# Koala Sensitive Road Design Plan

EPBC approval 2017/8090; Park Ridge, Queensland

Prepared for Pointcorp Heritage Park Pty Ltd
July 2024

8392 E

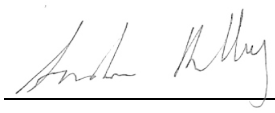
# Declaration of Accuracy

In making this declaration, I am aware that section 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth).

The offence is punishable on conviction by imprisonment or a fine, or both.

I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

An extract of section 491 of the EPBC Act is attached.

Signed: 

Full Name: Andrew Ridley

Organisation: Saunders Havill Group

Date: 17 July 2024

**491 Providing false or misleading information to authorised officer etc.**

(1) A person is guilty of an offence if the person:
  (a) provides information or a document to another person (the ***recipient***); and
  (b) knows the recipient is:
    (i) an authorised officer; or
    (ii) the Minister; or
    (iii) an employee or officer in the Department; or
    (iv) a commissioner;
  performing a duty or carrying out a function under this Act or the regulations; and
  (c) knows the information or document is false or misleading in a material particular.

(2) The offence is punishable on conviction by imprisonment for a term not more than 1 year, a fine not more than 60 penalty units, or both.

Note: Subsection 4B(3) of the *Crimes Act 1914* lets a court fine a body corporate up to 5 times the maximum amount the court could fine a person under this subsection.

# Document Control

Document: Koala Sensitive Road Design Plan for Park Ridge Residential Development, Clarke Road, Park Ridge, prepared by Saunders Havill Group for Pointcorp Heritage Park Pty Ltd.

## Document Issue

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Prepared by
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# Tables

# Reference Documents


TMR 2010 Queensland Department of Transport and Main Roads (2010), Fauna Sensitive Road Design Guidelines Volume 2 (TMR 2010)

DES 2020 Queensland Department of Environment and Science (2020), Koala Sensitive Design Guidelines Version 2 (DES, 2020).

# 1. Introduction

The below Koala Sensitive Road Design Plan (KSRDP) is submitted to the Minister for approval under Condition 3 C of the EPBC approval 2017/8090. The approved action is described as "To develop a residential, mixed use and medium impact industry precinct in Park Ridge, Queensland". A variation of conditions attached to the approval decision was made on 25 May 2022 to alter area of the third stage of clearing to the area now outlined in **Attachment A**. Clearing is yet to commence in stage 3, but design work has proceeded to a point that allows for the development of the KSRDP for approval by the Minister.

Condition 3C of the approval conditions state:

> c. Prior to commencing the **third stage of clearing,** submit for approval by the **Minister** a **Koala sensitive road design plan.** The **Koala sensitive road design plan** must detail the type and location of **safe fauna movement solutions,** traffic calming features and **Koala awareness signage** along roads adjacent to the **onsite conservation corridor,** along with justification for why this is sufficient to prevent **koala** death or injury from vehicle strike and to maintain habitat **connectivity** and wildlife movement opportunities along the **Logan Council Biodiversity Corridor.** The **Koala sensitive road design plan** must provide measures sufficient to prevent any Koala death or injury within the **development area** and along Green Road. The approval holder must not commence the **third stage of clearing** until the **Koala sensitive road design plan** has been approved by the **Minister** in writing. The approval holder must implement the approved **Koala sensitive road design plan.**

The retained onsite corridor passes along the northwest of the site and connects with Logan City Council Biodiversity Corridors to the north of Green Road and the southwest of the site. An additional vegetated corridor that is not part of the retained EPBC onsite corridor but is marked as recreation and open space on the Land Use Plan (**Attachment A**) will be retained along the waterway to the southeast of the EPBC corridor. A bund has been constructed across the waterway in the additional corridor to form a regional detention basin. This bund also provides access to the proposed residential area in stage 3.

## 1.1. Purpose of the Report

The purpose of this KSRDP is to provide details of the type and location of safe fauna movement solutions, traffic calming features and Koala awareness signage along with justification for why this is sufficient to prevent koala death or injury from vehicle strike and to maintain habitat connectivity and wildlife opportunities along the Logan Council Biodiversity Corridor. The KSRDP also outlines, performance criteria, monitoring, reporting, corrective action, responsibility, and timing of the installation of the various aspects of the design.

This report has been structured and prepared in accordance with the requirements of Condition 3 of the EPBC approval, and **DCCEEW**'s "*Environmental Management Plan Guidelines*" (the Guideline) under the EPBC Act.

## 1.2. Environmental Outcomes and Objectives

The condition (Condition 3) of the EPBC approval relevant to this KSRDP is presented in **Table 1**. This condition is associated with the requirement to develop a KSRDP to prevent koala death or injury from vehicle strike and to maintain habitat connectivity and wildlife opportunities along the Logan Council Biodiversity Corridor. A summary risk assessment and management table (**Table 2**) is also included that outlines the mitigation measures and monitoring activities.

The environmental outcomes to be achieved through implementing the KSRDP are:

- prevent any Koala death or injury within the development area and
- prevent Koala death or injury from vehicle strike and along Green Road.
- maintain habitat connectivity and wildlife movement opportunities along the Logan Council Biodiversity Corridor

These outcomes will be achieved through the installation of koala sensitive road design with the following objectives:

- Install koala exclusion fencing along the entire perimeter of the on-site conservation corridor,
- Install koala climb out poles are located along the development and road side of the koala exclusion fence,
- Install koala culvert furniture to the suitable corridor road crossing at the Green Road west location
- Construct a low speed esplanade road traversing the majority of the onsite corridor, and
- Install permanent koala awareness signage located along roads adjacent to the onsite conservation corridor as well as placed at the thresholds of corridor crossings.

Details on the objectives to meet the environmental outcomes set out in Condition 3 of the approval are detailed in **Table 1**, as well as a cross reference to their location in this report.

**Table 1: Compliance with Conditions of Approval**

| Ref | Cond. | Condition Requirement | Demonstration of how the plan addresses condition requirements | Reference |
|---|---|---|---|---|
| **1** | 3c | Detail the type and location of:<br>▪ safe fauna movement solutions, such as:<br>▪ fauna exclusion/Koala proof fencing<br>▪ fauna underpasses or overpasses<br>▪ and/or bridges as detailed in Queensland's road design guidelines | The plan details the type and location of safe fauna movement solutions as detailed in Queensland's road design guidelines, as follows:<br><br>1. Koala exclusion fencing will be installed along the entire perimeter of the on-site conservation corridor (other than the two openings on Green Rd), in accordance with Queensland's road design guidelines and Brisbane City Council standards, to stop koalas crossing the road surface and encourage koalas towards safe crossing passages (at corridor crossing points).<br>2. Koala culvert furniture will be retrofitted in accordance with Morton Bay Regional Council standard drawings to the suitable corridor road crossing at the Green Road west location.<br>3. Narrow, low-speed roads will be incorporated into the design layout for the residential development adjacent to the onsite corridor.<br>4. Koala climb out poles are located along the development and road side of the koala exclusion fence to prevent koala from becoming trapped on the development side of the fence. | **1. Section 7.1.2** page 22, **Attachment B**<br>**2. Section 7.2.2** page 23, **Attachment B Plan 1.2**<br>**3. Section 7.1.1**, page 22, **Attachment B**, **Plan 1.0**<br>**4. Section 7.1.3**, page 22, **Attachment B**, **Plan 1.0** |
| **2** | 3c | ▪ traffic calming features | The plan details the type and location of traffic calming features, as follows:<br><br>1. A low speed esplanade road traversing the majority of the onsite corridor will be incorporated into the design layout for proposed residential retirement development adjacent to the onsite corridor.<br>2. Roundabouts are located relatively close to the road crossings that aid in reducing speeds at corridor areas. | 1. **Section 7.1.1**, page 22, **Attachment B**, **Plan 1.0**<br>2. **Sections 7.2.2** and **5.2.3**, **Attachment B** |
| **3** | 3c | ▪ Koala awareness signage along roads adjacent to the onsite conservation corridor | The plan details the type and location of safe fauna movement solutions as detailed in Queensland's road design guidelines, as follows: | 1. **Section 7.1.4**, Page 22. **Attachment B**, **Plan 1.0** |

| Ref | Cond. | Condition Requirement | Demonstration of how the plan addresses condition requirements | Reference |
|---|---|---|---|---|
| | | | 1. Permanent Koala awareness signage will be located along roads adjacent to the onsite conservation corridor as well as placed at the thresholds of corridor crossings to raise driver awareness of wildlife. Awareness signage will follow guidelines for Traffic Road Use Management Volume 3. | |
| | | The KSRDP must provide a justification for why the measures detailed above are sufficient to: | | |
| **4** | 3c | ▪ prevent koala death or injury from vehicle strike. | The plan provides a justification for why the measures detailed above are sufficient to prevent koala death or injury from vehicle strike, as follows:<br><br>The project has been designed to locate the industrial zoned land away from the Logan Biodiversity Corridor and associated onsite corridor. The medium impact industry portion of the development is located away from the retained ecological corridor and therefore vehicle traffic is less likely to interact with Koala dispersing through the onsite corridor and Logan Biodiversity Corridor.<br><br>The area surrounding the development outside the Logan Biodiversity Corridor has largely been developed into low density residential estates or medium impact industry. There is a very low likelihood that Koala will enter the development from areas beyond the Logan Biodiversity Corridor and therefore, most of the Koala Sensitive Road Design elements are concentrated around the retained onsite corridor and the adjacent low density residential development.<br><br>A combination of structural koala sensitive measures has been used in the KSRDP to prevent koala death or injury from vehicle strike. Details of these measures along with the justification of how they are sufficient to prevent koala death or injury form vehicle strike is provided in **Section 7** of the KSRDP. | **Sections 6** and **7**, pages 19-25, **Attachment B** |

| Ref | Cond. | Condition Requirement | Demonstration of how the plan addresses condition requirements | Reference |
|---|---|---|---|---|
| | | | The primary management measure is the installation of koala exclusion fencing along the entire perimeter of the on-site corridor and on the project side of Green Road. Koala exclusion fence is highly effective at removing koala from roads and directing koala to cross roads at specified locations when installed in accordance with Queensland's road design guidelines and Brisbane City Council standards.<br><br>Narrow, low-speed roads within the development and the use of awareness signage reduce the risk that a koala will be actually struck in the highly unlikely event that an animal make its way on to a road. Climb out poles will be located on the development side of the koala exclusion fence to prevent animals from being trapped on the road side of the fence and are spaced every 200 m as per the Koala sensitive guidelines to minimise the time the koala is located outside of the corridor.<br><br>Koala culvert furniture will be retrofitted in accordance with Morton Bay Regional Council standard drawings to the suitable corridor road crossing at the Green Road west location. Koala culvert furniture increases the likelihood of the culvert being used to cross Green Road because koala can move through the culvert off the ground away from predators. The installation of culvert furniture will also provide movement opportunities through the culvert while the culvert has water flowing though it as there is currently no elevated passage through the culvert. | |
| **5** | 3c | ▪ maintain habitat connectivity and wildlife movement opportunities along the Logan Council Biodiversity Corridor. | The plan provides a justification for why the measures detailed above are sufficient to maintain habitat connectivity and wildlife movement opportunities along the Logan Council Biodiversity Corridor, as follows:<br><br>The Logan Council Biodiversity Corridor enters the site form the north of green road in two relatively narrow strips of vegetation bound on both sides by existing development. Both corridor crossing points are located on waterways and have stormwater culverts, but neither have any fauna movement infrastructure or signage. The western corridor arm has a stormwater culvert that is of suitable size for fauna furniture to be fitted but the eastern corridor culvert is too low. The KSRDP proposes the installation of culvert furniture to the western corridor and positioning of driver awareness signage at there the thresholds of the corridors. Koala exclusion fencing on the project side of Green Road will direct fauna including koala to these corridor points. In combination these measures will enhance the | **Section 3.1.2**, Page 13, |

| Ref | Cond. | Condition Requirement | Demonstration of how the plan addresses condition requirements | Reference |
|---|---|---|---|---|
| | | | habitat connectivity and wildlife movement opportunities north of the project. The Logan biodiversity corridor continues to the southwest of the site into retained vegetation and this connection will remain. Restoration works within the development have already begun with the removal illegally dumped domestic rubbish and the reinstatement of 4wd tracks that were through the onsite corridor. | |
| **6** | 3c | The KSRDP must also provide measures that sufficient to prevent any Koala death or injury within the development area and along Green Road. | In addition to the measures outlined above, the plan provides measures that sufficient to prevent any Koala death or injury within the development area and along Green Road, as follows:<br><br>The project has been designed to locate the industrial zoned land away from the Logan Biodiversity Corridor and associated onsite corridor. The medium impact industry portion of the development is located away from the retained ecological corridor and therefore vehicle traffic is less likely to interact with Koala dispersing through the onsite corridor and Logan Biodiversity Corridor<br><br>The area surrounding the development outside the Logan Biodiversity Corridor has largely been developed into low density residential estates or medium impact industry. There is a very low likelihood that Koala will enter the development from areas beyond the Logan Biodiversity Corridor and therefore, most of the Koala Sensitive Road Design elements are concentrated around the retained onsite corridor and the adjoining low density residential development.<br><br>A combination of structural koala sensitive measures has been used in the KSRDP to prevent koala death or injury from vehicle strike. Details of these measures along with the justification of how they are sufficient to prevent koala death or injury form vehicle strike is provided in **Sections 6** and **7** of the KSRDP.<br><br>The primary management measure is the installation of koala exclusion fencing along the entire perimeter of the on-site corridor and on the project side of Green Road. Koala exclusion fence is highly effective at removing koala from roads and directing koala to cross roads at specified locations when installed in accordance with Queensland's road design guidelines and Brisbane City Council standards. | **Sections 6** and **7**, **Attachment B**. |

| Ref | Cond. | Condition Requirement | Demonstration of how the plan addresses condition requirements | Reference |
|---|---|---|---|---|
| | | | Low speed roads within the development and the use of awareness signage reduce the risk that a koala will be actually struck should an animal make its way on to a road. Climb out poles will be located on the development side of the koala exclusion fence to prevent animals from being trapped on the road side of the fence and are spaced every 200 m as per the Koala sensitive guidelines to minimise the time the koala is located outside of the corridor.<br><br>Koala culvert furniture will be retrofitted in accordance with Morton Bay Regional Council standard drawings to the suitable corridor road crossing at the Green Road west location. Koala culvert furniture increases the likelihood of the culvert being used to cross Green Road because koala can move through the culvert off the ground away from predators. The installation of culvert furniture will also provide movement opportunities through the culvert while the culvert has water flowing though it as there is currently no elevated passage through the culvert. | |

**Table 2: Risk Assessment and Management Summary**

| Objective | Risk | Event or Circumstance | Risk Rating | | | Mitigation Measure | Timing, Frequency or Duration | Residual Risk Rating | | | Monitoring Activity | Management Trigger | Corrective Action |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Likelihood | Consequence | Risk Level | | | Likelihood | Consequence | Risk Level | | | |
| Prevent koala injury or death from vehicle strike. | Vehicle Strike within development | Vehicle Strike as a result of koala dispersing out of the retained Logan Biodiversity Corridor into development | Possible | Moderate | Medium | Installation of Koala exclusion fence as per DTMR standard drawing 1603 for Koala Proof Fence and Gate designs (**Attachment E**). Koala exclusion fences are highly effective are preventing Koala from dispersing into development | The permanent koala exclusion fencing that will prevent koala from entering the development area (**Attachment B, Plan 1.0**) will be installed within 3 months of completion of all clearing as per Condition 3b (vi) of the project's EPBC approval. | Rare | Moderate | Low | A post construction survey to be completed within 3 months of the completion of all clearing within the last stage of development.<br><br>Annual surveys as part of the Annual compliance reporting. | Koala exclusion fence not installed to specifications DTMR standard drawing 1603 for Koala Proof Fence and Gate designs (**Attachment E**)<br><br>Reported injury or death of koala within the development area | Rectify Koala Exclusion Fence to meet specifications within KSRDP **Attachment E.** |
| | | | | | | Koala climb-out poles installed every 200 m following guidelines in the as indicated by plan **Attachment B, Plan 1.0** in accordance with MBRC standard drawing GI-0520 (**Attachment G**). Climb out poles provide a way about | | | | | Koala climb-out poles not installed every 200 m as indicated by plan **Attachment B, Plan 1.0** in accordance with MBRC standard drawing GI-0520 (**Attachment G**)<br><br>Reported injury or death of koala within the development area | Rectify Koala climb-out poles to be in accordance with MBRC standard drawing GI-0520 (Attachment G) |
| | | | | | | Wildlife warning signage installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage as indicated on **Plan 1.0 (Attachment B)**. | Installation of roads and signage will occur once during civil construction and remain in place for the life of the project.<br>Infrastructure will be constructed as the new residential stages are developed. All infrastructure will | | | | A post construction survey to be completed within 30 days of the completion of construction works within the last stage | Wildlife warning signage not installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage not as indicated on **Plan 1.0 (Attachment B)**. | Rectify signage and locations to specifications and locations indicated in the KSRDP. |

| Objective | Risk | Event or Circumstance | Risk Rating | | | Mitigation Measure | Timing, Frequency or Duration | Residual Risk Rating | | | Monitoring Activity | Management Trigger | Corrective Action |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Likelihood | Consequence | Risk Level | | | Likelihood | Consequence | Risk Level | | | |
| | | | | | | Low speed (40 km/hr or less) esplanade road | be constructed to be installed prior to the completion of the final stage of residential development. | | | | of development.<br><br>Annual surveys as part of the Annual compliance reporting. | Esplanade road surrounding the retained corridor speed limit greater than 40 km/hr | Reduce speed limit on esplanade road to 40 km/hr |
| | | | | | | Separation of industrial area from onsite retained corridor | Achieved during planning stage of the project | | | | Annual Compliance Reporting surveys | Area adjacent to onsite retained corridor not used for residential development | Amend land misused to residential in compliance with EPBC approval. |
| | Vehicle Strike on Green Road | Vehicle Strike as a result of koala dispersing out of the retained Logan Biodiversity Corridor onto Green Road | Possible | Moderate | Medium | Installation of Koala exclusion fence south of Green Road as per KSRDP Plan 1.0 (**Attachment B**) | The permanent koala exclusion fencing and koala climb-out poles, will be installed within 3 months of completion of all clearing within stage 3 of the project | Rare | Moderate | Low | A post construction survey to be completed within 3 months of the completion of all clearing within the last stage of development.<br><br>Annual surveys as part of the Annual compliance reporting. | Installation of Koala exclusion fence south of Green Road is not as indicated within KSRDP **Plan 1.0** (**Attachment B**) | Rectify koala exclusion fence south of Green Road as per **Plan 1 (Attachment B)** in KSRDP. |
| | | | | | | Koala climb-out poles installed every 200 m as indicated by **Attachment B, Plan 1.0** in accordance with MBRC standard drawing GI-0520 (**Attachment G**) | | | | | Koala climb-out poles installed every 200 m as indicated by **Attachment B, Plan 1.0** in accordance with MBRC standard drawing GI-0520 (**Attachment G**) | Rectify koala climb out poles so that they are installed every 200 m as indicated by **Attachment B, Plan 1.0** in accordance with MBRC standard drawing GI-0520 (**Attachment G**) |

| Objective | Risk | Event or Circumstance | Risk Rating | | | Mitigation Measure | Timing, Frequency or Duration | Residual Risk Rating | | | Monitoring Activity | Management Trigger | Corrective Action |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Likelihood | Consequence | Risk Level | | | Likelihood | Consequence | Risk Level | | | |
| | | | | | | Wildlife warning signage installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage as indicated on **Plan 1.0 (Attachment B)**. | The wildlife signage along Green Road will be installed within 3 months of completion of all clearing within stage 3 of the project. | | | | | Wildlife warning signage not installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage not as indicated on **Plan 1.0 (Attachment B)**. | Rectify signage and locations to specifications and locations indicated in the KSRDP. |
| | | | | | | Retrofitting of Koala culvert furniture to Green Road west culvert koala furniture installed in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**). | The retrofitted culvert furniture within the culvert will be installed within 3 months of completion of all clearing. | | | | | Koala furniture not installed in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**). | Rectify installation of koala furniture to be in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**). |
| Maintain connectivity through the Logan Biodiversity Corridor | Fauna cannot disperse through the Logan Biodiversity Corridor | Fauna are not able to traverse the project site north across Green Road and south west in the Logan Biodiversity Corridor | Unlikely | Moderate | Low | Installation of Koala exclusion fence to direct fauna through retained corridor as per KSRDP **Plan 1.0 (Attachment B)**. | The permanent koala exclusion fencing and koala climb-out poles, will be installed within 3 months of completion of all clearing within stage 3 of the project. | Rare | Moderate | Low | A post construction survey to be completed within 3 months of the completion of all clearing within the | Koala exclusion fence not installed to specifications DTMR standard drawing 1603 for Koala Proof Fence and Gate designs (**Attachment E**) | Rectify Koala Exclusion Fence to meet specifications within KSRDP **Attachment E.** |

| Objective | Risk | Event or Circumstance | Risk Rating | | | Mitigation Measure | Timing, Frequency or Duration | Residual Risk Rating | | | Monitoring Activity | Management Trigger | Corrective Action |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Likelihood | Consequence | Risk Level | | | Likelihood | Consequence | Risk Level | | | |
| | | | | | | Wildlife warning signage installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage as indicated on **Plan 1.0 (Attachment B)**. | The wildlife signage along Green Road will be installed within 3 months of completion of all clearing within stage 3 of the project. | | | | last stage of development.<br><br>Annual surveys as part of the Annual compliance reporting. | Wildlife warning signage not installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage not as indicated on **Plan 1.0 (Attachment B)**. | Rectify signage and locations to specifications and locations indicated in the KSRDP. |
| | | | | | | Installation of Koala culvert furniture to Green Road west culvert in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**). | The retrofitted culvert furniture within the culvert will be installed within 3 months of completion of all clearing. | | | | | Koala furniture not installed in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**). | Rectify installation of koala furniture to be in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**). |

# 2. Project Description

## 2.1. Site Context

The project site is located in South-east Queensland within Logan City Council (LCC) Local Government Area, approximately 25 km south of Brisbane and 30 km east of Ipswich (**Figure 1)**. The Project area covers 116.35 ha of land. Within this area, a direct impact to 89.83 ha and functional loss of 28.01 ha of Koala and Grey-headed Flying-fox (GHFF) habitat was permitted under the EPBC approval conditions. A Master Land use plan divides the development of the site into 3 stages (**Attachment A**). Stages 1 and 2 have been developed as per the conditions of approval and detailed design for stage 3 is underway. The proposal includes the retention and restoration of an on-site conservation corridor approximately 12.96 ha located within the north-west corner of the development area. The retained area is part of the Logan Biodiversity Corridor system.

## 2.1. Project Description (Action)

The action approved under EPBC 2017/8090 is for an industrial, mixed use and residential development. The Southeast Queensland Regional Plan 2017 has identified Park Ridge as a major expansion area and a major enterprise and industrial area and the central and eastern portion of the referral area and the excised area form part of the strategic industrial corridor with the future state-controlled road, the Park Ridge Connector, linking to the Logan Motorway. The mixed-use zone has been designated to provide a major employment area with a variety of mixed-use activities including low impact industry, research and technology industry, service industry and warehouse. For example, business, residential, retail, service industry and tourist accommodation.

The western portion of the site will be a mix of low-medium density residential, recreation and open space and environmental management and conservation areas. The area zoned as environmental management and conservation will form part of the Logan City Biodiversity Corridor network and will be fully rehabilitated and managed to allow continued use by MNES as well as other fauna and flora. Access to the residential area will be from the east within the development and from the south via a separate residential development. The project includes three clearing stages starting in the eastern portion of the site and moving west. The residential precinct (stage 3) is the only stage of the site which has not yet been cleared. Construction is completed within the industrial and mixed use precinct (stage 1 and 2) and the commencement of clearing for the residential portion of the site is urgent.

## 2.2. Retained Onsite Corridor

The 12.96 ha of Environmental Management and Conservation vegetation will be retained and rehabilitated in the north western portion of the site to form part of the Logan City biodiversity corridor network. The retained area contains 12.61 ha of Koala habitat. A waterway traverses the western border of the corridor and another waterway connects the eastern extent to the existing Logan City biodiversity corridor to the north of Green Road. Most of the proposed retained area contains remnant vegetation of Koala food trees and Grey-headed Flying-fox foraging species.

### 2.2.1 Vegetation Communities

The onsite corridor can broadly be categorized into two vegetation communities. First, areas with waterways contained vegetation of 12.3.11 regional ecosystem present on the western and eastern extent of the retained area. Second, the area forming a corridor between the two waterways containing vegetation of 12.9-10.4 and 12.9-10.12 regional ecosystems.

The waterways within the retained area flow from south to north and pass under Green Road via culverts. The western waterway contains pools of permanent water with associated fish habitat (woody debris, minor bank overhangs) whereas the waterway on the eastern extent of the retained area has grass throughout the channel with no pools present. Trees associated with the two waterways are typical of the regional ecosystem and are dominated by *Eucalyptus tereticornis* (Forest Red Gum) with *Corymbia intermedia* (Pink Bloodwood) and *Melaleuca quinquenervia* (Broad-leaved Paperbark).

The central portion of the retained corridor area is a ridge line that protrudes south into the site. This area contains vegetation of endangered regional ecosystem 12.9-10.12. This regional ecosystem contains a mix of Koala food trees with *Corymbia intermedia* (Pink Bloodwood), *Corymbia citriodora* (Spotted Gum), *Angophora leiocarpa* (Smooth-barked Apple), *Eucalyptus fibrosa* (Broad-leaved Red Ironbark), and *Eucalyptus seeana* (Narrow-leaved Red Gum) all present within the canopy layer.

Photos: Waterway on the eastern extent of the retained area viewed from Green Road (left) and vegetation within the Endangered regional ecosystem 12.9-10.12 in the central portion of the retained area (right).

### 2.2.2 Rehabilitation and Management

The retained area used to contain many tracks utilized by illegal 4wd activities. Rehabilitation of the retained area will take place to reinstate the full ecological value of the vegetation for use by Koala and Grey-headed Flying-fox. Restoration activities within the onsite corridor have already taken place.

Photos: Onsite corridor revegetated vehicle access tracks.

### 2.2.3 Continued Protection

On completion of the development and rehabilitation of the retained corridor area the land will be dedicated to Logan City Council for environmental purposes to form part of the Logan City Biodiversity corridor network. Dedication of the retained area to council for environmental purposes will ensure the long-term protection and management of the retained area.

# 3. Koala Assessment

### 3.1.1 Baseline Koala Occurrence

The project site has undergone numerous ecological surveys between 2016-2020. These assessments have included:

- Random diurnal meanders (direct and indirect observations);
- Nocturnal surveys (spotlighting);
- Scat meanders; and
- Spot Assessment Technique (SAT).

The surveys were undertaken across the entire impact area as part of baseline assessments for EPBC referral. The results are detailed in Part A of the Preliminary Documentation but the koala results are presented here. No Koalas were sighted during the field surveys. Twenty-one (21) scat meanders were conducted across the site which triggered eight (8) SAT surveys (**Plan 1**). A summary of the SAT results is provided in **Table 2** and the raw data is shown in **Attachment I**. Evidence of Koala usage in the form of scats was low for the entire site. These estimates are taken from the Australian Koala Foundation Koala activity level classification table (following Philips and Callaghan 2011) using the East Coast (med-high) Activity Category. The evidence suggests that while the site is utilised by Koalas at times, the bulk of the area to be cleared would be considered relatively poor habitat for the species. Significant portions of the eastern portion of the site do not contain Koala habitat. The power easement and other areas of the site have also been cleared of Koala habitat trees.

**Table 3: Summary of baseline SAT results**

| | SAT (Spot Assessment Technique) Site No. | Evidence of Koala Use (%) | Koala Use (High/Medium/Low) |
|---|---|---|---|
| **2016, August** | 1 | 10.00 | Low |
| | 2 | 10.00 | Low |
| | 3 | 3.33 | Low |
| | 4 | 6.66 | Low |
| **2017, June** | 1 | 10.00 | Low |
| | 2 | 10.00 | Low |
| | 3 | 13.33 | Low |
| | 4 | 3.33 | Low |

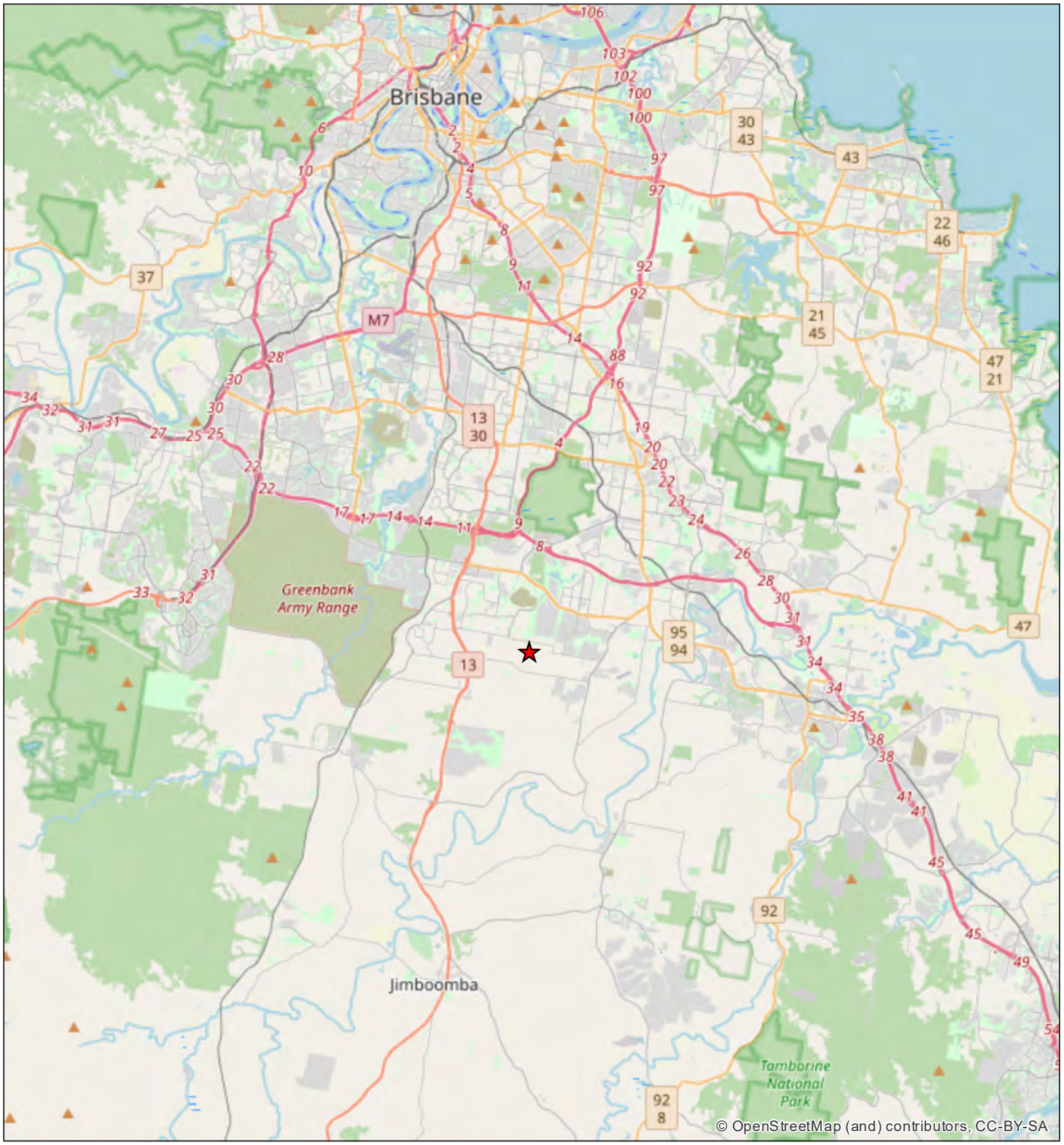
### 3.1.2 Koala Habitat Connectivity Assessment

The area of the site considered within this KSRDP boarder Green Road to the north, industrial development to the east and residential development to the south. The broader landscape in which the development is situated is undergoing rapid development. The only Koala habitat to the north of the site is within the Logan Biodiversity Corridor system (**Attachment B, Plan 1.0**). There is retained vegetation to the west of the site within also within the Logan biodiversity corridor. A residential development has been constructed to the south of the site.

The onsite corridor will form part of the Logan City Biodiversity corridor network that follows the waterways through the residential and industrial development and to the north and through rural residential lots to the southwest. The Logan Biodiversity Corridor network has been designed to facilitate movement of a broad range of fauna species including koala.

The Logan Council Biodiversity Corridor enters the site form the north of green road in two relatively narrow strips of vegetation bound on both sides by existing development. Both corridor crossing points are located on waterways and have stormwater culverts, but neither have any fauna movement infrastructure or signage. The western corridor arm has a stormwater culvert that is of suitable size for fauna furniture to be fitted but the eastern corridor culvert is too low. Culvert furniture will be installed to the western corridor and positioning of driver awareness signage at there the thresholds of the corridors. Koala exclusion fencing on the project side of Green Road will direct fauna including koala to these corridor points. In combination these measures will enhance the habitat connectivity and wildlife movement opportunities north of the project. The Logan biodiversity corridor continues to the southwest of the site into retained vegetation and this connection will remain. Restoration works within the development have already begun with the removal illegally dumped domestic rubbish and the reinstatement of 4wd tracks that were through the onsite corridor

The area surrounding the development outside the Logan Biodiversity Corridor has largely been developed into low density residential estates or medium impact industry. There is a very low likelihood that Koala will enter the development from areas beyond the Logan Biodiversity Corridor and therefore, most of the Koala Sensitive Road Design elements are concentrated around the retained onsite corridor and the adjoining low density residential development.




**Legend**

★ Referral area location

***Figure 1***

*Site Context*

Pointcorp Heritage Park Pty Ltd

***File ref.*** 8392 E Figure 1 Site Context A
***Date*** *10/07/2020*
***Project*** *Clark Road, Park Ridge*

0 1 2 4 6 8 10 *km*

N

*Scale (A4): 1:250,000 [GDA 1994 MGA Z56]*

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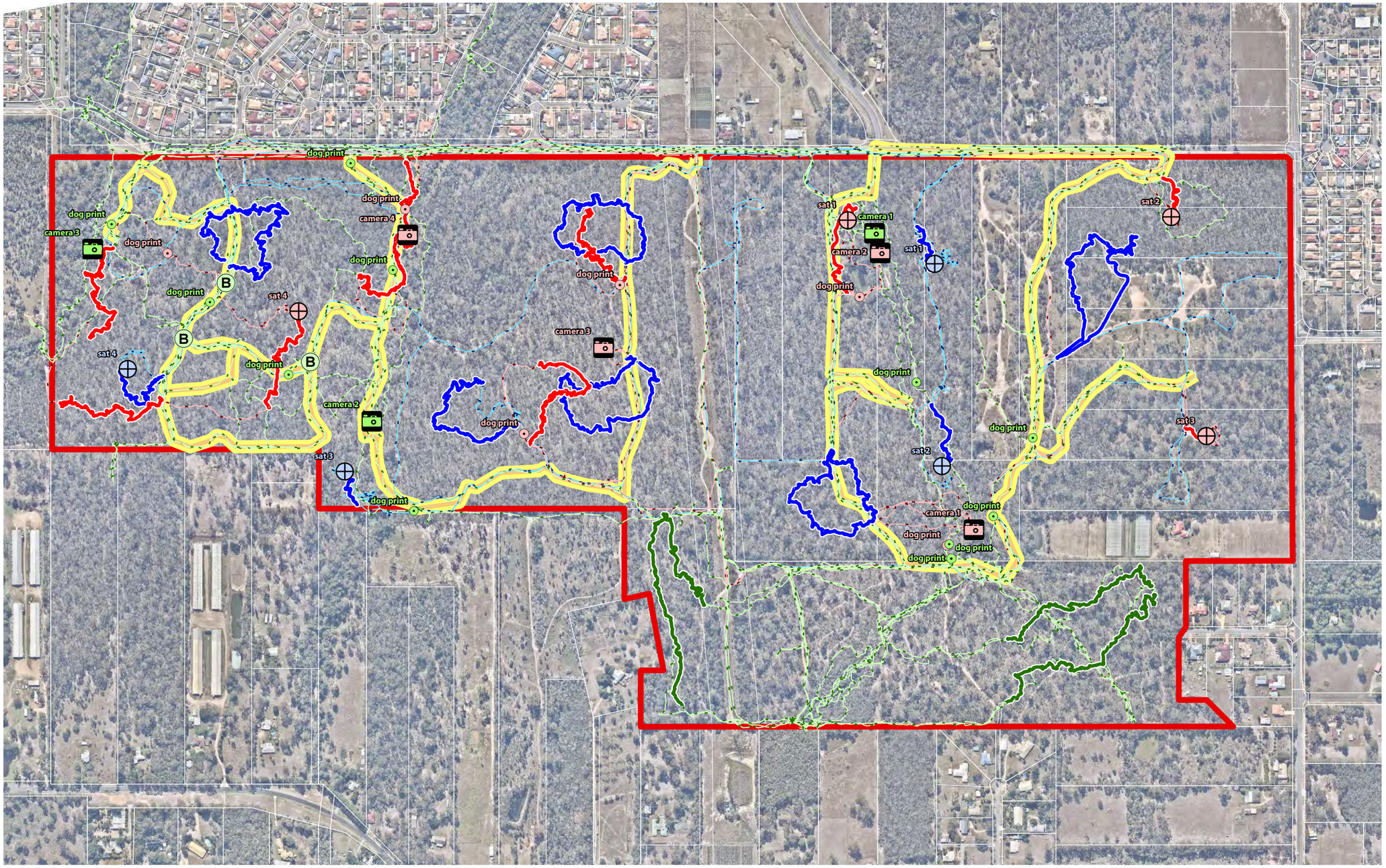
*Layer Sources*

# 1. FIELD SURVEY PLAN (2016-2017)




NOTES
This plan was prepared as a desktop assessment tool.
The information on this plan is not suitable for any other purpose.
Property dimensions, areas, numbers of lots and contours and other physical features shown have been compiled from existing information and may not have been verified by field survey. These may need verification if the development application is approved and development proceeds, and may change when a full survey is undertaken or in order to comply with development approval conditions. No reliance should be placed on the information on this plan for detailed design or for any financial dealings involving the land. Saunders Havill Group therefore disclaims any liability for any loss or damage whatsoever or howsoever incurred, arising from any party using or relying upon this plan for any purpose other than as a document prepared for the sole purpose of accompanying a development application and which may be subject to alteration beyond the control of the Saunders Havill Group. Unless a development approval states otherwise, this is not an approved plan.

*Layer Sources: QLD GIS Layers (QLD Gov. Information Service 2016), Aerial (Nearmap 2016)*

* This note is an integral part of this plan/data. Reproduction of this plan or any part of it without this note being included in full will render the information shown on such reproduction invalid and not suitable for use.

## LEGEND

- Referral area
- Qld DCDB

**Survey data - July 2017**

- Motion sensor camera
- Dog prints
- Bat echometer survey
- Koala Scat Meander
- Spotlight survey
- tracklog 20170719

**Survey data - June 2017**

- SAT location
- Motion sensor camera
- Dog prints
- Koala scat meander
- Tracklog

**Survey data - August 2016**

- SAT location
- Koala scat meander
- Tracklog

| Issue | Date | Description | Drawn | Checked |
|---|---|---|---|---|
| A | 11/09/2017 | Preliminary | TC | MS |
| B | 18/10/2017 | Preliminary | TC | MS |

Transverse Mercator | GDA 1994 | Zone 56 | 1:7,000 @ A3

0 100 200 300 m

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Park Ridge POINTCORP

ADDRESS/RPD: Clark Road, Park Ridge 18/10/2017 8392 E 01 EPBC Field Survey B

# 4. Existing Obligations to the Protection of Koala

The approval holder has serval existing commitments and obligations to mitigate potential threats to koala through the various development approvals in place for the project.

## 4.1. EPBC Koala Fencing Strategy and other conditions

Condition 3b of the EPBC approval 2017/8090 required a Koala Fencing Strategy to be prepared and implemented to guide the approval holder in achieving the outcomes under condition 3b.

The Koala Fencing Strategy directs the approval holder to install temporary koala exclusion fencing around areas of construction immediately following clearing to prevent koala from entering areas of development. Following this strategy, an exclusion fence will be installed around the perimeter of the onsite conservation corridor bordering the development. Koala will not be able to disperse from the onsite corridor into the development area from the time clearing has been completed to when the permanent koala fence has been installed.

Other conditions in EPBC approval 1-3 mitigate potential impacts to the koala by specifying the exclusion of domestic dogs from the onsite corridor and the separation the onsite conservation corridor from the industrial area These conditions are in in keeping with the management actions of this KSRDP.

## 4.2. State and Local Government

The existing obligations under State and Local Government mitigate impact to koala during the clearing of vegetation. The dominant legislation regulating clearing activities in Queensland is the Nature Conservative (Koala) Conservation Plan 2017 This legalisation controls the area and pattern of clearing allowed each day and hours of activity. A koala spotter must be present at the site of felling operations identify any tree at the site within which a Koala is present, as well as any tree that has a crown which is intermeshed or overlapping with such a tree; and advise the person who is authorised to conduct the felling operation, or that persons' representative, of the precise location of each such tree management item.

If a koala is encountered on site during clearing, works will be managed in accordance with the Nature Conservative (Koala) Conservation Plan 2017. This includes temporally stopping work establishing an exclusion zone of 50 m plus a corridor of the same width and allowing the animal to disperse on its own before work in the area continues. Koalas are not interfered with in any way unless they are at immediate risk of harm.

# 5. Potential Impacts and Risks

## 5.1. Threats and Potential Impacts to Koala

This KSRDP summarises all the identified threats to koala created by construction of roads within the approved project. The Referral Submission and Preliminary Documentation have provided detailed information on the anticipated impacts to koala because of the project. This information is summarised in the sections below.

## 5.2. Risk Assessment Prior to Mitigation Measures

Each of the identified potential impacts relevant to this KSRDP were analysed in the context of the proposed action and impacts to the koala within the Risk Assessment Tables (below) to identify where avoidance and mitigation measures will be implemented on the project site. The risk assessment is completed in accordance with the EPBC Act Environmental Management Plan Guidelines (2014) and characterises risk as low, medium, high or severe, as derived from the likelihood (highly likely, likely, possible, unlikely, rare) and consequence (minor, moderate, high, major and critical) risk matrix. These measures are presented in **Table 4**. Note, these likelihood and consequence ratings are based on conducting development activities **without** implementation of any of the proposed management measures. **Section 9** reviews the risk assessment after consideration of mitigation measures.

| | | Consequence | | | | |
|---|---|---|---|---|---|---|
| | | **Minor** | **Moderate** | **High** | **Major** | **Critical** |
| **Likelihood** | **Highly Likely** | **Medium** | **High** | **High** | **Severe** | **Severe** |
| | **Likely** | **Low** | **Medium** | **High** | **High** | **Severe** |
| | **Possible** | **Low** | **Medium** | **Medium** | **High** | **Severe** |
| | **Unlikely** | **Low** | **Low** | **Medium** | **High** | **High** |
| | **Rare** | **Low** | **Low** | **Low** | **Medium** | **High** |

### Likelihood and consequence

| **Qualitative measure of likelihood (how likely is it that this event or circumstances will occur after management actions have been put in place or are being implemented)** | |
|---|---|
| **Highly Likely** | Is expected to occur in most circumstances |
| **Likely** | Will probably occur during the life of the project |
| **Possible** | Might occur during the life of the project |
| **Unlikely** | Could occur but considered unlikely or doubtful |
| **Rare** | May occur in exceptional circumstances |

| Qualitative measure of consequences (what will be the consequence or result if the issue does occur) | |
|---|---|
| **Minor** | Minor incident of environmental damage that can be reversed |
| **Moderate** | Isolated but substantial instances of environmental damage that could be reversed with intensive effort |
| **High** | Substantial instances of environmental damage that could be reversed with intensive efforts |
| **Major** | Major loss of environmental amenity and real danger of continuing |
| **Critical** | Severe widespread loss of environmental amenity and irrecoverable environmental damage |

**Table 4: Risk assessment for potential impacts to koala as a result of vehicle strike**

| Impact | Likelihood | Consequence | Risk Rating |
|---|---|---|---|
| Vehicle Strike as a result of koala dispersing out of the retained Logan Biodiversity Corridor into development | Possible | Moderate | Medium |
| Vehicle Strike on Green Road as a result of Koala dispersing through the Logan Biodiversity Corridor | Possible | Moderate | Medium |
| Creation a barrier to connectivity through the Logan Biodiversity Corridor. | Unlikely | Moderate | Low |

### 5.2.1 Vehicle Strike within the development

The development will result in the creation of several new roads within areas that were previously vegetated. There will be a relatively long interface of development and the retained Logan Biodiversity Corridor within the site where koala may seek to disperse from into the development. It is **possible** that over the course of the life of the project and a koala would disperse from the retained vegetation into the development if no management measures were undertaken. If the koala was to be struck by a vehicle the consequences are **major** and there is a real danger that the animal could be injured or die.

### 5.2.2 Vehicle Strike on Green Road

There is the potential for the development to marginally increase vehicle usage on Green Road as a result of the residential activities. Green Road currently has no koala safe movement measures and is relatively constrained by current culvert designs as to the management measures able to be put in place by the proponent. It is **possible** that during the life of the project a koala could be struck by a vehicle on Green Road if no management measures were undertaken. If the koala was to be struck by a vehicle the consequences are **major** and there is a real danger that the animal could be injured or die.

### 5.2.3 Creation of a barrier to dispersal through the Logan Biodiversity Corridor

Development adjacent to corridors can impact the movement through or animals through the restriction of corridors creating edge effects and the creation of barriers such as fences or roads to limit the movement

of fauna. The retained corridor area meets the minimum thresholds for koala movement and even if no management activities were undertaken it is considered u**nlikely** that project would disrupt habitat connectivity and wildlife movement opportunities along the Logan Council Biodiversity Corridor. The consequence of creating a barrier to koala dispersal along the Logan Council Biodiversity Corridor is **high** given that koala would lose access to habitat. However, the Logan Council Biodiversity Corridor is a web of interconnected corridors, and koala are able to move into habitat through a number of routes.

# 6. Mitigation Measures

## 6.1. Objectives

The key objective of the mitigation measures is to mitigate the risks identified in Section 3. In order to meet this objective, this Koala Sensitive Road Design Plan (KSRDP) has been developed. The mitigation measures in this KSRDP:

1. Detail the type and location of:
    a. safe fauna movement solutions
    b. traffic calming features
    c. Koala awareness signage along roads adjacent to the onsite conservation corridor.
2. Provide a justification for why the measures detailed above are sufficient to:
    a. prevent koala death or injury from vehicle strike
    b. maintain habitat connectivity and wildlife movement opportunities along the Logan Council Biodiversity Corridor.
3. Provide measures that sufficient to prevent any Koala death or injury within the development area and along Green Road.

Along with the structural mitigation measures put in place by the KSRDP, other measures are identified below to ensure the objective and measures within the KSRDP will be achieved.

## 6.2. Environmental Training

The approved version of this KSRDP will be issued to all Development Managers, as well as site contractors and sub-contractors, and will be made available within the site construction office. Further, all people involved with the project will receive training to ensure they understand their responsibilities when implementing the KSRDP. Training on the KSRDP will be part of the broader environmental management and workplace health and safety procedures for the site.

The training will include the following actions:

1) Providing a copy of the KSRDP to all site staff, site contractors and sub-contractors;
2) Requirements of the KSRDP will be discussed during the design and construction phase of the project, including:
    a. explaining the requirements of the KSRDP and different individuals' roles under the KSRDP
    b. appropriate procedures for reporting environmental incident/emergencies
    c. site environmental controls that will be implemented (such as areas to be cleared, method of vegetation clearing, installation of exclusion fencing, etc.)
    d. discussion on potential consequences of not meeting environmental responsibilities

3) Making available the final copy of the KSRDP within the site construction office;

## 6.3. Emergency Contacts and Procedures

In the event of a koala strike during construction and implantation of the KSRDP the site manager must be contacted immediately and all works that have potential to cause further issues ceased. Once any threats have been nullified the Department of Environment and Science (1300 130 372) or RSPCA (1300 264 625) must be contacted to obtain further advice.

## 6.4. Overall Project Layout

The project has been designed to locate the industrial areas away from the Logan Biodiversity Corridor and associated onsite corridor. The medium impact industry portion of the development is located away from the retained ecological corridor and therefore vehicle traffic is unlikely to interact with Koala dispersing through the onsite corridor and Logan Biodiversity Corridor.

The area surrounding the development outside the Logan Biodiversity Corridor has largely been developed into low density residential estates or medium impact industry. There is a very low likelihood that Koala will enter the development from areas beyond the Logan Biodiversity Corridor and therefore, most of the Koala Sensitive Road Design elements are concentrated around the retained onsite corridor and the adjacent low density residential development.

The proposed residential development that is located adjacent to the onsite corridor is a residential retirement community with very low speed 6 m wide private roads decreasing the risk of Koala vehicle strike in the unlikely event that a koala enters the development (**Attachment B, Plan 1.0**). Additional traffic calming features such as speed bumps and chicanes are not applicable to the proposed retirement community as the roads are already designed to be very low speed. Roads located within the industrial area are well away from any koala habitat and therefore do not pose a risk of koala strike.

The combination of koala exclusion fencing and associated climb out poles and low speed roads adjacent to the onsite corridor provides a very strong mitigation measure for the risk of koala vehicle strike within the development area.

