>Deletion of dedicated fauna underpass and associated permanent fauna exclusion fencing Provision of combined fauna passage through the property access underpass at chainage 9480 Provision of permanent fauna exclusion fencing to the property access underpass at chainage 9480 (Map location 1A)</td>
<td>Yes</td>
</tr>
<tr>
<td>8500 Toolijooa Ridge</td>
<td>2</td>
<td>Minimum of three connecting rope bridges (one over existing highway, one over new highway, at least one on south-western side of new highway to nearby stand of vegetation)</td>
<td>Realignment of the 3 connecting rope bridges</td>
<td>Yes</td>
</tr>
<tr>
<td>9950 Broughton Creek bridge No. 1</td>
<td>3</td>
<td>Bridge (underpass) Scattered hollow logs, supplementary metal pipe tunnels</td>
<td>No deviation from Approved EA Design</td>
<td>Not applicable</td>
</tr>
<tr>
<td>9990 Broughton Creek bridge No. 1</td>
<td>4</td>
<td>Three connecting rope bridges (one over existing highway, one over new bridge, and one under new bridge)</td>
<td>Deletion of the rope bridge over new bridge</td>
<td>Yes</td>
</tr>
<tr>
<td>10700 Broughton Creek bridge crossing No. 2</td>
<td>5</td>
<td>Bridge (underpass) Scattered hollow logs, supplementary metal pipe tunnels</td>
<td>No deviation from Approved EA Design</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Chainage and location in Approved EA Design</td>
<td>Map location</td>
<td>Approved EA Design</td>
<td>Changes to the Approved EA Design</td>
<td>Will the new location and/or design result in acceptable biodiversity outcomes?</td>
</tr>
<tr>
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</tr>
<tr>
<td>10700 Broughton Creek bridge No. 2</td>
<td>6</td>
<td>Two rope bridges (one over new bridge and one under new bridge)</td>
<td>Deletion of the rope bridge over new bridge</td>
<td>Yes</td>
</tr>
<tr>
<td>11200 Broughton Creek crossing No. 3</td>
<td>7</td>
<td>Bridge (underpass) Scattered hollow logs, supplementary metal pipe tunnels</td>
<td>No deviation from Approved EA Design</td>
<td>Not applicable</td>
</tr>
<tr>
<td>11200 Broughton Creek bridge No. 3</td>
<td>8, 9, &amp; 10</td>
<td>Three rope bridges: two under new bridge (one to each side of creek – Map location 9 &amp; 10); and one adjacent to new bridge crossing the creek (Map location 8)</td>
<td>Realignment of rope bridges</td>
<td>Yes</td>
</tr>
<tr>
<td>12770 Princes Highway Western end of the Austral Park Road extension (1,200 m east of Tindalls Lane)</td>
<td>11</td>
<td>Dual use box culvert underpass (one side raised and dry for dedicated fauna passage) Fauna furniture, fauna fencing</td>
<td>Deletion of dual use box culvert underpass Provision of combined bridge at chainage 12815</td>
<td>Yes</td>
</tr>
<tr>
<td>13320 Princes Highway 600 m east of Tindalls Lane</td>
<td>12</td>
<td>Dual use box culvert (one side raised and dry for dedicated fauna passage) Fauna furniture, fauna fencing</td>
<td>No deviation from Approved EA Design</td>
<td>Not applicable</td>
</tr>
<tr>
<td>13360 Princes Highway 600 m east of Tindalls Lane</td>
<td>13</td>
<td>One rope bridge over new highway</td>
<td>Relocation of single rope bridge in the same vicinity</td>
<td>Yes</td>
</tr>
<tr>
<td>13680 Princes Highway 300 m east of Tindalls Lane</td>
<td>14</td>
<td>Dedicated fauna underpass Fauna furniture, fauna fencing</td>
<td>No deviation from Approved EA Design</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Chainage and location in Approved EA Design</td>
<td>Map location</td>
<td>Approved EA Design</td>
<td>Changes to the Approved EA Design</td>
<td>Will the new location and/or design result in acceptable biodiversity outcomes?</td>
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<tr>
<td>13700 Princes Highway about 300 m east of Tindalls Lane</td>
<td>15</td>
<td>Minimum of two connecting rope bridges (one over new highway and at least one on northern side of new highway to vegetation)</td>
<td>Deletion of the northern rope bridge</td>
<td>Yes</td>
</tr>
<tr>
<td>15900 Broughton Mill Creek</td>
<td>17</td>
<td>One rope bridge under new bridge at Broughton Mill Creek Scattered hollow logs and metal pipe tunnels, fauna fencing</td>
<td>Replacement of single rope bridge with two rope bridges</td>
<td>Yes</td>
</tr>
<tr>
<td>16000 Bridge at Berry</td>
<td>16</td>
<td>Bridge (underpass) over Broughton Mill Creek and Bundewallah Creek (Connollys Creek) Scattered hollow logs, supplementary metal pipe tunnels Fauna fencing</td>
<td>No deviation from Approved EA Design</td>
<td>Not applicable</td>
</tr>
<tr>
<td>16250 Bundewallah Creek (Connollys Creek)</td>
<td>18 &amp; 19</td>
<td>Two rope bridges (two under new bridge — Map location 18 &amp; 19, Figure 2.2) at Bundewallah Creek scattered hollow logs and metal pipe tunnels, fauna fencing</td>
<td>Deletion of the western most rope bridge (Map location 19) under the new Berry bridge on the same side as the Berry Sporting Complex</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Figure 4.1 Final fauna crossing structures
Figure 4.1: Final fauna crossing structures
Figure 4.1 Final fauna crossing structures