The KSRDP incorporates several Koala safety features. Some measures such as Koala climbing ledges through culverts are linked to road crossing whereas other elements are not linked to road crossings. They are:

- Low speed roads adjacent to the onsite corridor
- Koala exclusion fencing
- Koala climb-out poles
- Wildlife threshold signage
- Koala furniture retrofitted to suitable culvert on Green Road

Details of how each of these elements are incorporated in the KSRDP are provided below with justification of why they were included and their effectiveness in mitigating the risks identified in **Sections 6** and **7**.

## 6.5. Infrastructure

This KSRD indicates how project design and Koala safety elements have been used to meet requirements and prevent koala death or injury from vehicle strike within the development area and along Green Road as well as maintaining habitat connectivity along the Logan Council Biodiversity Corridor.

Detailed designs of fence and road infrastructure for the site are provided as **Attachment B**. Dimensions and standard drawings have been supplied to provide as much detail as possible given the current level design available for each design element. The fauna movement solutions were designed using the Koala-sensitive Design Guideline prepared by: Environmental Planning and Policy, Department of Environment and Science (**Attachment C**) and the Fauna Sensitive Road Design Manual published by the Queensland Department of Transport and Main Roads (**Attachment D**). Both documents are also available online at the below web addresses as of the date of issue:

https://environment.des.qld.gov.au/__data/assets/pdf_file/0025/102859/koala-sensitive-design-guideline.pdf

https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Fauna-Sensitive-Road-Design-Volume-2

Details of the overall Koala safe road design and each of the design elements is presented below.

# 7. KSRDP Infrastructure

The Koala- sensitive Design Guideline (2022) provides a number of measures which can facilitate landscape permeability and safe koala movement. These include:

- koala-friendly (allows koala movement) and koala exclusion (prevents koala movement into unsafe areas) fencing
- koala-safe road design (including crossing structures) and placement
- mitigation of construction-related threats (including vegetation clearing)
- koala-safe pools and other water bodies
- mitigation of threats from domestic dogs and livestock
- landscaping to maintain or enhance koala habitat and connectivity
- koala detection and monitoring, and sensitive vegetation clearing practices, such as use of innovative technologies and best-practice methods
- community awareness, engagement and koala stewardship programs.

The measures chosen will be influenced by the type, size, and location of the development. It is likely that several of each type of measure will need to be used in the design and layout of the development to maximise koala safety and movement.

The KSRDP presented here encompasses a number of these measures to appropriately maximise Koala safety. The design elements within the plan are discussed below with justification of how these measures are sufficient to prevent Koala death and injury as per the conditions of approval. The design elements of the KSRDP are categorised into three (3) broad sections. First discussion is provided regarding the overall project layout and management elements that are present across the project area, such as exclusion fencing. Second, the specific points where road cross corridors are discussed and finally the management

measures that could have potential been used, such as a land bridge, but were considered unsuitable for this KSRDP are listed with reasons as why they are unsuitable in this case.

### 7.1.1 Low speed esplanade road buffering onsite corridor

A low speed (40 km/hr or less) esplanade road will be constructed to buffer the majority of the onsite corridor from the development. The reduced speed of the road allows drivers more time to react to koala and other obstacles on the road. Retirement villages are typically very slow driving environments. The esplanade road also buffers the onsite corridor from domestic animals that may be present within the development reducing edge effects and increasing functionality of the onsite corridor.

### 7.1.2 Koala exclusion fence

A koala exclusion fence will be installed around the entire perimeter of the EPBC onsite corridor except for corridor crossing points on Green Road (**Attachment B, Plan 1.0**). The proposed koala exclusion fence is also effective in reducing other fauna movement including macropods. The fence will be in accordance with the DTMR standard drawing 1603 for Koala Proof Fence and Gate designs (**Attachment E**) which detail materials and dimensions of fencing along roads and at culverts. Pedestrian gate design for sections of fence along Green Road will be in accordance with the fauna exclusion fence standard drawing BSD-7009 prepared by Brisbane City Council (**Attachment F**). Koala exclusion fences are extremely effective at restricting koala from dispersing out of retained vegetation and into areas with vehicle traffic. The TMR technical standards list fencing as an appropriate barrier for koala and the superseded EPBC referral guidelines for the venerable koala list koala exclusion fencing as highly effective at mitigating risk of vehicle strike.

### 7.1.3 Koala climb-out poles

Koala climb-out poles allow koala that are located on the roadside of koala exclusion fence to return to the corridor. Climb-out poles are proposed to be located every 200 m along the exclusion fencing as outlined in the DTMR Technical document and will be in accordance with the MBRC standard drawing GI-0520 (**Attachment G**).

### 7.1.4 Wildlife threshold signage

The Wildlife warning signage is to follow design guidelines in Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. The proposed signage plan (**Attachment B**) indicates the locations of signage at thresholds to corridor crossings. Use of wildlife signage raises driver awareness to the presence of wildlife. There are used in combination with other structural mitigation measure were possible.

| | | |
|---|---|---|
|  | Wildlife Warning Sign with Target Board and 1300 ANIMAL (Koala)<br>Note: The diamond wildlife warning sign may be substituted for any animal-specific wildlife warning sign.<br>The 'SLOW DOWN' supplementary plate may be substituted for either distance supplementary plate (W8-17). | TC1622_1 ('B' and 'C' size) preferred sizes<br>('A' size should only be used when space is limited) |

| | | |
|---|---|---|
|  | NEXT ... km<br>Supplementary plate | W8-17-1 |
|  | NEXT ... m<br>Supplementary plate | W8-17-2 |

## 7.2. Road Crossings

Roads cross vegetated corridors at three points within the vicinity of the onsite corridor. One of the crossings is within the development where a road crosses a waterway known as the on-site bund crossing and two more crossings on Green Road (East and West) north of the site. **Attachment B, Plan 1.0** provides reference for these road crossing locations and **Plans 1.1**, **1.2** and **1.3** provide details of the measurement measures at each location.

### 7.2.1 Onsite bund crossing

The onsite bund crossing is south of the retained Logan Council Biodiversity Corridor. Koala exclusion fencing and associated climb out pole will be installed on the northern side of the crossing to direct koala and other larger mammals through the main portion of the biodiversity corridor. This additional corridor as it does not connect with any vegetation to the south and is exposed on all sides by roads. Koalas and other larger fauna will be directed through the onsite corridor which connects to a much larger areas of vegetation to the west of the site. Gliding mammals will be able to traverse the south of the bund via glider poles located either side of the bund crossing, and small animals will pass below the road via a low height fauna culvert suitable for (snakes, small mammals etc.) (**Attachment B, Plan 1.1**). The use of koala exclusion fencing north of the on-site bund greatly reduces the chances of koala being struck by a vehicle crossing the onsite bund.

### 7.2.2 Green Road west

The current culverts located on Green Road at the western arm of the Logan Biodiversity Corridor are of sufficient height to allow for the retrofitting of Koala culvert furniture (**Attachment B, Plan 1.2**). The fitting of the infrastructure will increase the likelihood of the culverts being used by koala and will likely be

attached to the side of the existing culvert. Attachment of the furniture to the side of the culvert decreases the chances of flood debris being caught within the furniture as the culvert is within the low flow channel of the existing waterway. The koala furniture installed in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**). Wildlife warning road signage will be installed at the either side of the corridor to highlight the area as a potential wildlife crossing point. For fauna other than Koala, trees along the road likely provide movement opportunities for gliding species and the current culvert provides connectivity along the Logan Biodiversity Corridor for Kangaroos and other ground dwelling species.

The use of the culverts to direct Koala under Green Road greatly reduces the risk of vehicle strike at this fauna crossing point. Koala exclusion fencing on the development site side of Green Road will direct larger fauna to the specific corridor crossing point. The corridor north of Green Road is already naturally restricted to this crossing point as a result of the existing development. Koala climb-out poles are proposed for the southern side of Green Road (**Attachment B**, **Plan 1.1**) to allow Koala to cross from the roadside of the exclusion fence into the retained corridor.

The crossing point is located relatively close to a roundabout which will reduce vehicle speed and the inclusion of wildlife road signage will make motorists aware that the location is a potential fauna crossing point.

### 7.2.3 Green Road east

The corridor crossing at Green Road east consists of low height culverts designed for stormwater. There are currently no koala safety measures at this crossing. The culverts are too low for the retrofitting of Koala infrastructure but are suitable for small mammals and reptiles. Koala exclusion fencing on the development site side of Green Road will direct larger fauna to the specific corridor crossing point. The corridor north of Green Road is already naturally restricted to this crossing point as a result of the existing development. Wildlife warning signage as discussed above will be installed on either side of the corridor to highlight the area as a crossing point for Koala to motorists. The combination of these two measures is the best outcome possible for this particular crossing given the culvert height restrictions. Koala climb-out poles are proposed for the southern side of Green Road (**Attachment B**, **Plan 1.0**) to allow Koala to cross from the roadside of the exclusion fence into the retained corridor.

## 7.3. Other Koala Infrastructure Not Applicable to this KSRDP

Other fauna safe movement solutions listed in Queensland's Road Design Guidelines (FSDR Vol 2), but these are unsuitable for this project, and were not included in the KSRDP or the supporting material which was approved as part of EPBC approval 2017/8090. For example, land bridges and overpasses, which are very costly structures are sometimes incorporated into large motorway designs where the road being crossed is shouldered by land of a higher elevation. For this reason, is not proposed, nor possible to be delivered for this project. Neither of these elements are appropriate for the current project design as the surrounding land is relatively flat and the corridors are at waterways. Cut and cover tunnels are not included in the project because the road design does not allow for such infrastructure. Pointcorp's development is confined to the land within the residential precinct and there are no roadworks are occurring on Green Road, outside of the development area.

Canopy bridges are not considered in the KSRDP because they are not suitable for Koala but are designed for use by smaller arboreal mammals such as possums. Refuge poles are not appropriate for this KSRDP as there are no areas where Koala is likely to be required to cross open areas without trees. Climb out poles

will be placed along all sections of Koala exclusion fence and these poles operate in a similar fashion to refuge poles in that they provide a structure for Koala to climb and escape predators.

# 8. Implementation Schedule

An implementation schedule has been developed and is presented as **Table 5**. The schedule provides the objective of each management action, the performance target set of the action, the specific mitigation measure and the method used, the location of the management measure, timing or frequency of the management action, the monitoring activity that will be used to determine the effectiveness of the mitigation measure, the management trigger for when corrective action will be engaged and the corrective action to occur.

The permanent koala exclusion fencing that will prevent koala from entering the development area (**Attachment B, Plan 1.0**) will be installed within 3 months of completion of all clearing as per Condition 3b (vi) of the project's EPBC approval that states.

> *Condition 3b (vi): Within 3 months of completion of all clearing, prevent access of Koalas into the development area from the onsite conservation corridor.*

Installation of the koala exclusion fence and climb out poles on the northern boundary of the site where it meets Green Road will also occur within 3 months of the completion of clearing.

Installation of the retrofitted koala furniture through the culvert western culvert of Green Road (**Attachment B, Plan 1.2**) and wildlife awareness signage on Green Road (**Attachment B**) will occur within 3 months of the completion of clearing.

Roads and wildlife awareness signage within the development (**Attachment B, Plans 1.0 and 1.1**) will be installed during the civil construction phase of the development. All roads and wildlife signage will be installed prior to the completion of the final stage within this stage 3 development area

**Table 5: Implementation schedule**

| Objective | Performance Target | Management Measure | Methodology | Location | Timing or Frequency | Monitoring Activity | Management Trigger | Corrective Action |
|---|---|---|---|---|---|---|---|---|
| Prevent injury or death to Koala within development area as a result of vehicle strike | No Koala injured or killed within the development area as a result of vehicle strike | Koala exclusion fence to prevent koala dispersing from onsite corridor into development site. | DTMR standard drawing 1603 for Koala Proof Fence and Gate designs (**Attachment E** and **F**) | locations shown on **Attachment B. Plan 1.0** | The fence is to be installed within 3 months of the completion of clearing in the last stage of the development | Post clearing survey within 3 months of the completion of clearing in the last stage of the development<br>Annual compliance surveys | Koala exclusion fence not installed to specifications DTMR standard drawing 1603 for Koala Proof Fence and Gate designs (**Attachment E** and **F**)<br>Reported injury or death of koala within the development area | Rectify Koala Exclusion Fence to meet specifications within KSRDP **Attachment E** and **F**<br>Review design and location to increase effectiveness of exclusion fencing |
| | | Koala climb-out poles to provide an escape pathway for animals on the development side of koala exclusion fence | Koala climb-out poles installed every 200 m as indicated by plan **Attachment B, Plan 1.0** in accordance with MBRC standard drawing GI-0520 (**Attachment G**). Climb out poles provide a way about | locations shown on **Attachment B. Plan 1.0** | The climb out poles is to be installed within 3 months of the completion of clearing in the last stage of the development | Post clearing survey within 3 months of the completion of clearing in the last stage of the development<br>Annual compliance surveys | Koala climb-out poles not installed every 200 m as indicated by plan **Attachment B, Plan 1.0** in accordance with MBRC standard drawing GI-0520 (**Attachment G**)<br>Reported injury or death of koala within the development area | Rectify Koala climb-out poles to be in accordance with MBRC standard drawing GI-0520 (**Attachment G**)<br>Review design and location to increase effectiveness of climb out poles |
| | | Wildlife warning signage to increase awareness of koala corridors | Wildlife warning signage installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage as indicated on **Plan 1.0 (Attachment B)**. | locations shown on **Attachment B. Plan 1.0** | Installation of roads and signage will occur once during civil construction and remain in place for the life of the project.<br>Infrastructure will be constructed as the new residential stages are developed. All infrastructure will be constructed to be installed prior to the completion of the final stage of | A post construction survey to be completed within 30 days of the completion of construction works within the last stage of development.<br>Annual surveys as part of the Annual compliance reporting. | Wildlife warning signage not installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage not as indicated on **Plan 1.0 (Attachment B)**. | Rectify signage and locations to specifications and locations indicated in the KSRDP. |

| Objective | Performance Target | Management Measure | Methodology | Location | Timing or Frequency | Monitoring Activity | Management Trigger | Corrective Action |
|---|---|---|---|---|---|---|---|---|
| | | | | | residential development. | | Reported injury or death of koala within the development area | Review design and locations to increase signage effectiveness |
| | | Low speed (40 km/hr or less) esplanade road | Standard civil engineering techniques with a speed limit of 40 km or less. | locations shown on **Attachment B. Plan 1.0** | Installation of roads and signage will occur once during civil construction and remain in place for the life of the project.<br>Infrastructure will be constructed as the new residential stages are developed. All infrastructure will be constructed to be installed prior to the completion of the final stage of residential development. | A post construction survey to be completed within 30 days of the completion of construction works within the last stage of development.<br>Annual surveys as part of the Annual compliance reporting. | Esplanade road surrounding the retained corridor speed limit greater than 40 km/hr<br>Reported injury or death of koala within the development area | Reduce speed limit on esplanade road to 40 km/hr<br>Review esplanade road speed limit to decrease risk of vehicle striking koala |
| Prevent injury or death to Koala on Green Road as a result of vehicle strike | No Koala injured or killed on Green Road as a result of vehicle strike | Koala exclusion fence to prevent koala dispersing from onsite corridor onto Green Road | DTMR standard drawing 1603 for Koala Proof Fence and Gate designs (**Attachment E** and **F**) | locations shown on **Attachment B. Plan 1.0** | The fence is to be installed within 3 months of the completion of clearing in the last stage of the development | Post clearing survey within 3 months of the completion of clearing in the last stage of the development<br>Annual compliance surveys | Koala exclusion fence not installed to specifications DTMR standard drawing 1603 for Koala Proof Fence and Gate designs (**Attachment E** and **F**)<br>Reported injury or death of koala on Green Road | Rectify Koala Exclusion Fence to meet specifications within KSRDP **Attachment E** and **F**<br>Review design and location to increase effectiveness of exclusion fencing |
| | | | Koala climb-out poles installed every 200 m as indicated by **Attachment B, Plan 1.0** in accordance with MBRC standard drawing GI-0520 (**Attachment G**) | locations shown on **Attachment B. Plan 1.0** | The climb out poles is to be installed within 3 months of the completion of clearing in the last stage of the development | Post clearing survey within 3 months of the completion of clearing in the last stage of the development<br>Annual compliance surveys | Koala climb-out poles not installed every 200 m as indicated by plan **Attachment B, Plan 1.0** in accordance with MBRC standard drawing GI-0520 (**Attachment G**) | Rectify Koala climb-out poles to be in accordance with MBRC standard drawing GI-0520 (**Attachment G**) |

| Objective | Performance Target | Management Measure | Methodology | Location | Timing or Frequency | Monitoring Activity | Management Trigger | Corrective Action |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Reported injury or death of koala on Green Road | Review design and location to increase effectiveness of climb out poles |
| | | Wildlife warning signage | Wildlife warning signage installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage as indicated on **Plan 1.0 (Attachment B)**. | locations shown on **Attachment B. Plan 1.0** | The wildlife signage along Green Road will be installed within 3 months of completion of all clearing within stage 3 of the project. | Post clearing survey within 3 months of the completion of clearing in the last stage of the development<br>Annual compliance surveys | Wildlife warning signage not installed as per Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020. Locations of signage not as indicated on **Plan 1.0 (Attachment B)**.<br><br>Reported injury or death of koala on Green Road | Rectify signage and locations to specifications and locations indicated in the KSRDP.<br><br>Review design and location to increase effectiveness of wildlife signage |
| | | Retrofit koala furniture to suitable culvert on Green Road | Retrofitting of Koala culvert furniture to Green Road west culvert koala furniture installed in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**). | locations shown on **Attachment B. Plan 1.0** | The retrofitted culvert furniture within the culvert will be installed within 3 months of completion of all clearing. | Post clearing survey within 3 months of the completion of clearing in the last stage of the development<br>Annual compliance surveys | Koala furniture not installed in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**).<br><br>Reported injury or death of koala on Green Road | Rectify installation of koala furniture to be in accordance with the MBRC standard drawing GI-0530/0531 (**Attachment H**). |
| Maintain connectivity through the Logan Biodiversity Corridor | Animals able to disperse through the Logan Biodiversity corridor via the project's onsite corridor | All of the above | As all of the above | locations shown on **Attachment B. Plan 1.0** | As above for specific management measures | Annual Compliance Reporting surveys | Lack of fauna using onsite corridor<br>Reported injury or death of koala on Green Road | Review fauna movement solutions to increase effectiveness of fauna safe movement solutions. |

# 9. Revised Risk Assessment following Mitigation Measures

A Risk Assessment Table (**Table 4**) was presented in **Section 5** to identify where avoidance and mitigation measures will be implemented. After consideration of the proposed mitigation and management measures described in **Sections 6** and **7, Table 6** presents the revised Risk Assessment and associated ratings for impacts to the Koala. The mitigation measures involve a combination of design and specific infrastructure to reduce the likelihood of the potential impacts.

**Table 6: Revised risk assessment for potential impacts to koala**

| Impact | Pre-mitigation Likelihood | | | Revised Likelihood | | |
|---|---|---|---|---|---|---|
| | Likelihood | Consequence | Risk Rating | Likelihood | Consequence | Risk Rating |
| Vehicle Strike as a result of koala dispersing out of the retained Logan Biodiversity Corridor into development | Possible | Moderate | Medium | Rare | Moderate | Low |
| Vehicle Strike on Green Road as a result of Koala dispersing through the Logan Biodiversity Corridor | Possible | Moderate | Medium | Rare | Moderate | Low |
| Creation of a barrier to connectivity through the Logan Biodiversity Corridor. | Unlikely | Moderate | Low | Rare | Moderate | Low |

# 10. Monitoring and Reporting Schedule

The following program describes the monitoring activities that will occur at the impact site. The monitoring approach has been developed to assess the success of the management actions to achieve performance criteria outlined in **Section 6**. The survey methodologies are presented in **Section 10.1** detailing the methods to be used for each three monitoring actions (**Sections 10.2-10.4**) and **Table 7** summaries the monitoring activity, parameters measured within each activity, the methodologies used, the location of the surveys and the timing, frequency or duration of each survey.

The monitoring actions directly relate to determining whether the performance criteria and approval conditions have been achieved. As such, the monitoring actions will need to determine the following:

- Were any koalas injured or killed within the development or on Green Road during the reporting timeframe?
- Are fauna able to disperse through the Logan Biodiversity corridor via the retained onsite corridor?
- Are vehicles traveling at 40 km/hr or less on the esplanade road boarding the retained corridor?
- Is the koala exclusion fence in place according to **Attachment B**, **Plan 1.0** and meets specifications in **Attachments E** and **F**?
- Are the wildlife awareness signs installed to the standards in Traffic and Road Use Management Volume 3 – Signing and Pavement Marking; Part 8: Wildlife Signing Guidelines November 2020 and located as per the signage plan (**Attachment B**)?
- Are the koala climb out poles installed and to specifications in **Attachment G** and located as per **Attachment B**?
- Has the retrofitted koala furniture been installed in the culvert for Green Road west to the specifications in **Attachment H**?

The following survey methodologies have been developed to measure the effectiveness of the management actions. **Section 10**.

## 10.1. Survey Methodologies

The below survey methodologies replicate those of the base line surveys carried out to determine koala usage of the area retained as an onsite corridor

### 10.1.1 KSRDP infrastructure

The infrastructure installed as part of this KSRDP will be inspected on foot and compared to drawings to determine if the installed infrastructure complies with this KSRDP. The locations of the infrastructure will recorded using a handheld GPS unit to ensure the infrastructure is located as per Attachment B.

### 10.1.2 Koala injuries or deaths

Each year the available data released through the Koala Hospital Data - Dataset - Open Data Portal from the Queensland Government available at www.data.qld.gov.au/dataset/koala-hospital-data for reported koala injuries or deaths within the development site or on Green Road. Park Ridge is a highly urbanised area and it is likely that koala injuries or death by vehicle strike would be reported should they occur.

The dataset will be reviewed each year and if any Koala injuries or deaths are reported, an investigation will be conducted by the environmental coordinator to identify the cause of the incident and identify the appropriate corrective action.

### 10.1.3 Connection of onsite corridor to broader Logan Biodiversity corridor

During each annual compliance survey, a monitoring of koala usage within the onsite corridor will occur. A general meander through the onsite corridor will survey the area for Koala and other fauna. The Spot Assessment Technique (SAT) will be used to measure historical koala usage of the onsite corridor. Montion sensor cameras will be installed where the Logan Biodiversity corridor system enters the project site to measure dispersal of fauna through the onsite corridor.

General meanders will consist of at least 30 mins of walking through the retained area looking into the canopy of trees for koala. Binoculars will be used to ascertain the gender and general health of any koala found. Locations of koala will be recorded using a portable GPS device.

The Spot Assessment Technique (SAT) (Phillips *et al.* 2011). The SAT method is an industry recognised technique for identifying presence/absence of koala at a site and is specified as an appropriate survey method in the now redundant *EPBC Act Referral Guidelines for the Vulnerable Koala*.

The SAT involves identifying a non-juvenile tree of any species within the subject site that is either observed to have a Koala or scats, or is known to be a food tree or otherwise important for Koalas, and recording any evidence of Koala usage of that tree including presence, identifiable scratches or scats. The nearest non-juvenile tree is then identified, and the same data recorded. The next closest non-juvenile tree to the first tree is then assessed and so on until 30 trees have been surveyed.

The number of trees showing evidence of Koala activity is expressed as a percentage of the total number of trees sampled to indicate the frequency of Koala usage. Assessment of each tree involves a systematic search for Koala scats beneath the tree within a 1 metre (m) radius of the trunk. After approximately two minutes of searching for scats, the base of the trunk is observed for scratches and the crown for Koala (refer Phillips & Callaghan 2011).

Motion sensor triggered camera traps will be installed at three (3) locations (one at each corridor crossing on green road and a one on the southwest boundary of the site) where the onsite corridor connects with the Logan Biodiversity Corridor. The cameras will be baited with peanut butter and oats mix and set for 2 weeks. Cameras will be fixed to a tree approximately 70 cm from the ground and 100-150 cm in front of the bait station.

The survey methodologies outlined above have been selected as they are scientifically robust and repeatable.

## 10.2. Monitoring Activity 1 – Post Clearing Survey

A survey is to be completed within 3 months of the completion of all clearing within the last stage of development. All permanent koala exclusion fencing, koala climb-out poles, and retro fitted koala furniture in the western culvert on Green Road is to have been installed prior to the survey.

## 10.3. Monitoring Activity 2 – Post Construction Survey

A survey is to be completed within 3 months of the completion of all construction within the last stage of development. The low speed esplanade road and wildlife signage will be fully installed prior to the survey.

## 10.4. Monitoring Activity 3 – Annual Monitoring Surveys

Annual surveys as part of the annual compliance reporting. As per Condition 19 of the EPBC approval, within three months of every 12 month anniversary of commencement of the action, **Pointcorp Heritage Park Pty Ltd.** will publish a report on their website addressing compliance with each of the conditions of this approval including implementation of the KSRDP. Surveys undertaking for the annual compliance reporting will include

**Table 7: Monitoring Schedule**

| Monitoring Activity | Parameters Measured | Methodology | Location | Timing, Frequency or Duration |
|---|---|---|---|---|
| Post Installation Survey following completion of **clearing** within last development stage | Correct installation of Permanent Koala exclusion fence, koala climb out poles and retrofitted koala furniture as per specification in KSRDP | Review infrastructure and compare to locations and specifications listed within RSRDP | Various locations as per Attachment B, Plan 1.0 | Within 3 months of the completion of all **clearing** within the last stage of development |
| Post Installation Survey following completion of **construction** within last development stage | Correct installation and construction of the low speed esplanade road, installation of wildlife awareness signage | Review infrastructure and compare to locations and specifications listed within RSRDP | Various locations as per Attachment B, Plan 1.0 | Within 3 months of the completion of all **construction** within the last stage of development |
| Annual compliance surveys to assess connection with logan biodiversity corridor and effectiveness KSRDP. | Connection of onsite corridor with Logan biodiversity corridor<br><br>Review of Koala hospital database which includes information such as:<br>Koala location<br>Size<br>Situation<br>If there was a young present<br>Whether the koala was hit by a car or injured because of dog attack etc. | Presence/absence for koala<br>SAT surveys for koala usage<br>Motion sensor camera data<br><br>Review of the Koala Hospital Dataset from the Open Data Portal of the Queensland Government | Within the onsite corridor and at connections with broader Logan biodiversity corridor<br>This is a desktop review with potential for follow up investigations on site | Annually as part of the ACR surveys. Cameras to be set for 2 weeks |

## 10.5. Reporting Requirements

Condition 17 of the EPBC Approval pertains to the maintenance of accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures required by this plan. As per Condition 19 of the EPBC approval, within three months of every 12 month anniversary of commencement of the action, **Pointcorp Heritage Park Pty Ltd.** will publish a report on their website addressing compliance with each of the conditions of this approval including implementation of the KSRDP. At this time, documentary evidence providing proof of the date of publication and any non-compliances will also be provided to **DCCEEW**.

The compliance report will include at least the following information:

- Details of any EPBC listed species encountered during normal operations including species, location, health and nature of interaction (i.e. crossing the road, within buffer areas, etc);
- Detail of any complaints received including date and time of complaint, details of the complaint and actions taken to resolve the issue;
- Details of any clearing works that have occurred at the site over the previous 12 month period;
- Any fauna encountered during the clearing including actions taken in response to the encounter (fauna spotter reports); and
- **Monitoring of management actions as outlined in Table 7**
- **Non-compliances with this KSRDP including details of the non-compliance and rectification actions taken.**

# 11. Adaptive Management

An adaptive implementation program will be used to ensure uncertainty is reduced over time, and that completion criteria are attained and maintained over the period of approval. As more information becomes available following ongoing performance monitoring, the management and monitoring regime will be reviewed and revised to maximise the likelihood of attaining and maintaining the outcomes to be achieved by implementing the KSRDP. Any updates to the KSRDP which do not result in a material change to the environmental outcomes, performance and completion criteria will be made by The Proponent without the requirement of informing the Department. If material amendments likely to alter the environmental outcomes, or performance and completion criteria are proposed to the KSRDP, the amendments and justification for the contingency measures will be provided to the Department in writing.

Adaptive management will be used to incorporate changes in any of the following areas:

1. Assimilation of new data or information - such as, updates to koala exclusion fencing or climb out pole specifications.
2. Project coordination and scheduling – to manage unforeseen disruptions to schedule such as inclement weather on contractor works for management actions and environmental consultant monitoring events.
3. Annual review of management measure effectiveness – to increase the frequency or change the method of management actions where monitoring performance criteria are not met.
4. Contingency for unplanned incidents – such as stochastic events including unplanned fires or floods.

## 11.1. Uncertainty

The plan identifies and manages uncertainty. To this end the plan specifies:

a) key data/information used to formulate the plan.

b) the limitations and/or uncertainty associated with the use of that data/information.

how limitations and/or uncertainty, and associated risks, are mitigated during plan implementation. For example, where a margin of safety is applied to management measures until uncertainty is reduced to an acceptable level or performance targets/completion criteria are attained/maintained.

To identify and manage uncertainty, the KSRDP used published guidelines provide specifications of infrastructure and overall project layout. The main limitation of the KSRDP are that koala are mobile animals and while providing opportunities to disperse, all habitat cannot be isolated from vehicles. Therefore, it is impossible to eliminate risk of vehicle strike entirely as koala may exist a habitat patch and move through areas not able to be fenced (e.g. suburban housing area) and then enter the project site from a direction that does not contain habitat must be open to allow traffic flow.

## 11.2. Corrective Actions

The corrective actions for the project following a monitoring action triggering management are summarised in the Implementation Schedule table (Table 5) in Section 8. The corrective actions fall into three broad categories.

### 11.2.1 Correct Installation of Infrastructure

If any of the infrastructure outlined in this KSRDP is observed to be not to the specifications provided or is not in the locations shown in Attachment B, the infrastructure will be rectified to become compliant with the KSRDP.

### 11.2.2 Injury or Death of Koala

Should any koala be injured or killed within the development or on Green Road north of the project site an investigation of the incident will occur, and a review of the design and location of mitigation measures will be undertaken to increase effectiveness of the KSRDP.

### 11.2.3 Creation of Barrier within Logan Biodiversity Corridor

If data demonstrates that a barrier has been created to fauna movement through the Logan Biodiversity Corridor, a review of the fauna movement solutions will be undertaken to increase effectiveness of fauna safe movement solutions. For, example adding additional culvert furniture or refuge poles to suitable culverts.

# 12. Roles and Responsibilities

The successful implementation of this KSRDP requires a number of key personnel to complete various roles.

**Proponent / Project Coordinator**

PointCorp Pty Ltd is the Proponent for the works as the EPBC Act approval holder and is responsible for the implantation conditions within the EPBC approval and this KSRDP.

**Environmental Coordinator**

The Environmental Coordinator will conduct monitoring activities and reporting.

**Administering Authority**

Department of Climate Change, Energy the Environment and Water (DCCEEW) is the government authority and issuer of approval conditions under the EPBC Act requiring this KSRDP as part of impact mitigation.

**Site Coordinator**

The Site Coordinator is a representative of the project team (typically the project overseer) and is responsible for coordinating the project consultants and construction contractor. This person or company will be responsible for managing non-compliance by appointed contractors and sub-contractors, including establishing additional management procedures if required.

**Civil Contractor**

The civil contractor is responsible for construction of the infrastructure within the KSRDP and any subcontracting that is required for specific infrastructure (e.g. installation of koala furniture in culverts).

# 13. Conclusion

The KSRDP has been produced to comply with the Koala-sensitive Design Guideline prepared by the Queensland Department of Environment and Science and the Fauna Sensitive Road Design Manual published by the Queensland Department of Transport and Main Roads. The design proposed has been developed to comply with the conditions of the EPBC approval to provide safe Koala passage through the onsite corridor and across Green Road. A number of koala sensitive design elements have been incorporated in the KSRDP including exclusion fences and retrofitting suitable existing culverts. The KSRDP makes use of existing design plans for structural elements to ensure they will function as planned.

# 14. Attachments

## Attachment A

Land Use Master Plan

## Attachment B

Koala Sensitive Road Design Plan

## Attachment C

Koala-Sensitive Design Guideline

## Attachment D

Fauna Sensitive Road Design Manual Volume 2, Chapter 6

## Attachment E

Department of Transport and Main Roads Koala proof fence and gate standard drawing 1603

## Attachment F

Brisbane City Council fauna exclusion fence standard drawing BSD-7009

## Attachment G

Moreton Bay Regional Council fauna escape pole standard drawing GI-0520

## Attachment H

Moreton Bay Regional Council fauna movement shelf standard drawing GI-0530 and GI-0531

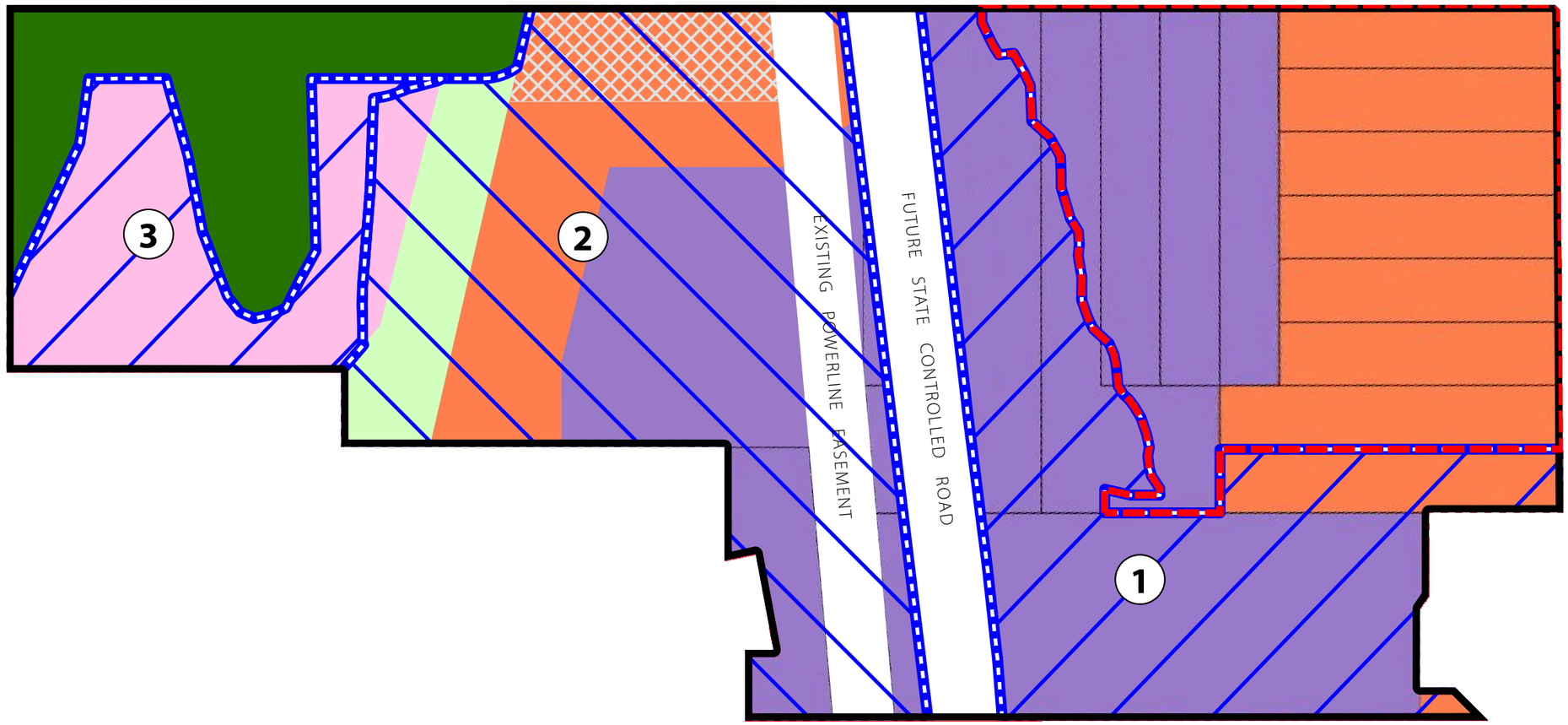
## Attachment I

Baseline raw data from SAT surveys

# Attachment A

## Land Use Master Plan

# 1. Proposed Land Use Masterplan




NOTES
This plan was prepared as a desktop assessment tool. The information on this plan is not suitable for any other purpose. Property dimensions, areas, numbers of lots and contours and other physical features shown have been compiled from existing information and may not have been verified by field survey. These may need verification if the development application is approved and development proceeds, and may change when a full survey is undertaken or in order to comply with development approval conditions. No reliance should be placed on the information on this plan for detailed design or for any financial dealings involving the land. Saunders Havill Group therefore disclaims any liability for any loss or damage whatsoever or howsoever incurred, arising from any party using or relying upon this plan for any purpose other than as a document prepared for the sole purpose of accompanying a development application and which may be subject to alteration beyond the control of the Saunders Havill Group. Unless a development approval states otherwise, this is not an approved plan.

*Layer Sources*
*Qld State Cadastre and Mapping layers © State of Queensland (Department of Natural Resources and Mines) 2020. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//*
*Aerial Imagery © Nearmap, 2020*

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LEGEND

- Referral area
- Excised area
- Existing lot boundaries
- Mixed use
- Mixed use (enterprise & technology precinct)
- Medium impact industry
- Low-medium density residential
- Recreation & open space
- Environmental management & conservation
- Clearing Stages

| Clearing Stage | Area (ha) | Estimated timeframes* |
|---|---|---|
| **1** | 32 | 2020 |
| **2** | 47 | 2021 |
| **3** | 13 | 2022 |

*Clearing of vegetation within stage one will commence once EPBC approval has been obtained. Commencement of stages two and three will be dependent on market demand but will not occur prior to the estimated dates.

| Issue | Date | Description | Drawn | Checked |
|---|---|---|---|---|
| C | 4/05/2022 | Clearing area updates | TC | AR |

0 50 100 150 200 m

Transverse Mercator | GDA 1994 | Zone 56 | 1:7,000 @ A3

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Pointcorp Heritage Park Pty Ltd

# Heritage Park, Park Ridge

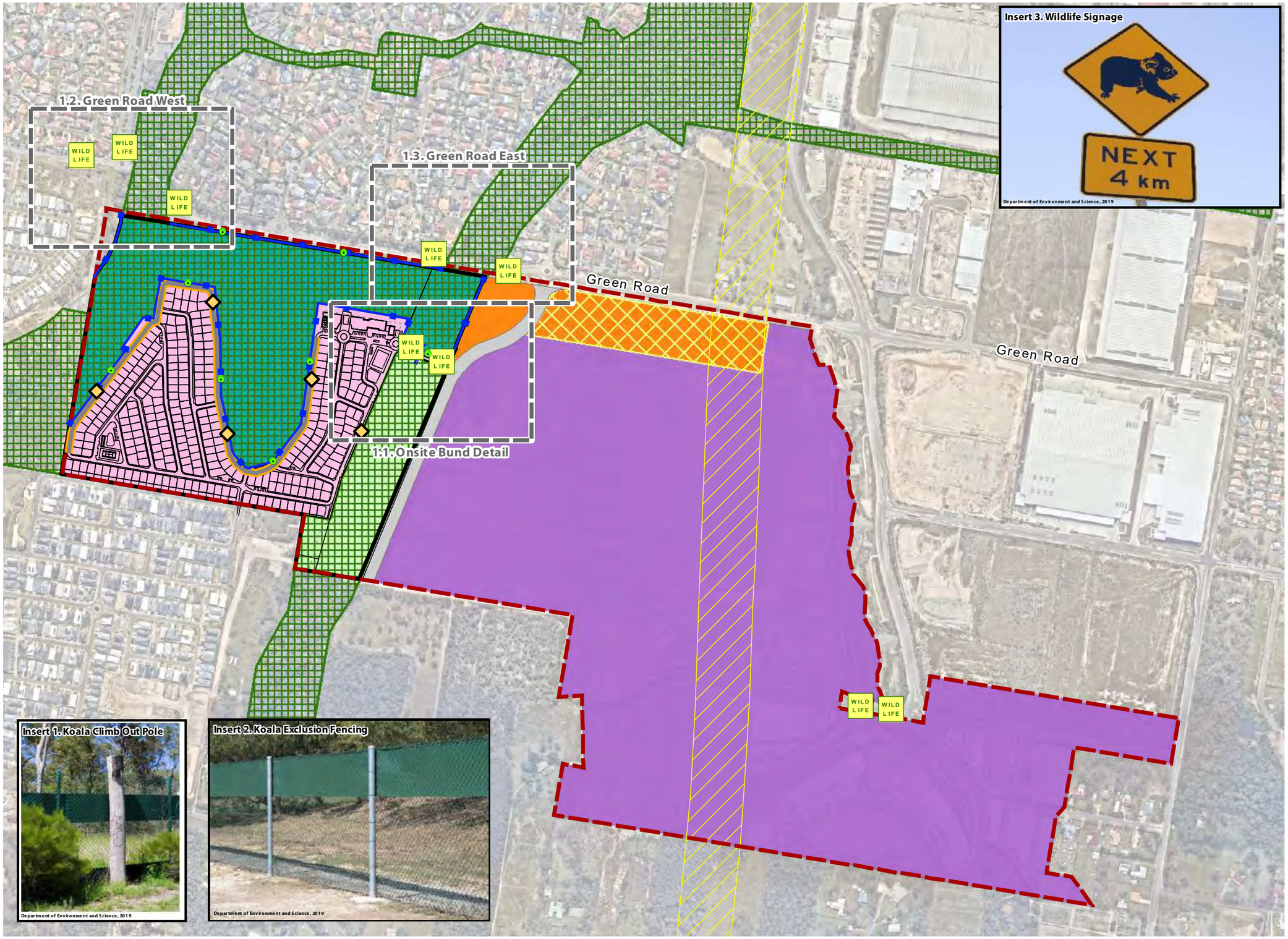
*ADDRESS/RPD: Green Road, Heritage Park*

*4/05/2022 | 8392 E 01 PD Proposed Landuse C*

# Attachment B

## Koala Sensitive Road Design Plan

# 1.0. Context Plan

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## Legend

- Referral area
- Future State road

**Development Detail**

- Surveyed Site Boundary
- Proposed project layout
- Low Speed Esplanade Road
- Amended Logan Biodiversity Corridor
- Local Recreation Park / Open Space
- Low density residential
- Mixed use
- Mixed use - Enterprise & Tech
- Medium impact industry
- Collector road
- On-site conservation corridor

**Koala Safety Design Measures**

- Interpretive Signage
- WILD LIFE — Wildlife Signage Locations
- Koala Climb Out Poles
- Koala Exclusion Fencing

| Issue | Date | Description | Drawn | Checked |
|---|---|---|---|---|
| D | 8/05/2024 | Client Updates | TC | AR |

0 100 200 m

Transverse Mercator | GDA 1994 | Zone 56 | 1:7,000 @ A3

saunders havill group

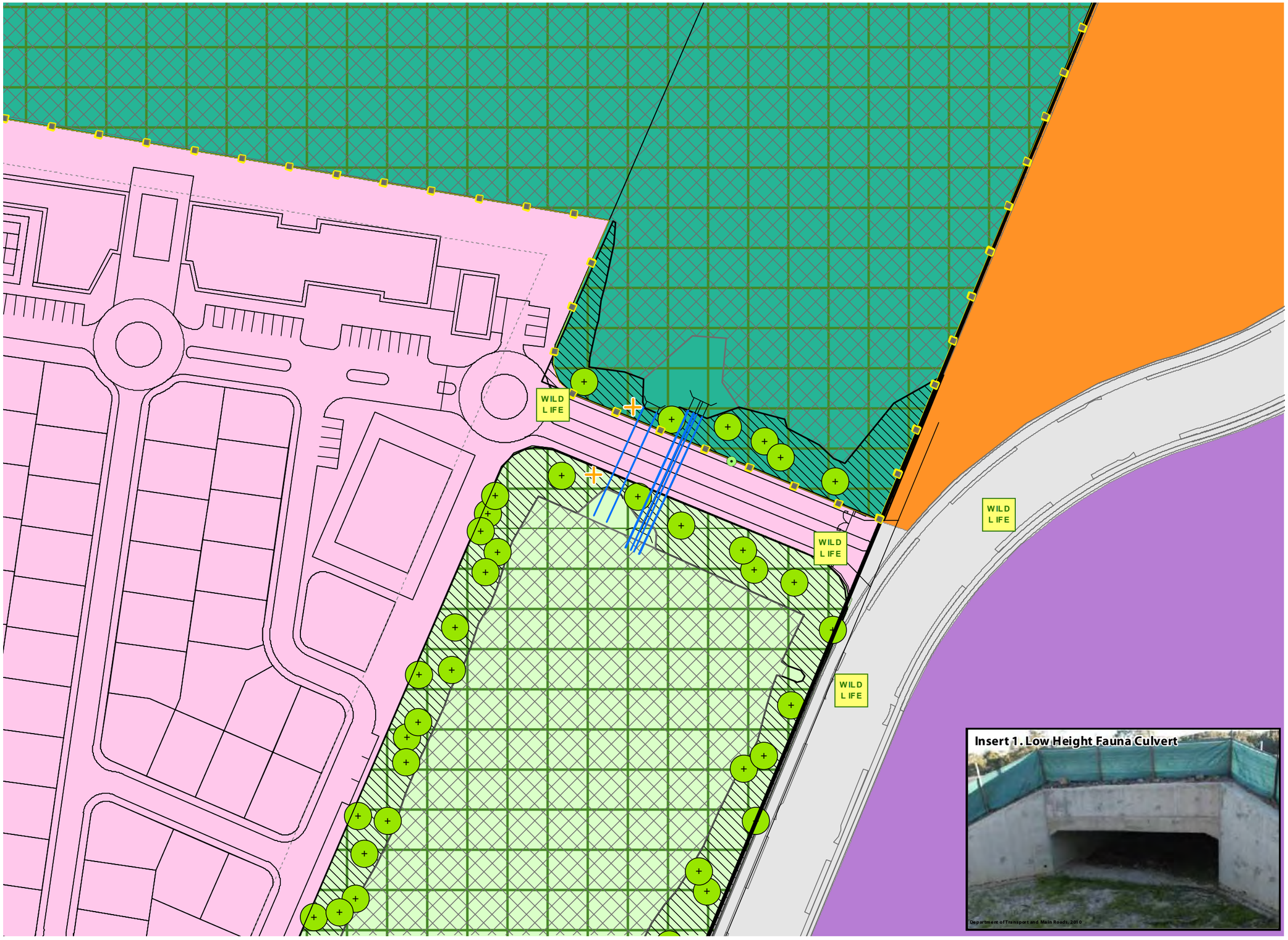
Pointcorp Heritage Park Pty Ltd

# Clarke Road, Park Ridge

*Address / RPD: Clarke Road, Park Ridge*

*8/05/2024 | 8392 E 01 Koala Context D*

# 1.1. On-site Detention Bund Detail




Notes:
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## Legend

- Surveyed Site Boundary
- Proposed project layout
- Low Height Fauna Culvert
- Amended Logan Biodiversity Corridor
- Local Recreation Park / Open Space
- Low density residential
- Mixed use
- Medium impact industry
- Collector road
- On-site conservation corridor

**Rehabilitation Works Detail**

- Waterway Batter (MZ1)
- Retained Vegetation Corridor
- Rockwork to Weirs
- Advanced Tree Planting

**Koala Safety Design Measures**

- Interpretive Signage Locations
- Wildlife Signage Locations
- Koala Climb Out Pole Locations
- Glider Pole Locations
- Koala Exclusion Fencing

**Insert 1. Low Height Fauna Culvert**




| Issue | Date | Description | Drawn | Checked |
|---|---|---|---|---|
| D | 8/05/2024 | Client Updates | TC | AR |

0 10 20 30 40 m

Transverse Mercator | GDA 1994 | Zone 56 | 1:1,000 @ A3

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Pointcorp Heritage Park Pty Ltd

# Clarke Road, Park Ridge

*Address / RPD: Clarke Road, Park Ridge*

*8/05/2024 | 8392 E 01.1 Koala Safe Design D*

# 1.2. Green Road West Design






Notes:
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## Legend

**Development Detail**

- Surveyed Site Boundary
- Amended Logan Biodiversity Corridor
- Local Recreation Park / Open Space
- Low density residential
- On-site conservation corridor
- Existing Culvert

**Koala Safety Design Measures**

- Wildlife Signage Locations
- Retrofitted Koala Furniture
- Koala Climb Out Poles
- Koala Exclusion Fencing

| Issue | Date | Description | Drawn | Checked |
|---|---|---|---|---|
| C | 8/05/2024 | Client Updates | TC | AR |

0 10 20 30 40 50 m

Transverse Mercator | GDA 1994 | Zone 56 | 1:1,300 @ A3

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Pointcorp Heritage Park Pty Ltd

# Clarke Road, Park Ridge

*Address / RPD: Clarke Road, Park Ridge*

*8/05/2024 | 8392 E 01.2 Koala Safe Design C*

# 1.3. Green Road East Design


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## Legend

- Surveyed Site Boundary
- Amended Logan Biodiversity Corridor
- Local Recreation Park / Open Space
- Low density residential
- Mixed use
- Mixed use - Enterprise & Tech
- Collector road
- On-site conservation corridor
- Existing Culvert

**Koala Safety Design Measures**

- WILD LIFE — Wildlife Signage Locations
- Koala Exclusion Fencing

| Issue | Date | Description | Drawn | Checked |
|---|---|---|---|---|
| C | 8/05/2024 | Client Updates | TC | AR |

0 5 10 15 20 25 30 35 40 m

Transverse Mercator | GDA 1994 | Zone 56 | 1:1,000 @ A3

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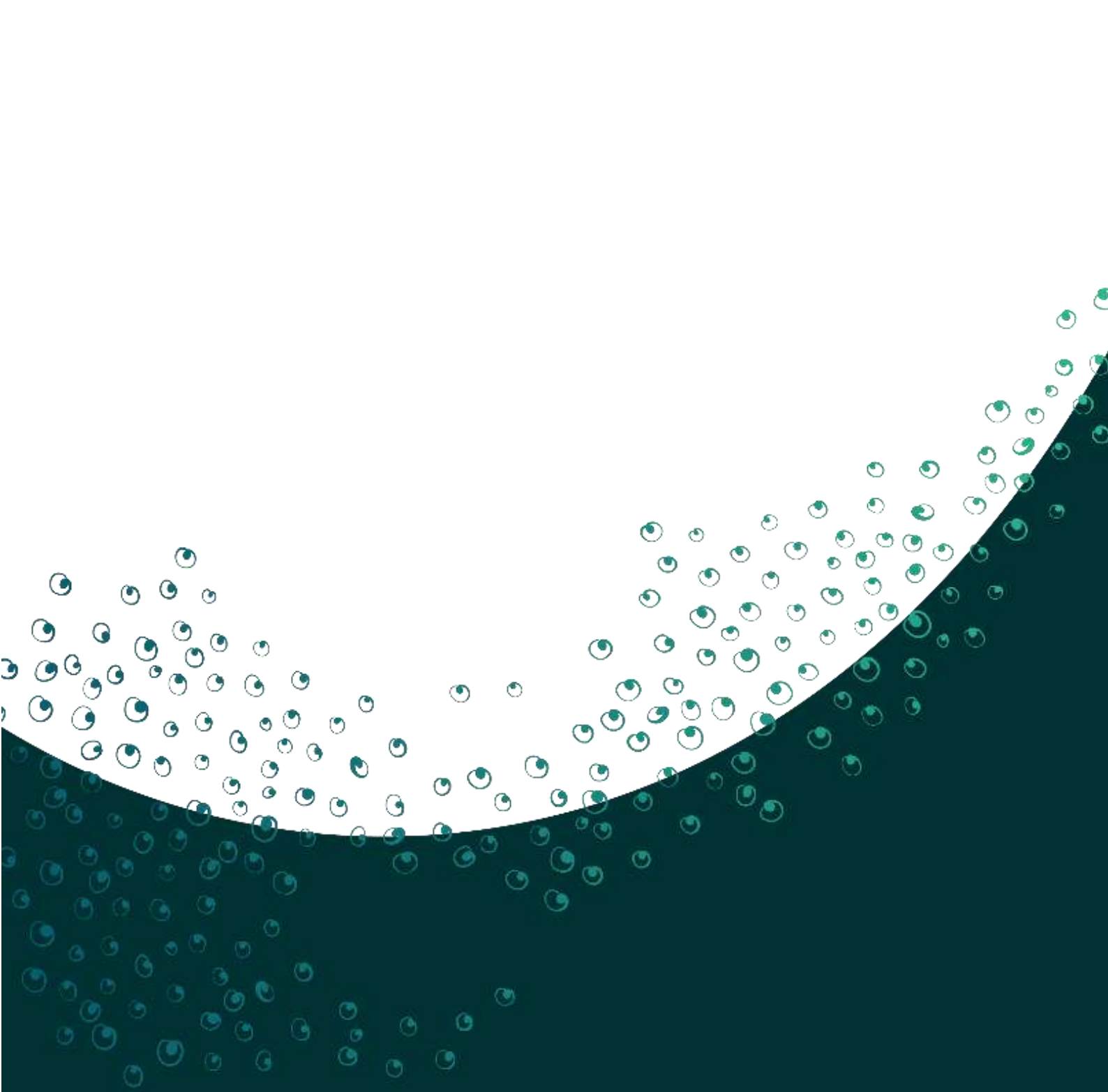
# Clarke Road, Park Ridge

*Address / RPD: Clarke Road, Park Ridge*

*8/05/2024 | 8392 E01.3 Koala Safe Design C*

# Attachment C

## Koala-Sensitive Design Guideline



# KOALA-SENSITIVE DESIGN GUIDELINE

## A guide to koala-sensitive design measures for planning and development activities

Queensland Government

Prepared by: Koala Policy and Oversight Team, Department of Environment and Science

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DES 2022. Koala Sensitive Design Guideline: Department of Environment and Science Government.

**Acknowledgements**.
Endeavour Veterinarian Ecology Pty Ltd was engaged by the department to review the guideline to ensure it reflects current best practice in koala sensitive design. The Department of Transport and Main Roads has reviewed and provided feedback on the guideline.

December 2022

# Contents

# 1. Overview

## 1.1. Purpose

The Koala-Sensitive Design Guideline (the Guideline) provides advice and information for landholders, environmental managers, land-use planners, infrastructure providers and development proponents to determine appropriate measures to avoid, minimise and mitigate the impacts of development and land-use planning on koala populations. It can be used by government and non-government organisations, developers, consultants and the community.

The Guideline provides information to support the assessment of development and facilitate compliance with the *Nature Conservation Act 1992*; State Code 25: Development in South East Queensland koala habitat areas, the State Supported Infrastructure Koala Conservation Policy (SI Policy), and the State Planning Policy (Biodiversity) (SPP).

The Guideline sets out actions that can be taken to:

- ensure koala safety and movement through enhancements to the design and layout of development
    - manage risks to koalas on-site during construction phases.

The Guideline supports adoption of Koala Sensitive Design (KSD) principles at all stages of the development process, including during planning for the site layout, the construction period and the ongoing end-use of the landscape.

Detailed information is provided in **Table 1:** Design solutions to mitigate threats to koalas and their habitat and achieve a permeable landscape at the regional and local scale.

Specific solutions to reduce risk to koalas during the operational works phase of development is provided in **Appendix 1**: Koala-sensitive operational works guidelines

Site-specific issues and scale will ultimately determine the best solutions for a particular circumstance. The Guideline sets out examples and options to solve problems and does not try to predict all possible circumstances.

*Note for transport infrastructure providers:*

Complimenting this Guideline is the associated Fauna Sensitive Transport Infrastructure Delivery Manual (FSTIDM) published by the Department of Transport and Main Roads. This Manual guides the planning, design, construction and maintenance of state-controlled transport infrastructure to minimise impacts and maximise benefits to wildlife, including koalas.

Details from this Guideline relevant to state-controlled transport infrastructure have been incorporated into the FSTIDM.

## 1.2. Koala-sensitive design (KSD) principles

Adherence to the below KSD principles will enhance the persistence and koala safe movement through human-altered landscapes. The principles aim to support healthy, viable koala populations into the future.

KSD principles include that development:

- retains, protects and improves koala habitat values in their natural state to allow koalas to feed, rest and move around safely
- achieves permeability by protecting and enhancing opportunities for the koala safe movement within and across a site
- reduces threats to resident and transient koalas

## 1.3. Use of the Guideline

The Guideline facilitates the persistence and safe movement of koalas by asking designers to apply the KSD principles and:

- identify threats that development activities may have on safe koala movement
- identify appropriate KSD measures to avoid and minimise those threats
- provide solutions and techniques to inform the planning, design and layout stages of development for retaining koala populations and providing for safety and movement
- provide approaches to managing and reducing impacts from operational stage of development
- provide koala-safe movement opportunities
- assist in achieving the outcomes sought in the SPP, SI Policy and State Code 25.

**Figure 1:** (photo Department of Environment and Science 2003)

# 2. Koala biology and ecology

Understanding koala behaviour, habitat use, and patterns of movement through the landscape is important to ensure that KSD measures are effective. While the measures in the Guideline are based on current best-practice methods, they are not an exclusive list of solutions. Alternative solutions can achieve KSD if developed with an understanding of koala biology and ecology.

Refer to SDAP State Code 25 and relevant guidelines for other key concepts relevant to KSD (SDAP State Code 25: Development in South East Queensland koala habitat areas).

## 2.1 Koala distribution

Koalas are distributed throughout Queensland and occur in a variety of eucalypt-dominated habitats (State koala mapping). Koalas are typically more abundant in the coastal regions of the state or along riparian zones where soils have higher nutrient and moisture content. Koalas can be found in remnant bushland, rural zones, suburban parks and reserves and residential areas, often in highly fragmented urban landscapes. Koalas can be permanent residents of these areas with established, stable home ranges, or transient and dispersing to alternative habitat. Koala distribution in the landscape can vary spatially and temporally in response to bushfire, drought or threat profile, for example.

## 2.2 Koala biology and habitat use

Koalas are predominantly arboreal animals, spending most of their time in trees. However, they also travel on the ground while moving between trees or habitat patches.

Key biological attributes to consider when using KSD principles to design or install measures are:

- koalas are suited to a predominantly arboreal life and have well-developed forelimbs and claws and excellent climbing abilities;
- an adult koala can extend their forelimbs over 90 cm from the ground and around 50 cm if reaching up and over a structure;
- koalas have the ability to jump up to 1.2 m from the ground;
- daily movements:
    - koalas are most active from dusk to dawn but often move during the day if disturbed or to seek shelter, or during the breeding season (end of June to January) when mating activity is heightened and animals are dispersing.
    - koalas will typically change trees at night, preferring to descend a tree and walk across the ground rather than move through the canopies of adjacent trees. Koalas can move a few metres per night or move a few hundred metres per night, or many kilometres overnight during times of dispersal.
    - koalas move slowly across the ground if not threatened and often with little regard to their surroundings.
- seasonal movements:
    - sub-adult koalas (prior to breeding) often disperse from their place of birth to new habitat and can move considerable distances (>10 km) before establishing a new home range. The drive to disperse is strong and koalas will manoeuvre through, over and under obstacles in their path.
    - koalas occupy home ranges that overlap with other male and female koalas, and depending on the forest structure and location, the size of a koala's home range can vary greatly from less than 1 ha to over 100 ha.
    - the home ranges of koalas can include cleared or highly fragmented areas.
    - koalas will use a variety of food and shelter trees in their home range, and a complex forest structure with mid-storey vegetation provides the best thermoregulatory opportunities for animals (which is particularly important as climate-change related impacts worsen).

# 3. Development planning, design and layout

## 3.1 Threats to koalas

Koala injury or mortality can be a direct result of anthropogenic threats associated with urbanisation and development or by indirect mechanisms such as misadventure following displacement. Specific threats to koalas from development activities should be identified and may include:

- loss or degradation of habitat
- habitat fragmentation and loss of connectivity
- vehicle strike (koala injury or death)
- domestic and wild dog attack (koala injury or death)
- drowning in pools
- increased prevalence of disease (increased susceptibility to disease due to stress caused by the above-mentioned threats)
- entrapment and injury during construction or operational-use phases of the development (see Appendix 1 for koala-sensitive operational works guidelines).

## 3.2 Habitat connectivity values for koala movement (permeability)

The successful movement of individual koalas through the landscape allows for genetic exchange between koala populations. This process improves genetic diversity and ultimately improves species resilience to change habitat, climate and threats at an evolutionary level. High rates of development, particularly in SEQ, are removing and fragmenting koala habitat and increasingly threatening the safe movement of koalas across the landscape. This has immediate impacts on koala survival, and negatively affects local population persistence and genetic diversity over medium to long-term timeframes.

Koala habitat quality and connectivity should be determined through environmental assessment and used in development planning, design and layout. Importantly, both existing and potential future habitat and connectivity corridors should be considered. For example, koalas may have been extirpated from an area due to historical threats, but the area may still provide valuable conservation resources which could be enhanced and protected to allow for re-establishment of koala populations in the future. Hence, the absence of koalas should not preclude the application of KSD measures in habitat or areas that otherwise are suitable for koala population re-establishment.

To determine the habitat connectivity value of the site to facilitate koala movement through the landscape, the following factors should be considered:

1. The site's location in a landscape context, with regard to:
    - areas identified as koala habitat areas (core or locally refined), or koala habitat restoration areas
    - areas identified as other remnant or regulated regrowth regional ecosystems where koalas are known to occur, or have occurred historically
    - other areas of environmental significance that need to be retained (e.g., habitat for threatened plants or ecosystems)
    - waterways and ecological corridors.

2. The local attributes of the site, including:
    - the presence, or likely presence, of koalas, or their presence historically
    - the condition and quality of the habitat
    - the presence of waterways or ecological corridors, or areas that are remnant or regulated regrowth regional ecosystems which koalas are known to use
    - edge effects and other indirect impacts of development on ecological features
    - the presence of infrastructure and services, such as roads, which present barriers for safe koala movement and dispersal
    - the presence of natural barriers, such as large waterbodies, which create barriers for koala movement and dispersal
    - temporal impacts on the quality and connectivity of habitat such as land-clearing, drought and bushfire.

- Any factors which diminish the site's habitat connectivity value for koala movement within, and adjacent to, the site and landscape, including:
- edge effects and other indirect impacts of development on ecological features
- the presence of infrastructure and services, such as roads, which present barriers for safe koala movement and dispersal
- the presence of natural barriers, such as large waterbodies, which create barriers for koala movement and dispersal
- temporal impacts on the quality and connectivity of habitat such as land-clearing, drought and bushfire.

In summary, the site's location and attributes with regards to the presence of koalas, location and condition of habitat, waterways and ecological corridors and any factors impacting on these values should be taken into consideration for planning and development.

An assessment of koala habitat connectivity values should include:

- a description of the use or potential use of the site, and areas adjacent to the site, by koalas, with consideration of spatial and temporal influences of koala distribution;
- a map of koala habitat, including bushland, groups of trees and individual trees; and
- a plan of movement corridors (connectivity), including regional and local-scale movement corridors, and existing and potential links between koala habitat within, and external to, the site.

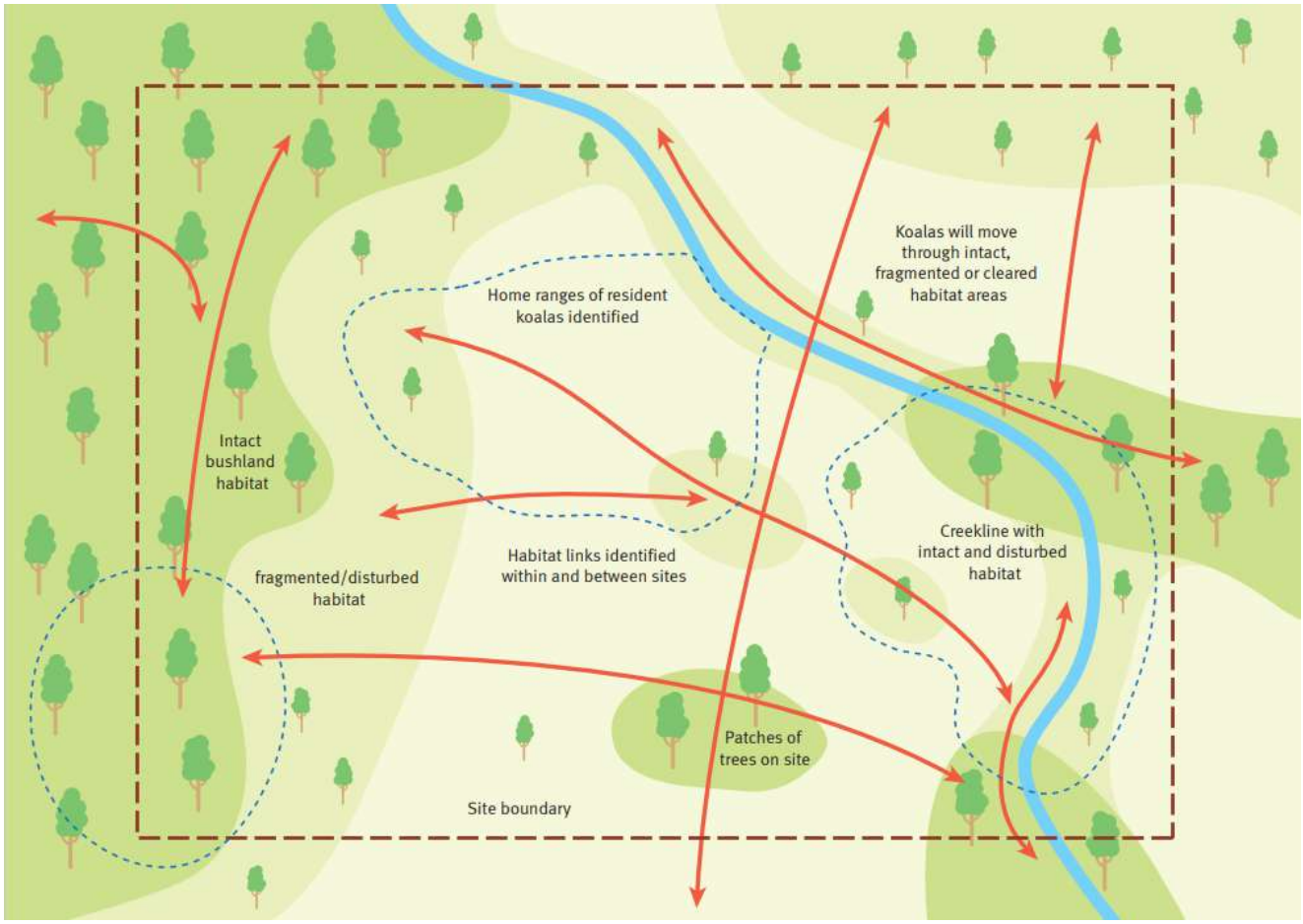



**Figure 2**. Example of assessment of koala habitat and connectivity value for koala movement, including on site values and broader landscape-scale connectivity for movement and genetic exchange.

## 3.4 Planning, design and layout for koala conservation

Following an assessment of koala habitat, connectivity values, and identification of threats; the planning, design, and layout of the development should:

1. Ensure areas of koala habitat values and habitat connectivity are protected and enhanced by:
   - creating large contiguous patches of koala habitat and habitat corridors that are at least 100 metres wide
   - retaining and enhancing vegetated stepping stones and highly connected patches (ie highly connected patches are areas less than 200 metres apart)
   - avoiding clearing non-juvenile koala habitat trees on the site, including individual, isolated trees
   - avoiding clearing of heat-refuge vegetation associated with larger habitat trees - maintaining floristic structure diversity
   - linking on-site koala habitat to koala habitat located external to the site, providing adequately spaced and sized habitat linkages - corridor establishment and enhancement
   - identifying rehabilitation areas on the site for revegetation consistent with the density, composition and distribution of native koala habitat vegetation, based on the pre-clearing regional ecosystem description
   - securing the long-term conservation of koala habitat areas using covenants or other private or public ownership arrangements.
   -
2. Locate and design the development to avoid adverse impacts on koalas, koala habitat values and habitat connectivity by:
   - selecting sites that will have least impact on koalas if developed, such as cleared land that has low koala habitat connectivity value
   - minimising the size and scale of the developable area in the development footprint and of individual buildings (e.g. higher density, multi-storey buildings may have less impact)
   - using development envelopes that are shaped and located to:
   - co-locate all associated activities, infrastructure and access strips
   - be within the least valued area of koala habitat on the lot
   - minimise the footprint of the development envelope area
   - minimise edge effects to areas external to the development envelope
   - create a buffer (road or park) between development and areas of koala habitat
   - ensuring enough area is maintained between development buildings and koala habitat trees to ensure trees will not be removed for safety (fire and falling).

3. Locate and design transport routes (bikeways, busways, roads and rail lines) to avoid fragmentation and clearing of koala habitat and to retain habitat connectivity, including:
   - avoiding transecting large contiguous areas of koala habitat or cleared land with high potential for koala habitat or connectivity corridors
   - using speed reduction devices such as speed bumps, roundabouts, chicanes, speed warning signs and painted road treatments on roads in koala-sensitive areas
   - incorporating koala crossings (over and underpasses) and using koala exclusion fencing to ensure koalas are funnelled towards koala crossings and away from busy transport routes
   - considering use of viaducts, extending bridge spans, and using tunnelling to avoid and minimise direct impacts (vegetation clearing) and indirect impacts (road trauma) on koalas.

4. Use native vegetation in landscaping and habitat restoration activities that provide food, shelter and movement opportunities for koalas.

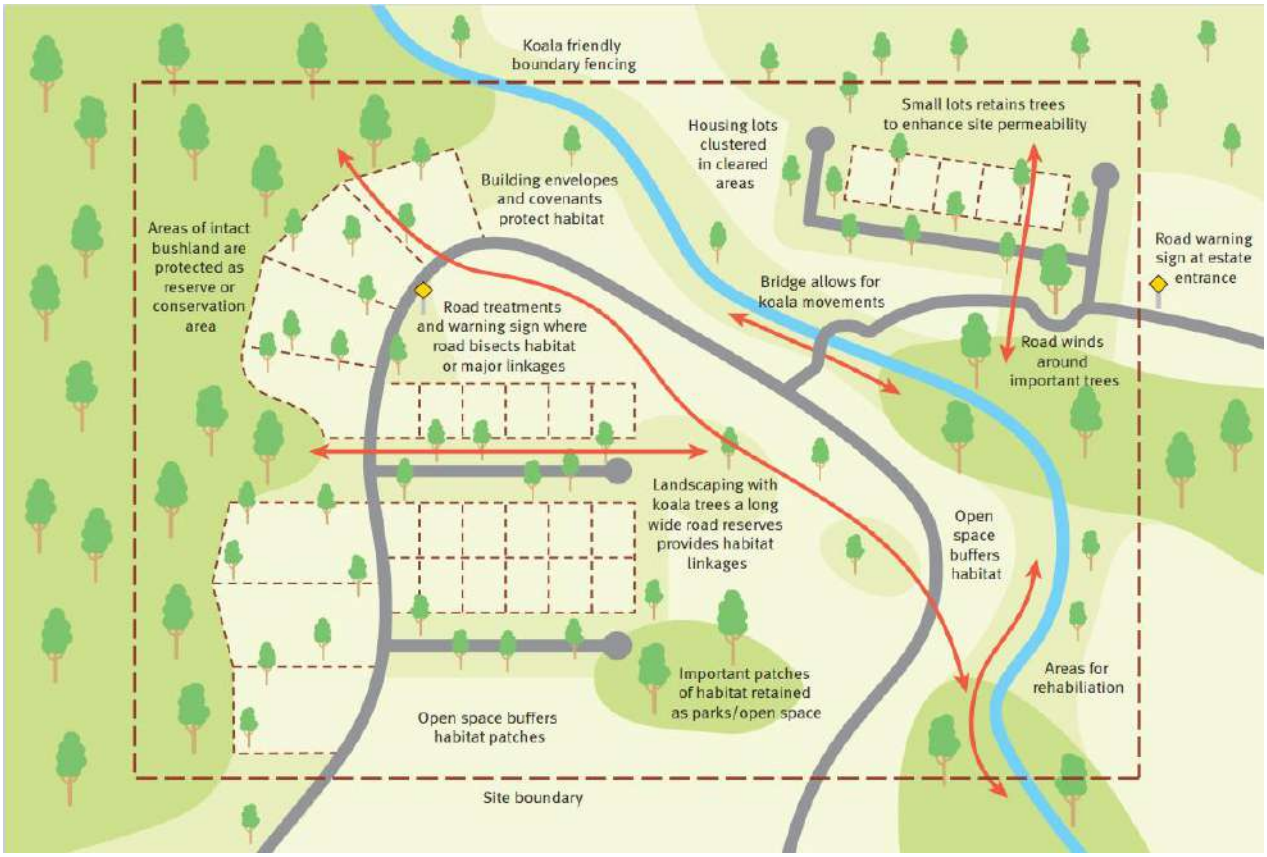



**Figure 3** Example of a koala sensitive urban design - illustrates how infrastructure and development can be planned and designed to maximise retention of koala habitat and connectivity.

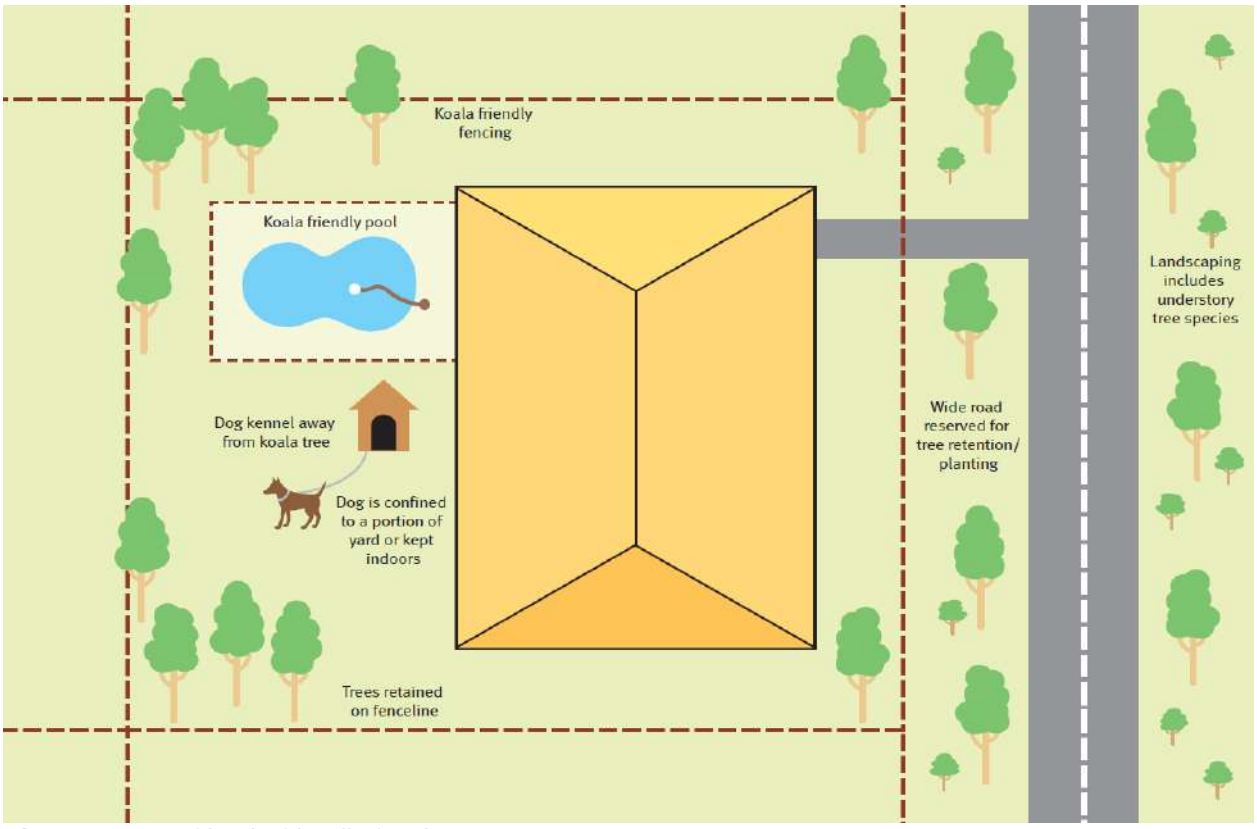



**Figure 4**. Use of koala-friendly fencing

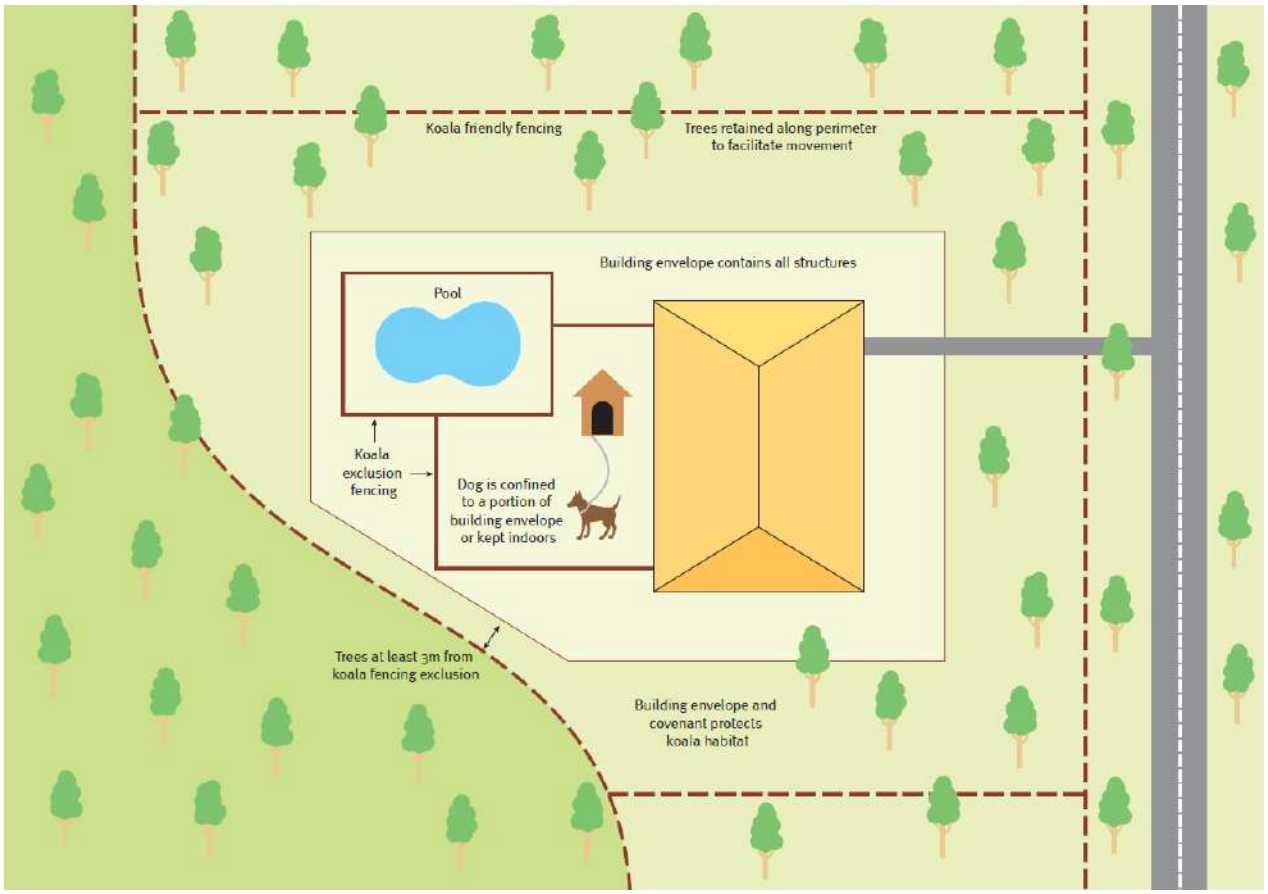



**Figure 5**. Use of a development envelope and koala exclusion fencing

# 4. Designing koala-safe movement solutions

KSD measures which can facilitate landscape permeability and safe koala movement include:

- koala-friendly (allows koala movement) and koala exclusion (prevents koala movement into unsafe areas) fencing
- koala-safe road design (including crossing structures) and placement
- mitigation of construction-related threats (including vegetation clearing)
- koala-safe pools and other water bodies
- mitigation of threats from domestic dogs and livestock
- landscaping to maintain or enhance koala habitat and connectivity
- koala detection and monitoring, and sensitive vegetation clearing practices, such as use of innovative technologies and best-practice methods
- community awareness, engagement and koala stewardship programs.

Measures chosen will be influenced by the type, size, and location of the development. It is likely that several of each type of measure will need to be used in the design and layout of the development to maximise koala safety and movement.

**Table 1: Design solutions to mitigate threats to koalas and achieve a permeable landscape at the regional and local scale;** provides design solutions to achieve good koala conservation outcomes including koala-exclusion and koala-permeable fencing designs, ways to navigate transport corridors, pools and dogs, koala habitat revegetation and enhancement approaches, and engaging the community to be koala aware. These design solutions can be applied to a range of development scenarios at strategic and/or site level.

For each measure, the performance outcome; the best practice solutions to achieve the desired outcome; and effective alternative solutions are provided. Supporting information, additional notes and maintenance issues are discussed.

To ensure ongoing success, all implemented measures need operational maintenance and management plans which should include responsibilities and trigger point events for checking that the installed item or fence is in its best working order (e.g., removing fallen logs from koala exclusion fencing after a fire or a storm).

**Appendix 1** has been provided with this Guideline to set out how to reduce koala injury and mortality specifically from construction activities which is critical to prevent harm to koalas during construction of developments.

## 4.1. Note on development size and scale

The size and scale of the development will largely dictate the project budget and the capacity to implement all best practice KSD solutions. There is a strong community expectation that koala populations are conserved and managed and factored into large infrastructure project budgets so that best practice solutions are adopted. These may include:

- comprehensive telemetric monitoring and management/protection of koalas to enable the reliable location of potentially large numbers of koalas during vegetation clearing operations
- use of experienced koala spotters or fauna spotter/catchers
- the deployment and maintenance of a holistic suite of mitigation infrastructure and associated structures, and appropriate and relevant offset contributions.

However, it is often not always practical for small or single lot developments to capture and tag koalas to monitor and easily locate koalas in the area being cleared. In these instances, it may be more practical to use existing information and risk-based approaches including experienced koala spotters (fauna spotter/catchers) and arborists who will be present during vegetation clearing and ensure best practice methods are used that avoid harm to koalas and other fauna. Ensuring habitat is cleared with the utmost caution may negate the need to collar and intensively monitor koalas that may be in patches of habitat undergoing clearing.

New detection technology and methods are emerging, such as thermal-capability drone surveys, which can significantly improve koala detection prior to vegetation clearing operations and may prove to be cost effective.

# Table 1: Design solutions to mitigate threats to koalas and their habitat and achieve a permeable landscape at the regional and local scale.

## 4.1 Koala-permeable fencing

**Supporting information**

Development that incorporates koala-friendly fencing assists koala movement and dispersal within and across the development site. Inappropriate fencing reduces the permeability of the landscape to koalas and can result in the funnelling of koalas to unsafe crossing points, injury, and death. Koala-friendly fencing can allow unimpeded movement of koalas between areas of habitat and can be built within properties or on lot boundaries. Koalas are skilful climbers but readily take a path of least resistance and prefer to push under or through a structure before climbing it. With this in mind, koala-friendly fencing achieves permeability by allowing koalas to climb over, under or through the fencing and ensures koalas are not entrapped by the placement and design of fencing materials (such as barbed wire or narrow palings).

**Performance Outcome 1:** *Allow koalas to easily climb through, over or under a fence to provide a permeable landscape.*

## Design specifications

### Best practice

1. Fencing raised off the ground with a minimum spacing of 300 millimetres from the ground to the fencing material, such as post and rail, provides the most permeable solution for koalas (Figure 4.1.1).
2. Incorporate existing trees into the fence to facilitate movement (Figure 4.1.2).
3. Use of push-under and push-through devices are preferred to traditional 'escape poles' constructed of treated timber poles, the effectiveness of which is not proven.
4. Fence tops must avoid barbed-wire or sharp ends (such as are used on some chain-mesh security fencing) which can entrap or snare koalas and other wildlife.

### Alternative solutions

**Fence design must:**

- ensure gaps in the fence are large enough to allow a koala to easily pass through
- gaps are of a size (less than 60 millimetres) to allow koalas to climb over but prevent koalas climbing through and getting stuck in the fence (Figure 4.1.2 and 4.1.3)
- use rails or slats that have spaces of at least 15 mm between vertical slats and 20 millimetres between horizontal rails that koalas can climb. Alternately, use materials such as timber posts or chain wire that a koala can easily grip and climb

**Figure 4.1.1** Post and rail fencing provides the most permeable fencing solution for koalas.

**Figure 4.1.2.** Fences incorporating trees and of slatted design provide ideal movement solutions for fence permeability to koalas.

- install a climbable timber post or log if fencing material is unclimbable. Post is a minimum 125 millimetres in diameter) leaning against the top of the fence but positioned at an angle to the fence so the log is not flush with the fence and climbable by a koala (i.e. the perpendicular space between the base of the log and the bottom of the fence is at least 400 millimetres (Figure 4.1.4).
- install a simple koala bridge (particularly suited to minimum security fences) to ensure safe movement over barbed wire using timber logs of at least 125 millimetres in diameter of the following design:
    - timber logs are positioned adjacent to and within 1 metre of each other on either side of the fence and extend above the fence. A cross piece of similar diameter to the logs connects the two vertical timber posts that are within 1-4 metres of each other on either side of the fence (Figure 4.1.5).

## Maintenance

Maintenance is essential to ensure the proper functioning of the fence design. Develop maintenance plans, outlining required inspection and maintenance schedules of fencing to:

- replace parts or whole structures as per manufacture's recommendations (e.g. items that will perish over time when exposed to the elements)
- keep weeds away from key koala access points such as push-under structures and the bases of wooden poles to ensure detection and use of structures by koalas.

## Notes:

1. Fencing materials must be rigid to support climbing by a koala.
2. To encourage the use of climbing poles associated with chain link or mesh fencing, fit the base of the fence with 600 millimetres skirting to ensure koalas cannot see through the fence, but instead must look up. Koalas can often be seen pacing back and forth trying to find a way through fencing to visible trees on the other side and will attempt to push under sections of unsecured fencing.
3. Consider the movements and permeability requirements of other fauna when installing koala friendly fencing.

**Figure 4.1.3**. Small-spaced fencing slats allow koalas to climb the fence while reducing entrapment between slats.

**Figure 4.1.4**. A wooden bridge over security fencing designed to facilitate the safe movement over the fence and barbed wire by koalas but effectiveness is not well established.

**Figure 4.1.5**. A timber post or log secured to an unclimbable fence allows entry to and exit from a property or habitat on either side of the fence.

## 4.2 Koala-exclusion fencing

**Supporting information**

The use of koala exclusion fencing may be appropriate to prevent koalas from entering an area that poses an unacceptable degree of risk, such as a road corridor, sewage sediment pond, or a construction site. Koala exclusion fencing limits landscape permeability and should only be used where there is a direct threat to koala safety and used in conjunction with associated infrastructure to provide locations of safe movement opportunities. As such, exclusion fencing has the dual purpose of guiding koalas towards koala-safe crossing points such as fauna movement underpasses or overpasses. Exclusion fencing can be temporary, or permanently installed to suit the duration of the threat.

The following situations are suitable to use koala exclusion fencing:

- domestic dog enclosures in larger properties (greater than 800 m2) to limit koala and dog interactions
- high speed/volume roads or rail lines, in association with fauna crossing structures
- swimming pools where pool design is unsafe for koalas
- construction sites where activities or works may cause harm to koalas such as vegetation clearing, digging of pits or trenches, the dewatering of ponds or dams and entrapment in site equipment. Temporary fencing that stops koala access is appropriate in this instance.

Koala exclusion fencing may not be suitable for use in the following situations:

- on roads where traffic speed is already slowed, for example, adjacent to traffic lights
- habitat linkages that would be completely severed and are important at a local or regional scale for maintaining connectivity in the population
- where the placement of driveways, local roads or other landscape features that can't be readily fenced are within close proximity to the proposed exclusion fencing, reducing the effectiveness of fencing if it were installed in areas where fencing would reduce line of sight or visibility and pose a safety risk.

**Performance Outcome 2:** *Exclude koalas from an area of high risk through the installation of an impermeable fence or barrier*

## Design specifications

### Best practice - koala-proof fencing material

- Fencing material consisting of brick, metal sheeting, Perspex or timber fencing with no gaps between palings creates a smooth unclimbable surface to koalas (Figures 4.2.1-4.2.3)
- Fencing supports and posts are located within the zone where koalas are being excluded, or they are fitted with a koala shield (Figure 4.2.4)
- Unclimbable sheeting (metal or Perspex) 600 millimetres or greater in width is retrofitted to the fencing and gates to prohibit climbing by koalas. The top of the sheeting is 1.5 metres from the ground to prohibit koalas jumping up and grabbing the fencing material above the sheeting

**Figure 4.2.1**. (photo D de Villiers) Koala exclusion fencing with unclimbable sheeting on the habitat side of the fence prevents koala access to the road corridor or other unsafe environments. Fencing is flush with a cement footing to prohibit koalas pushing under the fence.

**Figure 4.2.2**.(photo D de Villiers) Brick walls create a barrier to koala movements.

- Sheeting is fitted to fencing material at a height that is comfortable for a koala jumping from the fence to the ground. For example, 1.8 metre high fencing should fit sheeting at 0.9 m to 1.5 m off the ground, not at the top of the 1.8 metre high fence (Figure 4.2.5)
- Fencing is flush with a cement edging on the ground or retrofitted with additional wire to prohibit erosion and washouts where gaps under the fence will allow egress by koalas (Figure 4.2.1 and Figure 4.2.6)
- Particular attention needs to be paid to gates to ensure it is not a point of entry for koalas, either when left open or where the gates provide gaps (Figure 4.2.7)
- Fencing is installed with a skirt of chain mesh (permanent) or corflute (temporary) of minimum 1.0 metre width, that is fixed to the base of the fence (up to 300 millimetres) with the remainder resting on the ground, prohibiting the pushing or digging under the fence by animals. This is particularly necessary where the ground is uneven, or undulating or temporary/construction fencing is erected
- Fencing has a 90 degree return of at least 50 metres in length at the fencing boundaries to encourage koalas back into the bushland and not onto the road or other unsafe environment where the fence ends. Ideally the end of the return is angled back into the patch of habitat
- Trees and shrubs are excluded from within 3 metres of the fence and tree canopies of trees adjacent to the fence are trimmed to remove links to tree canopies on the other side of the fence (Figure 4.2.5).

**Figure 4.2.3**.(photo D de Villiers) Colourbond fencing flush with the ground creates a barrier to koala movements.

## Alternative solutions

Where visual amenity, cost, or other factors such as engineering considerations (wind loading) prohibit best-practice design, alternative designs can still provide some degree of effectiveness in minimising koala egress to unsafe areas and the mitigation of koala mortality. This includes the use of:

- fencing that is less than 1.5 metres high, creating a partial barrier to koalas (Figure 4.2.8)
- floppy top fencing – previously used in New South Wales (NSW Road and Maritime Services is now installing chain link with metal panel in preference to floppy-top fencing).

Trees retained within the 3 metre fence buffer can be collared with metal sheeting to prohibit access by koalas under the following conditions:

- the top of the metal sheeting needs to be a minimum of 1.5 metres from the ground
- the tree cannot have overlapping branches or canopy or with a trunk within 3metres of adjacent trees.

**Figure 4.2.4**. (photo David Fleay Wildlife Park) Fencing supports fitted with a 'koala shield' prevents koalas climbing the support.

## Maintenance:

Maintenance is essential to ensure the integrity of the koala-proof fencing. Develop maintenance plans, outlining required inspection and maintenance schedules of fencing to:

- replace parts or sections of fencing that may have sustained damage due to vandalism, storm or floods or tree falls
- remove saplings, broken branches and climbing weeds that provide climbing opportunities for koalas to navigate over the koala proof fence - a cleared buffer of approximately 3m would be appropriate

- ensure there are no wash-outs or areas of erosion leading to gaps underneath fencing that will allow animals to push under the fence.

## Notes:

Koalas can climb a variety of fencing materials and structures that may seem unlikely, for example smooth metal signposts, patio supports and pool fences (Figure 4.2.9). Consider the agility and high dispersal drive of koalas in the breeding season when designing structures to exclude koalas from an area. Consider the permeability of the regional landscape and the functioning of the local site within this context and if there are alternative safe movement paths in the landscape for koalas before excluding koalas from a key habitat link or corridor.
Small gaps in fences or poorly maintained fences can significantly reduce the effectiveness of koala proof fencing, wasting resources and good intentions (Figure 4.2.10).

**Figure 4.2.7**.(photo D de Villiers) Poorly designed gates provide avenues for koala egress to the road corridor (gaps are shown between and under the gates).

**Figure 4.2.5.** (photo D de Villiers) Unclimbable metal sheeting should be fitted to fencing over 1.5 m at a height that is comfortable for a koala to jump to the ground. All vegetation within 3m of the fence has been removed.

**Figure 4.2.6**.(photo D de Villiers) Fencing can be retrofitted with additional wire cover gaps under koala proof fencing where the ground is undulating.

**Figure 4.2.9**. (photo D de Villiers) Koalas are agile and can climb a variety of structures that may seem unlikely, such as pool fencing.

**Figure 4.2.8**. (photo D de Villiers) Reduced fencing height creates a partial barrier to koalas and discourages koalas climbing the fence and entering the road corridor.

**Figure 4.2.10**. (photo D de Villiers) Even small gaps in koala proof fencing will significantly reduce the effectiveness of the fencing.

# 4.3(A) Koala-safe transport infrastructure - design and placement

## Supporting information

Vehicle-related accidents are a key threat to koala survival. Effective road design and infrastructure placement in koala habitat areas can significantly reduce injury and premature death of koalas and benefit the long-term viability of koala populations by providing safe crossing opportunities, reducing habitat fragmentation and loss and maintaining habitat permeability and linkages. Major roads and local roads require different approaches to manage road-related impacts on koalas. Major roads have the purpose of moving large volumes of vehicles as quickly as possible in a safe and efficient manner and typically represent multi-lane highways and arterial roads. Local roads provide access to local amenities for communities and are made up of a network of suburban streets where mitigation solutions can aim to reduce speed and traffic volumes.

**Performance Outcome 3A:** *Design and placement of roads avoids or minimises impacts to koalas and their habitat*

## Design specifications

## Best practice– road design and placement

Appropriate road alignment and design mitigates threats to koalas and their movement by considering and planning for the following:

- identify the location of koala habitat and habitat linkages in the regional landscape and ensure significant habitat areas are not dissected or further fragmented
- upgrade existing roads to avoid building new roads
- minimise loss of habitat
- allow minor deviations in roads and driveways to retain important koala habitat trees.
- estimate the number of vehicles likely to use the proposed road, anticipated vehicle speeds and the likely volumes of traffic between 6 pm and 6 am (local roads)
- incorporate features that slow traffic such as narrowing roads, roundabouts, chicanes, curves or other speed reduction structures such as speed bumps (Figure 4.3.1)
- locate koala road crossing points in areas of reduced speed zones, ideally less than 40 kilometres per hour (local roads) (Figure 4.3.2)
- increase the visibility of koalas entering the road corridor by managing vegetation and landscaping within and adjacent to the road corridor
- light roads at identified or potential koala crossing points to improve the visibility of koalas when animals are most active between dusk and dawn
- incorporate trees along streets with wide verges (not wide busy streets), particularly at "go slow" points (Figure 4.3.3)
- install koala crossing warning signs and road treatments
- provide painted road treatments across lanes to mark the beginning of zones where drivers must be alert for koalas crossing roads (Figures 4.3.4 and 4.3.5)

**Figure 4.3.1**. (photo D de Villiers) Winding local roads with slow points helps to reduce vehicle speed and avoid collisions with koalas.


**Figure 4.3.2.** (photo D de Villiers) Koala crossing zone has a reduced speed limit to slow vehicles and allow the detection of koalas crossing the road between habitat patches.

- deploy Vehicle Activated Signs or Variable Message Signs/SAM (speed awareness monitors) to display interactive messages, for example, a koala smiley face or cautionary message if vehicle speed is appropriate for the zone, or a 'Slow Down' or sad face if vehicle speed conflicts with the intended speed of the conservation zone (Figure 4.3.6a-c)
- use digital signs with vehicle activated lights or messaging to engage drivers
- use temporary and mobile signage and deploy signs in road mortality hotspots in suitable places and times (Figure 4.3.7)
- use simple and unambiguous messaging and text on signs.

## Alternative solutions

The full or partial adoption of best practice solutions will largely depend on the type of road, the site-specific road environment, where it sits in the broader landscape, and community acceptance of treatments. Not all solutions will be practical all the time, and there may be a spatial and temporal aspect to road treatments. For example, temporary signage may be installed at certain times of the year (the koala breeding season) or moved to areas where recent crossings or vehicle collisions have been observed. Deploy static road signs on sign posts or painted road treatments to alert drivers to koala crossing points or 'go-slow' areas (Figure 4.3.8a-d).

## Maintenance

Improve the visibility of koalas entering the road corridor through vegetation management and landscaping by:

- regular mowing of grassy road edges
- trimming the lower branches of vegetation adjacent to, and within, the road corridor to improve the visibility of koalas crossing roads. vegetation near the road trimmed of lower branches and vegetation to improve the visibility of koalas entering the road corridor
- planting dense bushes and shrubs away from the edge of road or edge of the medium strip.

Maintain koala signage and road treatments for currency and messaging relevant to the location and season.

## Notes:

- Static signs fixed in position have been demonstrated to be less effective at changing driver behaviours than variable messing signs or SAM signs, particularly the longer the sign is left in place.
- Driving at a reduced speed through koala habitat gives the driver a greater chance to avoid koalas on the road.
- Vehicles travelling at reduce speed and striking a koala may result in reduced injury and death of the animal.

**Figure 4.3.3**. (photo D de Villiers) Meandering local roads with wide road reserves and easily visible surrounds can support koala habitat and facilitate safe movements in urban areas by slowing traffic.


**Figure 4.3.4**. (photo D de Villiers) A painted koala road treatment is a stark visual reminder to drivers that they are entering a zone where koalas cross the road.


**Figure 4.3.6.** (photo D de Villiers) Vehicle activated signs displaying variable messaging depending on passing vehicle speed, with positive green koala smiley face when travelling below the speed limit (left), a cautionary message at the speed limit warning the driver to be alert to koalas crossing the road (middle), and a red unhappy face if the vehicle is travelling faster than the recommended speed in the conservation zone (right).


**Figure 4.3.5.(**photo D de Villiers) A painted 'koala zone' alerts drivers to the possible presence of koalas on the road.

**Figure 4.3.7**.(photo D de Villiers) Mobile signage can be deployed in road hotspot areas or during times when there is a risk of koala vehicle strikes.






**Figure 4.3.8 a-e** (left and above).(photos D de Villiers) Static signs are less effective at changing driver behaviour the longer they are in place.