Legend
- Approved EA road design
- Fulton Hogan Final Design
- Watercourse
- Rope bridge over road
- Rope bridge over and under bridge
- Rope bridge adjacent to bridge
- Water body
- Rope bridge under bridge
- Rope bridge adjacent to bridge
- Roads
- Dedicated fauna underpass
- Dual use underpass
- Fauna fencing
- Bridge (underpass)
- Crossing location number
5. Conclusions

A number of changes to fauna crossings have been proposed in the Final Design compared with the Approved EA Design. Some of the changes proposed, such as deletions of additional rope bridge provisions at Broughton Creek bridge number 1 and 2 and Bundewallah Creek and the combining of bridges and fauna underpasses near the Austral Park Road extension, are ecologically sound and maintain important linkages recognised and provisioned for in the Approved EA Design.

Parsons Brinkerhoff supports the fauna crossing infrastructure changes to the Approved EA Design, as proposed. The changes and adjustments are associated with project design constraints, safe offsets to existing infrastructure such as the eastern gas pipeline and existing main roads, or where underpasses could be incorporated with other project infrastructure, such as bridges. Although changes were applied as a consequence of necessity under these circumstances, the ecological integrity of the Approved EA Design was largely not diminished by the changes and the Final Design should realise relatively similar fauna connectivity in the locality when compared to that which currently exists pre-construction. In addition, OEH and DPI (Fisheries and Aquaculture) have been consulted and have accepted the proposed changes.
6. References

Abson, RN & Lawrence, RE 2003, *Monitoring the use of the Slaty Creek wildlife underpass, Calder Freeway, Black Forest, Macedon, Victoria, Australia*,


Mader, HJ 1984, 'Animal habitat isolation by roads and agricultural fields', *Biological Conservation*, vol. 29, no. 1, pp. 81-96.


Soanes, K, Lobo, MC, Vesk, PA, McCarthy, MA, Moore, JL & van der Ree, R 2013, 'Movement re-established but not restored: Inferring the effectiveness of road-crossing mitigation for a gliding mammal by monitoring use', *Biological Conservation*, vol. 159, no. 0, pp. 434-41.


Taylor, BD & Goldingay, RL 2012, 'Facilitated movement over major roads is required to minimise extinction risk in an urban metapopulation of a gliding mammal', *Wildlife Research*, vol. 39, no. 8, pp. 685-95.

Taylor, BD & Goldingay, RL 2014, 'Use of highway underpasses by bandicoots over a 7-year period that encompassed road widening', *Australian Mammalogy*, pp. -.


Appendix A

Final fauna crossing locations
NOT FOR CONSTRUCTION

FOXGROUND AND BERRY BYPASS
FAUNA CROSSINGS
SHEET 18

INFORMATION DOCUMENT
FBB-K-FAUNA_CROSSINGS_0118