# 4.3(B) Koala-safe transport infrastructure - koala crossing infrastructure

## Supporting information

Roads can be fitted with a range of measures to reduce koala and vehicle collisions and facilitate safe and unimpeded koala movement across roads, particularly at identified or potential koala crossing points where roads intersect or fragment koala habitat and major habitat linkages. Structures should be incorporated into road design and layout and can take the form of land bridges or overpasses over roads or underpasses beneath roads, taking the form of natural crossing points under bridges, or culverts. Environmental and physical aspects relating to the landscape and topography will often influence the type, dimension and placement of road crossing structures. Budgetary considerations also heavily influence the installation of fauna solutions – fauna crossing structures are more likely to be installed on state road projects compared to the upgrade or construction of local roads.

***Performance Outcome 3B:*** Design and placement of fauna crossing infrastructure reduces koala road mortality

## Design specifications

## Best practice– road crossing infrastructure

Install one or more land bridges, covered in natural substrate and vegetation, to connect habitat on either side of a road (Figure 5.3.9):

- wide bridges provide a more natural avenue for koalas to cross roads and negate the lighting and flooding issues associated with underpasses
- install escape or refuge poles on the bridge for predator avoidance while vegetation is becoming established
- bridge design conforms to road safety standards and prevents koalas and other animals from falling from the overpass into the road corridor and oncoming traffic
- land bridge is designed exclusively for wildlife movement and prohibits dual uses such as pedestrian or cyclist crossings.

Install one or more fauna overpasses/bridges to link habitat across the road (Figure 4.3.10 & Figure 4.3.10a)

- structures are as wide as possible, with a minimum width of 60 centimetres to comfortably accommodate the crossing of koalas
- build the overpass with stable, rigid materials
- rehabilitate or retain habitat at the overpass to funnel animals to the crossing structure
- design conforms to road safety standards and prevents koalas and other animals from falling from the overpass into the road corridor and oncoming traffic
- provide natural under road bridge fauna movement solutions (Figure 4.3.11)

**Figure 4.3.9**.(photo: google earth) A landbridge designed for use by wildlife has well established trees and ground cover to facilitate crossing.

**Figure 4.3.10**.(photo: google earth). A fauna overpass links habitat on either side of a main road.

- set bridge footings back from the creek edge to provide koalas with the most natural movement opportunities across unsubmerged or non-waterlogged land beneath the road bridge
- incorporate koala furniture, where warranted.

Install large 3 metre x 3 metre box culverts or pipes in strategic areas in the landscape to improve permeability and safe movements of koalas (Figure 4.3.12).

- the culvert is fauna specific and not dual purpose – as such, it may still be located in a riparian zone, however, it is adjacent to the waterway, placed higher than the typical level of the creek and is not required for drainage
- locate the culvert where the floor will remain dry except in significant rain events where the structure quickly dries out
- lengthy underpasses are avoided, for example, by using split carriageways to ensure natural light penetrates the structure
- deploy fauna furniture of post and rail design, using salvaged timber, where possible
- horizontal logs placed as high off the ground as possible to avoid predators with a minimum space of 600 mm between the top of the horizontal log and the culvert's roof
- horizontal logs are supported by vertical logs at regular intervals (approximately 2-3 m) along the underpass for koalas to ascend or descend the koala furniture as required
- logs are greater or equal to 150 millimetre in diameter, or horizontal planks are greater or equal to 150 millimetre in width
- koala furniture extends beyond the underpass into koala habitat
- retain vegetation up to the entrance of the underpass, including koala food trees and groundcover without obstructing access to the culvert
- mandatory installation of koala exclusion fencing and other associated infrastructure on all sides of the crossing structure to improve the effectiveness of the underpass or overpass and to funnel animals to the crossing point (4.3.13)
- fencing extends for a minimum of 150 metres on either side of the crossing structure.

Vegetated habitat linkages are retained or established by securing or enhancing habitat on either side of the road and crossing structure to encourage use and planting koala food tree species relevant to the local area and the regional ecosystem.

Crossing structures are installed at regular intervals along sections of road adjacent to koala habitat or habitat linkages.

- multiple culverts (approximately 100 metres apart) within a large patch of bushland will facilitate more natural ranging behaviour by the resident animals who have relatively unimpeded access to adjacent patches of habitat
- single large culverts spaced a maximum distance of one structure every 2 kilometre will allow adequate landscape scale connectivity and genetic exchange for dispersing animals.

**Figure 4.3.10 a**.(photo: Brisbane City Council). An overpass links habitat on either side of Boundary Road, designed for koalas and other fauna

**Figure 4.3.11** (photo D de Villiers) Under-bridge crossing point for wildlife, with wide buffer to bridge footings that can accommodate fauna furniture to assist with movments and predator avoidance.

## Alternative solutions

While large, fauna specific box culverts are best practice, there is a range of underpass designs and dimensions that are also suitable for use as fauna crossing structures. The number, type and positioning of fauna structures is a balance between ecological, engineering, and budgetary considerations.

Underpasses can take the form of:

- dual purpose culverts/pipes – used for vehicle or pedestrian access but are suitably placed for use by fauna.
- drainage culvert (single) – function is primarily drainage but can be used by fauna when dry.
- multiple culverts – culverts function as drainage devices but culverts are slightly elevated above the creek bank and are mostly dry to facilitate fauna movements outside major rain events.
- Box culverts of a minimum 1.5 metres x1.5 metres dimension are the minimum size for a single or dual carriageway on local roads. This size may include koala furniture.

Box culverts with dimensions as small as 900 millimetres can still be effective (Figure 4.3.14), however small culverts exclude the installation of fauna furniture, or escape poles; reduce natural light penetration and potentially reduce the use of the structure by koalas; and are only suitable for installation on single or dual carriageways less than 30metres wide.

## Maintenance:

Crossing structures must be routinely inspected to ensure access points around the culvert and the culvert itself remain free from weeds or build-up of debris. The effectiveness of the crossing structure often relies on koala proof fencing to funnel or guide animals to the safe crossing points. Maintenance of fencing must include:

- a maintenance plan outlining inspection schedules and repair budgets
- management of vegetation adjacent to the structure to improve the use of culverts by koalas.

## Notes:

- Natural substrate (resembling the forest floor) on the floor of the underpasses is ideal, but koalas are comfortable walking on most hard surfaces and will readily walk on concrete.
- Koalas need to be encouraged to use fauna underpasses by funnelling animals to entrances with koala exclusion fencing.
- Installing koala furniture throughout underpasses provide a means of escape for animals encountering predators in culverts. However, there is almost no evidence that koalas prefer to use furniture in culverts. Rather, almost all recorded crossings through underpasses by koalas have been on the ground.
- Koalas can incorporate underpasses and other crossing structures within their home ranges and become regular users of these structures (Figure 4.3.15).
- A lack of consistent monitoring data and robust comparative data for culverts means there is little statistical support for determining the best and most effective design to suit different environmental situations.

**Figure 4.3.12**. (photo D de Villiers) A 3.0 m x 3.0 m box culvert provides maximum light penetration and is large enough for fauna furniture to aid movmement and predator avoidance.

**Figure 4.3.13**.(photo D de Villiers) Koala exclusion fencing constructed along a rail line. Without barrier fencing, koalas will likely walk across the rail line and avoid the dedicated fauna crossing point/culvert. Fencing completed below.

**Figure 4.3.14**.(photo D de Villiers) Small 900 mm box culverts can still provide movement opportunities for koalas but are too small for the installation of koala furniture and will have reduced natural light penetration.

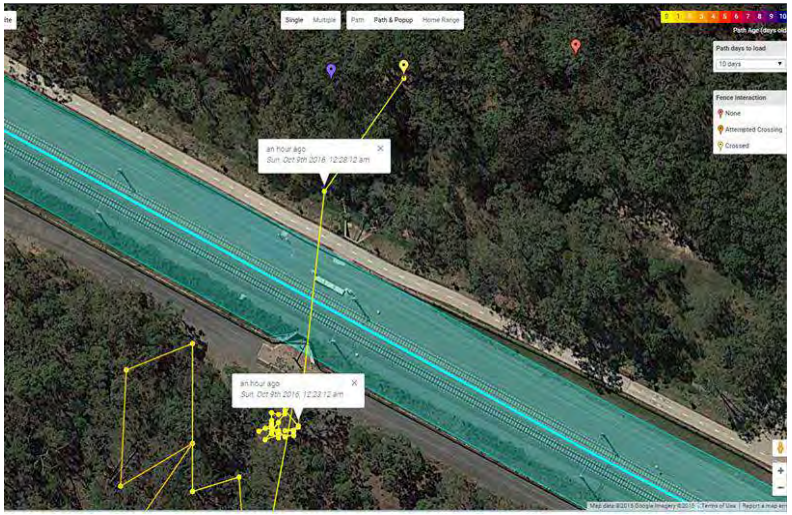



**Figure 4.3.15**. (photo: Endeavour Veterinary Ecology K-Tracker) Koalas will readily use culverts as part of their home range. A male koala uses one of the dedicated fauna crossing under a rail line.

## 4.3 Koala-safe transport infrastructure design and placement – road egress structures

### Supporting information – road egress structures

Koalas often find their way onto road or rail corridors and can become trapped between road barriers and fencing and disorientated during movements through the landscape. Road egress structures provide a means for koalas to readily exit the transport corridor into the safety of adjacent habitat. These structures are used in conjunction with koala exclusion fencing and take the form of escape poles, koala gates or egress valves or other designs installed on the roadside to help koalas exit into bushland. Exclusion fencing is typically a one-way design, where sheeting prohibits koala entry from the habitat side to the road corridor. However, while the fencing on the side of the road corridor is climbable by koalas, navigating vehicle traffic and lane barriers can leave koalas disorientated and wandering on the road or along the road corridor.

***Performance Outcome 3:*** Design and placement of road egress structures and reduces koala road mortality by allowing rapid egress from transport corridors and meet other environmental and safety requirements.

## Design specifications

### *Best practice*– road egress structures

1. Install one or more of the following road egress structures on state and local road koala mortality hotspots:
    - one-way koala escape gates, placed within the fence provide a means for koalas to manoeuvre through exclusion fencing (Figure 4.5.16).
    - install koala escape gates in areas where koalas can access the transport corridor, for example, near on/off ramps that can't be fenced adequately to exclude koalas.
    - escape gates are made of Perspex with a spring balanced/counter lever design to wield to gently pressure of a koala pushing through the gate flaps in one direction (Figure 4.3.17).
    - koala escape gates should be deployed with fencing 'wings' to maximise encounters and use of the structure. Additional fencing aims to funnel koalas to the egress structure.
2. Fencing with a minimum of a 300 mm gap from the ground to the fencing material, is fitted with a 1.0 m wide skirt made from UV stabilised netting and placed on the habitat side of the fence (Figure 4.3.18).
    - netting must be small enough to avoid the entrapment of koalas and other wildlife (mesh size <8 mm) from pushing through the netting.
    - the flexible skirting is lightweight and allows a koala to crawl underneath the netting from the road corridor but cannot easily be lifted to crawl underneath the netting from the habitat side.
3. Deploy egress structures in areas where koalas are known or likely to enter transport corridors, particularly where koala proof fencing ends or in the vicinity of on and off ramps that allow access to the road corridor.

Figure 4.3.16. (photo: Jonathan Hanger) A koala escape gate is fitted along fencing to provide one-way access out of the road corridor.

**Figure 4.3.17**.(photo: Jonathan Hanger) Perspex gates with a spring balanced/counter lever design will wield to gentle pressure of a koala pushing through the gate flaps in one direction but will not allow a koala to push open the gates to access the road corridor.

- deploy at least two koala gates a maximum of 250m apart on each side of the egress point onto the road corridor.
- deploy escape solutions with fencing to funnel animals to egress structures.

4. Design egress structures to meet environmental and safety constraints along state and local road networks.

### *Alternative solutions*

Alternative designs need to carefully consider the climbing ability, natural behaviours and movements of koalas to be effective. Structures such as escape ramps have been used with limited success, however they remain a valid means of egress from the road corridor if designed correctly.

1. Escape poles, placed vertically in close proximity to koala exclusion fencing allow koalas to ascend the pole and manoeuvre over the fence and out of the transport corridor or other unsafe environment (Figure 5.3.19).
    - poles are a minimum 125 mm in diameter treated pine logs or salvaged timber.
    - poles are positioned within 300mm of the fence on the opposite site of the habitat area to ensure it is detected by a koala travelling along the fence trying to access safe habitat.
    - escape poles are paired with a pole on the other side of the fence and a horizontal cross piece of the same diameter joining the two vertical poles to allow koalas to easily manoeuvre over the fence, facilitating a more rapid exit from the transport corridor.
    - the egress pole extends a minimum of 600 mm vertically above the height of the fence allowing a koala to survey its surroundings. The ingress pole is a minimum of 300 mm above the height of the fence.
    - the horizontal pole securely connects the two vertical poles and is secured to the side of both poles or flush with the poles (see note below).
    - the habitat-side /ingress escape pole is fitted with a smooth ‘collar’ material that a koala cannot climb with the top of the collar a minimum of 1.5 m from the ground (Figure 4.3.20); or the ingress pole can be ‘floating’ at a minimum of 1.2 m to a maximum of 1.5m off the ground and out of reach of a koala or (Figure 4.3.21).
    - metal sheeting is installed vertically from the top to the bottom of the fence and with a minimum of 600mm either side of the pole to prohibit koalas climbing the fence and accessing the escape pole above the unclimbable collar (Figure 4.3.20).
    - attach 600 mm metal sheeting or other screening material to the bottom of the fence for a minimum of 10 m either side of the escape pole to encourage the koala to look up at the trees and be more likely to detect the pole.
    - deploy escape poles between and beyond koala gates to provide a variety of egress options for animals.
    - poles are spaced at regular intervals (~50 m), or more frequently in areas where koalas are likely to access the transport corridor, such as in the vicinity of on-ramps and off-ramps.

**Figure 4.3.18**.(photo: Jonathan Hanger) A skirt of netting allows a koala to push underneath the fence from the road corridor but cannot easily be lifted for koalas to travel in the reverse direction.

2. Escape poles are only installed on the egress/unsafe side of the fence (Figure 4.3.22).
    - the pole is within 300 millimetres of a maximum 1.5 metres high fence to allow a koala to confidently jump from the pole extending at least 600 mm beyond the height of the fence, over the fence to the ground on the habitat side of the fence; or to manoeuvre to the top of the fence and slip down the panelling into safe habitat.
    - the pole is within 300 millimetres of a fence over 1.5 metres in height, with metal sheeting fitted below the top of the fence – koalas are able to climb part way down the fence and slip/jump to the ground at the point where the sheeting is fixed to the fence.
3. Escape ramp placement, design and construction will dictate its effectiveness (Figure 4.3.23).
    - use fencing wings to funnel koalas to the ramp where road safety permits installation of additional fencing along the road corridor.
    - ensure the structure is a minimum of 1.2 metres high and is fitted with metal sheeting or other unclimbable material on and around the ramp's installation point.
    - provide a natural substrate and maintain to eliminate ground cover that will reduce detection and use by koalas
4. Escape ladders assist koalas to navigate steep natural and cement embankments (Figure 4.3.24).
    - wooden rungs of a minimum 100 millimetres diameter or width placed a maximum of 300 millimetres apart and securely fixed to the embankment allows a koala to grip and climb the structure
    - install wide structures made with climbable materials to facilitate detection and use by koalas.

## Maintenance

Egress solutions with moving or pliable components will need a maintenance schedule based on manufacturer's specifications to replace worn or perishable parts of the structure (e.g. push under solutions with netting or egress valves with hinged doors). The maintenance schedule must also include weed management to keep the structures clear of vegetation that could block entry to the egress device or hinder the correct functioning of the device.

## Notes:

Knowledge of the koala's preference to push through or under a fence saw the development of the koala gate. Other innovative solutions must be based on knowledge of koala movement and behaviour to achieve desired outcomes.

Escape poles can provide for resting forks for use by koalas; however, the escape pole or other structure's main purpose is to facilitate the rapid egress of the koala from an unsafe environment to safer habitat.

Trials and monitoring of structures should occur to ensure designs that 'in theory' would seem appropriate are actually used as intended by koalas. For example, determine the preferred orientation of rungs on an escape ladder might involve testing if koalas are more inclined to use a ladder with horizontal or vertical rungs (Figure 4.3.24).

**Figure 4.3.19**. (photo D de Villiers) A double-sided escape pole may facilitate the more rapid exit of koalas from a transport corridor. Metal sheeting on the habitat side stops koalas from climbing the fence and reaching the pole above the sheeting.

**Figure 4.3.20**. (photo D de Villiers) The ingress pole on the habitat side of the fence must prohibit climbing by koalas – here the pole is fitted with smooth metal sheeting and the fence adjacent to the pole is pannelled to stop koalas climbing the chain-link fencing and grabbing the pole above the metal collar.

**Figure 4.3.24**.(photo: google earth). A koala escape ladder is installed on a steep embankment to facilitate rapid egress by koalas from the road corridor in a known koala crossing location.

**Figure 4.3.21**. (photo: oreton Bay Regional Council). A 'floating' double-sided escape pole negates the need to koala-proof the inner/ingress pole.

**Figure 4.3.22**. (photo D de Villiers) Escape poles placed along a road corridor will allow koalas to exit the road corridor and jump over the koala exclusion fencing to the safety of adjacent habitat.

**Figure 4.3.23**.(photo D de Villiers) A koala escape ramp may assist to funnel koalas into secure bushland.

## 4.4 Mitigating construction related threats to koalas – vegetation clearing

### Supporting information - vegetation clearing impacts

Development often requires the removal of koala habitat, particularly for community infrastructure, transport corridors and residential development. Construction activities, whether on a single lot or large-scale infrastructure or residential development projects, can significantly impact koalas and their habitat in the following ways:

- death and injury to koalas from vegetation clearing operations, both directly through the felling of koalas out of trees, and indirectly when the loss of habitat puts koalas in hazardous environments, such as the forced dispersal of displaced koalas across roads (Figure 4.4.1).
- the introduction of site hazards that can cause entrapment, injury and death, such as water bodies, trenches, pits, netting, wiring and fencing
- disruption to movement paths of koalas from the placement of equipment and infrastructure on site
- tree damage, loss and habitat degradation from weed incursion and spread, fire, dust and waste material and poorly defined work zones
- increased traffic movements during construction, both within the development site and on roads used to access the site
- increased noise, particularly sharp loud bursts of sound, compared to low rumbling of machinery.

The size and scale (and associated budget) of the development will guide the level of mitigation methods required and adopted during construction works, however all works regardless of the scale, must ensure koalas are not injured or killed during site works.

***Performance Outcome: Manage the risk to koalas from vegetation clearing***

## Design specifications

### Best practice

1. Robust detection/survey methods are used to locate koalas prior to the commencement of vegetation clearing operations via:
   - on-ground observational surveys by experienced koala ecologists or spotters
   - thermal imaging drone surveys
   - detection dog surveys with dogs trained to detect live animals
   - GPS and BLE near-real-time or programmable monitoring devices (Figure 4.4.2).

2. Koalas can be readily located through radio-telemetry or GPS on the development site if captured prior to vegetation clearing activities and fitted with a monitoring device.

   - mapping interfaces and ‘locate now’ features on GPS tracking units can allow the monitoring of animals remotely and in almost near real-time.

Figure 4.4.1**.(photo D de Villiers) Tree clearing operations in koala habitat areas can cause signifcant harm to koalas both directly through habitat loss and injury, and indirectly from associated site hazards.**

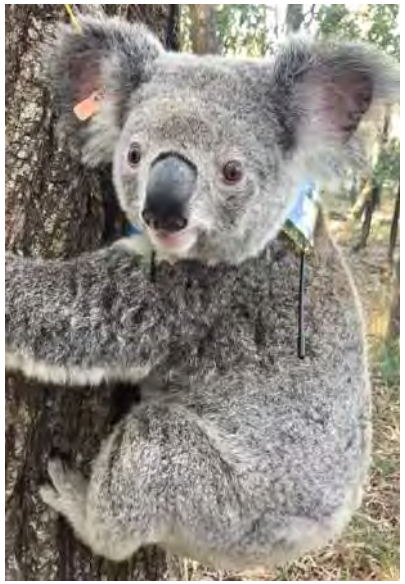


**Figure 4.4.2. (photo D de Villiers) GPS collars can provide real-time location data for koalas where there is the potential for injury during site works.**

- pre-clearing radio-tracking of animals in the clearing footprint will ensure koalas are located and their position identified.

3. Trees with koalas are clearly flagged with a specific colour or design of flagging tape and the on-site fauna spotter is alerted.
•
4. Temporary fencing is installed around the perimeter of the site to minimise the haphazard emigration of fauna from the site into unsafe environments during clearing.

    - temporary fencing is fitted with a panel of unclimbable material of a minimum 600 mm width, with the top of the sheeting 1.5m from the ground (see section 5.2 Koala exclusion fencing). Temporary fencing is typically secured on footings that leaves a large unsecured gap beneath the panels that will provide unwanted movement opportunities for wildlife (Figure 4.4.3).
    - temporary fencing has a skirt of sheeting (e.g. corflute, small gauge wire) to stop the egress of animals under the panels, or fencing is of the type designed with bars that extend to the ground to keep larger fauna from pushing under the fencing (Figure 4.4.4).

5. Sequential clearing of vegetation is conducted, in the manner described in the *Nature conservation (Koala) Conservation Plan 2017*, as the most practical way of ensuring the safe exit of koalas by their own means from the clearing footprint.

    - clearing is staged (dependent on the size of the site) and timed to provide a minimum of 12 hours between clearing events.
    - appropriate habitat links, or trees retained as stepping stones, are maintained from the clearing site to adjacent habitat areas.
    - clearing is in the direction of retained habitat, adjacent habitat or local corridors to ensure koalas are not isolated in an island of vegetation.
    - trees are thinned out on the site prior to bulk clearing to encourage resident koalas to establish new home ranges.
    - no tree in which a koala is present, and no tree with a crown overlapping the tree with a koala is cleared, as per the Nature Conservation (Koala) Conservation Plan 2017.

6. Trees are felled in a controlled manner using a vertical tree grab on an excavator (Figure 4.4.5)
•
7. Experienced koala spotters are present during tree clearing and during mulching operations (*see notes below).

Figure 4.4.3**.(photo D de Villiers) Temporary fencing is typically secured on footings with panels raised off the ground. This design allows egress of fauna into unsafe areas during clearing operations or in the construction zone.**

Figure 4.4.4**. (photo D de Villiers) Temporary fencing with bars to the ground will prohibit the movement of koalas to hazardous areas on the construction site.**

## Alternative solutions

Many of the solutions listed above reflect legislative requirements and, as such, are mandatory.

It is the responsibility of the development proponent to ensure no harm or injury to koalas during habitat clearing, and any alternative solutions to habitat clearing practices need to be developed within the legislative framework. For example:

- trees approved for clearing can be ringbarked to encourage the relocation of resident koalas in the weeks prior to felling. Ringbarking of trees should be conducted in the same sequential clearing manner described above.
- areas of vegetation can be fenced with koala exclusion fencing (section 4.2 and above) to physically prohibit entry by koalas. Fencing can be expanded as koalas move into adjacent areas. However, spotters must still be present when habitat is cleared, regardless of the likely absence of koalas.

## Maintenance

Fauna exclusion fencing must be maintained to ensure there are no points of egress for koalas into the construction zone. Fencing description and maintenance should form part of a wildlife management plan for the site.

## Notes:

1. Koalas are cryptic and can be easily missed during surveys (Figure 4.4.6). Inexperienced observers can miss over 50% of koalas on a site. Innovative technologies using drones, Bluetooth beacons and GPS monitoring devices with near-real time data displayed on the cloud are proven effective means of monitoring the movements and wellbeing of koalas during vegetation clearing operations.
2. Thermal drone detections are optimised when conducted in the coolest part of the night and before sunrise, however there is a high possibility that the koala will change trees between the time of the detection and dawn, particularly during times of heightened activity in the breeding season. Thermal drone detections are still possible at dawn where there is less risk of the animal moving.
3. Clearing a tree housing a koala is prohibited under the Nature conservation (Koala) Conservation Plan 2017. Additionally, the capture and relocation of koalas requires a permit and approval from the state government and is only granted in very exceptional circumstances.
4. Koalas have been known to spend months in a small patch of the last remaining stand of trees on a development site where clearing has resulted in an island of vegetation. This can significantly delay clearing and prove costly for developers and significantly impact construction schedules.
5. Well-hidden young koalas can easily be missed in dense canopies.

Figure 4.4.5**.(photo: Brian Coulter**) An excavator with a tree grab can gentle lower trees to the ground, reducing the risk of broad-scale clearing and felling on fauna such as the koala.

## 4.4 Mitigating construction related threats to koalas – site hazards

***Performance Outcome:*** *Manage the risk to koalas from construction-related threats from hazardous site activities*

### *Design specifications*

### Best practice

Construction activities can introduce hazards to a site and cause injury and death of koalas and degradation and loss of habitat. There are some simple measures that can reduce risk to koalas.

1. Site inductions and pre-start meetings are put in place to convey information to construction personnel and raise awareness of koalas on site and protocols relating to the protection of koalas and their habitat. For example:

    - contact list and procedures for sick or injured koalas requiring rescue are provided at induction
    - site operational works planning is in consultation with fauna spotters/ecologists at the start of the day.

2. Retained habitat is clearly demarcated with temporary fencing, tape and/or other visible markers, and access to this habitat is restricted to reduce the degradation and loss of habitat. For example:

    - restricting vehicle access and reducing risk of machinery damage
    - avoiding disturbance to the ground underneath the drip line of retained trees to avoid tree root damage
    - managing general access/use by site personnel
    - managing waste or spoil disposal to limit the spread of weeds
    - limit the use of open flames or equipment that could spark a fire and result in bushfire (Figure 4.4.7).

3. Safe movement paths between areas of habitat on site are maintained:

    - install signage on access tracks and go-slow points where koalas are known to cross the site
    - enforce speed limits
    - avoid placing equipment around vegetation used by koalas
    - fence off obstacles and structures and other site hazards that could entrap, injure, or kill a koala with koala exclusion fencing (see above and Section 4.2) including:
    - steep embankments, trenches and pits (Figure 4.4.8)
    - areas or structures that can hold water that don't have suitable egress points
    - recently dewatered dams or those currently being dewatered that can leave muddy substrates that can trap and effectively drown a koala Figure 4.4.9)

**Figure 4.4.6. (photo D de Villiers)** The koala in this picture was very difficult to spot, and detection rates vary widely with the level of experience of the observers and the vegetation type and cover.


**Figure 4.4.7.** Operational works on construction sites can introduce a range of hazards that can cause direct or indirect injury and deaths to koalas.

- equipment such as discarded fencing, mesh, wiring and other construction materials

4. Fencing encloses only those areas needed to ensure koala safety on site.
5. Domestic dogs are prohibited on site or restrained at all times.
6. Night-time vehicle movements on site and travelling to and from the site is restricted when koalas are most active between 6pm to 6am.

## Maintenance

Fauna exclusion fencing must be maintained to ensure there are no points of egress for koalas into the construction zone. Fencing description and maintenance should form part of a wildlife management plan for the site.

**Figure 4.4.8.(photo D de Villiers)** Deep post holes for koala proof fencing along a state road upgrade entrapped a koala that could not climb out of the hole.

**Figure 4.4.9. (photo D de Villiers)** Dewatered of dams and sediment ponds can entrap koalas and effectively drown an animal in mud. A koala has walked over a drying surface and was entrapped and died as it sunk in wet mud at the centre of the dam.

# 4.5 Mitigating threats from wild and domestic dogs

## Supporting information

Trauma from domestic and wild dogs continues to have an ongoing and constant impact on koala populations and is the third most common cause of koala injury and death after disease and vehicle-related trauma. Unlike

wild dogs, domestic dogs rarely attack koalas for a food source – rather, they are defending their territory (back yard) and driven by a hunting instinct to chase animals. Mortality rates from dog attacks are high - around 80% of koalas attacked by domestic dogs are killed, and almost 100% of koalas attacked by wild dogs are killed and partly or wholly consumed.

Domestic dog and wild dog control are highly emotive issues. Domestic dog control is problematic because owners are reluctant to:

- acknowledge the capacity of their dog to kill a koala
- confine or restrain dogs to the house or portion of the yard to limit koala and dog interactions.

Wild dog or dingo control is controversial and difficult as wild dogs:

- have been a part of the landscape for many thousands of years and are considered native wildlife in protected areas (Nature Conservation Act 1992) and also a declared pest species (Biosecurity Act 2014) under different legislation outside these areas. Landowners are obliged to take steps to control wild dogs on their land.
- are an apex predator and regulate ecological processes by keeping other pest animal species, such as cats and foxes, and overabundant species at sustainable levels in the environment.
- can effectively switch prey selection and within short timeframes have disproportionate impacts on native threatened species, including the koala.

Community awareness and public education campaigns can provide citizen science data on the spatial and temporal distribution of wild dog populations in the local area.

***Performance Outcome 4A:*** *Mitigate the risk of injury and death of koalas from domestic dogs*

## Best practice design specifications

1. Dog free or 'eco/green' estates entirely mitigates dog and koala interactions (Figure 4.5.1).

    - covenants support the prohibition of dogs within the residential development

2. Koalas and domestic dogs are kept apart on the property to reduce interactions that can cause injury and death to koalas.

    - dogs are confined to the house or a portion of the backyard from dusk to dawn when koalas are most active (small lot residential yards less than 800m$^2$) (Figure 4.5.2).
    - dogs are confined to a koala proof fenced area around the house, where property can be protected, but unfettered access to the entire property is limited (large lot residential and rural properties over 800m$^2$).
    - dogs undergo behavioural training to learn to avoid wildlife (e.g. The 'Leave it' program developed by Redland City Council and Griffith University) (Figure 4.5.3)
    - the property is fenced with koala-exclusion fencing to prohibit entry to the yard by koalas.


**Figure 4.5.1**.(photo D de Villiers) Dog-free areas effectively mitigate the threat of impacts to koalas from domestic dogs by negating interactions.

3. Development layout provides dedicated dog and koala separation areas.

    - dog off-leash areas are built away from areas of koala habitat and incorporate koala exclusion fencing (section 4.2) to keep koalas out of the enclosures.
    - reserves and areas of retained bushland are separated from residential areas by a road as a buffer to avoid yards with dogs adjacent to koala habitat (Figure 4.5.4).
    - house yards are fenced, and the remainder of the backyard is open and permeable to koalas.
    - signage that is easily interpreted outlines dog-owner's responsibilities in parks and reserves.

4. Domestic dog owners are engaged with dog expos and 'dog day out' days where koala and wildlife messaging can be delivered in a targeted approach in a relaxed atmosphere.

***Performance Outcome 4B:*** *Mitigate the risk of injury and death of koalas from wild dogs*

## Best practice design specifications

1. Determine the presence or absence of wild dogs on and adjacent to the site (Figure 4.5.5).

    - conduct surveys seasonally throughout multiple years to assess the presence, distribution and abundance of wild dogs.
    - deploy trail cameras across the site to detect wild dog activity
    - use thermal imaging drones to census the dog population
    - analyse passively collected samples (dog scats) to estimate number of genetically distinct animals in the area.

2. Enhance habitat and habitat linkages to maximise avenue of escape for koalas in the landscape where wild dogs are known to be present.
3. Install escape poles and other egress structures to facilitate rapid escape into treed habitat areas along easements, transport corridors and swathes of cleared areas where dogs roam.
4. Install refuge poles along powerline and infrastructure easements that cannot be rehabilitated to allow a refuge and means of escape for koalas crossing cleared areas.

    - poles are a minimum of 125 mm in diameter and have 1-2 resting forks that are a minimum of 3 m from the ground
    - refuge poles can be salvaged during tree clearing operations.
    - poles are placed at 10 m-20 m intervals

5. Engage local landholders to report sightings of wild dogs to track spatial and temporal distribution and abundance in the region to ensure the population is being managed at sustainable levels.


Figure 4.5.2. (photo: Helen Binstead) Domestic dogs are kennelled or confine to a portion of the yard at night when koalas are most active and dogs are unsupervised.

Figure 4.5.3.(photo: Griffith University) Dog training programs, such as "Leave it', aim to reduce dog and koala interactions.

## Maintenance:

Egress solutions with moving or pliable components will need a maintenance schedule based on manufacturer's specifications to replace worn or perishable parts of the structure (e.g. push under solutions with netting or egress valves with hinged doors). The maintenance schedule must also include weed management to keep the structures clear of vegetation that could block entry to the egress device or hinder the correct functioning of the device.

## Notes:

- Wild dog control is the responsibility of landowners under the *Biosecurity Act 2014*, however many urban local councils have active pest management programs to monitor and manage wild dogs in their jurisdiction.

**Figure 4.5.5**. (photo: Endeavour Veterinarian Ecology) An image of a wild dog caught on infra-red camera. This dog was solely responsible for the death of approximately 80 koalas in 18 months.


**Figure 4.5.4**. (photo: Google Earth) Suburban streets create a buffer between residential development and conservation areas in Redland City.

## 4.6 Koala-safe pools, ponds and other waterbodies

### Supporting information

Koalas are reasonable swimmers and have been observed swimming across creeks and rivers in search of habitat or during dispersal or mating opportunities during the breeding season. However, koalas cannot swim for prolonged periods and will become waterlogged and drown. Koalas have been recovered drowned in backyard swimming pools, water treatment ponds, along beaches and in creeks.

Backyard swimming pools are a particular threat to koalas as they cannot grip the typical smooth lip of inground pools to pull themselves out of the water. Animals trapped in pools become exhausted from swimming back and forth looking for an exit and drown (Figure 4.6.1). Koalas can also succumb to shallow bodies of water, or areas that are drying out after inundation and get trapped in mud and asphyxiate or succumb to hyperthermia. Providing suitable methods of egress from waterbodies and boggy areas provides a safe and permeable environment for koalas.

***Performance Outcome 6:*** *Mitigate the risk of injury and death of koalas from pools and other waterbodies*

## Design specifications

### Best practice

Install koala proof fencing to prohibit koalas' access to waterbodies (see section 4.2) or install measures to allow egress from water or areas drying after water inundation.

1. Construct and landscape pools and other bodies of water with egress points

    - shallow lagoon-style entries that are level with the ground and consist of solid substrate (Figure 4.6.2).
    - landscaping features around the pool, ponds or dams such as rocks, wooden decking or vegetation that a koala could reasonably access and climb

2. Include structures to assist a koala's egress from pools, ponds or other bodies of water

    - place a large diameter (>80 mm) marine rope with float in the water, with a length suitable to span most of the width of the body of water. Ensure some of the same length of rope is securely tied to an anchor point on the ground beyond the pool (Figure 4.6.3).
    - place a log, wooden beam or other material of width/diameter greater than 100 mm that is easily gripped by a koala into the waterbody with the end fixed securely beyond the water body at or near the ground.

Figure 4.6.1. (photo Bree Wilson) Backyard swimming pools and other waterbodies, where exit from the water is difficult, can trap and drown koalas.

- fit a floating animal escape ramp to the pool to facilitate exit from the water.

3. Install koala-exclusion fencing (section 4.2) around the perimeter of the pool, pond or water body to prohibit entry by koalas.

- perspex, glass or other material can be used to improve the aesthetics of the pool area.
- ensure fencing complies with Australian Standards and section 4.2, koala-exclusion fencing.

## Alternative solutions

Devices to mitigate drowning can comprise a range of materials that a koala can grip and climb. These solutions must:

- float on the surface of the water so the structure is easily encountered by koalas
- be sturdy so that the structure does not flip over when a koala grips it, pulling the koala under the water
- be securely anchored to a point external to the pool to allow exit from the water and over the smooth lip of the pool.

## Maintenance

Egress solutions with perishable components will need a maintenance schedule based on manufacturer's specifications.

## Notes:

1. Pool fencing must also comply with Australian Standards and relevant state and local government requirements. See AS AS1926-2012 Fencing for swimming pools and Queensland standard QDC MP3.4.
2. Pool covers, unless held taught, can trap a koala, and drown an animal when the weight of the koala pulls the cover below the surface of the water.

**Figure 4.6.2**. (photo: D de Villiers) Pools with lagoon-style exit points allow koalas to easily exit the pool.

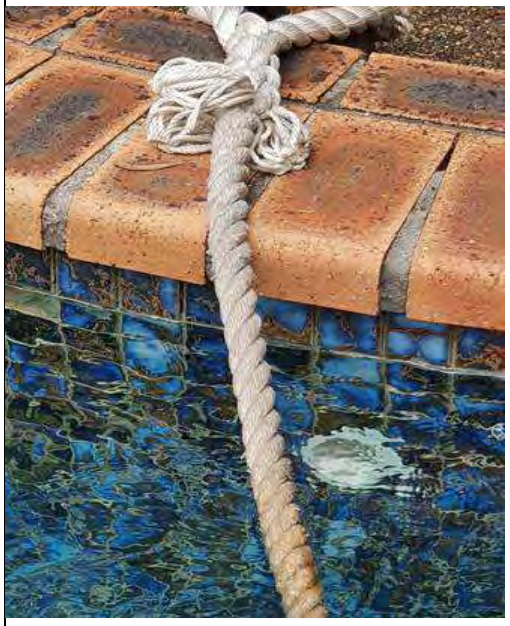


**Figure 4.6.3**. (photo: D de Villiers) Large diameter marine rope securely anchored to a structure beyond the pool can provide a point of egress out of the water and be placed at opposite ends of a pool.

## 4.7 Koala habitat revegetation and enhancement

### Supporting information

The loss, fragmentation, alteration, and degradation of koala habitat at a local level can have broader ramifications for the regional koala population. In extreme situations, habitat linkages and movement paths can be altered, areas of habitat separated, and threats introduced that limit dispersal and safe movement opportunities for koalas. Restricted genetic exchange in the population is also a long-term consequence of reduced landscape permeability. Strategic mapping of important habitat linkages and corridors can identify area for conservation, habitat restoration and targeted mitigation of threats. Appropriately designed development (section 3.3) should ensure the maximum possible retention of koala habitat values.

Habitat revegetation, enhancement and landscaping of residential estates, properties and public spaces with koala habitat trees can offset habitat loss at a local scale, provide additional habitat for urban koalas and improve habitat connectivity and permeability. Koala habitat trees grow quickly in coastal areas of South East Queensland and can provide a food and shelter resource for koalas in as little as 2-3 years (Figure 4.7.1). Revegetation with koala food tree species as a food resource and understory species to provide shelter from extremes of weather provides the complexity of habitat that koalas require and should guide koala habitat revegetation programs.

***Performance Outcome**: Restore and enhance koala habitat to improve landscape permeability*

**Figure 4.7.1.** photo: D de Villiers) A koala rests in a three year old tree, planted as part of a large koala habitat offset. The person on the right of the tree gives an indication of the tree height.

## Design specifications

### Best practice

1. Assess the site's location within the regional landscape and consider where revegetation efforts will provide the most benefit to koalas and koala habitat values in a local and regional context.

    - revegetate areas to improve habitat connectivity within and between the site and adjacent areas.
    - revegetate in bioregional corridors and locally significant habitat corridors to enhance vegetation in these priority zones.
    - revegetate in locations to enhance or buffer areas of existing vegetation, or to improve the quality of areas of degraded habitat (Figure 4.7.2).

2. Habitat is restored to reflect the site's original or endemic regional ecosystem vegetation type.

    - ecological assessment of vegetation (desktop and on-site validation) is undertaken to confirm the site's regional ecosystem and ratio of canopy and understory species.
    - seedlings grown from locally collected seed are planted to enhance revegetation efforts as they are best suited to local conditions
    - seedlings are planted at densities slightly higher than the average stem density for the regional ecosystem to account for up to 10% tree loss as the habitat matures.
    - site preparation, planting and maintenance is carried out by experienced habitat restoration teams.

**Figure 4.7.2** Revegetation provides habitat and habitat linkages and permeability to other areas of koala habitat in the landscape.

- tree species are mixed, not planted in monocultures around the site, and planted in areas on the site that are better suited to that species.
- access by the public or residents is limited or prohibited while the habitat is regenerating.

## Alternative solutions

1. Establish koala habitat through direct seeding or natural regeneration.

    - plants that germinate may be more resilient than tube stock, however, a large volume of seed is needed to ensure a similar level of cover to tube-stock planted revegetation areas.

2. Bias the planting to focus on preferred koala food trees and increase the ratio of preferred to non-preferred species occurring in the regional ecosystem.

3. Involve local community groups, schools, and other stakeholders to assist with revegetation efforts.

    - planting is under the supervision of an experienced bush regeneration team member to distribute species around the planting area and supervise planting techniques.

## Maintenance

Maintenance of revegetation areas is essential to maximise plant establishment, growth and survival. Maintenance should include:

- watering during plant establishment, and then as required
- control of grazing by native animals or trampling by cattle during establishment using temporary fencing to keep animals out of the area
- weed control to reduce competition and smothering of trees

## Notes

1. Plant to suit environmental conditions to ensure seedlings will have the best chance of establishment. Avoid planting in extremes of weather where heat waves, cold snaps or flooding can kill trees.
2. Trials are currently being conducted to determine the effectiveness of drones in the dispersal of koala habitat seeds and may be suitable for the restoration of large areas.

# Definitions

**Connectivity** means the extent to which individual patches of koala habitat areas are functionally linked to each other in a larger network of koala habitat areas.

Connectivity can be achieved in two different ways:

1. structural connectivity which refers to physical connections between koala habitat areas which includes areas of native vegetation;

2. functional connectivity which refers to the ability for koalas to safely move between patches of koala habitat areas without increasing the risk of injury or death of a koala.

‘**Go slow’ point** is an area where koalas are expected to cross a road and features have been incorporated to reduce vehicle speed.

**Koala furniture** are structures that are placed within, or used in association with, road crossing structures that increase the ability of koalas to move through an

area. For example, for example, a log may be placed horizontally within a culvert to encourage koalas to pass under a road rather than across it where they may be

hit by a car.

**Koala habitat means:**

- an area of vegetation where koalas live; or
- a partially or completely cleared area used by koalas to cross from an area of vegetation where koalas live to another; or
- an area of vegetation where koalas do not live, if the area primarily consists of koala habitat trees and is reasonably suitable to sustain koalas.

Note: as defined under Nature Conservation (Koala) Conservation Plan 2017.

**Koala habitat area** means an area shown on the Koala Conservation Plan Map that the chief executive of the Nature Conservation Act 1992 has determined to be a koala habitat area due to the combination of biophysical measures and suitable vegetation of the area.

Note: as defined under *Nature Conservation (Koala) Conservation Plan 2017*.

**Koala safe infrastructure** means infrastructure that provides for safe movement either above or below an area that poses a risk to safe koala movement, such as a fauna overpass or underpass with koala safety fencing associated with a road.

**Safe koala movement opportunity** is a measure that is intended to:

- minimise threats to resident and transient koalas; or
- achieve permeability to provide for the safe movement of koalas within and across a site; or
- provide food or refuge sources for koalas.

**Urban purpose** means urban purpose as defined in the *Planning Regulation 2017*

# Appendix 1: Koala-sensitive operational works guidelines

## Background

New developments in koala habitat areas are likely to have significant adverse impacts to koalas unless koala-sensitive design guidelines are applied. In addition, the process of developing a site poses risks to koalas that inhabit, use or move through the site during operational/construction works. These risks include, but are not limited to:

1. displacement of resident koalas into dangerous areas, onto roads and into areas that do not supply their food, water and shelter needs, leading to illness, injury, starvation and death;
2. entrapment of koalas in fencing, ditches, trenches, holes and sediment collection areas, leading to death and serious injury;
3. death and serious injury of koalas caused by vegetation clearing works.

These koala-sensitive operational works guidelines will assist proponents and their construction contractors to reduce risks to koalas by applying reasonable and appropriate measures during approved operational works. They should be read in conjunction with other Codes and guidelines, including the *State Code 25: Development in South East Queensland koala habitat areas* and the *South East Queensland Koala Conservation Strategy 2020-2025;* and any conditions imposed on development approvals.

## Early engagement of qualified experts in koala detection and management

Proponents should engage with koala ecology and management experts early in the planning phase to ensure that:

1. koala presence and koala habitat values in and around a proposed development site are well understood;
2. koala-sensitive design principles are considered and applied where appropriate to a proposed development;
3. requirements for active koala management are well understood prior to commencement of operational works, including engaging with DES if koala translocation is being considered;
4. management of risks to koalas during operational works is adequately planned for and appropriate measures implemented, particularly during the vegetation removal phase.

Proponents must engage a DES-approved fauna spotter/catcher and/or koala spotter well prior to the commencement of vegetation clearing and works. The fauna spotter/catcher should make a preliminary assessment of the site at least one month prior to the commencement of vegetation clearing works, to ensure adequate time is available to discuss the appropriate management of koalas on, or using, the site. This might include a need for translocation of koalas by a suitably qualified service provider, when displacement of the koalas into dangerous areas or unsuitable habitat is a likely consequence of the vegetation clearing.

Further information regarding relocation, translocation and release rules can be found here: Relocation and release of rehabilitated koalas | Environment | Department of Environment and Science, Queensland (des.qld.gov.au)

## Use of innovative approaches to meeting regulatory obligations and community expectations

Prior to commencement of vegetation clearing and preferably during the planning and design phase, thorough surveys of bushland and trees on the site should be conducted to detect koala presence and/or evidence of use – such as presence of scats (faecal pellets) and characteristic scratches on smooth-barked trees.

## Use of thermal drones for koala detection

New technologies, such as thermal drone surveys, can be very effective at rapidly detecting koalas in bushland. This can increase koala detection rates up to around 80-90%, significantly reducing risk of inadvertent harm during vegetation clearing works. Drone operations must abide by Civil Aviation Safety Authority (CASA) and animal ethics requirements. This approach is highly recommended to ensure that proponent and their contractors use all reasonable methods to avoid harming or killing koalas during vegetation clearing works.

## Use of koala tagging and monitoring programs

For large development sites with significant numbers of koalas (or likely to be used by large numbers of koalas) should consider implementing a koala tagging and monitoring program well prior to the scheduled commencement of operational works. Such programs involve the capture and radio-telemetric tagging of koalas on a site, which can facilitate several beneficial outcomes:

1. informing the koala-sensitive design and planning by providing data on the movements and use of the site by koalas;
2. demonstrating that a proponent is applying best-practice approaches to the protection and management of koalas, thereby meeting both regulatory obligations and community expectations;
3. facilitating the rapid detection and protection of koalas during vegetation clearing works;
4. facilitating and informing community stewardship models for koala management as the development matures.

## Choosing appropriate vegetation clearing methods and machinery

Choosing appropriate vegetation clearing methods and machinery can significantly reduce the risk of causing harm to, or death of, koalas during operational works. Koalas can be very difficult to see in some vegetation types, with detection rates as low as 15% in some habitat types. This means that inappropriate methods have a high likelihood of causing severe injury or death to koalas, which may expose a proponent or contractor to prosecution under several State Acts, and a stop-work order.

Suitable vegetation clearing machinery are excavators mounted with tree-grabs or grapples. These can be fixed or rotating grapples suitable for larger machines. Use of tree-grabs allows for vegetation to be 'peeled' away in layers from the standing vegetation, which significantly improves visibility for the spotter/catcher, and reduces the risk of non-detection of fauna. The use of fixed or rotating grapples also facilitates the controlled felling of fauna-containing or habitat trees and provides a means of demonstrating compliance with animal welfare and nature conservation regulatory obligations.

For larger habitat trees, both arborists' methods and use of elevated work platforms to allow for the removal of koalas and other fauna from such trees is the preferred method when this can be achieved safely and by suitably qualified personnel and as a part of an approved koala management program. A tree *must not* be felled by any means if a koala is known or reasonably suspected to be in the tree.

The use of bulldozers, mobile mulching heads, and excavators with only a bucket or ripping hook does not facilitate the controlled fell of vegetation and are not recommended. The use of inappropriate machinery leading to the death of a koala or other wildlife could expose a proponent or contractor to prosecution because of the failure to use reasonable and appropriate measures to avoid the harm.

## Sequential clearing and leaving suitable wildlife escape routes

Approved vegetation clearing must be conducted in a sequential fashion and in a direction that aids displaced koala movement into remaining suitable habitat. Proponents and contractors should review the other relevant documents relating to koala protection during vegetation clearing (mentioned above).

## Koala and fauna fencing

Fauna fencing can be used to either:

1. Facilitate koalas and other fauna movement across the fenced area when movement is essential for their welfare and to maintain ecological connectivity between areas that are safe for wildlife.
2. Exclude koala and other fauna from areas that are dangerous, such as roads and active construction areas.

## Koala-permeable fencing

Koala permeable fencing should be used when construction or other fencing is required to allow for koala and fauna movement. Permeable fencing can be easily achieved by allowing a gap of up to 300mm under the lower rail or edge of the fencing. This is because most terrestrial wildlife and koalas, when they are moving across the ground, prefer to push under a fence, rather than climb or jump over it. Commonly used construction panel fencing

can readily be made koala-permeable by allowing for several sections where a small dug-out or depression exists or is created under the lower bar of the panel.

## Koala-exclusion fencing

Koala exclusion fencing can be achieved by lining the 'safe' side of the construction panel fencing with a sheer material such as Corflute® plastic sheeting/rolls, or similar sheer sheeting of 900-1200mm in height. Design specifications for permanent koala exclusion fencing are outlined in section 5.2 Koala exclusion fencing in the *Koala-Sensitive Design Guidelines*.

## Use of other measures to protect koalas during operational and construction works

Proponents should engage a koala expert to ensure that other risks that arise during operational works and construction phases are adequately mitigated. These include, but are not limited to the following hazards:

1. Trenches, pits, sediment ponds – these can fatally entrap koalas.
2. Swimming pools and other bodies of water with unclimbable sides.
3. Netting, barbed wire and other materials that can entrap or ensnare koalas.
4. Electricity poles, towers and cranes, which can be climbed by koalas and cause work stoppages and direct hazards to koalas.

In most cases, temporary or permanent fauna exclusion fencing can be used to mitigate risks by isolating the hazard area from koala ingress. More sophisticated methods using radio-telemetric tags and danger beacons can be used when combined with a koala tagging and monitoring program, to alert koala management personnel when koalas move into danger areas.

# Attachment D

## Fauna Sensitive Road Design Manual

## Volume 2, Chapter 6

# 6. MEASURES TO ACHIEVE FAUNA SENSITIVE ROADS

# 6 MEASURES TO ACHIEVE FAUNA SENSITIVE ROADS

- This section of the manual describes the purpose of fauna mitigation measures and the detailed descriptions of each measure.
- The content and directions in the manual are considered as best case scenario outcomes. Based on this, the aim for fauna sensitive road design should be to produce the best overall, locally relevant outcome, considering site specific limitations.
- There is a great detail of ambiguity on the definition of structure types. In this manual the definitions for structure types have been adopted from van der Ree *et al.* (2007) for consistency.
- For a more detailed review see Hayes (2006).

***Table 6.0.1 Definitions of options aimed at achieving fauna sensitive road design (adopted from van der Ree et al. 2007).***

| Title | | Description |
|---|---|---|
| **OVERPASS** | | **Passage of animals above the road** |
| Land bridge |  | A bridge extending over a road, typically 20 to 70 metres wide. The bridge is covered in soil, planted with vegetation and enhanced with other habitat features (for example, logs, rocks and so on). Also known as an eco-duct or wildlife bridge. |
| Overpass (small roads) |  | A narrow bridge (not hour-glass shaped) above a major road, which allows human or vehicular access across the minor road. The road on the overpass is typically a minor road, which may be unsealed or a single lane. Additional areas adjacent to the road may be utilised for fauna movement. |
| Cut and Cover Tunnel |  | The road passes below ground level through a tunnel with the area above available for revegetation and use by some fauna species. |
| Canopy bridge |  | A rope or pole suspended above the traffic, either from vertical poles or from trees. Used by arboreal and scansorial (climbing) species. |
| Pole |  | Vertical poles placed in the centre median, on the road verge or on an overpass to provide species that glide with an intermediate landing and multiple launch opportunities. Alternative designs can be utilised to provide refuge from predators for tree-kangaroos or other arboreal species. |
| **UNDERPASS** | | **Passage of animals below the road** |
| Culvert |  | Square, rectangular or half circle in shape and may be purpose built for fauna passage or water drainage, or a combination of both. They are typically pre-cast concrete cells, or arches made of steel. |

| Title | | Description |
|---|---|---|
| Tunnel |  | Typically round pipes of relatively small diameter (for example, less than 1.5 metres in diameter). May also be known as an eco-pipe. |
| Passage below bridge |  | A structure that maintains the grade of the road or elevates the traffic above the surrounding land, allowing animals to pass under the road. Facilitates water drainage or the movement of local human traffic and secondarily facilitates fauna passage. Vegetation clearing can also be minimised (clearing only required for bridge piers or pylons) and allow natural vegetation to grow under the infrastructure. |
| **NON-STRUCTURAL MITIGATION** | | **Items that facilitate natural permeability** |
| Canopy connectivity |  | The linear clearing is kept sufficiently narrow to allow the tree canopy to remain continuous above the road or where discontinuous, sufficiently narrow to allow gliders (and other volant species) to safely traverse. |
| Local traffic management |  | Devices to reduce the speed, volume of traffic or increase awareness of fauna, for example, road closures, chicanes, crosswalks, lighting, signage. |
| **BARRIERS** | | **Structures that create a barrier to animals entering the road corridor or using road furniture** |
| Fencing |  | Stops animals crossing the road surface, and is used as an integral component encouraging animals towards safe crossing passages. |
| Chemical Repellents |  | Used on a temporary basis (for example, when a breach in a fauna exclusion fence occurs) to discourage animals from approaching the road. |
| Perching Deterrents |  | Prevents birds perching on top of road furniture. |
| **HABITAT ENHANCEMENT** | | **Structures that improve the functionality of the road corridor and surrounding areas for fauna species** |

| Title | | Description |
|---|---|---|
| Frog Ponds |  | Aimed at re-creating frog breeding opportunities |
| Nest Boxes |  | Provides replacement nesting and roosting opportunities for fauna when tree hollows are removed. |
| Artificial Shelter Sites |  | Non-natural material placed within the road corridor or adjacent areas to restore or replace lost habitat. |

Fauna mitigation structures are designed with a specific purpose in a specific environment. As such, the drawings and designs for fauna mitigation structures vary. The following are general descriptions, functions and design considerations for fauna mitigation measures outlined in the above table, with the information provided to be used as a guide only.

Generally, the integration of anthropocentric measures (reducing speed limits, raising awareness) with fauna sensitive structures (providing crossing structures, escape routes from roads and discouraging road use by fauna) results in the retention of habitat connectivity and lowers road kill faster and is more effective than implementing individual mitigation measures (van der Ree *et al.* 2007).

General factors to consider which influence the success of structures:

- Dimensions;
- Openness;
- Location;
- Habitat quality;
- Connectivity with wildlife corridors;
- Features of passage approach;
- Presence of furniture within the passage (logs, ropes, vegetation cover, and so on);
- Fencing;
- Period of time that structure has been available for usage; and
- Ability to view habitat on the other side of the road (Finegan 2004).

All of these factors must be considered to ensure the success of the proposed fauna mitigation measure as it is costly to upgrade/modify structures after the road has been constructed.

- Fauna mitigation structures should be considered where:
    - A habitat, community or species is or is planned to be 'significantly damaged' by the presence of a road.
    - Species vulnerable to impacts of barriers and traffic are located near a road.
    - Habitat connectivity is reduced, primarily by infrastructure.
    - The most appropriate mitigation measure is a fauna crossing.
    - The road is fenced (PIARC 2007).
    - A section of the road has a high fauna roadkill rate.

- The road crosses a regular fauna passage.

- When installing a fauna mitigation structure consider:
  - Target species (see Table 6.0.2).
  - Natural and existing fauna pathways.
    - Place fauna structures as close as possible to these pathways.
  - Access to structure.
    - Future land development may decrease the effectiveness or use of the installed structure.
  - Provision of canopy connectivity.
    - The presence of canopy connectivity has been proven to positively affect the use of structures.
  - Topography, as highest species diversity usually occurs in hilly terrain.
  - Suitability and purpose of vegetation.

*Table 6.0.2 Suitability of different types of fauna structures for a selection of commonly addressed species or groups of species.*

| | Overpasses | | | | Underpasses | | | Non-structural mitigation | | Barriers | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Land bridge | Overpass (small roads) | Canopy bridge | Poles | Culvert | Tunnel | Passage below bridge | Canopy connectivity | Local traffic management | Fencing | Chemical repellents |
| Fishes | - | - | - | - | ○ | ○ | ● | - | - | - | - |
| Frogs | ● | ○ | - | - | ○ | ○ | ● | ○ | - | ● | - |
| Mammals: macropods | ● | ● | - | ● | ○ | - | ○ | - | ○ | ● | ? |
| Mammals: arboreal species | ● | ● | ● | ● | ○ | ○ | ○ | ● | ○ | ● | ? |
| Mammals: koalas | ● | ● | - | ● | ● | ○ | ○ | - | ○ | ● | ? |
| Mammals: platypus | - | - | - | - | ○ | ○ | ● | - | - | ? | - |
| Mammals: bats/flying foxes | ● | ● | - | - | - | - | ● | ● | - | - | - |
| Mammals: small-size | ● | ● | - | ○ | ● | ● | ● | - | ○ | ● | ? |
| Birds: flying | ● | ● | - | - | - | - | ○ | - | - | - | - |
| Birds: non-flying | ● | ● | - | - | ○ | - | ● | - | ○ | ● | ? |
| Reptiles: snakes and lizards | ● | ○ | - | - | ○ | ○ | ● | - | - | - | - |
| Reptiles: turtles | ● | ○ | - | - | ● | ● | ● | - | ○ | ○ | - |
| Invertebrates: insects and spiders | ● | ○ | - | - | ● | ● | ● | - | - | - | - |

● optimal solution ○ can be used with some adaptation to local conditions

- unsuitable ? unknown, more research required

## *6.1 Overpass: Land Bridge*

A land bridge is a bridge which extends over a road, typically between 20 to 70 metres wide. The bridge is covered in soil, planted with vegetation and enhanced with other habitat features (for example, logs, rocks and so on) (Figures 6.1.1 to 6.1.3). It is also known as an eco-duct or wildlife bridge. Refer to Section 9.2: Case Studies: Compton Road, Brisbane City Council for an example project.

### 6.1.1 Target species

- All species, excluding aquatic.

***Figure 6.1.1 Land bridge at Compton Road, Brisbane (Robinson-Wolrath 2007). Rope ladder installed to cater for arboreal species.***

### 6.1.2 Design specifications

- Width:
  - Dependent on the purpose, surrounding topography, environment and target species, for example, birds require a wider bridge.
  - Existing land bridges range from eight to 870 metres in width.
  - 50 metres or greater:
    - will be utilised by the widest variety of species; and
    - animals will exhibit natural behaviour.
  - A narrower land bridge will be used by some species if designed appropriately.
- Location of land bridge:
  - Animal movement hotspots.
  - Consider all animals, including birds, invertebrates, bats and reptiles.
  - In high cuts to align with the natural ridge contours, where possible.
- Depth of Soil:
  - Dependent on planned vegetation.
  - Acts as a limiting factor to vegetation height.
  - Indication of soil depth required for specified groups:

- Grass: 300 mm
- Shrubs: 600 mm
- Trees: 1.5 – 2 metres

- Vegetation considerations:
  - Native to the area and provide food sources and habitat requirements for target species (for enticement purposes).
  - Choose planting which will attract target species to the structure.
  - Fast growing local grasses (and other palatable species) that provide a food source are ideal for attracting macropods.
  - Flowering and seeding plants serve as attractants to birds.
  - Maintain remnant mature vegetation leading up to the bridge abutments to encourage early use of the fauna structure and maintain invertebrate populations.

    Ground covers suitable for small mammals, reptiles and invertebrates are:

    - Wood and bark pulp;
    - Leaf litter near and around planted vegetation; and
    - Large logs placed in a mosaic fashion (Figure 6.1.3).

    A moderate density of leaf litter in various stages of decomposition to cover 70-80% of the ground layer of fauna structures will encourage invertebrate species use.

    For species with roosting or resting requirements (for example, gliders and koalas) provide sufficient number of trees to ensure there are adequate options to allow them to change trees at least once every 24 hours.

- Furniture:

Glider poles (where appropriate), boulders, rocks, logs provide opportunities for a broad range of species.

- Compliance with standard bridge clearance is required (Queensland Department of Main Roads 2005a).
- Ensure vegetated approach embankments to elevated land bridges are formed to a gentle 1:3 gradient, when required.
- Use a natural material base on land bridge (see 'Vegetation Considerations' above).
- Construct land bridge so macropods cannot see the traffic or headlights passing on the road beneath. Edges should be lined with high, wooden or blocked out exclusion fences to minimise noise and visual disturbance.
- Prohibit vehicle access by placing structures at either end, such as large boulders or guard rails.
- Although some countries prefer a few larger land bridges, it has been found that a greater number of small land bridges are more beneficial.

*Advantages*

- Provides a more natural crossing for fauna, particularly disturbance-sensitive species.
- Is utilised by a wide range of terrestrial species, including bats, birds, butterflies.
- Maintains genetic diversity through habitat and population connectivity.
- Provides a new habitat.
- Proven to provide a guiding-line function, encouraging birds to cross roads at safe crossing points.
- Encourages community and tourist interest in fauna crossings.

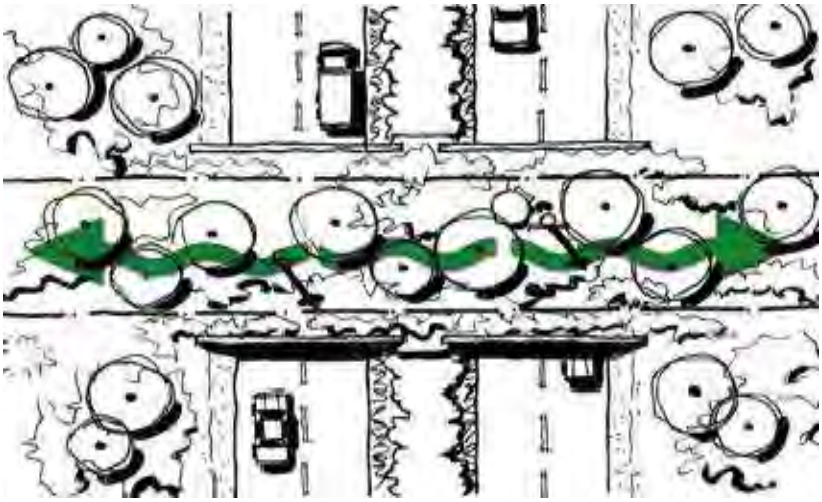
*Disadvantages*

- Success is dependent on several variables (for example, width, fauna exclusion fencing, vegetation, light, noise disturbance, suitability of vegetation, provision of artificial shelter sites and minimised human disturbance).
- Is costly.
- No standard design principles have been established in Australia.
- Must provide a variety of furniture types to cater for all of the target species.
- Has the potential to have a large disturbance footprint in order to establish approaches to and supports for the structure.
- Requires fencing to direct species to structure. This may not always be beneficial in otherwise undisturbed areas.
- May occur within the home range of a limited number of individuals constraining access for territorial species.

*Maintenance Requirements:*

- At least a yearly major maintenance.
- Ensure revegetation has established and is similar to existing, surrounding vegetation, where possible.
- Maintain furniture.

a) Cross section view



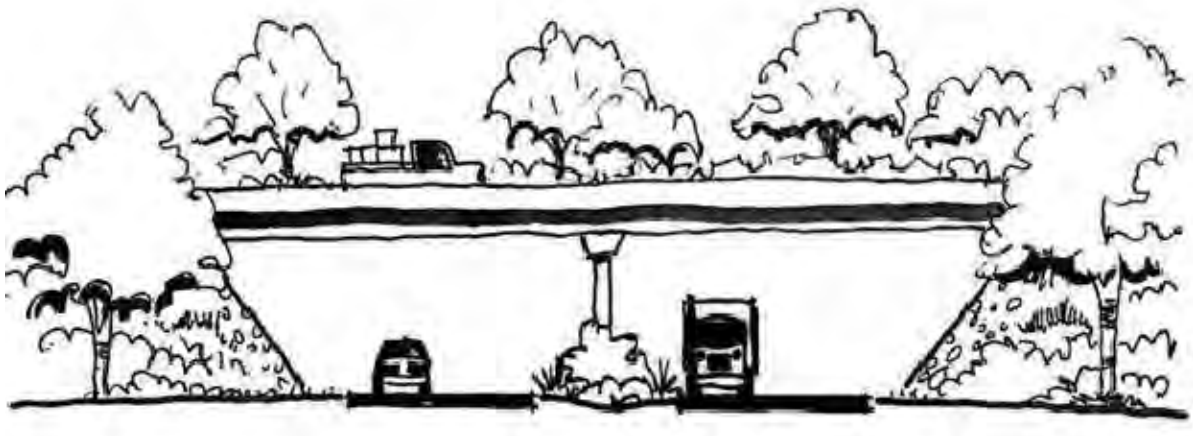
b) Plan view

***Figure 6.1.2 Land bridge designed to accommodate a wide variety of species, including arboreal species as indicated by the presence of glider poles.***

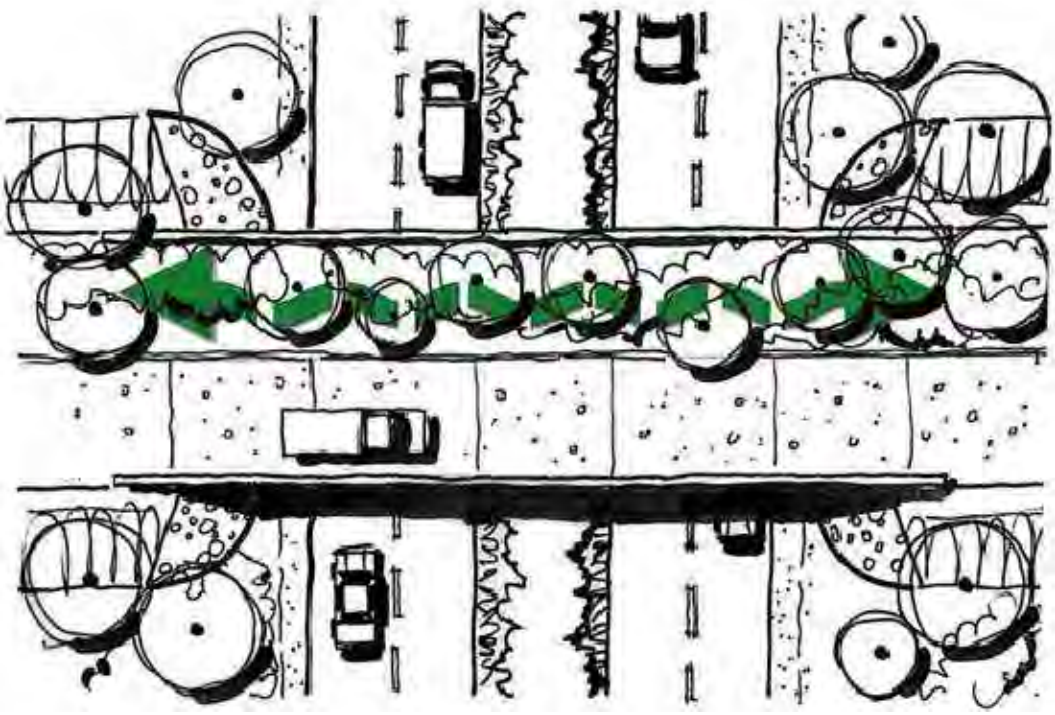
***Figure 6.1.3 Vegetation and habitat structures provided for reptiles on the Compton Road land bridge (Scott 2007).***

## *6.2 Overpass: Small Roads (dual purpose)*

A small road (dual purpose) is a bridge above a major road, which is narrow (not hour-glass shaped) and allows human access across the road (Figures 6.2.1 and 6.2.2). The road on the overpass is typically a minor road, which may be unsealed and may be a single lane.

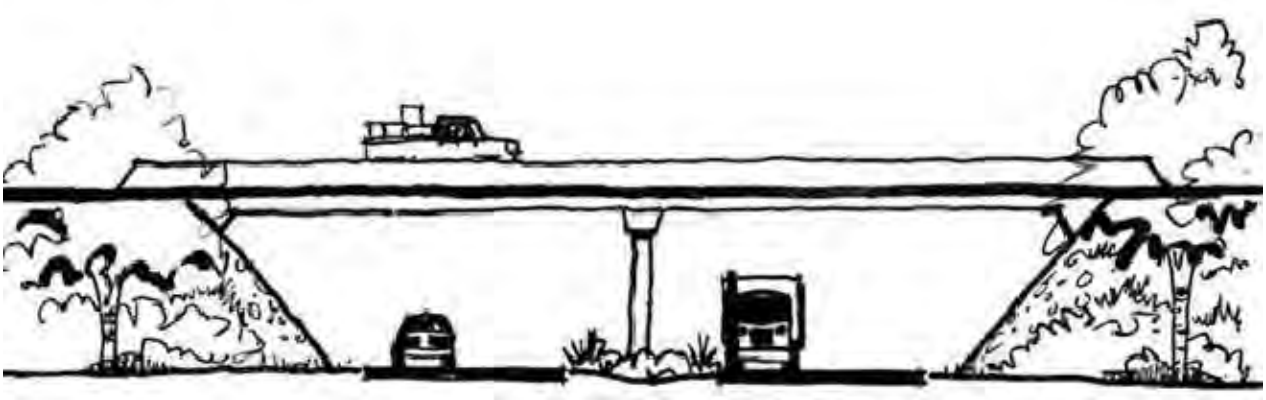


a) Cross-sectional view

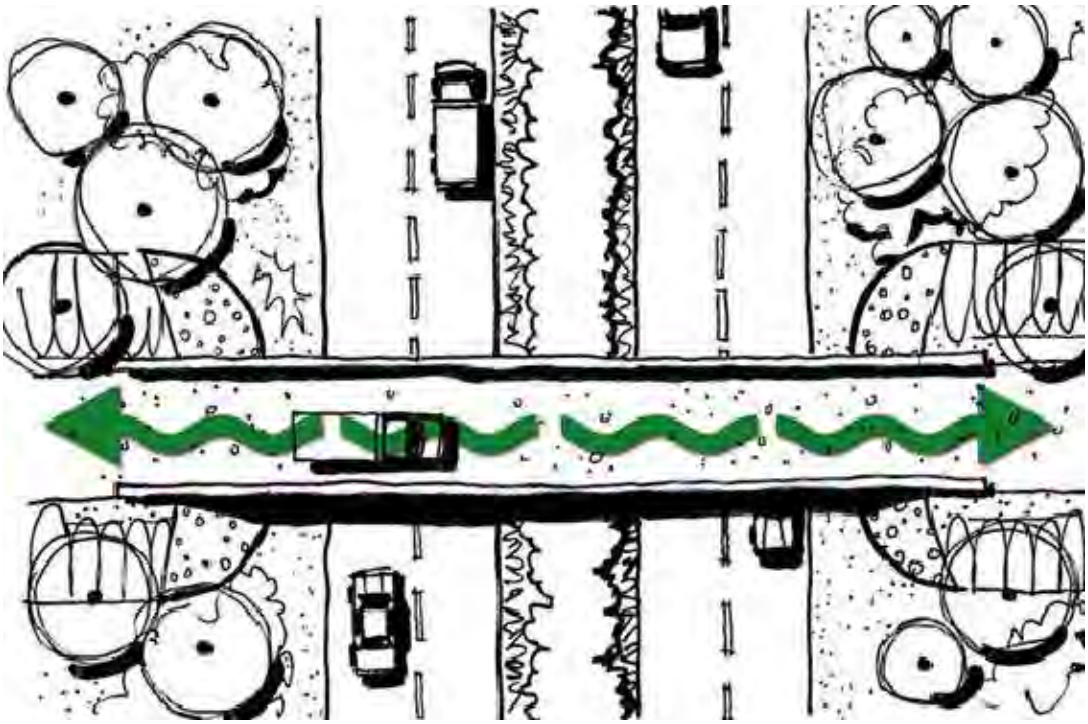


b) Plan view

***Figure 6.2.1 Optimal design of a dual purpose overpass with a dedicated fauna-crossing section.***



a) Cross-sectional view



b) Plan view

***Figure 6.2.2 Less optimal dual purpose overpass with fauna and local traffic sharing the complete structure.***

## 6.2.1 Target species

- All species, excluding aquatic.
- Less suitable for highly sensitive species due to the likely impact of human disturbance.

## 6.2.2 Design specifications

- Ensure a section solely dedicated to fauna movement.
    - Width of approximately eight metres but will be dependent on the target species concerned.
- Road crossing should be a low speed environment.
- Drainage from the fauna crossing section shall be adequately designed to ensure no negative effects on the road crossing area.
- The structure is usually ‘tanked’ (waterproofed) and geofabric is utilised to provide a barrier between the soil, plants and the bridge structure.
- Furniture should be constructed to encourage use by target species. For example, rocks, boulders, leaf litter, glider poles, rope bridges.
- Fencing should be considered to exclude humans and vehicles from the fauna crossing section.
    - Fencing can be a combination of fauna exclusion fencing and solid wooden fencing to block out the impact of traffic and street lights on nocturnal fauna (refer to Section 6.18.2: Lighting).

*Advantages*

- Provides a more natural crossing for fauna than culverts.
    - May be utilised by a wide range of terrestrial species including bats, birds, butterflies.
- Likely to maintain a minimum level of genetic diversity through a degree of habitat and population connectivity.

- Provides a new habitat.
- Encourages community and tourist interest in fauna crossings.
- A cost-effective means to provide both fauna crossing opportunities and vehicular/pedestrian traffic.

*Disadvantages*

- Success is dependent on several variables (for example, width, fauna exclusion fencing, vegetation, light and noise disturbance).
- No standard design principles have been established in Australia.
- Must provide a variety of furniture types to cater for all of the target species.
- Has the potential to have a large disturbance footprint in order to establish approaches to and supports for the structure.
- Requires fencing to direct species to the structure. This may not always be beneficial in otherwise undisturbed areas.
- May occur within the home range of a limited number of individuals constraining access for territorial species.

*Maintenance Requirements:*

- At least a yearly major maintenance.
- Ensure that revegetation has established and is similar to existing, surrounding vegetation, where possible.
- Ensure vegetation does not cause any safety issues for the adjacent road.
- Maintain furniture.

## *6.3 Overpass: Cut and Cover Tunnel*

The road passes below ground level through a tunnel, with the area above available for revegetation and use by some fauna species (Figure 6.3.1).

***Figure 6.3.1 A cut and cover tunnel.***

### 6.3.1 Target species

- All species, excluding aquatic.

### 6.3.2 Design specifications

Refer to Section 6.1: Overpass: Land Bridge for relevant concepts and design specifications.

- Each site must be assessed (according to factors such as topography, geology and grade) to determine suitability.
- At least 1.5 metres of soil is required on top of structure to enable revegetation with tree species.

*Advantages*

- Provides a more natural crossing for fauna as it is a continuation of the existing landscape.
- May be utilised by a wide range of terrestrial species including bats, birds, butterflies.
- Maintains genetic diversity through natural habitat and population connectivity.
- Encourages community and tourist interest in fauna crossings.
- Is ideal for an at-grade fauna crossing.
- Disturbance can be minimised as construction may occur under the dedicated fauna crossing in the form of a tunnel.
- Unnecessary to provide additional furniture to encourage use by fauna, as area above road can be revegetated.

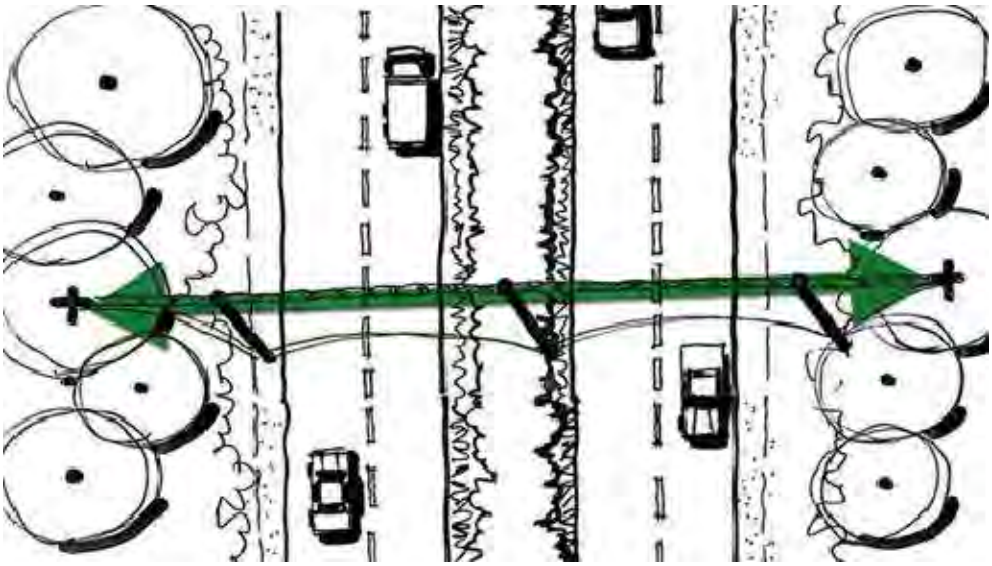
*Disadvantages*

- Success dependent on several variables (for example, width, fauna exclusion fencing, vegetation, light and noise disturbance).
- Expensive.

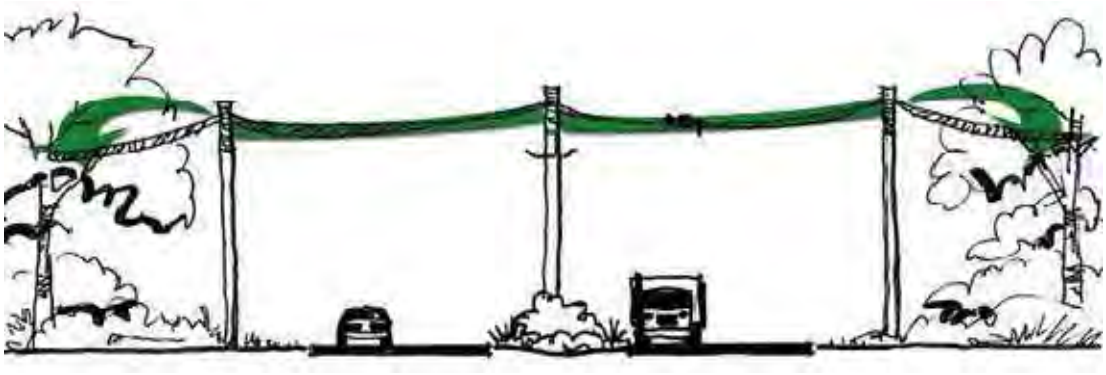
## *6.4 Overpass: Canopy Bridge*

A canopy bridge is a rope or pole suspended above the traffic, either from vertical poles or from trees to provide canopy connectivity (Figure 6.4.1). This structure is used by arboreal and scansorial (climbing) species (Figure 6.4.2).

***Figure 6.4.1 Canopy bridges (ladder and box) over Palmerston Highway, North Queensland (Scott 2007).***



a) Plan view



b) Cross-sectional view

***Figure 6.4.2 Diagrammatic representation of a canopy bridge designed to accommodate arboreal species.***

## 6.4.1 Target species

Refer to Section 7.4: Arboreal Species for additional species information.

## 6.4.2 Design specifications

- There are no standards regarding optimal dimensions of rope tunnels or ladders. Investigations during the design phase are required to determine the size of the largest animal most likely to use the structure.
- Supports are usually constructed from recycled electricity poles.
- Minimum of seven metres clearance from the road (to allow for traffic to pass underneath as well as sufficient height above traffic noise). Some have been constructed 12 metres above the road.
- Connected to adjacent vegetation via ropes (Figure 6.4.3).
- Provide crossing opportunities for possums every 100 – 120 metres when possum home ranges coincide with the road corridor.
- A cost-benefit analysis is required in areas with a high number of tree-kangaroos, before the installation of rope structures and/or culverts.

- Consider potential conflict with adjacent powerlines and other service infrastructure.
- Comply with safety requirements when structural supports are placed in the road median or road-edge. These may need safety barrier or guardrail protection.
- Consider roadway clear zone requirements and design of roadside hazards (refer Chapter 8 of TMR Road Planning and Design Manual 2005).
- More research is required to determine the effectiveness of scenting the rope with urine to attract use by target arboreal species.
- Construction technique previously utilised:
    - Screw eyelets into the pole and attach rope and attach 12-14 gauge marine grade silver (high UV rating) rope and stainless steel cables and frames (for rope tunnel).
    - Attach sheet metal above the rope bridge connection points to prevent arboreal species from ascending further.
    - Attach sheet metal or metal cones to support poles in the middle of the roadway to ensure animals are unable to descend in the median between traffic lanes, and to hinder predators from using the structures.
    - Appropriately tension canopy bridge.

***Figure 6.4.3 Canopy bridge at Compton Road, Brisbane. Bridge is connected to the surrounding environment by ropes (Robinson-Wolrath 2007).***

**a) Rope tunnel**

- Refer to Figures 6.4.4 and 6.4.5.
- Dimensions are: 200 mm high x 300 mm wide.

- Design ensures stability when two or more individuals are crossing simultaneously or in strong winds.

- Design allows fauna to avoid predators or another individual crossing simultaneously.
- Design considerations:
  - Ensure entrances and exits are rectangular.
  - Connected to poles via steel cables.
  - A stainless steel frame can increase strength of tunnel.
  - Vegetation growth on tunnel may promote use, particularly when vegetation is a food source.
  - Case study: A rope tunnel in New South Wales has been constructed which is covered in shade cloth to reduce headlight glare. No monitoring of this structure has been undertaken to determine effectiveness.
- Species-specific information:
  - Research has shown that green, Herbert River and lemuroid ringtail possums utilise rope tunnels.
  - Rainforest ringtail possums have been observed crossing a rope tunnel which is 45-50 metres long.
  - Brushtail possums and squirrel gliders have been observed utilising a rope tunnel that is 70 metres long.
  - Some species (particular possums and rodents) prefer to travel on top rather than through the tunnel.

***Figure 6.4.4 Rope tunnel crossing, northern New South Wales (Robinson-Wolrath 2007).***

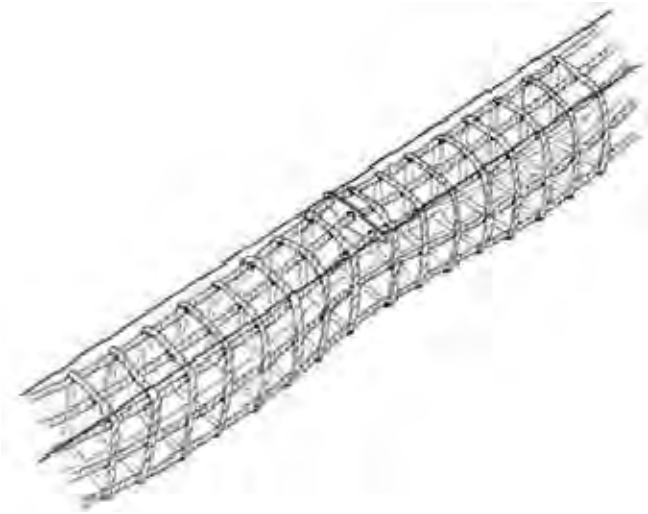


*Figure 6.4.5 Rope tunnel*

**b) Rope ladder**

- Refer to Figure 6.4.6.
- Preferred canopy bridge structure.
- Constructed to resemble a ladder.
- Adapted from tunnel design because research found possums only crossed on top of the traditional box canopy bridge structure.
- Attracts more species than other types of canopy bridge structure.
- Design considerations:
  - Research indicates there is no correlation between the rope ladder's use and its length (Weston 2003).
  - Ensure stability even when two or more animals are crossing simultaneously or in strong winds.
- Species-specific information:
  - Ringtail possums predominantly utilise these structures.
  - Case study: A rope bridge constructed where no connectivity existed before was utilised within five months by ringtail and brushtail possums (Weston 2002).

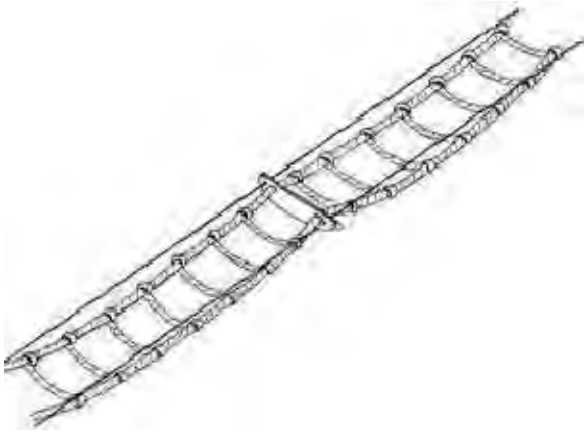


*Figure 6.4.6 Rope ladder.*

**c) Single rope crossings**

- Refer to Figure 6.4.7.
- Excludes use by several fauna species.
- Requires regular maintenance as it is affected by turbulence and is susceptible to losing tautness which reduces overhead height.
- Species specific information:
    - Ringtail possums have been known to cross single wires 8 mm wide and 50 metres long (Magnus *et al.* 2004).

***Figure 6.4.7 Single rope crossing structure.***

*Advantages for canopy bridge structures:*

- Economical.
- Allow species that never descend to the ground to migrate and disperse.
- Used by a variety of species.
- Possess tourist appeal which increases awareness of wildlife.

*Disadvantages for canopy bridge structures:*

- No standard design principles established.
- Single rope crossings are not utilised by the majority of fauna due to stability, turbulence and weight issues.
- Single rope crossings are susceptible to loss of tautness which reduces overhead height clearance.

*Maintenance requirements for canopy bridge structures:*

- Ensure ropes do not deteriorate or decay.
- Inspect on an annual basis or after storm events (or similar events causing tree falls).
- Ensure that heavy vegetation does not grow on bridge as it can place stress on the bridge, increase decay rate and cause false triggering of monitoring cameras.
- Single rope crossings require regular maintenance as they are affected by turbulence.
- Single rope crossings require more frequent inspections and maintenance.

# *6.5 Overpass: Poles*

Vertical poles placed in the centre median, on the road verge or on overpasses to provide species with intermediate landing points and/or multiple launch opportunities (Figures 6.5.1 and 6.5.2). Alternatively, poles can also aid species to disperse in open areas by providing refuge from predators.

## 6.5.1 Target species

- Glider Poles:
  - Species which have the ability to glide between vegetation.
  - Refer to Section 7.4: Arboreal species.
- Refuge Poles:
  - Koalas.
  - Tree-kangaroo species.
  - Refer to Section 7.5: Koalas and Section 7.8: Macropods.

## 6.5.2 Design specifications

**a) Glider poles**

- Primary use is to provide a launching pad for gliders.
- May be a temporary measure while awaiting canopy connectivity.
- Locational considerations:
  - Fauna movement pathways.
  - Natural tree growth and future canopy connectivity (poles will not be utilised if a canopy crossing is available).
  - Use by juveniles (may have shorter glide distances).
  - Topography.

*Design requirements:*

- Gliders prefer to glide between trees but if a pole is closer they may utilise the pole.
- Can be constructed from used electricity poles or tree trunks salvaged from the site.
- Consider potential conflict with adjacent powerlines and other service infrastructure.
- Consider height of poles, height of crossbars and distance between poles. Use trigonometry to determine the specific requirements.
- Minimum height of 12 metres. Additionally, must be of sufficient height to allow gliders to pass over trucks.
- Cross bars should be provided at various heights. Highest crossbar at least 11 m above the ground.
- Distance between poles:
  - Allow for an average of 1.8 metres flying distance with a one metre loss in elevation.
  - Research on sugar, mahogany and squirrel gliders shows an average glide angle is 30.5º with a one metre loss in height for every 1-2 metres in glide length.
- Attach metal around poles (below launch points and any refuges) to stop gliders from descending to the ground.
- Predation refuges can be added. Presently the design for such refuges consists of: three PVC pipes (110 x 380 mm) attached to each pole at heights of approximately 9, 10 and 11 metres.

- Structural supports placed in the road median or road-edge may require safety barriers or guardrail protection to comply with safety requirements.
- Roadway clear zone requirements and design of roadside hazards need consideration (refer Chapter 8 of TMR Road Planning and Design Manual 2005).
- For additional species-specific information see Table 6.5.1.
- Case study: glider poles in the Miriam Vale region were not used at all by gliders as they preferred to utilise remaining trees (Wormington 2006).
- Case Study: squirrel gliders adapted easily to utilising glider poles at Compton Road, Brisbane. They were frequently recorded on glider poles within a year at sites where they had not previously occurred.
- Case study: research regarding the requirement for vegetation at the base of glider poles is inconclusive. It has been suggested that glider poles without vegetation around the base will remain unused (van der Ree *et al.* 2007). However, other research indicates gliders will use the glider poles if they can sense food on the opposite side of the road.

***Table 6.5.1 Specific recommendations regarding glider poles***

| Species | Average glide lengths | Minimum crossbeam (launch) height | Spacing between structures | Height of structure |
|---|---|---|---|---|
| sugar glider (Petaurus breviceps) | 48 m with a launch height of 25 m[1]. | 11.96 m (average) [1]. | Maximum distance 60 m[3]. | Dependent upon length required to glide (ie distance between structures). Use trigonometry to determine. |
| squirrel glider (Petaurus norfolcensis) | 80 m with a launch height of 45 m[1]. Average glide of 30-40 m[2]. Average glide length is one metre with one metre decrease in height. | 11.96 m (average) [1]. | Maximum distance 60 m[3]. | |
| yellow-bellied glider (Petaurus australis) | Maximum 30 m glide[4]. | 11.96 m (average) [1]. | No more than 30 m. | |
| mahogany glider (Petaurus gracilis) | Glide length unknown. | 11.96 m (average) [1]. | | |
| greater glider (Petauroides volans) | 25–35 m with a launch height of 20-25 m[1]. | 11.96 m (average) [1]. | Maximum distance 60 m[3]. | |
| feathertail glider (Acrobates pygmaeus) | Maximum glide of 20–30 m[1]. | 11.96 m (average) [1]. | No more than 30 m. | |
| General | Most species can glide 1.8m with a one metre loss in altitude[1]. Average glide angle is 30.5 degrees. | | All Australian gliders (except feathertail and yellow-bellied gliders with a maximum glide of 20–30m[1]) can glide at least 60m[3]. | |

[1]Australian Museum Business Services 2001

[2] van der Ree 2006

[3] Weston

[4] Strahan 1995

*Advantages*

- Cost-effective technique for ensuring connectivity.
- Acts as stepping stones for crossing traditionally unfavourable habitat.
- Provides refuge from predators.
- Utilised by a variety of fauna.
- Encourages community and tourist awareness.

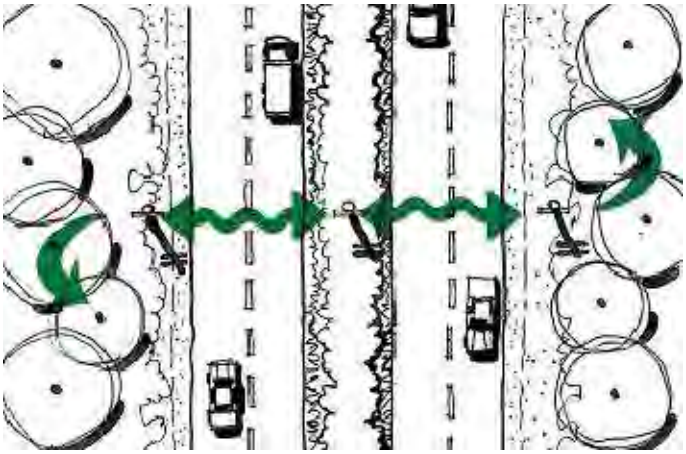
*Disadvantages*

- Rate of use dependent upon species present.
- May remain unused if not positioned correctly.
- No standard design principles have been established.

*Maintenance Requirements:*

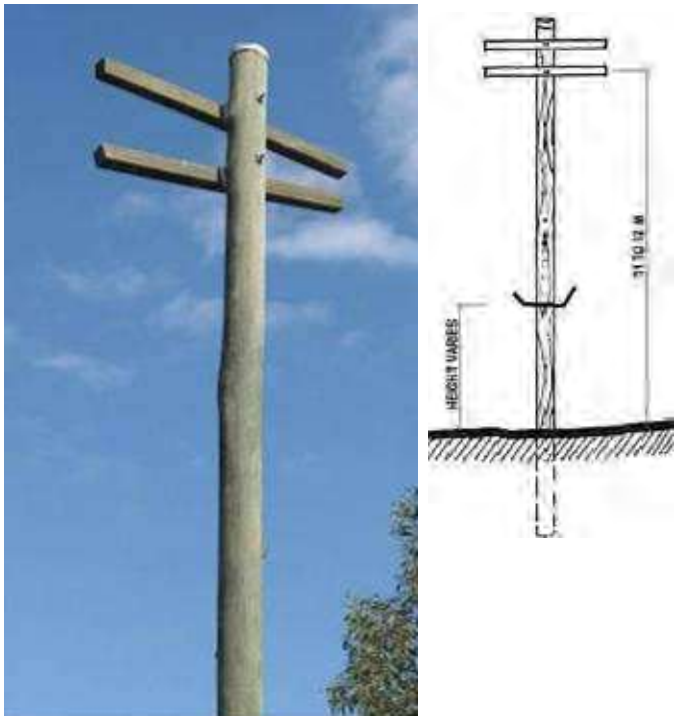
- Ensure glider poles and crossbeams are not decayed.
- Tree trunks require more frequent replacement than reused electricity poles.

a) Cross-sectional view



b) Plan view

***Figure 6.5.1 Indication of glider movement utilising glider poles to cross a road.***




a) b)

***Figure 6.5.2 a) Glider pole at Compton Road, Brisbane (Robinson-Wolrath 2007). b) Glider pole.***

**b) Refuge poles**

- Primarily used for predation refuge for tree-kangaroos and koalas.
- May be used in conjunction with vegetative corridors or utilised as a temporary measure while awaiting revegetation works to mature.

Tree-kangaroos

- At least five metres in height.
- Constructed out of old electricity poles with four treated pine pieces of wood (100 x 50 mm rafters) bolted together to form a pyramid shape (Figure 6.5.3).
- Most efficient and effective when installed in rows across open areas and along known tree-kangaroo dispersal routes.
- Case study: tree-kangaroo refuge poles have been installed as part of the Anderson Road Landscape Linkage Package. Four poles were installed at 30-40 metres intervals for use by Lumholtz tree-kangaroos (Figures 6.5.3 and 6.5.4).
    - Constructed of old electricity poles.
    - Cross bars were bolted to poles five metres above ground level for tree-kangaroos to rest on.
    - Covered with shade cloth to provide shelter for animals that may become stranded during the day.
    - Main pole is 300-400 mm in diameter. This is considered to be the upper end of stem size climbed by the target species.
    - The lower part was roughened and a thick rope was installed to aid climbing.
- There are currently no reports indicating effectiveness of these structures.

*Advantages*

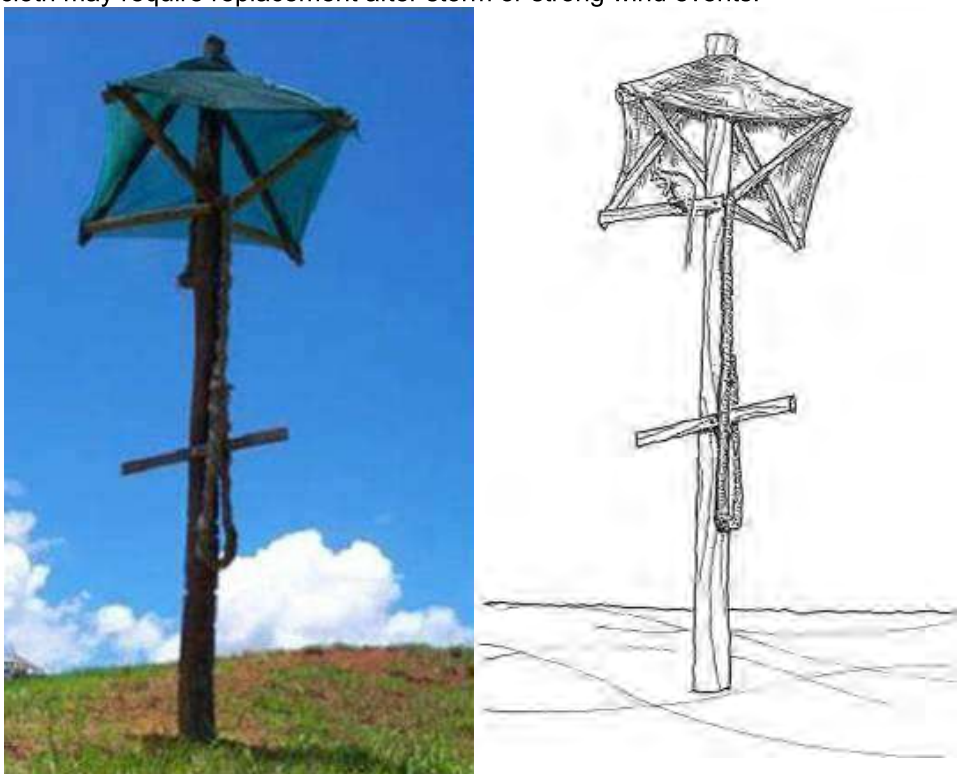
- Structures are a cost effective way of maintaining habitat connectivity.

*Disadvantages*

- Short life span (5-10 years).

*Maintenance Requirements:*

- Low maintenance.
- Shade cloth may require replacement after storm or strong wind events.



a) b)

***Figure 6.5.3 a) Tree-kangaroo refuge pole (Tree-Kangaroo and Mammal Group 2008). b) Tree-kangaroo using a refuge pole.***

***Figure 6.5.4 Refuge poles installed as part of the Anderson Road Landscape Linkage Package (Tree-Kangaroo and Mammal Group 2008).***

**Koalas**

- Escape poles installed on the roadside of fencing to provide koalas with a refuge if unable to escape the road corridor.
- Utilised at the entrance and exit points to fauna culverts to provide resting and predator avoidance points.
- 200 mm diameter is optimum but no more than 500 mm in diameter.
- Sufficient height (between three and six metres) to provide refuge from predators such as dogs.
- Timber or rubberized cement.
- Installed at least every 200 metres along the road.
- Installed against fauna exclusion fencing may provide a means for koalas to return to vegetative side unassisted (Figure 6.5.5).
    - Metal sheeting must be installed to prevent koalas from using poles to gain access to road corridors.
    - Research into the effectiveness of this design is required as metal sheeting requires koalas to jump down from poles.
- Can be installed in place of suitable vegetation on land bridges, in front of and throughout underpasses and anywhere else they are required.
- Install on the basis of expert advice.

*Advantages:*

- Allows safe escape from road.
- Provides refuge from predators.
- Inexpensive.
- Does not affect efficacy of fence.
- Can be used by a variety of fauna species.

*Disadvantages:*

- In most circumstances, requires person to remove the koala to habitat side of fence (Figure 6.5.6).
- May remain unused if incorrectly positioned.

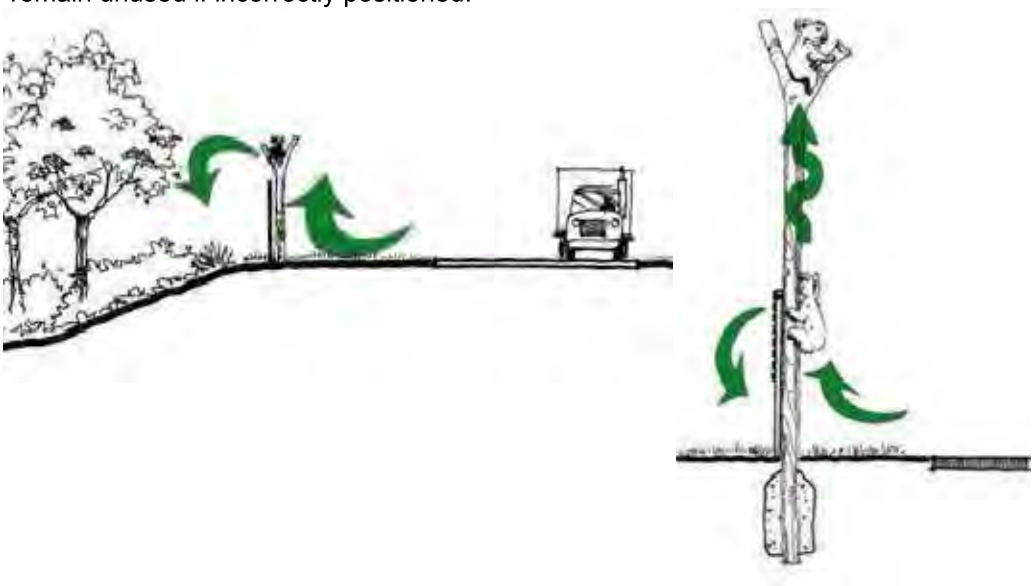


***Figure 6.5.5 Escape pole design aimed at assisting koalas to escape the road corridor and return to vegetative side unassisted.***

***Figure 6.5.6 Escape pole at Compton Road, Brisbane. Note: Koalas must be assisted to return to vegetative side of fence.***

## *6.6 Underpass: Culvert*

Culverts are square, rectangular or half circle in shape and may be purpose built for fauna (terrestrial and/or aquatic) passage or water drainage, or a combination of both. They are typically pre-cast concrete cells or steel arches.

Factors affecting the success of a fauna culvert:

- Substrate, may be species-specific (for example, concrete, mulch, bare earth).
- Presence of hiding places or escape routes.
- Presence of suitable vegetation cover, native plant species, rocks and logs at entrances, exits and throughout.
- Length (should be minimised, but dependent on openness).
- Drainage requirements.
- New technology and methods.
- Monitoring.

### 6.6.1 Target Species

- Most aquatic and terrestrial species.

### 6.6.2 Design Specifications

- Consider the safety of all road users.
- For the design and location of the ends of the structures (ie wing walls) check clear zone and road side hazard requirements.

*Design determined by:*

- Target species (aquatic or terrestrial species):
    - Specific groups of fauna.

  - Behaviour of fauna.
- Environment:
  - Hydraulic requirements.
  - Soils.
- Dimensions (dependent on size of road itself).
- Cost of construction.
- Cost of maintenance.
- Monitoring requirements.

**a) Design of structures for aquatic species**

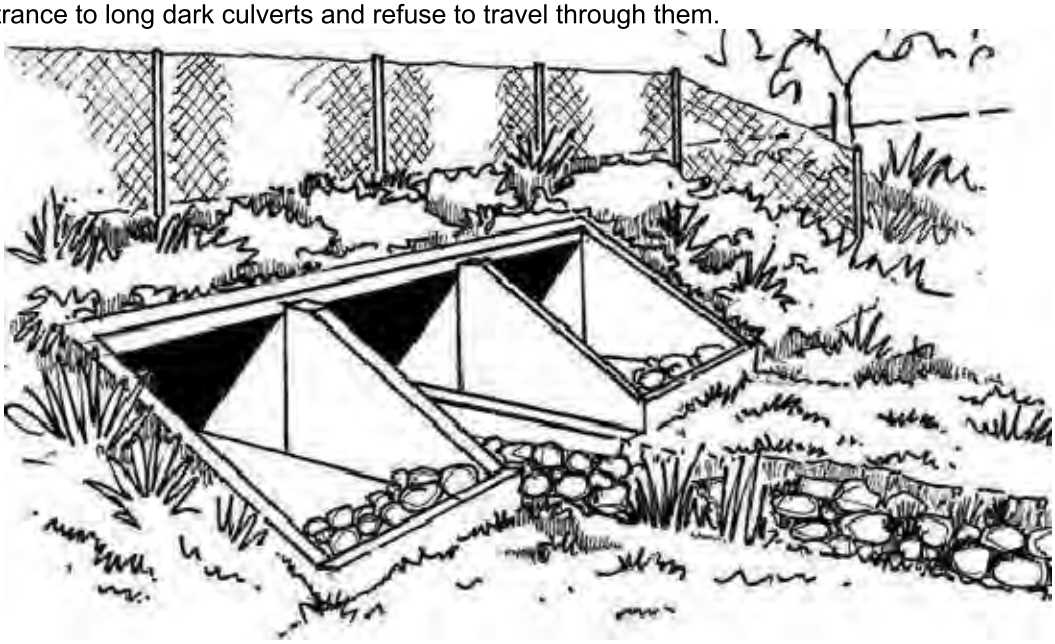
- Design in close consultation with an appropriate expert or the Queensland Primary Industries and Fisheries.
- Consider specific fish passage requirements when selecting culvert type.
- Arch, pipe or box-shaped cells allow water to pass underneath the roadway.
- Usually made of concrete or galvanised corrugated steel pipe.
- Types of culverts (Table 6.6.1 in descending order of preference):
  - Arch culvert.
  - Open-bottom box culvert.
  - Stream simulation design with buried base box culvert.
  - Multicell culverts.
  - Closed-bottom box culvert.
  - Pipe culvert.
- Design and/or maintain appropriately to ensure effective fish population connectivity.
- Perched culverts are not appropriate. Larger bottomless and buried base box culverts are preferred for fish passage.
- Ensure erosion and scour management is adequate.
- Usually made of concrete or galvanised corrugated steel pipe.
- Stream simulation design recommends:
  - Burying the base of the culvert and reconstructing the stream bed within the cell.
  - Cell width to be as wide as the bank full waterway width.
  - Cell area to be as large as the bank full waterway area.
  - Install multicell culverts at the same level as the waterway bed profile. The low flow cell must provide for fish passage at low flows with the outer cells providing for fish passage at mid and flood flow levels.
  - Install the base of the culvert cell at the waterway gradient.
- Sediment control debris deflector walls can be used to reduce the impact of debris blockages on fish passage while also reducing maintenance costs. Debris deflector walls decrease flow velocities at the entrance to culverts causing suspended partials to fall outside the culvert rather then accumulate in baffle structures (Figure 6.6.1).
- Optimal culvert placement allows for fish movement in high and low water flows (Figure 6.6.2).
- For information on the general effectiveness of structures refer to Table 6.6.2.

*Advantages*

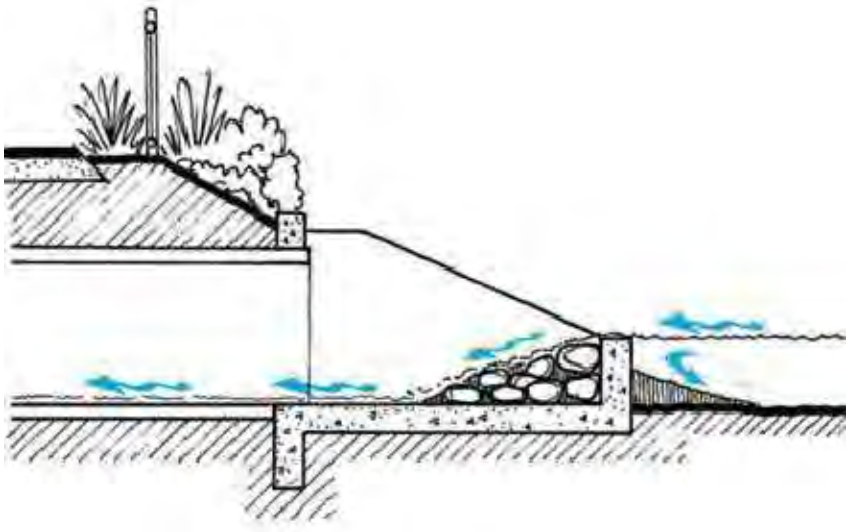
- Must be designed and maintained correctly to maintain fish passage.

*Disadvantages*

- If not designed and maintained appropriately will be ineffective (for example, Figure 6.6.3).
- Head cut erosion, if present, creates fish passage issues.
- Elevated culvert crossings (above the stream bed) create a drop on the downstream side causing a physical barrier to fish (100 mm is a barrier to most native fish) (Cotterell 1998).
- If culverts are too long they form physical and behavioural barriers to fish. Some fish hesitate at the entrance to long dark culverts and refuse to travel through them.

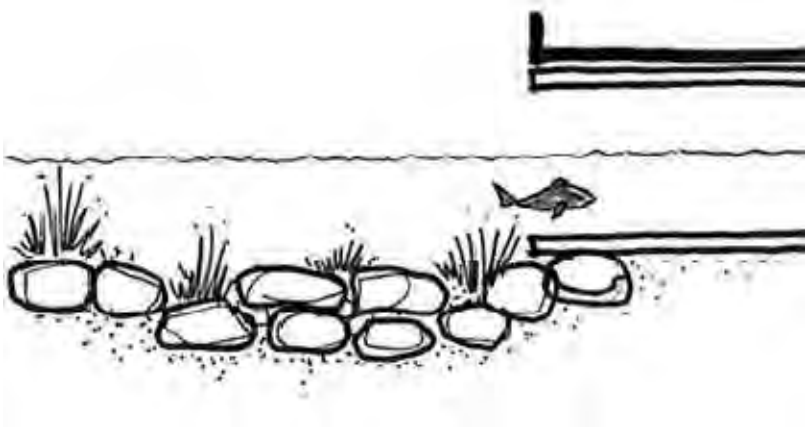


a) Perspective view

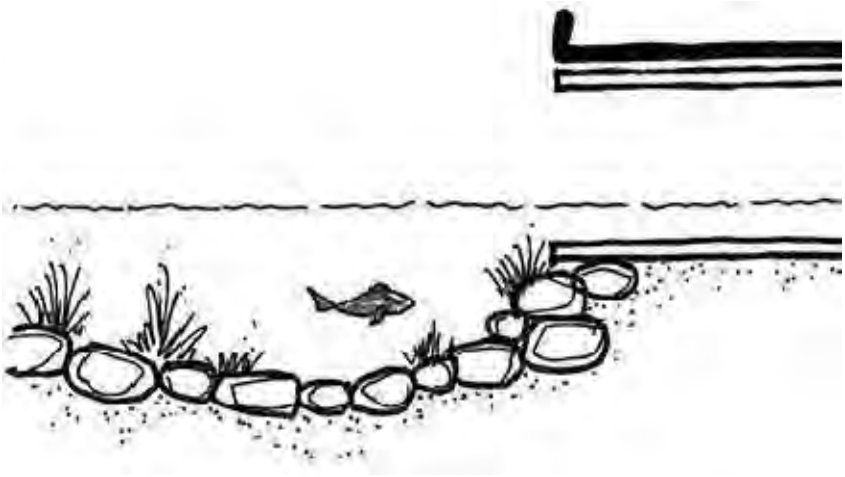


b) Cross-section

***Figure 6.6.1 Debris deflector walls decrease flow velocities at the entrance to culverts causing suspended partials to fall outside the culvert rather then accumulate in baffle structures (Fairfull and Witheridge 2002).***



a) Fish passage maintained during high flow



b) Fish passage maintained during low flow

***Figure 6.6.2 Optimal culvert position allows for fish movement in high and low water flows.***

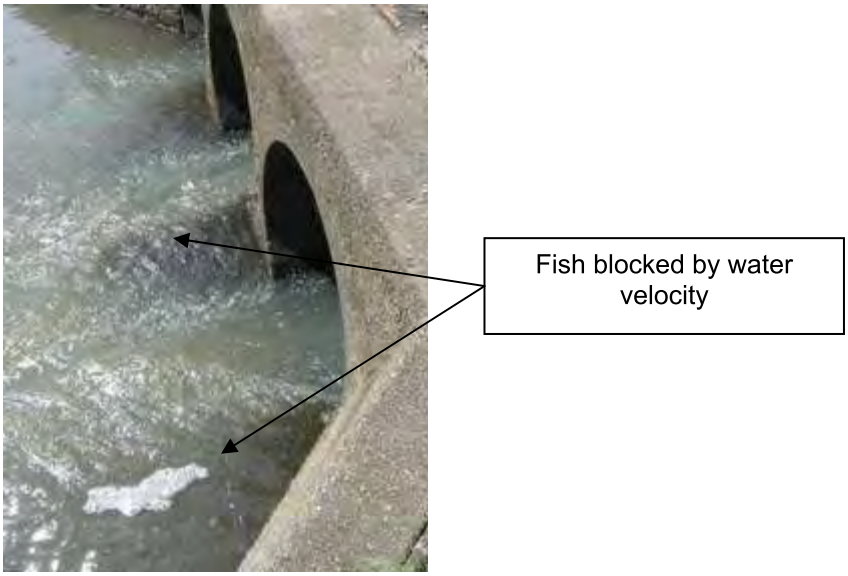
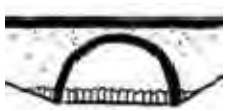
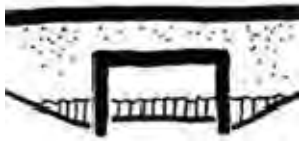
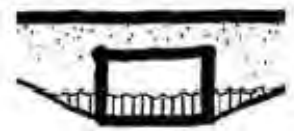



***Figure 6.6.3 Water velocities blocking fish passage (Yates 2010).***

*Table 6.6.1 Types of culverts for aquatic species (in order of descending preference).*

| Type | | Details | Advantages | Disadvantages |
|---|---|---|---|---|
| Arch culvert |  | • Arch culverts should be no more than six metres in length and have a minimum three metre width, when light maximisation is proposed. | • Retains the natural stream bed profile and original flow of water. | • The advantages of using arch culverts (for example, increased light and free water flow) may be lost if they are not wide enough (minimum width three metres)<br>• The installation of arch culverts involves excavation for the culvert footings which can cause substantial disturbance to natural stream beds and banks. |
| Open-bottom box culvert |  | • Retains the natural streambed with a box-shape culvert overhead. | • Retains the natural stream bed profile and original flow of water.<br>• If large enough, flow will not be constricted and debris will not be trapped during normal flow conditions. | • If poorly designed, installed or maintained it can be a barrier to fish passage in all flow conditions. |
| Multicelled culvert |  | • If multiple culverts are needed to span the stream bed, one or more should be slightly lower than the others to concentrate low flows and allow fish to swim through. | • May ensure there is flow during low flow periods. | • One large culvert spanning the width of the waterway is preferable to two or more small culverts because it is usually more efficient hydraulically.<br>• If poorly designed, installed or maintained it can be a barrier to fish passage in all flow conditions. |
| Closed-bottom box culvert |  | • Entirety of crossing is box-shaped concrete structure, retaining no natural stream bed.<br>• Important to consider flow velocities within culvert. | • May be simpler to construct if stream is redirected throughout construction. | • If poorly designed, installed or maintained it can be a barrier to fish passage in all flow conditions.<br>• If poorly designed erosion may cause drop downs at the end of the culvert. |

| Type | | Details | Advantages | Disadvantages |
|---|---|---|---|---|
| Pipe culvert |  | • Entirety of crossing is pipe-shaped concrete structure, retaining no natural stream bed.<br>• Important to consider flow velocities within culvert. | • May be simpler to construct if stream is redirected throughout construction. | • If poorly designed, installed or maintained it can be a barrier to fish passage in all flow conditions.<br>• If poorly designed erosion may cause drop downs at the end of the culvert. |

***Table 6.6.2 Factors that determine the effectiveness of culverts for aquatic species movement***

| Considerations | Description | Mitigation |
|---|---|---|
| Flow velocity | • Function of slope, roughness, culvert size and length. To control velocity, all these parameters should be considered in the passage design.<br>• In natural streams, channel irregularities, pools, meanders and other similar features provide zones of slow water where fish can rest. These areas do not exist in culverts where the velocities are uniform throughout and are usually greater than those in natural channels.<br>• Velocity should not exceed pre-development conditions (determine target fish species' requirements). | • Include baffles and/or rocks sized at 25% culvert width, spaced the same distance apart, or using the natural stream bed.<br>• Install a larger size culvert than that required for hydraulic flow.<br>• Use a greater number of culverts (multiple culverts).<br>• Increase the depth of the culvert below the stream bed.<br>• Design so the weakest fish can swim through the structure. |
| Flow depth | • Important there is sufficient water inside the culvert to allow the fish to pass through.<br>• The depth depends on the cross-sectional shape. Box culverts disperse flow to a greater extent than pipe culverts which concentrate water during low flow.<br>• Curtain aprons reduce water depth. | • Flow depth should be a minimum of 200-500 mm to encourage fish passage.<br>• Design to ensure the largest fish remain submerged. |
| Turbulence | • Increasing the internal surface roughness of culverts increases water turbulence within the culvert.<br>• Turbulence can also be an issue at the culvert inlet.<br>• Culvert alignment and headwall shape influence water turbulence. | • Decrease surface roughness (Note: this will affect water velocity. The balance between increasing surface roughness to decrease flow velocity and decreasing surface roughness to decrease turbulence is unknown).<br>• Culvert cells should be aligned with the waterway ensuring turbulence does not increase through the cell.<br>• Natural waterway bed of bottomless and buried culverts best provides for fish passage.<br>• In higher velocity locations the headwall may need to be rounded to reduce turbulence. |
| Debris blockage | • Debris itself will not create a barrier, but when combined with other difficulties, such as increased water velocity and/or culvert length, the total effort required may exceed the swimming ability of the fish.<br>• Trapped debris may also cause injury to fish.<br>• Debris can impair a fish's swimming ability and in turn affect their spawning | • Wide, short box culverts are the most desirable to ensure minimum debris accumulation.<br>• Avoid debris blockage by conducting routine maintenance checks.<br>• At sites with high debris loads, debris deflector walls may be required to avoid blockage.<br>• Wider culvert cells have fewer |

| Considerations | Description | Mitigation |
|---|---|---|
| | success and increase mortality. | debris issues. |
| Sediment control | • Sedimentation can reduce the culvert's hydraulic capacity, increase upstream flood levels, fill habitat and fish resting pools, and cause the permanent flooding of terrestrial pathways (dry cells). | • Vary the invert level of culverts to simulate the channel's natural cross section, but this may not allow sufficient flood capacity.<br>• Alternatively, construct sediment training walls in front of the 'dry' cells (Figure 6.6.1).<br>• Larger culvert cells (bottomless or adequately buried) allow sediment transport to remain at equilibrium.<br>• Additional measures must be taken to prevent undercut and head cut erosion from occurring. |
| Length | • Excessive length, when coupled with excessive water velocity or turbulence, can create a barrier to fish passage.<br>• The majority of fish are unable to maintain burst speeds long enough to swim the entire length of most culverts. If the distance is too great (greater than six metres), fish may tire before reaching the other end and be swept back downstream (dependent upon target species).<br>• Long culverts can be dark, which may discourage some fish species. | • Construct perpendicular to the flow to minimise the length needed (less than four metres) and allow fish to swim through, where possible.<br>• Ideally, culverts should be less than six metres, if no resting areas are available and/or water velocity is faster than pre-development conditions.<br>• Longer culverts may be considered if other requirements for effective fish passage are met (for example, lower water velocity, greater width and illumination). |
| Width | • If culverts are not as wide as the natural stream bed, water flow is restricted and water velocity increased.<br>• Narrow culverts are dark and tend to accumulate debris, which may result in blockage. | • Large diameter culverts provide easy access and are easy to maintain.<br>• Should be at least 600 mm wide, but the overall crossing structure should be as close as possible to the natural stream width to ensure minimum flow restriction. |
| Lighting | • Long dark, or intermittent light patches (gaps or skylights) can be a barrier to fish passage. | • Maximise available natural light by making the dimensions of the culvert as large as possible.<br>• Skylights set in the bridge decking are only justified when endangered fish species are present that are sensitive to total darkness. |
| Water level across inlet and outlet | • For culverts which are not at stream level the jump or drop may be impassable for most fish. | • In situations where erosion is a likely issue in the future, arch structures are preferable.<br>• Countersinking of culverts below the stream bed is strongly recommended. Design culverts with a specified minimum countersunk dimension (a |

| Considerations | Description | Mitigation |
|---|---|---|
| | | minimum of 20% of the culvert diameter). |
| Culvert slope or gradient | • If culverts are placed on a significant slope, most fish will be unable to negotiate them. | • Crossings should be placed in parts of the stream where slope is minimal.<br>• Avoid using culverts on a waterway that has a gradient of more than two percent (1:50). The gradient immediately downstream of the culvert should be less than five percent (1:20) so fish can approach the culvert outlet.<br>• The culvert gradient should be similar to that of the stream, which should be gently sloping.<br>• For multicelled culverts follow the natural waterway bed profile. |

**Multicell culverts**

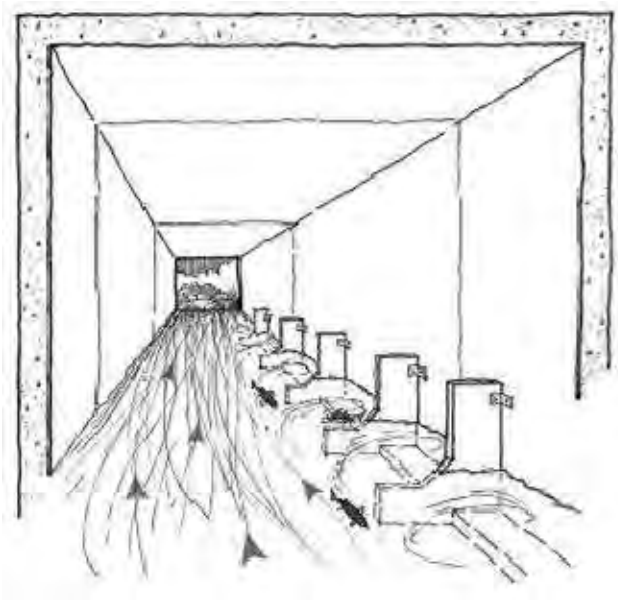
- A multicell culvert spanning the entire stream is more beneficial to migrating fish than a single culvert that does not span the stream width.
- Allows water velocity to remain similar to the natural stream condition.
- Box and pipe culverts can be utilised into multicell culvert designs.
- Pipe culverts can be used mid-stream to move the bulk of the water, with box culverts installed at the stream edges where water flow velocities allow fish passage.
- When installing multicell culverts, they should be staggered at different heights, with the lowest in the middle of the stream channel, concentrating the water during low flow.
- Install at the waterway bed profile.

**Baffles**

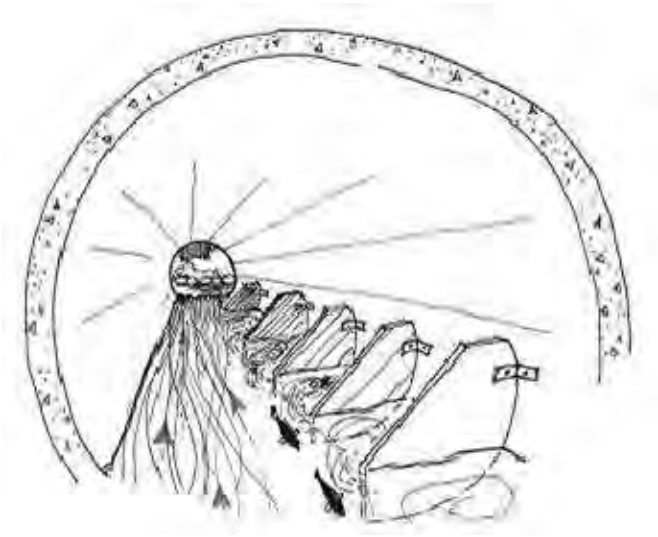
- Refer to Figures 6.6.4 and 6.6.5.
- Before installing seek expert advice to ensure correct placement.
- Appropriate for new culverts and retrofit for existing culverts, but should only be used when stream simulation designs cannot be implemented.
- Act as energy dissipators.
- Increase roughness of the surface of the culvert to reduce water velocity.
- Change the flow pattern in the immediate vicinity, creating a sequence of slow and fast water zones. This allows fish to use burst speed to advance from one resting place to the next and cruising speed to swim through the resting zones.
- For multiple parallel culverts, only those near the stream banks should be fitted with baffles.
- Types of baffles include: offset baffle, spoiler baffle, side/corner baffle, angle baffle, notch baffle, weir baffle (Kapitzke 2009).

*Disadvantages*

  - Likely to snag debris and therefore, require additional maintenance.

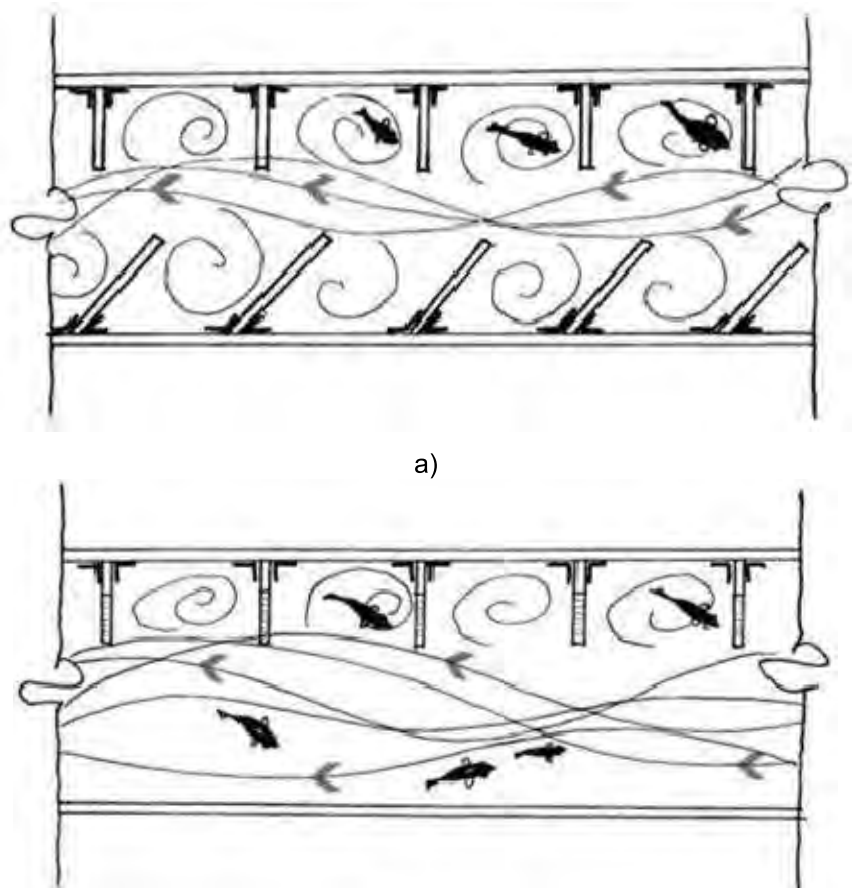


a)



b)

***Figure 6.6.4 Cross sectional view of baffle designs.***
***a) Baffle design for a box culvert***
***b) Baffle design for a pipe culvert (Kapitzke 2009).***



a)

b)

***Figure 6.6.5 a) Culvert section with baffles installed on both sides of the culvert b) Culvert section with baffles installed on one side of culvert. This allows high velocity water flows on one side and provides rest areas for fish species (Kapitzke 2009).***

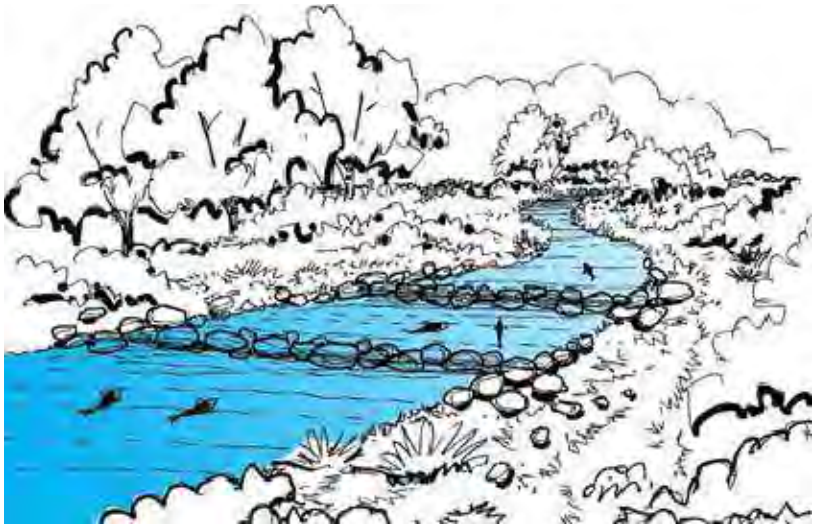
**Culvert rehabilitation**

- Existing culverts can be rehabilitated to improve fish passage conditions. This can be done by:
  - Inclusion of baffles to the bed of wet cells.
  - Downstream channel modifications to raise low-flow water levels within the culvert.
  - The addition of sidewall roughness.
  - Upstream channel modifications to remove drop inlets or excessively steep rock ramps.
- Fishways may be installed to address existing fish movement barriers and outlet erosion drop issues.

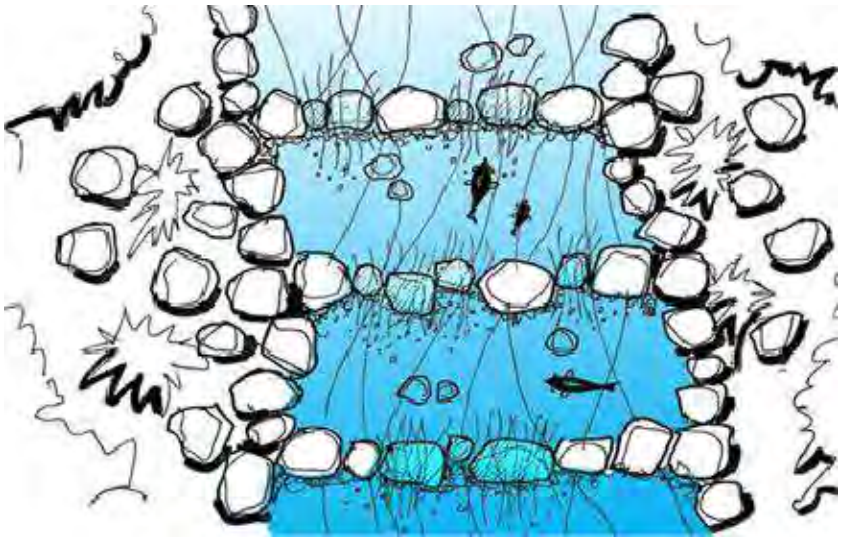
**Rock ramps**

- Are constructed by placing large rocks placed within the stream to form a staircase-type arrangement. This slows flows and forms resting locations for fish at the exit of culverts or leading up to weirs (Figure 6.6.6).
- Accommodates up- and down-stream migration.
- Allows migration even during low flow.
- Are used by a variety of fish, in particular smaller fish.
- Cater for a variety of fish behaviour and movement patterns.
- Gradient and design are determined by maximum swimming speeds of various fish.
- Full width rock ramps are optimal but partial rock ramps are most common.

- Design correctly to ensure appropriate hydraulic conditions.
- Can incorporate traverse or randomly placed ridge rocks to mimic flow conditions (Kapitzke 2009).



a) Perspective view



b) Perspective view

c) Cross-sectional view

***Figure 6.6.6 Rock ramps allow fish migration during a variety of flow periods.***

**Fords**

Fords are vehicle crossings that are approximately level with the river bed. Low flows pass over the structure rather than through a culvert. If the bed level is raised by the use of concrete or rocks, the crossing then becomes a causeway.

- Used when infrequent vehicle use is anticipated (if more frequent use is anticipated, a permanent or temporary culvert may be needed to prevent disturbance to the channel).
- Fords are 'wet' crossings so they should be used only when flows are low or non-existent.
- Fords are suitable for intermittent waterways with little or no defined drainage channel, no lasting pools and little or no vegetation.

*Design requirements:*

- Site to have a stable, non-erodible rock or bedrock base to minimise siltation from traffic.
- Sandy, vegetated and silty sites are not appropriate.
- Install perpendicular to the waterway.
- Concrete fords should have a 'V'-shaped or rounded notch on the lowest point of main channel so fish can swim across the ford during times of low flow. The 'V' or notch should be at least 50 mm deep and 300 mm wide.
- Avoid deep box cuts on the approaches to the ford. The height of the banks adjacent to the ford should be less than two metres.
- If rocks are used they should be almost level with the stream bed and not affect flows significantly.
- Only clean material from another site should be used. Excavating rock from the stream is rarely acceptable.
- Ensure the surface of the ford is erosion-proof, for example interlocking angular rock or concrete.
- Should not be made of smooth concrete.
- Design access tracks to ensure sediments and pollution do not enter the waterway.

*Advantages*

- If designed in accordance with environmental requirements there may be a cost-effective compromise between vehicle movement and fish passage.

*Disadvantages*

- A fence may be needed to stop livestock entering the stream from the ford.
- Poorly designed and sited fords may trigger stream bed and bank erosion.
- Frequent use of unhardened fords may destabilise the channel.
- A vertical drop created due to erosion will prevent or create difficulties for fish and other aquatic animals to travel upstream across the ford.
- Flows are often spread across the width of fords during low flows. As a result, the water may be too shallow to allow fish and other aquatic animals to cross.

**Causeways**

Causeways are structures which raise the base of the stream bed. They allow water through a culvert during low flows but are inundated during floods.

They are:

- Typically located on waterways with intermittent flows, poorly defined drainage channels and semi-permanent pools that provide habitat for aquatic animals.
- Suitable for wide shallow streams with gravel and soft substrate beds when bridge or culvert construction is too expensive and intensive use is not anticipated.

*Design requirements:*

- Sited on a straight waterway stretch with a minimal gradient perpendicular to the waterway.
- Normal hydraulic regime should be preserved, where possible.
- Provide stable substrate and scour-resistant material immediately downstream (if not tidal).
- Do not site near a riffle or pool.
- 'Key' ends of the causeway into the bank for between three and five metres.
- Construct the causeway surface of erosion-proof material, such as interlocking angular rock or concrete.
- Avoid deep box cuts on the approaches to the causeway.
- Incorporate culverts that adequately provide for fish passage, particularly during low flow conditions.
- Must be low enough to allow fish passage during high flows.

*Advantages*

- If designed in accordance with environmental requirements, they may be a cost-effective compromise between vehicle movement and fish passage.

*Disadvantages*

- Can restrict fish movement.
- Poorly sited causeways can lead to erosion of the stream bed and banks.
- A drop caused by erosion may be created on the downstream side of the causeway. This may make it difficult for fish and other aquatic animals to cross.

**b) Design of structures for amphibian species**

- Refer to Section 7.2: Amphibians for additional species-specific information.
- Design in close consultation with amphibian experts, as different species have specific requirements.

*Design requirements:*

- Refer to Figures 6.6.7 and 6.6.8.
- Location and design based on expert knowledge of the target species and frog migration routes in the project area.
- Connect known habitat areas, with consideration of current and future land uses.
- Orient culverts along known movement routes, such as those between breeding and foraging areas.
- Average dimensions: one metre high and three metres wide. Length should, preferably, not exceed 30-35 metres.
- Construct a channel through the centre. This holds water during dry periods to encourage amphibian use.
- Allow rain to moisten the substrate within the culvert.
- Line base of the culvert with a natural substrate: earth or humus (amphibians are unlikely to pass through culverts with a concrete base).
- Design variations can include hanging pieces of shade cloth at regular intervals throughout the culvert to provide refuge (Figure 6.6.8). See Section 9.1 Case studies: Tugun Bypass.
- Encourage use by spraying inside of the culvert with water from nearby water bodies (ponds or streams inhabited by amphibians). Note: there must be sufficient water to proceed with this option.
- Fencing:

- Exclusion of adult cane toads from the culverts can be achieved by erecting fine mesh or 500 mm vertical metal at the entrance to the culverts (refer to Section 9.1).
- Frog fencing used in conjunction with culverts to direct and encourage use.

*Construction:*

- Minimise/avoid impact on the vegetation surrounding culvert entrances. If entrances are severely trampled during construction frog usage may be limited.

*Advantages:*

- If designed in close consultation with amphibian experts, structures will be effective in allowing movement across a road barrier.

*Disadvantages:*

- If not designed in close consultation with experts structures are likely to be ineffective.

a)

b)

***Figure 6.6.7 a) Frog culvert at Tugun Bypass (Robinson-Wolrath 2007). b) Frog culvert at Tugun Bypass with shade cloth installed to provide amphibian refuge (Robinson-Wolrath 2007).***

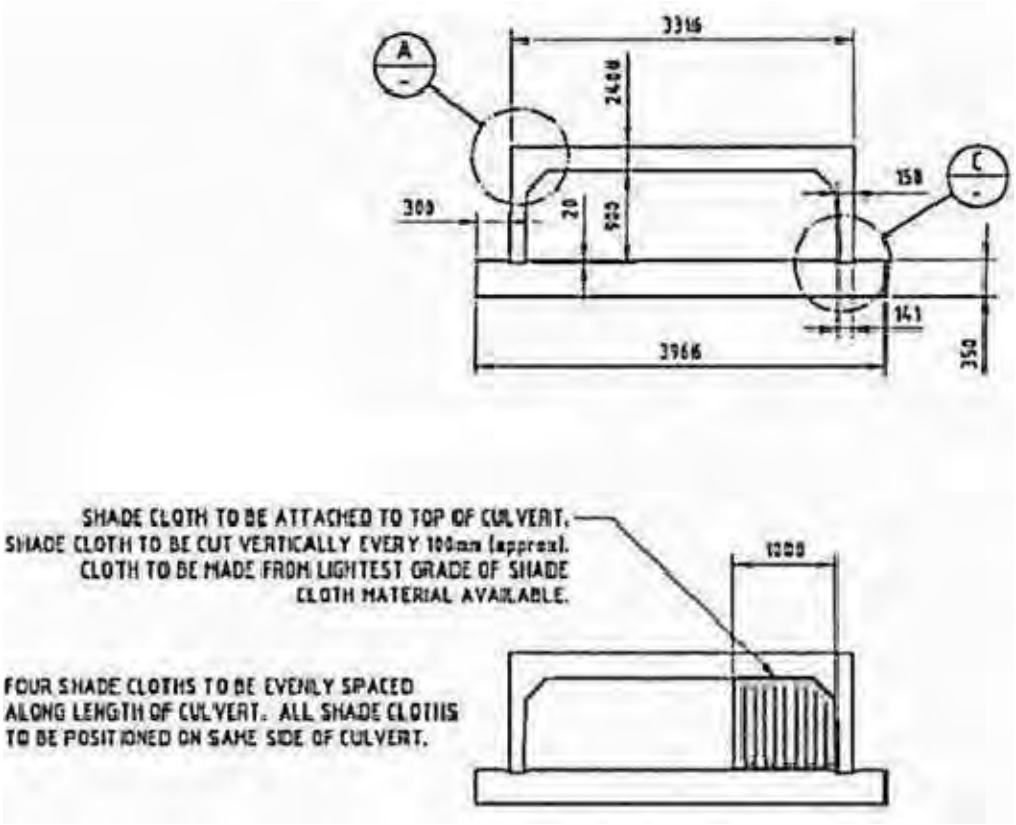


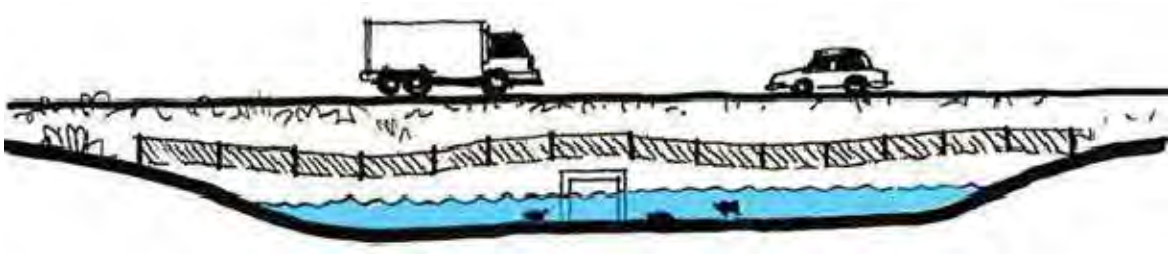

***Figure 6.6.8 Cross section drawing of frog culvert adapted from drawing 3003181-DRN- 020-3076 (Pacific Alliance Link 2006d).***

### c) Design of structures for turtles

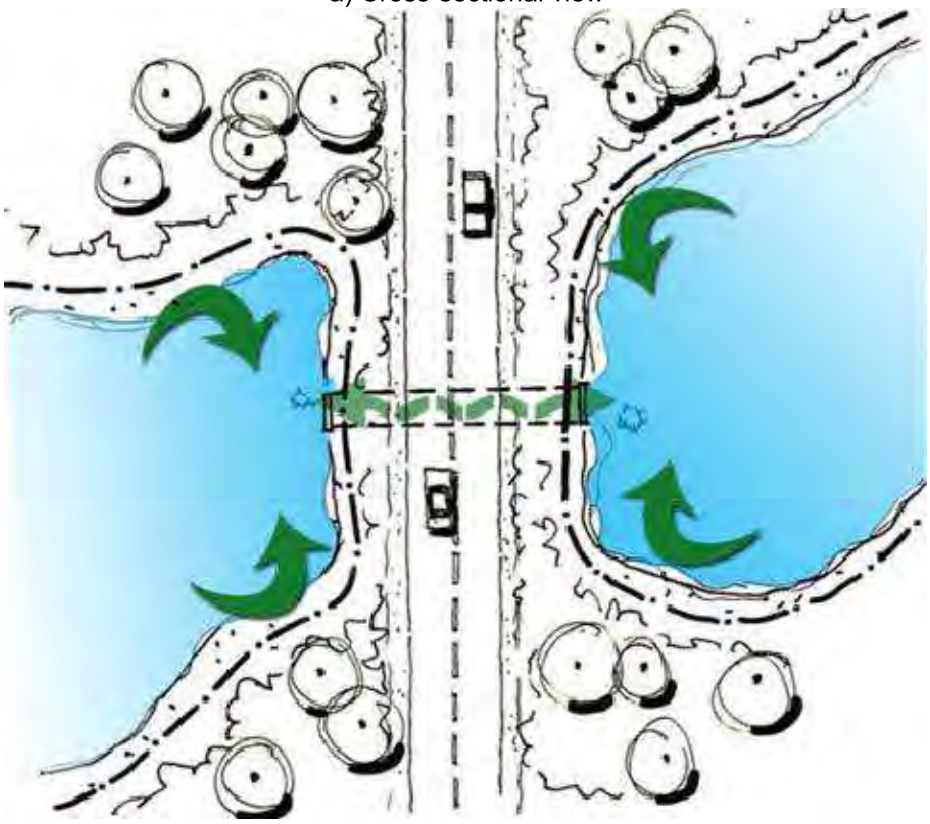
Underpasses have been used to link aquatic habitats for turtles (Figure 6.6.9).

In overseas locations, increasing the number of culverts is known to decrease predation at fencing and people stealing turtles as pets (or meat). In these circumstances it is recommended that turtle culverts be placed every 200-300 metres, although this must be determined in relation to the target species.

A 3.5 metre diameter and 46.6 metre long round corrugated metal drainage culvert has been used in north-western Florida (USA) for multiple fauna species. The specific turtle species targeted were Florida cooters, yellow-bellied sliders and mud turtles (Aresco 2003).



a) Cross-sectional view



b) Plan view

***Figure 6.6.9 Culverts can be used to link turtle habitat disconnected by a road. Guide fencing is shown.***

**d) Design of Structures for platypus**

- Must not have an exposed concrete base:
  - Platypus are known to avoid concrete-based culverts (interferes with their electromagnetic sensitivity) and will risk crossing the road instead.
  - Install bio-baffles to reduce smoothness of culvert.
- Ensure platypus can comfortably enter and exit the culvert.

- Prefer culverts with low flow rate (no more than 2.4 m/second and need to be able to grip onto culvert surface).
- Greater amounts of vegetation cover in and around the culvert are known to be associated with reduced roadkill levels.
- Require stable banks to burrow into, therefore the maintenance of riparian tree roots (such as from Casuarina trees) in the vicinity of the culvert is essential.
    - If possible, revegetate and reconsolidate denuded banks as quickly as possible with native trees and shrubs (for example, Eucalyptus, Casuarina and Callistemon).
- To be constructed in association with appropriate fencing preventing access to the roadway.

*Effectiveness:*

- Platypus have a 'long term memory' so the structure must be ideal from the start. Poor design has resulted in culvert avoidance even when modifications are made at a later stage.
- Construction recommendations:
    - Construct during the driest part of the year (May – September) and when platypus are not rearing young (April – August).
    - Ensure water flow is maintained at all times.
    - Minimise the time taken for heavy plant operations (for example, pile driving) and if possible confine these to a discrete time period.
    - Minimise the length and width of bank destruction necessary for construction access.
    - Avoid large alterations to bank profiles that may redirect water flow.
    - Avoid compromising stream and bank sections that are preferentially used by platypus.
    - Retain the voids between the gravel and rocks within the natural waterway ensuring aquatic invertebrates are retained.
    - Prevent water pollution, sedimentation and substrate disturbance ensuring the survival of local aquatic invertebrates (foraging resource).

Advantages:

- Encourage natural movement up- and downstream.

Disadvantages:

- If constructed incorrectly, platypus will actively avoid these areas for the long term.
- Electromagnetic fields from culvert supports may interfere with platypus electroreception (Magnus *et al.* 2004).

**e) Design of structures for terrestrial species**

- Size:
    - The 'Relative Aperture' of a culvert is one method to ensure utilisation of the structure by a large variety of fauna.
    - Relative Aperture = length/opening width or height.
    - Optimal size: relative aperture to be less than eight.
    - 3 metre x 3 metre box culverts are generally considered suitable to accommodate a wide variety of terrestrial fauna species (including macropods, koalas and flightless birds).
    - Minimum vertical clearances between the ground and roof of the structure are chosen to accommodate the targeted fauna species.
    - To encourage the passage of a variety of small to large fauna species, a minimum vertical clearance of three to five metres is considered necessary.

- Size of the culvert must be cost-effective.
- A 3.4 metre high x 3.7 metre wide culvert has been installed for the safe passage of cassowaries in North Queensland (Figure 6.6.10). This structure has a dry ledge with a 'natural' surface. The effectiveness of the structure is uncertain at present.
- For small mammals, pipes or rectangular tunnels should have a diameter/width of 0.4 – 2 metres. This is, however, dependent on the structure's length, openness and the specific target species. A diameter of 1.5 metres or greater is suitable for multiple small mammal species.
- Rectangular tunnels are preferable for small mammals (Figure 6.6.11).
- When constructing pipe structures for small mammals ensure the diameter is large enough to allow the bottom section of the structure to be filled in to provide a horizontal surface.

- Substrate:
  - As natural as possible.
  - Place gravel, mulch or embedded rocks into the bottom of the culvert unless surrounding substrate can be replicated.
  - Openings to lead directly into the habitat (not concrete).
  - Travel of arboreal fauna along bare ground in an underpass increases their vulnerability to introduced predators such as dogs, foxes and cats.
  - Prevent waterlogging and in general provide dry passage for fauna. Koalas require a dry substrate.
  - Roughen surfaces with a gradient.
- Vegetation:
  - Plant entrances with appropriate and potentially palatable vegetation (for example, eucalypts, shrubs and grassy groundcover).
  - Ensure there is a continuum of habitat to the underpass entrance.
  - Although most native fauna prefer complex vegetation structure near underpass entrances (three to 50 metres from entrance), macropods prefer a simple vegetation structure.
    - For macropod corridors include open and closed forest and a mixed vegetation structure.
- Furniture: (Figures 6.6.12 - 6.6.18).
  - Provide a dry ledge or similar within dual purpose culverts. Those without ledges are known to be avoided.
  - Include horizontal and vertical poles and netting attached to pylons where appropriate to target species.
  - Place horizontal logs for passage as high above the base of the opening as practical, allowing 0.6 metre ceiling clearance for fauna passage (Figure 6.6.15a).
  - Vertical logs are secured to the invert of the concrete base slab and soffit of the culvert ceilings by attachment brackets (Figure 6.6.15b).
  - Interconnecting logs can provide a dry passage for koalas whilst also providing refuge from predators.
    - Outside and within the culvert: refuge poles (three metres tall and 200 mm diameter) are effective where introduced predators are likely to attack koalas (Figure 6.6.14).
    - It is important to ensure that the poles are located at least three metres away from koala exclusion fencing.
  - The advantages of using lead-up logs at either end of the culvert for predator use or avoidance is unknown (Figure 6.6.12c).
  - A break in the middle of the culvert (if a median strip exists) is preferred if the culvert is located under a four-lane road.

- Skylights should be avoided as excess runoff, traffic noise and other additional barrier effects can reduce effectiveness of a fauna crossing structure.
- Overlapping rocks and boulders to be placed inside a large opening to provide predator protection for small mammals and/or reptiles.
- Refuge poles and ropes can also be used for animals, such as koalas and arboreal species, for predator evasion (Figures 6.6.12a and 6.6.14).
- General reptile furniture includes tiles, logs, mulching and stones and will increase the likelihood of usage by reptile species. Similar furniture will increase the likelihood of small mammal usage due to increased prey distribution (ie. invertebrates).
- Provide shelter and guidance for small mammals.

- Fencing:
  - In accordance with Department of Transport and Main Roads' Standard Drawings Roads Manual - Standard Drawing 1603: Fauna exclusion fencing.
  - Constructed to guide fauna towards the culvert entrances (Figures 6.6.12b, 6.6.17 and 6.6.18).
  - Construct culvert prior to the erection of permanent fencing.
  - Conventional fencing is unsuitable when small mammals are part of the target species.
    - Wire-mesh size and height must be adapted to prohibit these species from the road corridor.
  - See Section 6.11: Barriers: Fencing for additional fencing information.
- General:
  - Ensure that underpass entrances lead to natural habitat on both sides and that this view is visible from culvert entrances.
  - The installation of several underpasses at one location decreases the possibility of interference caused by other fauna movement (species interactions), provides alternative routes to bypass predators, decreases travel time to find safe crossing and enables more equal population distribution.
  - Minimum gradient of 1% and a maximum gradient of 1:2 for small mammal species. This is, however, dependent on the target species.
  - Ponds, cleared areas and noise near underpass entrances were found to discourage use by macropods.
  - For macropods, dry passage at all times within the culvert must be provided. Culverts that do not provide a dry crossing are known to be avoided.
  - Long and narrow underpasses deter macropods.
  - Appropriate height of a culvert for macropods will be influenced by gait behaviour.
  - Eastern grey kangaroos can utilise 3 metre x 3 metre box culverts (Australian Museum Business Services 2001).
  - Red-necked wallabies are known to use box culverts 3 metre x 3 metre and 800 mm diameter purpose-built arches (Australian Museum Business Services 2001).
  - Swamp wallabies can utilise box culverts 3 metre x 3 metre, 1.2 metre x 2.4 metre, and 2.8 metre diameter purpose-built arches (Australian Museum Business Services 2001).
  - Small culvert usage tends to be dominated by small mammals, with these species preferring established culverts.
  - Keep entrances free from human disturbance and avoid artificial light.
  - Provide unobstructed access.

***Table 6.6.3 Table of considerations when designing a macropod underpass.***

| Structure | Considerations |
|---|---|
| Underpass location | • Construct at regular intervals.<br>• Ensure that there are a sufficient number of underpasses to allow escape crossings, especially during fire.<br>• Investigate repetitive macropod movements before installing fauna structures.<br>• Locate fauna structures at locations with highest rates of roadkill. |
| Culvert | • Either end of culvert must be clearly visible.<br>• Take measures to reduce water pooling.<br>• Include at least one ledge or similar for dry crossing.<br>• Avoid lights within culverts. |
| Underpass flooring | • Concrete floors had higher rates of crossings by echidnas, wallabies, kangaroos, possums and water rats than koalas.<br>• Encourage sedimentation of flooring for a more natural environment.<br>• Take measures to avoid water pooling. |
| Size | • Macropods and koalas prefer underpasses with large diameters.<br>• Refer to above section discussing optimal 'Relative Aperture' dimensions.<br>• 3 m x 3 m box culverts are preferable for macropod species.<br>• Underpasses with height smaller than the width are more commonly used by fauna.<br>• Lengths longer than 20 m have generally lower use. |
| Furniture –lights | • Open skylights may cause noise and other associated pollution issues.<br>• May encourage vegetation growth. |
| Furniture – refuge poles | • Provides safety for koalas.<br>• May encourage underpass use by koalas. |
| Furniture – ledges | • Favoured by smaller fauna although koalas do utilise them.<br>• Place in the top two-thirds (towards the roof) of the underpass.<br>• Ensure slope at both ends of the culvert is 1:5 or vertical to ensure that predators are unable to utilise the ledges (research is required to determine the ideal slope if any). |
| Silt traps | • Discourage fauna use when located near underpass entrances. |
| Fencing | • Install to ensure fauna are protected from predators/pests/disturbances.<br>• Ensure that fencing does not trap animals, especially during fire.<br>• Ensure that fencing guides fauna towards the underpass. |
| Vegetation | • Underpass openings need to be vegetated.<br>• Provide forest structure to cater for needs of all fauna.<br>• Allow access to, and view of, entrance and exit. |

*Advantages*

- Utilised by a wide variety of fauna.
- Provides new habitat, unlike some other structures which merely serve to connect habitats.

*Disadvantages*

- Success is determined by several variables (for example, size, vegetation, furniture, guide fencing, clearance).
- Can be expensive.
- At present, dual purpose culverts in Queensland designed to accommodate drainage and fauna passage have had problems. Currently, may be better to have separate drainage and fauna movement structures.
- Due to the size of some culverts designed for small mammal movement, maintenance can be difficult.
- If there is an insufficient openness of the culvert, vegetation provided within the structure will deteriorate.

*Maintenance Requirements*

- Ensure vegetation establishes.
- Ensure vegetation consists of diverse species and heights.
- Control weeds and silt buildup.
- Maintenance should occur at least once a fortnight during construction and be ongoing.
- Maintain furniture.
- Undertake inspection of entrances twice a year to ensure access for fauna.

a) Entrance for culvert and showing relative height of passage

b) Ledge for dry passage within the culvert

***Figure 6.6.10 Underpass with a ledge to provide dry passage for cassowaries, Mission Beach, Queensland (Scott 2007).***

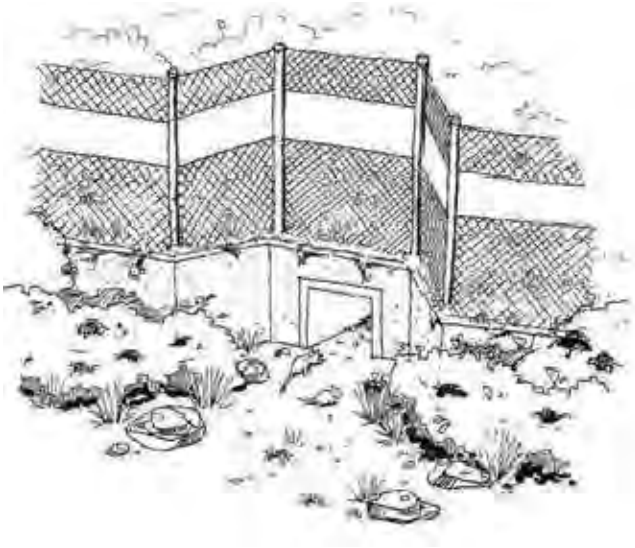
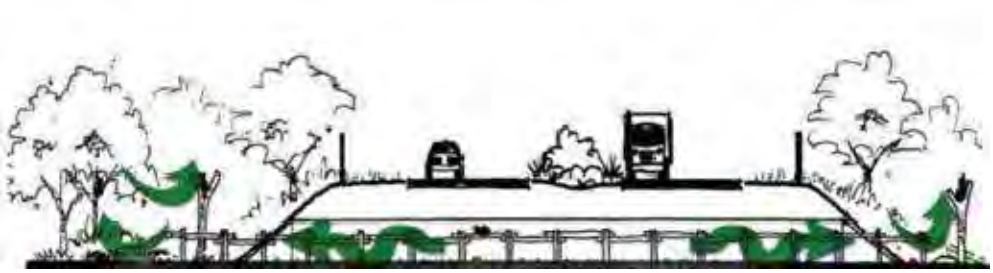
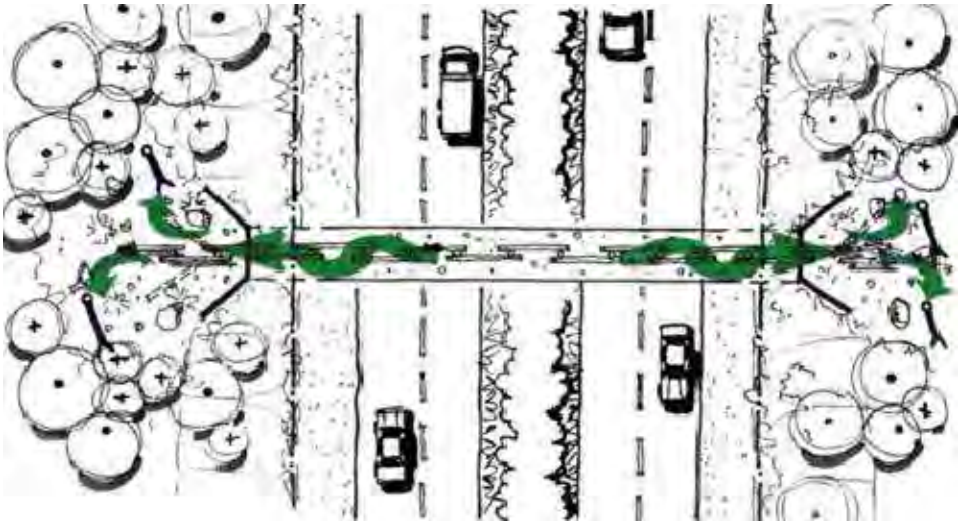


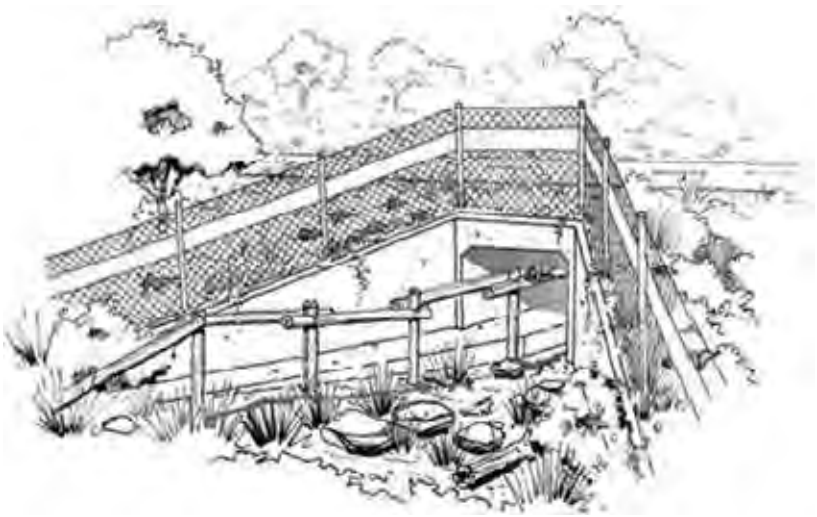
***Figure 6.6.11 Small mammal culvert design.***



a) Cross-sectional view



b) Plan view



c) Simplified entrance drawing

***Figure 6.6.12 Diagram of general fauna culvert with furniture that can accommodate koalas. Note: optional extensions (lead-ups) on either end of the horizontal furniture logs. Note: fauna exclusion fencing is used to guide fauna into culverts ('straight' fence design) (Figure b).***

***Figure 6.6.13 Lead up pole to a horizontal log used to traverse the culvert at a safe height (Robinson-Wolrath 2008).***

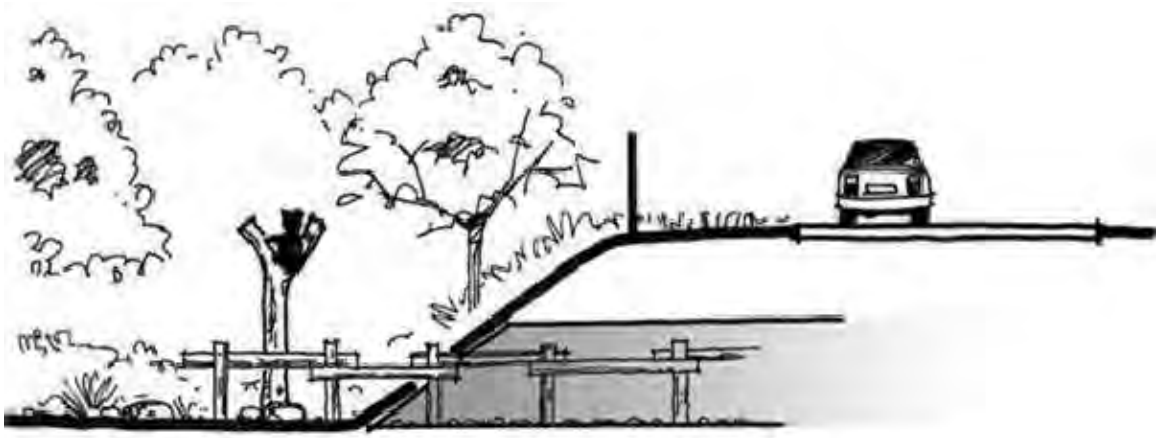


*Figure 6.6.14 Refuge pole being utilised by a koala at the entrance to a culvert.*

a)

b)

*Figure 6.6.15 a) Fauna underpass from Bonville Upgrade (NSW Roads and Traffic Authority project) indicating required height for horizontal logs (Robinson-Wolrath 2008).*
*b) Brackets used to affix vertical logs to underpass base, used on Yelgun to Chinderah project (NSW Roads and Traffic Authority project) (Robinson-Wolrath 2008).*

a)

b)

c)

*Figure 6.6.16 Different types of fauna underpasses Compton Road, Brisbane (Scott 2007).*
*a) East Evelyn Range, North Queensland (Scott 2007). Trawler ropes were installed to accommodate arboreal movement.*
*b) Yelgun to Chinderah, northern New South Wales. Designed to accommodate a number of species, including birds.*

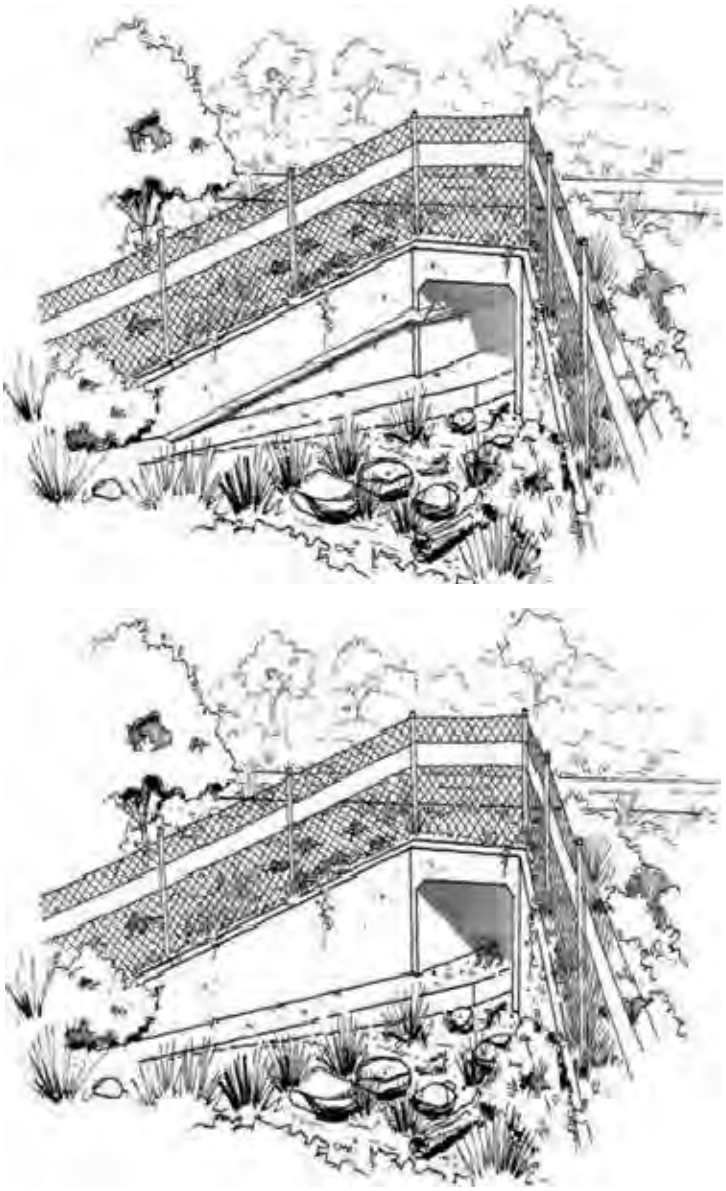
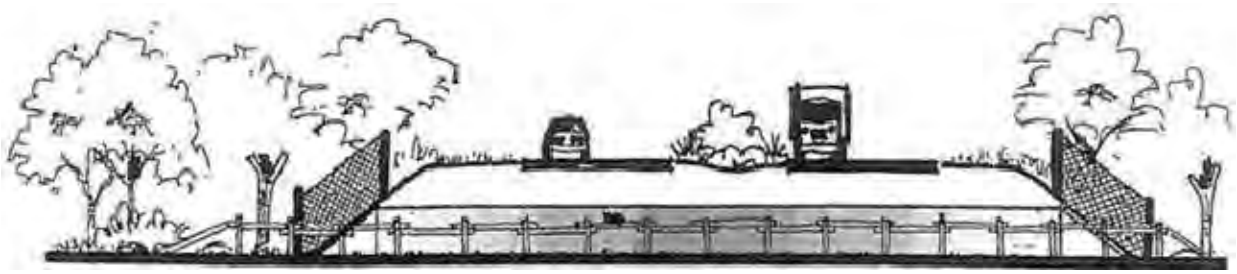
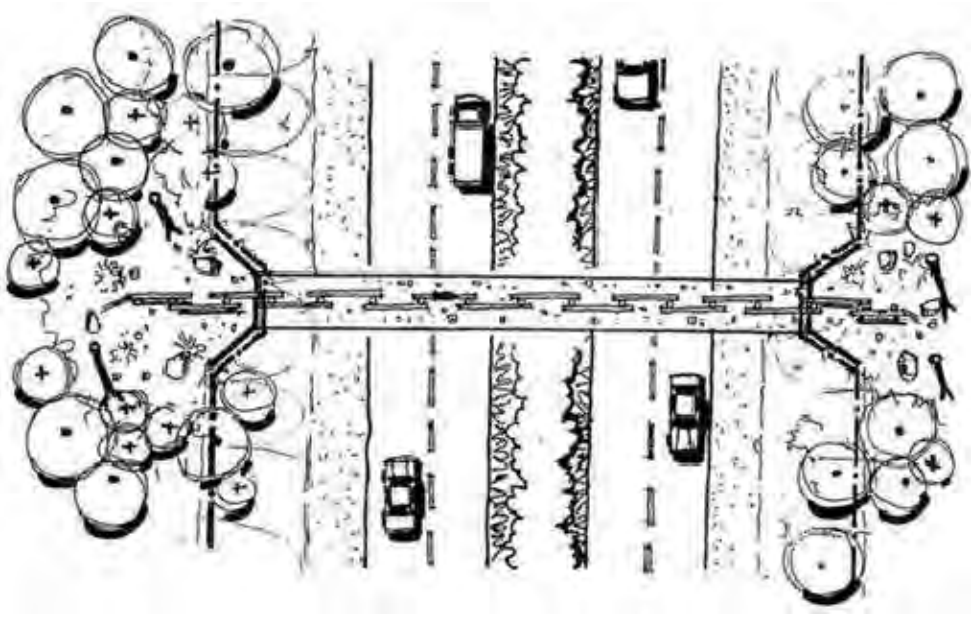


*Figure 6.6.17 Furniture used to encourage underpass use by multiple species.*



a) Cross-sectional view



b) Plan view

***Figure 6.6.18 Fauna exclusion fence installation used to guide fauna to culvert entrances ('jagged' fence design).***

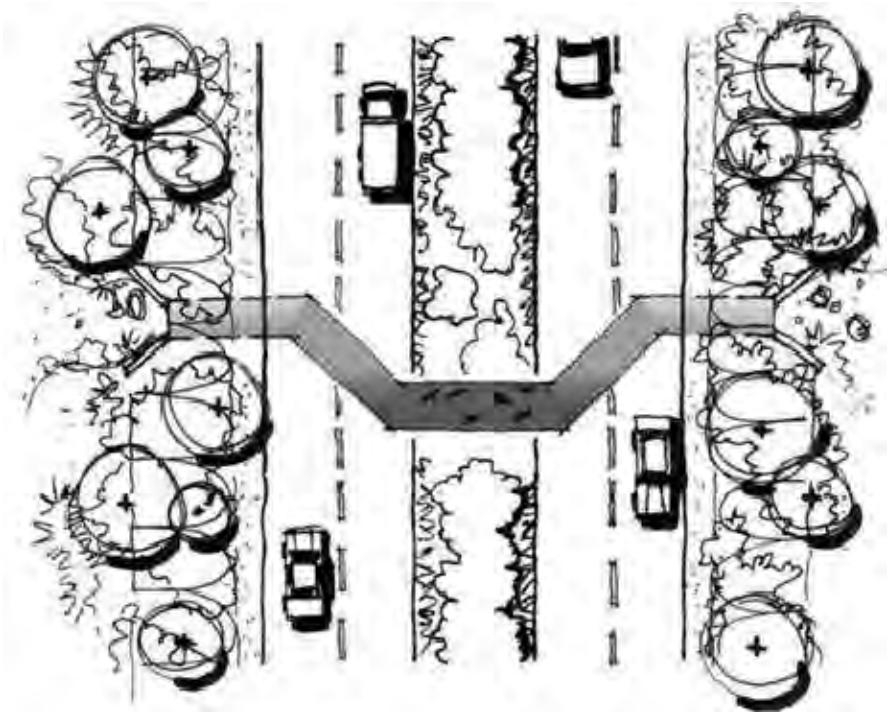
**f) Design of structures for bats**

No purpose-built bat structures should be built without contact and ongoing involvement of a bat specialist.

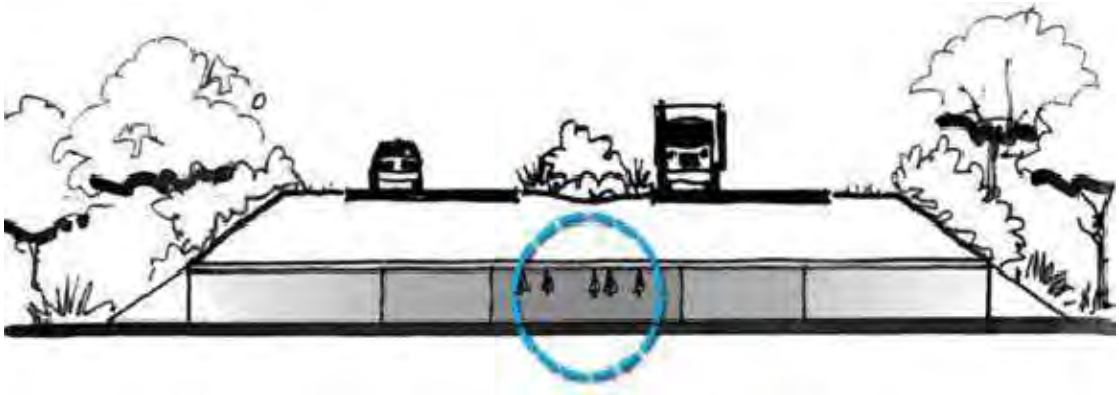
*Design requirements:*

- Designs are dependent on the target bat species, the environment and the culvert's purpose.
- A general design requirement may be, for example:
  - 1.5 to 2 metres in diameter.
  - Of sufficient length to allow enough bends to prevent light from reaching the main roosting site (Figure 6.6.19).
    - If only one bend is to be constructed, it should be sufficient enough (approximately 30 – 40 degrees) to ensure darkness at the roosting site.
  - Have height variation along its length and at least two entrances, preferably at different heights.
    - If this is not possible or the aim is to simply provide a roosting site then driving a culvert into a pile of fill may also be suitable if designed appropriately.
  - Roosting sites have been constructed utilising concrete culverts, pipes and tyres.
  - Construct the roost area out of rough rock or have the roof of the roosting area roughened.
  - A carefully-designed fence at the entrance may be required to keep people out. A sign may be provided to inform the public why access is denied. Design the fence appropriately to ensure bat access remains.
- Airflow needs to be established:
  - Two entrances at different levels (preferred option) or a single entrance with the interior of the roosting area to be inclined/declined to create temperature and pressure differentials to establish air flow.
  - Should not be so strong as to create wind, but rather act to facilitate air replacement in the structure.
  - There are no simple design guidelines to achieve appropriate airflow.

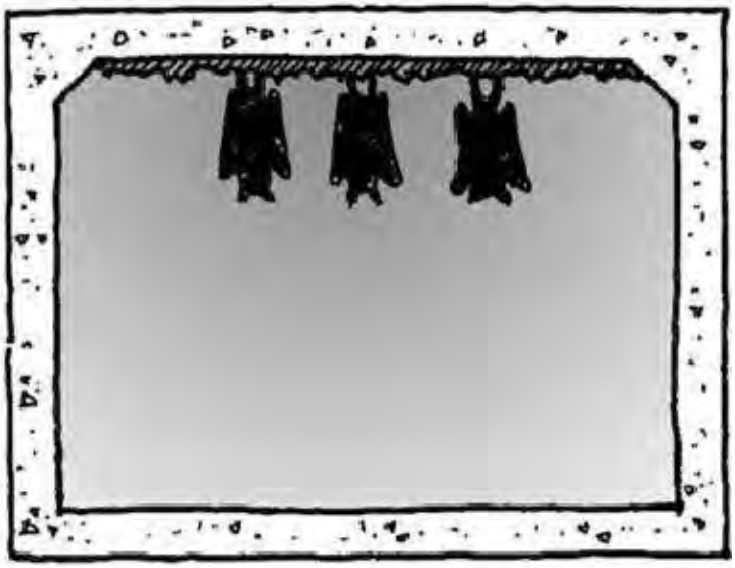
- A range of temperature regimes at various points in the structure needs to be created.
    - Designed to accommodate as many different species as possible by establishing a range of different conditions.
    - May be achieved by constructing roof avens that trap warm air and some sections which are low and trap the cold air.
- A high degree of temperature and humidity buffering from the ambient conditions is preferred.
- Structures need to be built to protect bats from predators (rats, snakes and so on). This can be achieved by:
    - Smoothing lower walls of the roost area without any projections from the ground or any shelves.
    - Provision of total darkness, as this may act as a barrier to some predators.
- Construct roosting sites within the structure out of rock (preferred) or a wood material.
    - Steel can rust and cause damage to bats' feet.
    - Steel can act as a conductor of heat and, therefore, transfer heat away from the roost site.
    - Wood material does not last for a long period of time, particularly in the 'underground' environment of a roosting site.
    - Bats prefer to roost on clean surfaces.



a) Plan view illustrating a possible bat culvert design providing a dark roosting site.



b) Cross-sectional view showing the light gradient created from bends in the culvert.



c) Magnified view of a bat roost section (circled in blue in (b))

***Figure 6.6.19 Bat culvert. Note the rough roof roosting surface and smooth side walls to prevent predation.***

## *6.7 Underpass: Tunnel*

Typically round pipes of relatively small diameter (for example, less than 1.5 metres in diameter). May also be termed an eco-pipe.

### 6.7.1 Target species

- Small-sized fauna, depending on dimensions, and whether it is wet or dry.
- Limited applicability to medium- to large-sized fauna.

### 6.7.2 Design specifications

- Refer to Section 6.6: Underpass: Culvert for detailed information on design features to enhance the tunnel's functionality.
- Suitable for aquatic fauna if installed below water level but hydraulic preferences of aquatic fauna must be taken into consideration.
- Only suitable for terrestrial fauna if the tunnel is located in an area that does not experience flooding.

- Design improved when a dedicated drainage pipe is installed alongside a fauna-dedicated tunnel.

## *6.8 Underpass: Bridge*

A structure that maintains the grade of the road or elevates the traffic above the surrounding land, allowing animals to pass under the road (Table 6.8.1). It facilitates water drainage or the movement of local human traffic and secondarily the passage of wildlife.

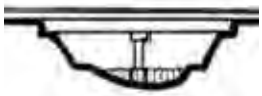
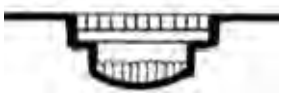
### 6.8.1 Target species

- All fauna

### 6.8.2 Design specifications

- Movement corridors provided under bridges are the most appropriate crossings for sites with threatened species, fish habitat or aquatic vegetation.
- Bridges with no in-stream support sections are the only crossings that pose no physical barrier to fish movement.
- Generally, bridge structures have the least impact on aquatic fauna passage as they normally involve minimal disturbance to the water flow and aquatic habitat.
- Used when frequent fish crossings are anticipated.

***Table 6.8.1 Types of bridges.***

| | | |
|---|---|---|
| Single span bridge |  | No intermediate support pylons |
| Multiple span bridge |  | One or more intermediate support pylons |
| Viaduct |  | A long multi-span bridge |
| Grid bridge |  | Constructed from railway lines and welded beams, with concrete abutments and piers, they range from 6-100 metres in length and are relatively cheap to build. |

*Design requirements for aquatic species:*

- Built to avoid marine plants and/or high value fish habitats, where possible.
- Designed to span the waterway with no in-stream supports, wherever possible.
- Designed and constructed to accommodate all flow conditions.
  - Seek expert advice on a range of issues, including geography, hydrology, hydraulics, geotechnical and geochemical issues and road geometry.
  - Place piers and footings beyond the channel and above the high water mark to avoid constricting the channel and reducing the flow area.
- Need to consider erosion management (aimed at decreasing maintenance costs).
- Use grated decking on a multilane bridge to allow light and moisture to penetrate. Only consider if the risk of pollution from road spills is minimal.
- In the case of multiple lane bridges, a gap between lanes will assist in allowing light penetration under the bridge.

- Skylights are only justified where endangered fish species sensitive to total darkness are present.
- Construct perpendicular to the waterway, where possible.
- Placement should aim to minimise future maintenance requirements.
- Consider future maintenance requirements and associated disturbance of fish habitats with the aim of minimizing maintenance-related disturbance.
- Elevated approach roads across floodplains need to include culvert cells to reduce flooding and to allow fish passage along the floodplain.
- Construction materials to have clean fill, with no potential to leach and pollute waterways.

*Advantages:*

- Limited disturbance to the environment if designed in accordance with environmental requirements.

*Disadvantages:*

- Reduces stream stability.
- Can degrade water quality as a result of road runoff.
- Increases flood flow velocities.
- Blockage of fish passage on floodplains caused by elevated approach roads.
- Limited light penetration under bridge affects in-stream and bank vegetation and in turn affects habitat values and water velocities.
- Creates a non-physical barrier for some aquatic species which avoid dark, colder areas during daylight hours.
- Incorrect placement of pylons/footings leads to the creation of eddies, increased water velocity and turbulence which may delay migrating fish as a result of confused flow signals.
- May produce adverse hydraulic conditions due to increased velocities, channel simplification or excessive water surface drops (Kapitzke 2009).

*Design requirements for terrestrial species:*

- Use grated decking on a multilane bridge to allow light and moisture to penetrate. Only consider if the risk of pollution from road spills is minimal.
- In the case of multiple lane bridges, a gap between lanes will assist in allowing light penetration under the bridge.
- Where terrestrial passage is required under a bridge, all reasonable and practical efforts should be taken to restore and/or maintain continuous riparian cover along the channel banks. This should occur on both banks, but if not practical, then priority should be given to the bank which is more likely to form part of a fauna movement path.
- Where possible, move bridge abutments away from the watercourse banks to increase the opportunity for terrestrial passage along the banks and overbank areas.
- Include culvert cells in elevated approach roads across floodplains to reduce flooding and to allow fauna passage along the floodplain.
- Provide vertical logs cast into concrete footings and attached to underside of bridge or top of arch spans for fauna passage.
- Viaducts provide the most effective form of passage for birds under the road (Figure 6.8.1).
- Viaducts and bridges are suitable for cassowaries.
    - Landscape with cassowary food trees to act as an attractant.
    - Use appropriate guide fencing.
    - Provide dry passage.

- Current design: Revegetated and reprofiled embankments underneath bridge. This has been successful in enabling safe cassowary passage.

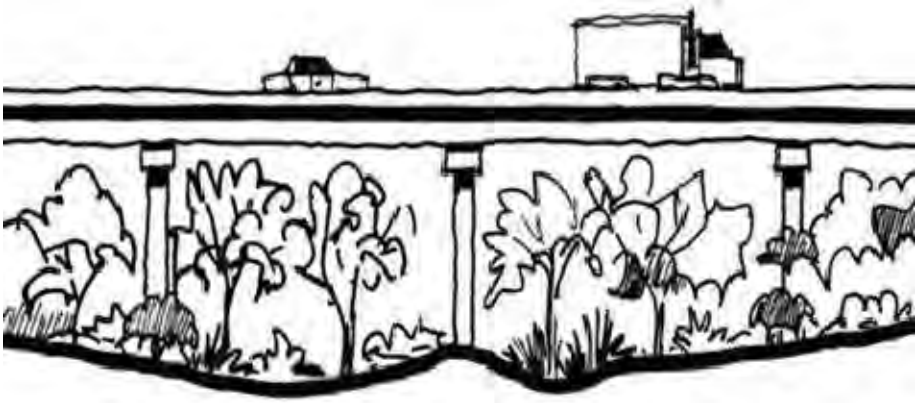
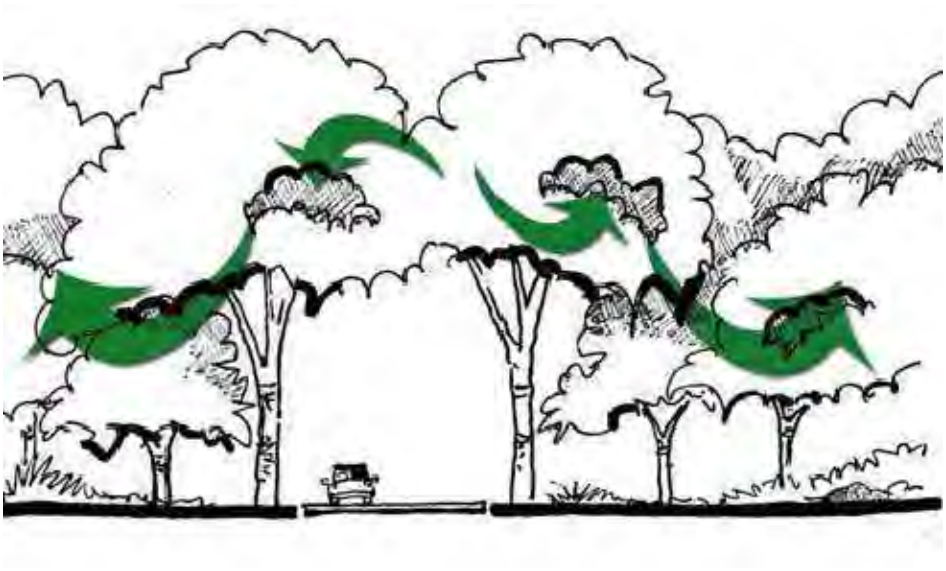


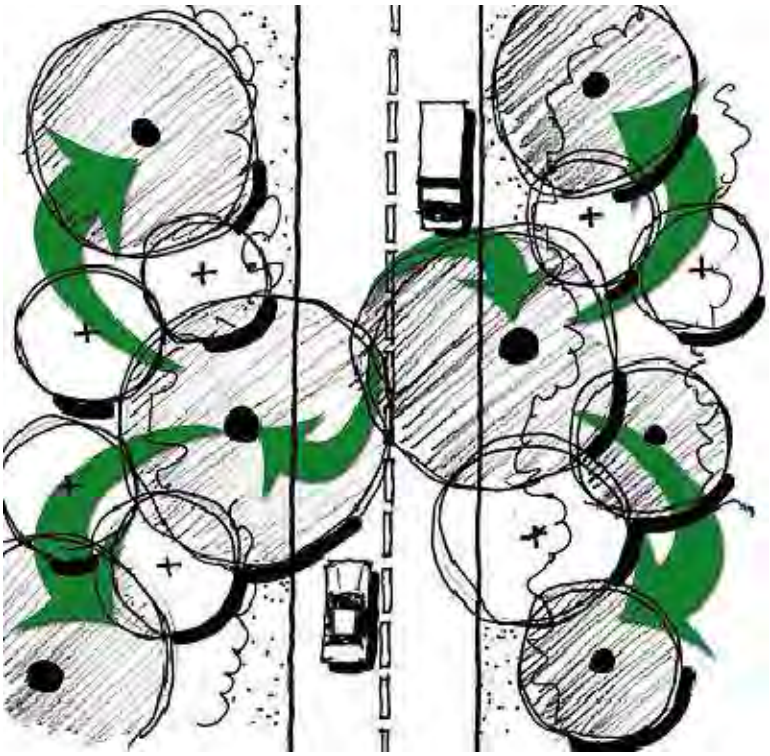
***Figure 6.8.1 Viaduct design which can be utilised by bird species.***

## *6.9 Non-structural mitigation: Canopy Connectivity*

The width of the linear vegetation clearing is kept sufficiently small to allow the tree canopy to remain continuous, or where not continuous, sufficiently small to allow gliders (and other volant species) to safely traverse the clearing (Figure 6.9.1).



a) Cross-sectional view



b) Plan view

***Figure 6.9.1 Diagrammatic representation of canopy connectivity designed to accommodate arboreal species***

## 6.9.1 Target species

- Arboreal species.
- Flight birds.
- Flying invertebrates.

## 6.9.2 Design specifications

- Refer to Section 7.4: Arboreal species for additional species information.
- Arboreal species prefer natural canopy connectivity to artificial structures.
- Ensure there is a minimum clearance of seven metres to allow traffic to pass underneath the canopy.
- Retaining a median strip between two carriageways is an effective way to ensure that the target species can pass from one side to the other with relative ease (Figure 6.9.2).
- Ensure final layout and elevation of the carriageway does not alter the drainage significantly to ensure conditions are appropriate for the survival of median vegetation.
- Clear zone and roadside barrier design requirements need to be considered.
- Vegetation:
    - For the Wet Tropics World Heritage Area, it is important to retain median strip vegetation to enhance canopy crossings.
    - Retention of large trees is crucial for glider conservation as these are preferentially chosen for foraging. Large trees also provide hollows, which younger trees cannot supply.

*Species-specific information:*

- Retaining mature trees with 400-800 mm diameter is not only important for shelter, but also produces flowers more regularly than smaller trees. This is particularly important for feathertail gliders, sugar gliders, squirrel gliders and yellow-bellied gliders.
- Lemuroid ringtail possums are more affected by lack of canopy connectivity than traffic volume.
- Canopy connectivity is also important to small mammals as it reduces edge and linear barrier effects.

*Advantages:*

- Low maintenance.
- Low cost, if additional land available.
- Preferred by fauna.
- Aesthetically pleasing for motorists.
- Enhances and creates habitat connectivity, allowing migration and dispersion.

*Disadvantages:*

- Safety issues relating to falling branches or animals.
- Can utilise intact canopy connections only over narrow roads.
- Overhead clearance issues.
- Without fencing, canopy connectivity may encourage fauna towards road-edge.
- Area underneath the canopy (ie the road) may become damp and slippery in tropical areas.
- Costly if land purchase is required.

*Maintenance Requirements:*

- Maintain necessary overhead clearance.
- Maintain dead and decaying branches in areas adjacent to the road.
- Retain mature trees with 400-800 mm diameter for shelter and foraging resources.
- Retention of large trees is crucial for glider conservation as these are preferentially chosen for foraging and roost opportunities.

a)

b)

***Figure 6.9.2 Maintained median strip of mature vegetation to facilitate safe glider migration.***
***a) Pacific Motorway, Bonville Upgrade, New South Wales Roads and Traffic Authority.***
***b) Pacific Motorway, Brunswick Heads, New South Wales Roads and Traffic Authority.***

## *6.10 Non-structural mitigation: Local Traffic Management*

Local traffic management incorporates devices aimed at reducing the speed or volume of traffic, for example, road closures, chicanes, crosswalks, lighting, signage, rumble strips. These measures raise driver awareness to the presence of wildlife.

### 6.10.1 Target species

- All species.

### 6.10.2 Design specifications

- Numerous methods and devices installed to change driver behaviour and result in slower speeds. For example,
  - Bends in roads (Figure 6.10.1).
    - The inclusion of bends in roads and maintaining appropriate vegetation clearing may assist with slowing traffic in areas where fauna cross the road.
    - May alternatively decrease advanced warning of fauna in the road corridor.
  - Chicanes (Figure 6.10.2a).
  - Raised crosswalks (Figure 6.10.2b).
  - Signage (Section 6.10.2a; Figure 6.10.3).
  - Rumble Strips (Figure 6.10.5).
- Most effective in low speed areas.
  - In high speed areas, it is reported that there is not a significant drop in roadkill events after the installation of signage (Coulson 1982).
- Where practicable, maximise visibility of the fauna crossing area in both directions of road traffic.

- Local traffic management measures are most effective when installed in conjunction with other measures of mitigation.
- Permanent and temporary signage has been installed in North Queensland in an attempt to reduce vehicle collisions with cassowaries (Figure 6.10.3).
- The success of permanent signage in reducing roadkill and public awareness diminishes over time, particularly with local residents who are regular travellers on the target roads.
- Reduction in speed limits may have the potential to reduce fauna roadkill. Such mitigation needs to be accompanied by public education and enforcement (policing).

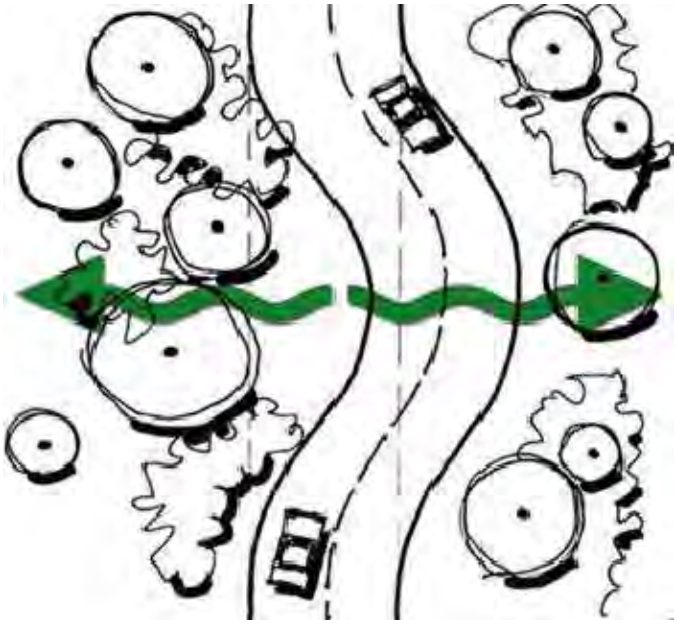
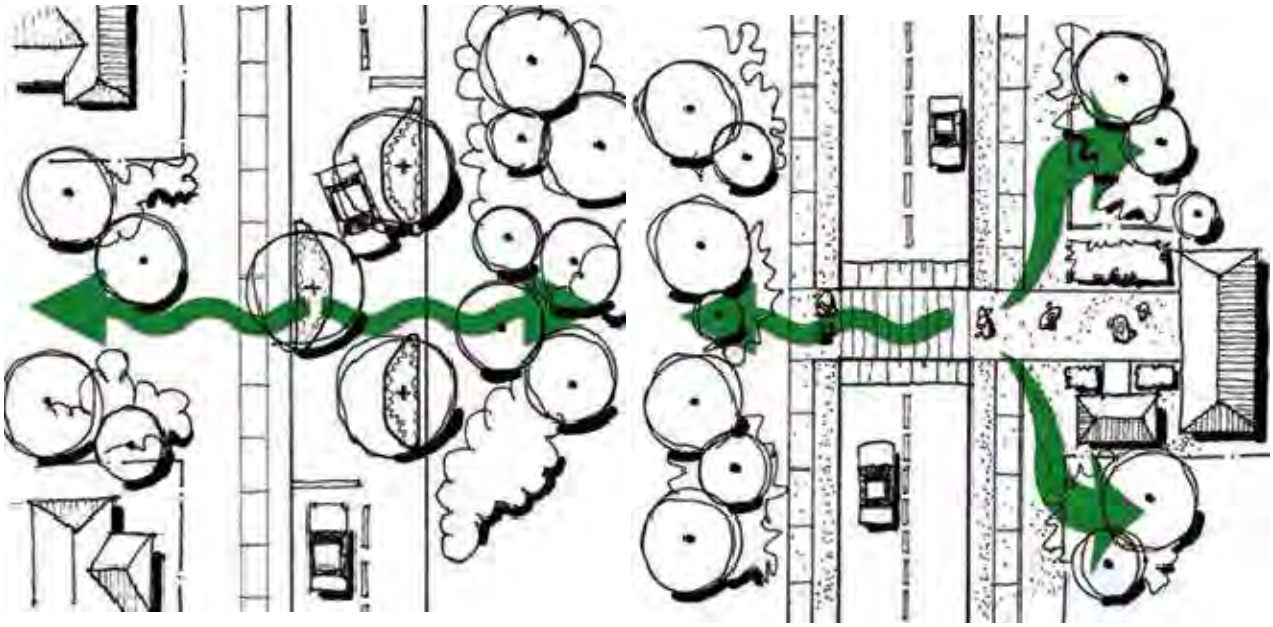


***Figure 6.10.1 Roads with bends are likely to increase safe fauna crossings due to decreased vehicular speed.***



a) b)

***Figure 6.10.2 Diagram showing increased likelihood of safe fauna passage (displayed with green arrows) using:***
***a) Chicanes***
***b) A raised pedestrian crosswalk.***


***Figure 6.10.3 Warning sign used to alert drivers to the presence of cassowaries on the road, Mission Beach, Queensland (Scott 2007).***

**a) Signage and road markings**

- Signs for kangaroos and wallabies are the same. They have a fluorescent yellow background colour to make them more visible at dawn and dusk when these animals are more active (Figure 6.10.4).
- Wildlife corridors do not warrant the installation of significant wildlife conservation areas signs but may be signed (if warranted) using wildlife warning or wildlife information signs.
- Generally, where there is a high risk of local extinction, signs alone are insufficient for mitigation purposes.


a)


b)

***Figure 6.10.4 a) Macropod warning sign, Brisbane, Queensland. b) Wildlife information sign indicating a wildlife survey area (McKirdy 2008).***

Sign placement

- In areas which are regularly inhabited by macropods (habitat and crossing points that are not seasonal locations).
- Utilise the WILDLIFE (or similar signs) if there are more than two species requiring signs in the same area.
- If animals are expected to cross in an area over 1km long, then a NEXT…km sign should be added (Queensland Department of Main Roads 2007).

*Rumble strips*

- Rumble strips have been installed in North Queensland as a tool to alert both drivers and cassowaries to changed conditions (Figure 6.10.5).

- Over time their effectiveness is reduced as regular drivers become familiar with the modified road surface.

***Figure 6.10.5 Rumble strips on the road aimed at slowing traffic in a cassowary area, Mission Beach, Queensland.***

**b) Wildlife warning reflectors**

*Target Species*

- Ungulates.

*Background*

- Originally designed to scare target species from the road corridor by sending vehicular lights into their eyes.
- Manufactured and distributed under the names Swareflex (Austria) and Streiter-Lite (USA).
- Field trials have been undertaken in Australia by Ramp and Croft, as well as the Queensland Department of Main Roads, to determine effectiveness of these reflectors on macropod species.
- Unsuccessful at reducing wallaby and kangaroo vehicle collisions (Ramp and Croft 2006; Scott 2003).
- Animals habituate to reflectors very quickly (Ramp and Croft 2006).

## *6.11 Barriers: Fencing*

Fencing stops animals crossing the road surface, and is used as an integral component aimed at guiding animals towards safe fauna crossing structures or passages.

### 6.11.1 Target species

- All species, excluding flighted birds, most invertebrates and some reptiles.

## 6.11.2 Design specifications

- Fencing design shall generally be in accordance with Chapter 8 of TMR's Road Planning and Design Manual (June 2005).
- Type of fauna fencing is dependent upon:
  - Specific purpose;
  - Specific species;
  - Maintenance considerations;
  - Cost-effectiveness;
  - Land use;
  - Topography;
  - Vegetation; and
  - Property access requirements.
- Types of fauna fencing:
  - Fauna exclusion/koala proof fencing (Main Roads Standard Drawing 1603).
    - Refer to Section 6.11.2a
  - Floppy-top fencing (New South Wales standard fauna exclusion fencing).
  - Temporary fencing
    - May be erected or other types of temporary structures put in place when environment/habitats on the roadside are being changed leading to an increase in animal movement.
    - For example, sugar cane burning may result in animal movement across roads and consequently an increase in the amount of fauna roadkill.
  - Construction barriers
    - Erected to ensure animals do not enter the roadway while under construction.
  - Frog fencing
    - Refer to Section 6.11.2b.
    - Refer to Section 9.1 Case Studies: Tugun Bypass.
  - Turtle fencing
    - Refer to Section 6.11.2c.
  - Cassowary fencing
    - Refer to Section 6.11.2d.
- General Considerations:
  - Ensure fencing is used in conjunction with fauna crossing structures.
  - Ensure regular fence breaks if fauna exclusion fencing is installed in areas that do not have crossing structures. This allows for concentrated fauna movement.
    - Necessary to prevent trapping of animals in the case of a fire.
    - Signs may be erected near fence breaks to alert drivers that fauna may be crossing.
  - Fauna exclusion fences may separate a population into less sustainable smaller populations with no provision for recolonisation.
- Extend fencing either side of a safe crossing point to act as a funnel to guide animals (Figure 6.11.1). At least 150 metres is recommended but this is dependent on environmental conditions such as topography and vegetation.

- Include a 'return' design at the end of fencing to direct animals towards the habitat. The return should extend a minimum of 10 metres. Alternatively, placing boulders at the end may encourage fauna to return to intact habitat.
- Construct in conjunction with other fauna mitigation measures and only after other fauna mitigation measures have been completed.
- Provide exit points to enable animals caught within the road corridor access to the adjacent habitat.

*Advantages:*

- Fauna are unable to cross the road, eliminating the chance of vehicle collision.
- Designs have been trialled, tested and monitored extensively, confirming their efficacy.

*Disadvantages:*

- Regular maintenance required.
- Maintenance costs.
- Without ‘returns’ success cannot be guaranteed.
- Has the potential to trap fauna in the event of fire.
- Fauna exclusion fencing alone, while reducing roadkill, may be more detrimental in negating dispersal than the road acting as a barrier.

*Maintenance Requirements:*

- Maintenance needs to occur regularly and for perpetuity.
- Failure to maintain fauna exclusion fencing may result in animals climbing over or through weaknesses in the fencing.

**a) Fauna exclusion/ koala proof fencing**

- Refer to Section 7.5: Koala.
- In koala habitat areas the fence must comply with Main Roads Standard Drawing 1603.
    - Barrier to most fauna.
    - Guide fauna towards crossing sites.
    - Sheet metal must be above wire (at the top of the fence) such that the selvedges are positioned below the top of the sheet metal strip (Figure 6.11.2).
- Exclude fauna from the road corridor but allow them to escape from the road.
    - Large tree stumps, build earthen berms or escape poles on the roadside of exclusion fencing can be utilised to allow fauna to escape the road corridor.
- Conduct surveys of routes, paths and home-ranges of fauna before installation of fencing and escape structures. Fencing should account for repetitive pathway behaviour, as many species are averse to changing paths and will try to use the same path even if it is blocked.
- Implement measures to stop animals entering the road at the end of fauna exclusion fencing resulting in fauna roadkill hotspots. For example fence ‘returns’ (Figure 6.11.1).
- Must be installed with knowledge of other fauna which may impact upon the design of fauna fencing (such as amphibians).
- Construct metal flaps at the base of fencing where the fence crosses drainage lines to ensure fauna cannot pass under the fence at these points (Figure 6.11.3).
- Plastic strips at the bottom of fauna exclusion fencing may be used to stop the movement of small to medium-sized reptiles onto the road (Figure 6.11.4).
- Habitual climbers, such as carpet snakes, will not be stopped by generic fences. Specifically designed fencing with smaller openings will be required.

- If bandicoots are within the project area fauna exclusion fencing needs to be constructed from fine galvanised wire mesh or other material with gaps no larger then 20 mm. The foot of the mesh is to be buried to a depth of at least 150 mm and rise at least 500 mm above the ground (Department of Environment and Climate Change 2002).
- Fencing for guiding koalas to fauna structures (such as underpasses) can be configured in two designs:
    - Straight design. This design does not tie into the entrance to culvert or alternative fauna structures. This is less preferred as it can create predator traps and requires more maintenance.
    - Jagged fence design. This design ties into the culvert entrance. This is the preferred design.
- Koala exclusion fencing must have a three metre buffer free of vegetation (excluding grasses) on habitat side of the fence (Figure 6.11.5).

*Advantages:*

- Metal sheets can be attached to any type of fence.
- More secure and economical than other forms of fauna exclusion fencing.
- 100% success rate at keeping koalas off roads when maintained.

*Disadvantages:*

- Requires regular maintenance to ensure no vegetation growth.

*Maintenance Requirements:*

- Must maintain a three metre buffer on the habitat side of the fence, free of vegetation (excluding grasses) (Figure 6.11.5). Buffer area must not have any vegetation that could be used to climb over the fence.
- Vegetation from the roadside should be maintained to ensure it cannot be utilised to access the road corridor (for example, remove overhanging branches, creepers, etc.).
- Maintenance/inspections should occur once a week and be ongoing.
- Maintenance vehicles only require a 1.5 metre clear zone on the habitat side of the fence for access purposes.

**Self-closing gate**

- Allows koalas to pass through the gate from the roadside, after which the gate is designed to automatically lock to prohibit re-entry to road.

*Advantages:*

- Allows safe escape from road.
- Able to be used by a variety of fauna.
- Inexpensive.
- Does not affect efficacy of fence.
- Reduces roadkill.

*Disadvantages:*

- Not all koalas are able to use gates because their weight and height is not sufficient.

**One-way fence**

*Design Requirements:*

- Enables koalas to pass from the roadside, through fauna exclusion fencing, by means of a ‘drop-down’ to the safe side of the fencing (Figure 6.11.6).
- The break in the fence is designed in conjunction with guide fencing to the return drop (Figure 6.11.6).

- The purpose of the structure being a 'drop' is to ensure fauna are unable to climb over from the habitat side of the fence, that is, a one-way fence (Figure 6.11.7).

*Advantages:*

- Simple.
- Effective.

*Disadvantages:*

- Requires continued maintenance.

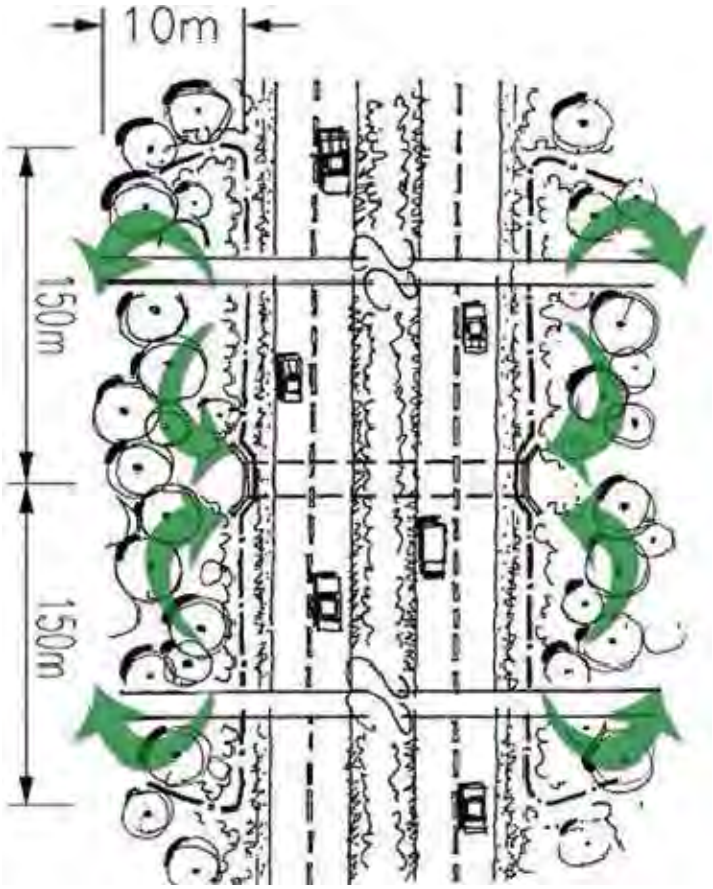



***Figure 6.11.1 Optimal design of fauna exclusion fencing on either side of a crossing structure with incorporated returns at both ends.***

*Figure 6.11.2 Incorrectly installed fauna exclusion fencing. For correct installation details refer to Main Roads Standard Drawing 1603.*

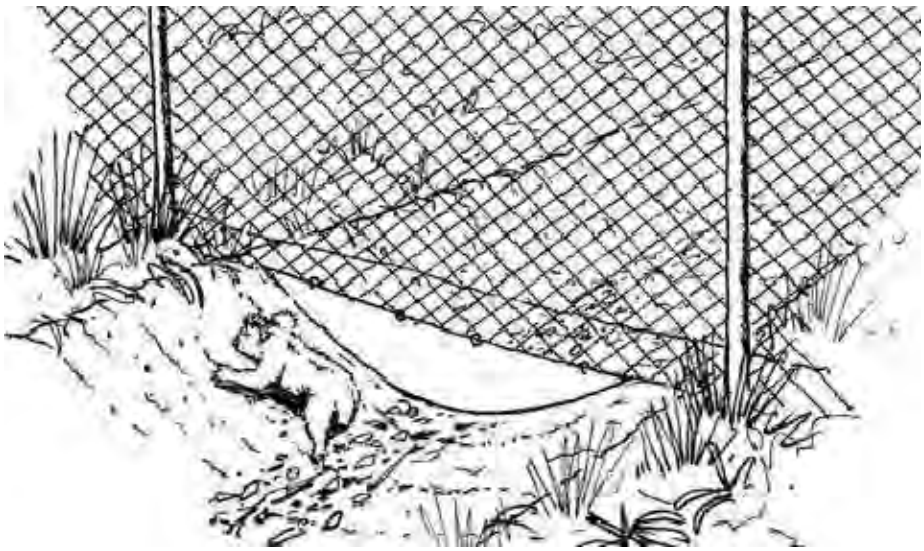


*Figure 6.11.3 Flap joined to the bottom of fauna exclusion fencing to prevent fauna penetrating road corridors at drainage line.*

*Figure 6.11.4 Plastic strips at the base of fauna exclusion fencing can be used to prevent movement of reptiles into the road corridor (Scott 2007).*

*Figure 6.11.5 Fauna exclusion fencing (floppy top) with a three metre clearance buffer on vegetative side, Bonville Upgrade (Roads and Traffic Authority) (Robinson-Wolrath 2007).*

a) b)

***Figure 6.11.6 One-way fence to allow koalas to escape from the road corridor.***
***a) Photo taken from the drop-off side of a one-way fence located at Yelgun to Chinderah section of the Pacific Motorway (NSW Roads and Traffic Authority).***
***b) The ramp leading up to the drop-off side of the fence.***

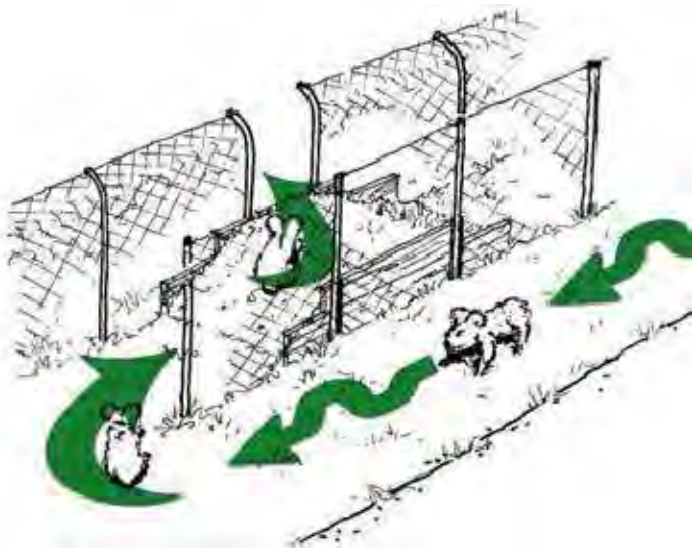


***Figure 6.11.7 Use of a one-way fence design by koalas to escape the road. If not using floppy-top fencing, attach sheet metal in accordance with Main Roads Standard Drawing 1603.***

**b) Frog fencing**

- Prevents the movement of amphibians across the road but also directs them towards culverts providing safe passage.
- Design in close consultation with amphibian experts as different species have different requirements.

**General frog fence**

- Currently being monitored for effectiveness.

- Consists of a 5 mm insertion rubber clamped to a galvanised backing plate then attached to a chain wire fence. The current design is 400 mm high with a 150 mm wide sloped roof to discourage amphibian access (Figure 6.11.8).
    - Expected minimum lifetime of 20 years.
- Can be attached to other fauna fencing or security fencing (Figure 6.11.9).
- Construct using:
    - A solid sheet of durable rubber (insertion rubber) which reaches approximately 400-500 mm high.
        - The insertion rubber is chosen for its durability, availability and the length of the rolls (50-100 m) supplied.
    - Recycled plastic planks (200 mm x 40 mm x 3 m)
    - Recycled plastic posts:
        - one at each end of the planks (75 mm x 75 mm x 1200 mm)
        - a post at mid-span (50 mm x 50 mm x 1200 mm)
    - Construct the roof (155 mm at an angle of 45 degrees from the planks) and lip (30 mm at an angle of 45 degrees from the 'roof') of pre-fabricated galvanised sheets (1.2 mm). This is attached to the top of the planks.
    - Purpose of using recycled plastic planks and posts:
        - Long term durability;
        - Do not require painting or sealing;
        - Made from recycled products;
        - Installed using manual labour; and
        - Easily repaired using hand tools.
- Set fence 60-100 mm into the ground to prevent movement under fences.
- Clear vegetation one metre on either side of the fence.
- Angling the fence toward culvert entrances has been found to be more effective than being constructed parallel to the road.

**Temporary frog fence**

- Used during construction (Figure 6.11.10):
    - Shade cloth set into the ground and attached to reo hooks.
    - Issues have arisen with durability and the cost of maintaining this form of temporary fencing.

**Untrialled barrier fence**

- Concrete drainage-like ditch alongside the fence (vegetated side). Frogs have a strong preference to avoid concrete surfaces, therefore a sufficiently wide and deep ditch may hinder movement towards the fence itself. This structure should not be used for drainage per se, and if it is, a mesh of some sort must be placed above water level to prevent frogs utilising the structure to breed after rain.

*Maintenance Requirements:*

- It is imperative that vegetation remains clear of both sides of the frog fence.
- Ensure there are no breaches to the fence.
- Maintenance checks should occur on a regular basis.

*Advantages:*

- Avoids roadkill of amphibians.

- Encourages amphibians to utilise dedicated amphibian culverts in order to maintain population connectivity.

*Disadvantages:*

- Ongoing and regular maintenance is vital for its effectiveness.
- The current temporary construction frog fence design has had durability and maintenance cost issues.

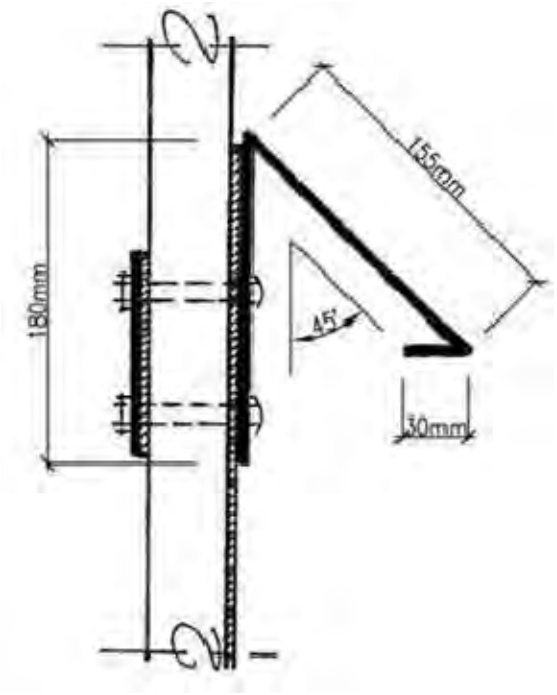
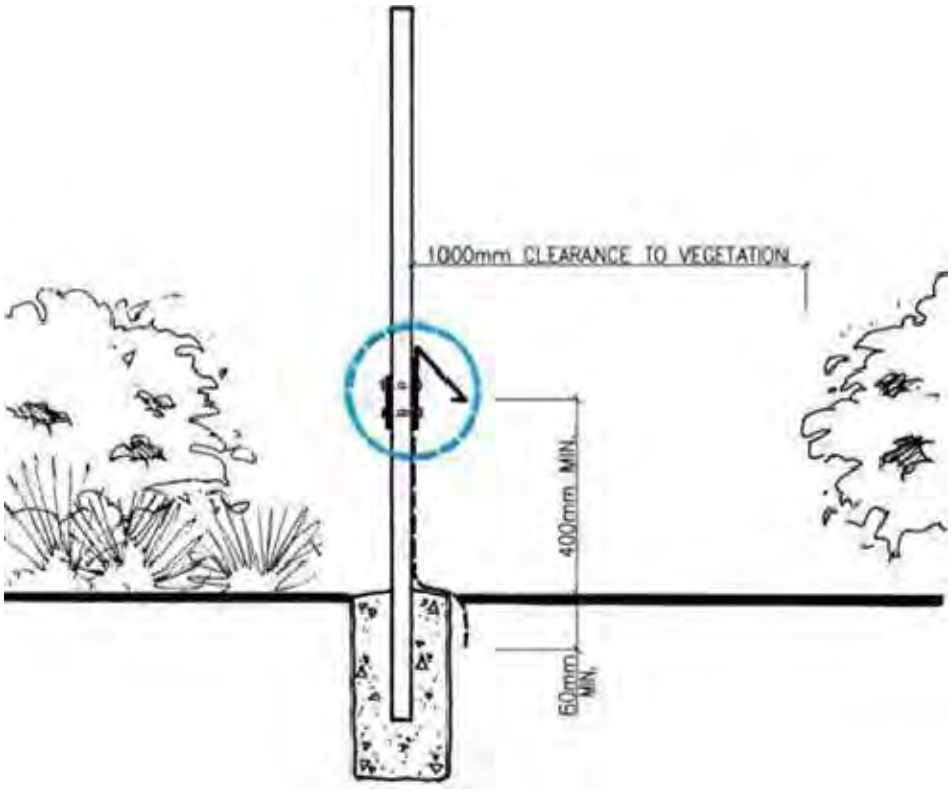
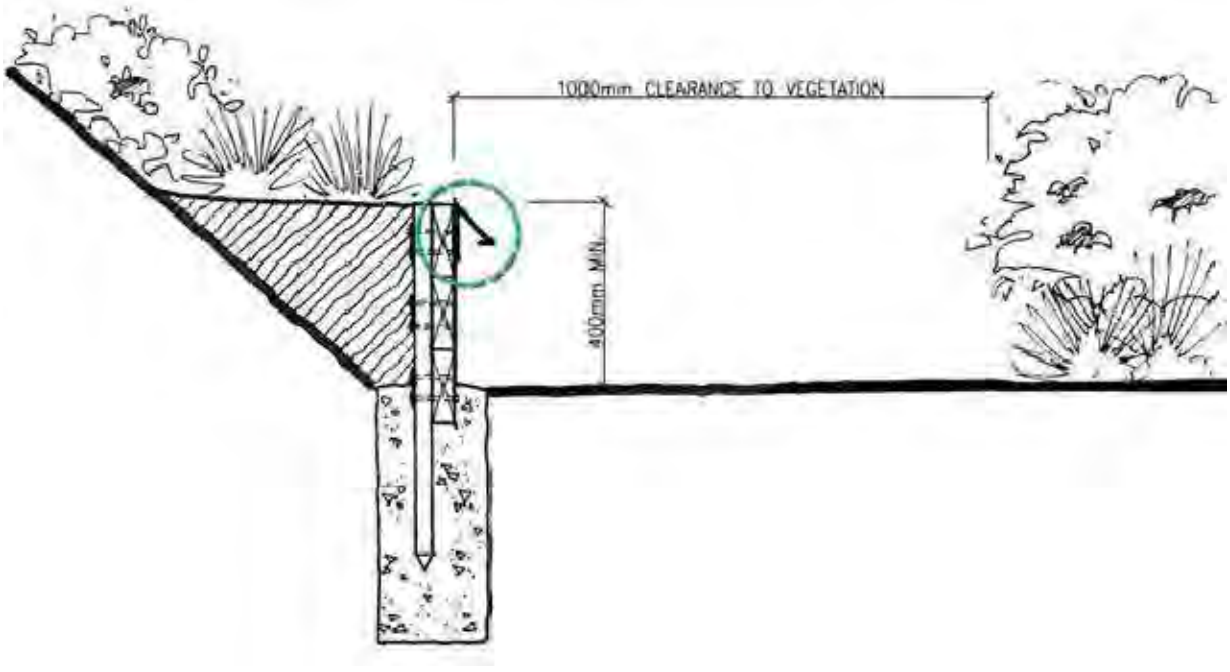



***Figure 6.11.8 Cross-section of frog fence design (adapted from 3003181-BFF-020-6003) (PacificLink Alliance 2006d).***




a)




b)

***Figure 6.11.9 a) Frog fence attached to an existing fence (adapted from 3003181-BFF-020-6003) (PacificLink Alliance 2006d).***
***b) Free-standing frog fence (adapted from 3003181-BFF-020-6003) (PacificLink Alliance 2006d).***

*Figure 6.11.10 Temporary frog fence, Tugun Bypass (Robinson-Wolrath 2007).*

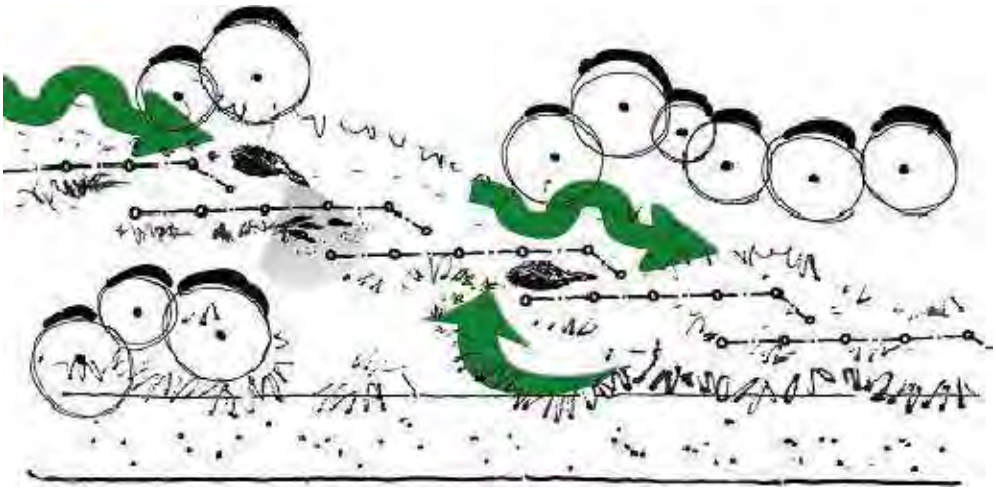
**c) Turtle fencing**

The design for turtle fencing has been sourced from overseas situations. The applicability of the design to Australian turtle species has been untrialled.

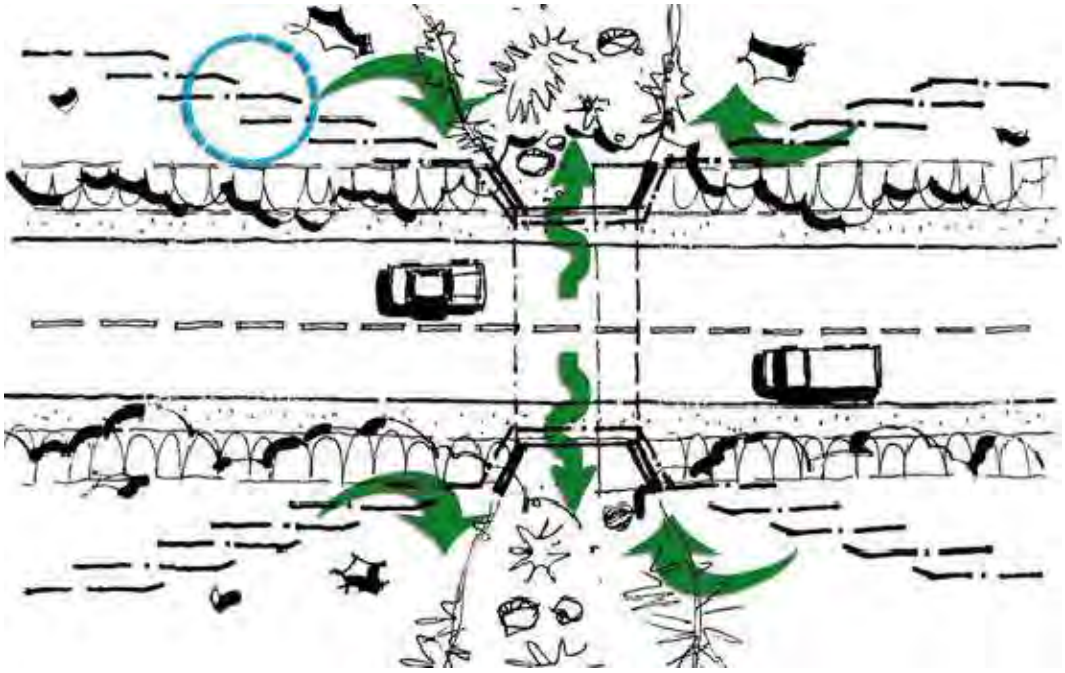
- Designed to divert turtles away from the road and through a turtle-specific culvert.
- 600 mm high woven vinyl erosion control fencing with pre-attached wooden stakes. Preferably installed at the edge of the mowed road corridor.
- The bottom edge of the fence must be buried 200 mm. The above-ground height of the fence is thus 400 mm.
- The ends of the fence should be turned back gradually towards the water at least 80-100 metres.
- Single-entrance screen funnel traps have also been used.

**d) Cassowary fencing**

- Constructed to direct cassowaries to fauna crossing points (Figure 6.11.11).
- Constructed of shade cloth to inhibit view of habitat on other side of the road (Figure 6.11.12). If habitat on other side of road is visible through fence, cassowaries will attempt to pass through fence and often end up becoming entangled.
- Space underneath the fence allows small mammals to pass through and enables easy access for slashing machinery.
- Vertical gaps in the fence allow cassowaries trapped on the road to be directed to the habitat side.
- Signage to be placed at the end of the barrier fence to alert drivers to the presence of potential cassowary crossings.
- The effectiveness of the current fence design to guide cassowaries to installed fauna crossing structures is unknown and the desire to fence large portions of the road corridor to ensure effectiveness may not be appropriate.



a) Detailed fence design



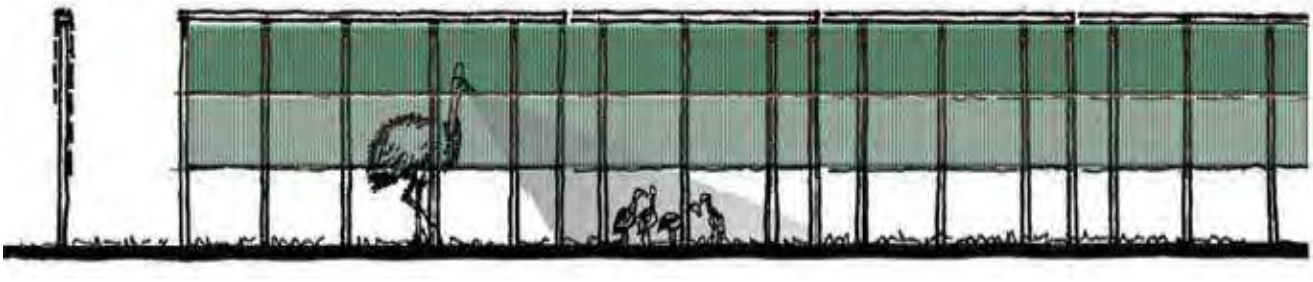
b) Overview

***Figure 6.11.11 Cassowary fencing guiding birds towards the safe fauna crossing structure.***

a) Cassowary fence position in relation to the road (on left hand side of the road).

b) Detail of fencing with shade cloth and gap at base

***Figure 6.11.12 Detail of current cassowary fence design with escape gap.***



Cross-sectional view

***Figure 6.11.13 Space underneath the fence allows small mammals to move through the broader landscape.***

## *6.12 Barriers: Chemical Repellents*

### 6.12.1 Target species

- Macropods.

### 6.12.2 Design specifications

- Species-specific effectiveness and responses are varied. For example, the pademelon responded to a scent by approaching it to investigate whilst the wallaby fled from it (Ramp *et al.* 2005).
- Temporary use may be appropriate. This will reduce the likelihood of habituation to the scent.
    - For example, could be used while maintenance crews mend gaps in fauna exclusion fencing.
- Case study:
    - Tested the response of western grey kangaroos to the urine of dingoes, which initiated a flight response, while human urine initiated no response (Parsons *et al.* 2007).

## *6.13 Barriers: Perching Deterrents*

Birds perching above roads can cause a hazard when excretion lands on passing cars. The installation of perching deterrents on road furniture, such as light poles, can reduce this risk.

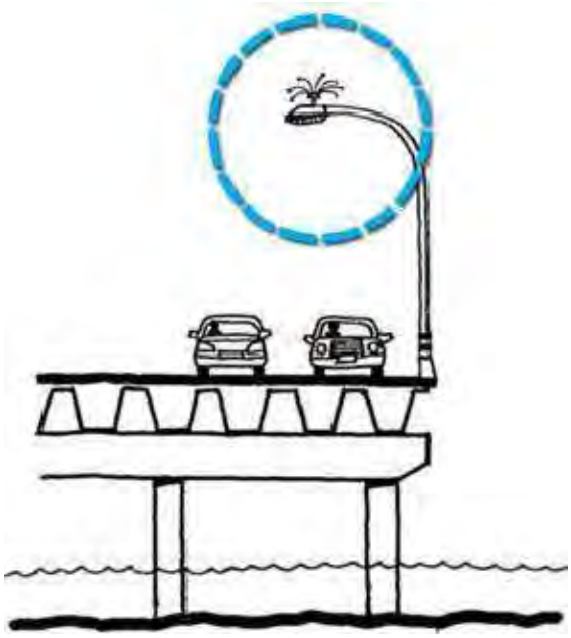
### 6.13.1 Target species

- Birds.

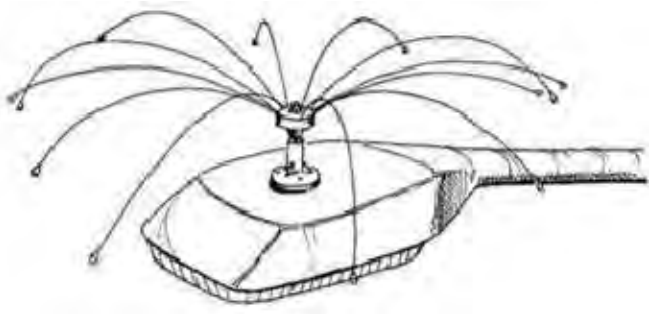
### 6.13.2 Design specifications

- 'Spider' deterrents fitted to the top side of lights (Figure 6.13.1).
- Light poles designed to deter pelican roosting opportunities (Figure 6.13.2)
- A bird deterrent wire attached to the gantry cross bar, with associated bird perches constructed to extend three metres out from the gantry (Figure 6.13.3).
- Case study:
    - Pelicans along the Houghton Highway (South-east Queensland) rest on the top of light poles causing a hazard when their droppings landed on windscreens of motor vehicles and visors of motorcycle riders.
    - Mitigation:
        - 'Spider' deterrents have been retrofitted to the top side of lights.
        - A bird deterrent wire attached to the gantry cross bar, with associated bird perches was constructed.

- ‘Safe’ perch structures are to be installed on the new bridge (Figure 6.13.3b).



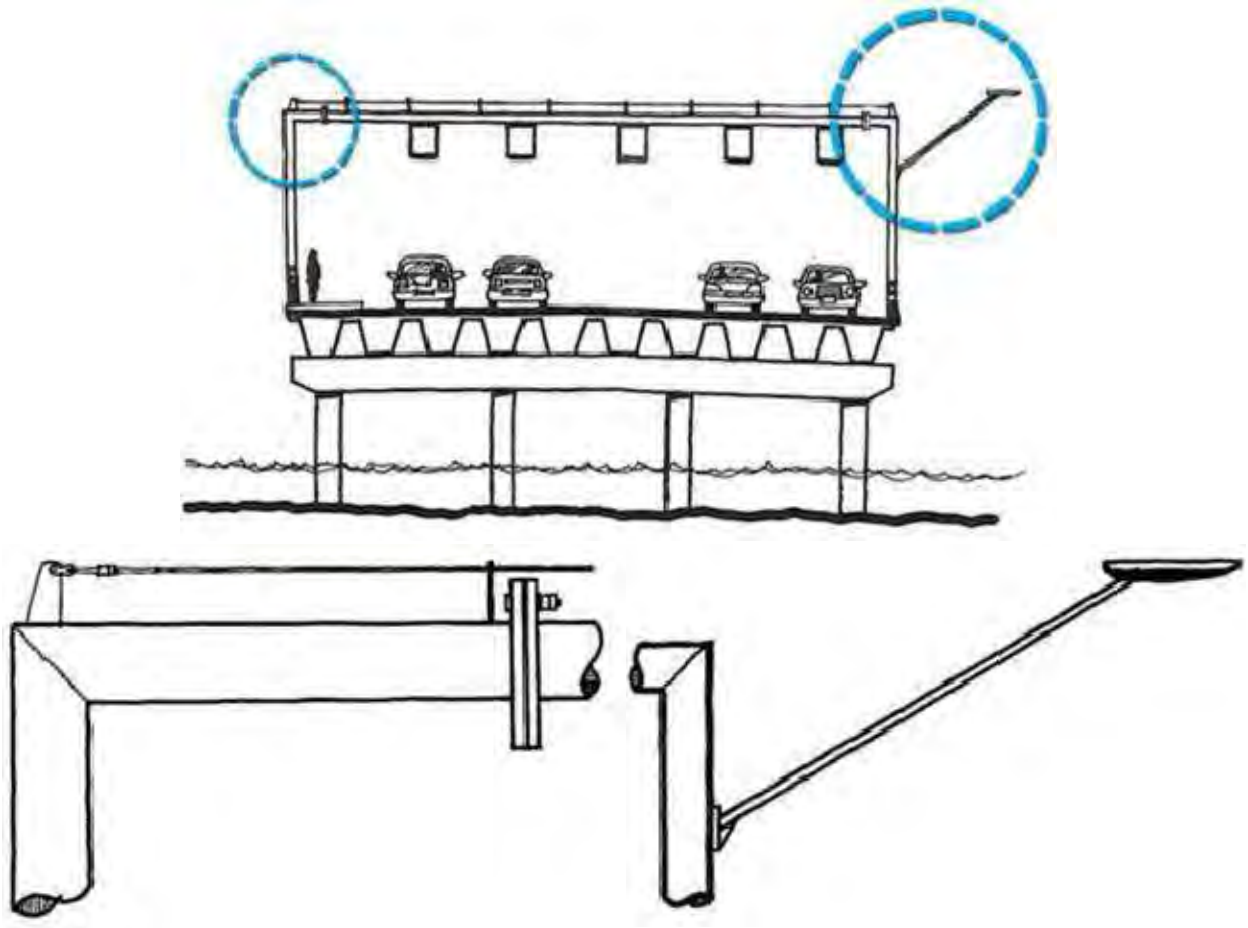
a) Location of spider deterrent on light pole



b) Detailed view of spider deterrent

***Figure 6.13.1 Spider deterrent on top of light poles reduces potential hazards from perching.***

*Figure 6.13.2 Light pole designed to deter roosting opportunities*



a) Detailed drawing of deterrent wire b) Detailed drawing of perch structure

*Figure 6.13.3 a) Bird deterrent wire on the top of a gantry to stop bird perching.*
*b) A perch structure installed to provide a safe, hazard free place for perching.*

## *6.14 Habitat enhancement: Frog Ponds*

Frog ponds are small constructed ponds and pools aimed at recreating breeding opportunities for target species.

### 6.14.1 Target species

- Amphibian species.

### 6.14.2 Design specifications

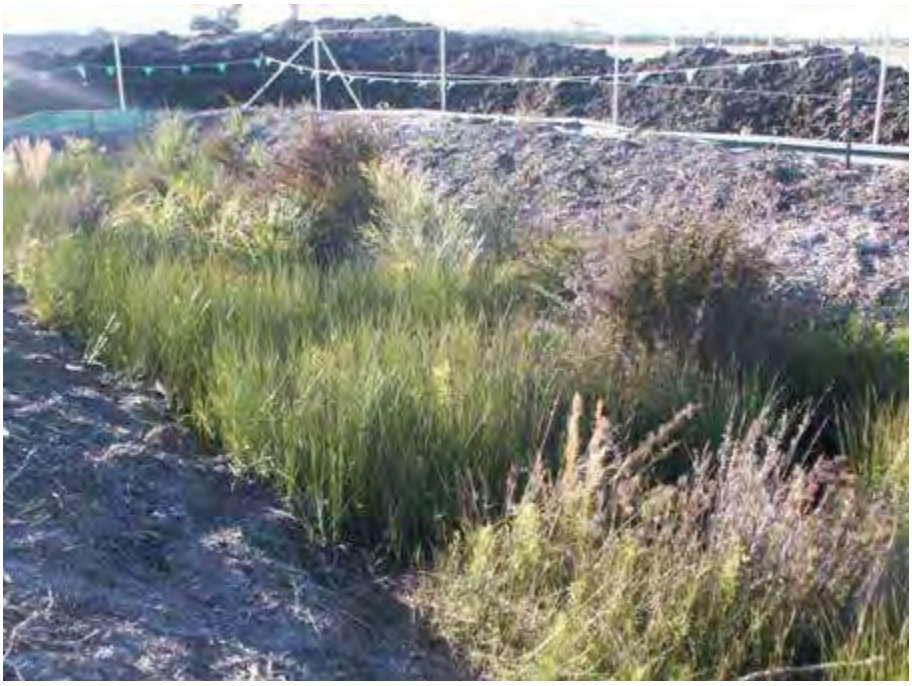


***Figure 6.14.1 Frog pond, Tugun Bypass (Robinson-Wolrath 2007).***

*Site selection:*

- Consult with local amphibian experts.
- Locate in areas where conditions replicate the species' known requirements. For example, pH, salinity, absence of known predators.
- Site constraints will often dictate the placement and form/shape of the ponds. For example, the approximate design criteria for the wallum sedge frog as part of the Tugun Bypass project (Pacific Link Alliance 2006) was:
    - Minimum of 1.5 metres deep with a gradient sloping to 0.3 metres at pond edges.
    - Approximately 15-20 metres long and 5-10 metres wide.

*Timing:*

- Construction of ponds must be conducted during a dry period (for example, spring) leading up to a pronounced rainfall event (normally in summer) to enable machinery access to the site with minimal damage and to enhance the likelihood of transplanted vegetation survival.

*Site preparation:*

- Appropriate preparation of frog ponds is critical to their success.
- The physical and hydrological conditions must match the requirements of the target species.
- Consider:
    - Physical conditions (site topography);

- Soil characteristics, as they play a fundamental role in determining the vegetation community and therefore, habitat potential;
- Hydrology; and
- Outlet control enabling water level control.

*Design requirements:*

Design in close consultation with amphibian experts.

Specific to the target species.

In some cases, steep sides (as close to vertical as possible) are required to ensure cane toads do not utilise the structure.

Ensure pond is appropriately vegetated.

## *6.15 Habitat enhancement: Nest Boxes*

### 6.15.1 Target species

- Arboreal species.
- Bats.

### 6.15.2 Design specifications

**a) Arboreal species**

*Background*

- If the tree with roosting/nesting opportunities requires removal it is important to consider replacing this lost resource with a nest box (see Figure 6.15.1) or similar structure in a nearby suitable tree. A ratio of at least 1:1 is recommended.
- When a hollow tree is removed note the species that potentially utilised the hollow to ensure replacement nest boxes are species-specific and appropriate.
- Different species utilise different hollow sizes and thus require different styles of nest boxes.

***Figure 6.15.1 Glider nest box installed in South-east Queensland (Scott 2007).***

*Design requirements:*

- Height of nest box will determine its use:
  - Install between three and eight metres above the ground. This is dependent on target species and environment.
  - Species-specific information:
    - Eastern pygmy possums are the only species to prefer nest boxes lower than two metres.
- Orientation and general placement of next boxes must take into account:
  - Rainfall.
  - Sunlight (must provide shade during summer).
  - Probability of human disturbance (avoid installing along walking tracks).
  - Natural nesting habits. Undertake baseline surveys prior to the removal of hollows to determine nest box spacing and orientation.
- Each species requires:
  - A different style of nest box. Collect information from natural hollows before replacements are constructed.
  - Due to competition between exotic birds and native species for nest boxes, construct with entrances that are either covered with a baffle, rear-entry entrances, or have a slit-entrance on base (determined by target native species).
- Density of nest boxes:
  - Species have different nest densities and spacings.
  - Separate individual nest boxes by approximately two to four metres.
  - Clusters of nest boxes to be separated by approximately 20 metres.

- Materials:
  - Nest box wall thickness should, ideally, be a minimum of 30 mm, to provide the greatest resistance to external temperature variation.
  - Plywood: 18-25 mm thick and can be sourced from environmentally-friendly companies.
  - Hardwood: Approximately 30 mm thick and can be sourced from waste products from timber production.
  - Non-toxic organic timber sealer should be used.
  - Metal edging on lid is required to prevent damage by chewing.
  - Internal material does not have to be provided in most nest boxes unless specifically designed for bats.
    - Bats require internal plastic mesh or shade cloth to allow them to cling to or climb within the nest box.
- Dimensions and entrance locations:
  - Internal widths of 80-160 mm and 160-240 mm are most commonly used.
  - Do not use nest boxes with less than 200 mm between the entrance and nest box floor, unless target species requires an entrance in the floor.
  - Entrances can be a hole located:
    - at the front near the top;
    - as a hole on the side near the top; or
    - as a slit on base or hole on back, towards the tree.
- Tree attachment:
  - Preferable to use a strap allowing tree growth, that does not damage the tree.
  - Attached by either wiring directly to the trunk or using wire hooks put through a loop placed around the trunk (easier to remove).
  - The use of metal is not recommended as it can corrode quickly and will cause damage to trees.
- Species-specific details:
  - Feathertail gliders, sugar gliders and phascogales are the most common fauna found in nest boxes (Beyer and Goldingay 2006; Goldingay *et al.* 2007).
  - Brushtail and ringtail possums use nest boxes with an internal volume of 46 900 $cm^3$.
  - Feathertail gliders:
    - Generally prefer small rear-entry boxes, large slit-entrance boxes and wedge-shaped bat boxes, all with 25 mm or smaller entrance diameters.
    - Comparisons between the different designs of nest boxes with small entrances (wedge and non-wedge) have revealed no strong preference.
    - Avoid medium sized rear-entry boxes with 45 mm diameter entrances.
    - Require an internal volume of 3 900 $cm^3$.
  - Sugar gliders:
    - Use nest boxes with small but high entrances (Ball and Goldingay 2007).
  - Greater gliders:
    - Prefer tree canopies so are unlikely to be attracted to nest boxes.
  - Squirrel gliders:
    - Rear entry: 150 x 250 x 350 mm.

- Medium sized rear-entry boxes with 45 mm diameter entrances are also utilised.

- General Design Considerations:
  - An ecologist should be onsite during clearing to ensure that hollows and replacements are removed and reinstated with minimal impact and disturbance.
  - Nest box use is dependent on seasons (except for feathertail gliders) and presence of competitors (Beyer and Goldingay 2006).

*Maintenance Requirements:*

- Maintain furniture within nest box.
- Remove pests/competitors from nest box.
  - At a minimum, should occur after fires and storms. Frequency of maintenance is otherwise unknown.
- Utilise monitoring information to determine whether location, orientation or any other factors need to be altered.

**b) Bats**

- Some road crossing structures have been retrofitted with various geometric designs of timber bat roosts. These have usually been installed beneath bridge decks or culvert ceilings.
  - These roosts only provide refuge for bat species that are found in association with water and forage of water.
- The central ceiling areas of long sheltered culverts or the soffit of concrete bridge decks between composite girders is the best location to encourage small bat roosting.
- To reduce human disturbance (if likely) install blackout screens and 'no-go' zones (Figure 6.15.2).
- Case study: Bat roosts have been installed under bridges in New South Wales. However, in some cases, despite careful planning and expert advice they remain unused (Figure 6.15.3).
- Bat droppings are a health hazard. Where provisions are made for bat roosting, such roosts must be well clear of areas requiring maintenance access or human movement.

*Advantages:*

- Provides a form of mitigation for bats when their natural roosting sites are disturbed.

*Disadvantages:*

- Requires expert advice to ensure appropriate location for roosts.
- Needs careful consideration about location to ensure health hazards associated with bat droppings are avoided.

*Figure 6.15.2 Blackening screens used to stop any disturbance of areas designated for bat roosting, Brunswick Heads, northern New South Wales.*

*Figure 6.15.3 Timber bat roost under a bridge at Brunswick Heads, northern New South Wales*

## 6.16 Habitat enhancement: Artificial Shelter Sites

### 6.16.1 Target species

- Reptiles
- Invertebrates

### 6.16.2 Design specifications

In selected prioritised locations the use of artificial shelter sites may be used to benefit reptiles.

- Cropped/slashed grass in piles can be used as artificial habitat for reptiles.
- Placement of non-combustible, durable cover, such as roofing tiles or sheet metal, along selected road corridors may be useful. Informal studies have shown these can provide suitable shelter for reptile species. Imperfect 'rejects' of these ‘cover’ materials can be obtained for minimal cost from manufacturers and demolition sites.

- The placement of artificial shelter sites should not impact on the overall health of the remnant vegetation, thus recommended for existing weedy sites.

**a) Pavers and roof tiles**

- Used as a technique to restore lost or degraded habitat.
- Dimensions:
    - Large pavers (300-450 mm wide and 50-100 mm thick) with a variety of crevice sizes (up to 10 mm) may be used to maximise the diversity of retreat sizes for snakes and lizards (Webb and Shine 2000) and also create habitat for both juveniles and adults.
    - Invertebrates prefer small crevices.
    - For reptiles, pavers should not be thinner than 5 mm as they become too hot over the summer months.
    - 5 mm thick pavers may be attractive to various species of invertebrates.
- Many invertebrate species prefer habitat created by pavers exposed to sunlight over those located in the shade.

*Advantages:*

- Inexpensive.
- Long lasting.
- Unlikely to be attractive to rock thieves.

*Disadvantages:*

- Long term effectiveness remains unknown.

## *6.17 Considerations which influence effectiveness of fauna structures*

The effectiveness of fauna mitigation structures varies between locations and is likely to be species- or species-group specific. Nevertheless, there are certain aspects of their design that can strongly influence their effectiveness and should be considered.

### 6.17.1 Aspects that positively influence rates of fauna structure use

- Funnelling of fauna (often with the assistance of fencing) through a narrow habitat corridor to a fauna mitigation structure.
- Planted vegetative corridors should mimic the original habitat.
- Abundant and high-quality habitat near to entrance of the structures.
- Dirt or natural substrate floors.
- Large openness ratios (length x width x height of underpass).
- Absence or low rate of use by humans.
- Presence of furniture, such as logs, rocks and vegetation on or in the structure.
- Several structures placed within home-ranges will result in fauna utilising new structures much more quickly.

**a) Vegetation management in vicinity of structures**

- Abundant and high-quality habitat near to entrance of the structures.
- Careful plant selection (in consultation with experts) to provide habitat opportunities for fauna.
- Appropriate maintenance intervention levels will ensure objectives of vegetation planting are preserved.

- Retention of the existing vegetation in the median or provision of a careful revegetation scheme in the median may assist in mitigating habitat fragmentation.

**b) Density of fauna mitigation structures**

- Dependent upon the target species and the distribution of the habitat types in the area.
- In some cases, one or more wide fauna passages will be appropriate, whereas other passage issues may be better resolved with a larger number of smaller-scale measures.
- The behaviour of target species can be used as a guiding factor.
- Higher density of passages should be provided in natural areas, for example, forests and wetlands, than in densely built-up or intensively-used agricultural areas.
    - However, in areas where there are many artificial barriers due to transport infrastructure or built-up areas, fauna passages can be essential in maintaining the general permeability of the landscape. In such cases, solutions can be integrated with all remaining open corridors.
- The density of passages in relation to the environmental goals has been poorly studied and requires additional research.

**c) Location of fauna mitigation structures**

- Decisions regarding the location of fauna mitigation structures need to be made on the basis of sound knowledge regarding fauna movements and the distribution of important habitats.
- Where clearly defined animal trails exist locate proposed fauna mitigation structures as close to them as possible.
- Topography and landscape structure are often used to identify likely migration and movement routes, for example, continuous forest, valley bottoms and streams.
- Planning is crucial. Ensure all fauna passages consider the surrounding landscape. For example, access to the passage must be guaranteed in the future.

**d) Integration into the surroundings**

- Fauna passages should be well-connected to the surroundings:
- By habitat corridors leading towards passages for small animals.
- Barriers that prevent or hinder animals from reaching fauna passages must be removed.
- Where other infrastructure elements are located nearby, an integrated approach to defragmentation is required.

**e) Table drain management**

- A number of methods can be employed to mitigate the negative impacts table drains may have on fauna passage, including:
    - Line ditches with concrete to prevent water pooling;
    - Line ditches with boulders to prevent animals entering;
    - Spray roadside with biodegradable herbicide;
    - Slash vegetation; or
    - Concrete roadsides.
- Of the above mitigation procedures, spraying, slashing and concreting roadsides are least feasible due to cost and requirement for ongoing maintenance. In particular, slashing vegetation should be avoided as regrowth is attractive to fauna.

### 6.17.2 Aspects that negatively influence the rates of fauna structure use

**a) Table drain management**

- Road run-off into roadside ditches can lead to water accumulation and vegetation that may attract fauna away from fauna structures and result in roadkill.

**b) Vegetation management**

- Careful plant selection (in consultation with experts) will either provide or reduce habitat opportunities for fauna.
- Plant selection to be based on the purpose of the planting (for example, preventing birds foraging adjacent to roads or provision of habitat).
- Careful and ongoing maintenance of vegetation is required. Appropriate maintenance intervention levels will ensure objectives of vegetation planting are preserved.
- Regrowth of roadside vegetation (for example, after fire burn-offs in the road reserve new grass shoots may attract macropods to graze) can lead to an increase in macropod roadkills at these sites.
- Plant selection:
    - Flowering plants within close proximity to the road pavement should be trimmed prior to flowering to reduce the presence of foraging birds and possible interactions with vehicles.
    - Sterile grass species can be chosen to avoid the seeds attracting fauna to the roadside.

## *6.18 Other methods that influence the effectiveness of fauna structures*

### 6.18.1 Education

- Education is of critical importance and must be available to and encouraged for all on-site staff, construction staff, office staff and the community.
    - On-site and construction staff:
        - Ensure staff take due care when removing vegetation and translocating fauna.
        - All on-site staff need to be trained to know what measures to take when rescuing fauna (Refer to Section 9.1: Case Studies: Tugun Bypass).
        - Toolbox talks and 'strip maps' can be used by staff to raise awareness of areas containing important/high populations of fauna or fauna mitigation structures.
    - Community:
        - Appreciation of the community's local fauna is encouraged. This will ensure revegetation, maintenance and other activities can be undertaken with economic and social benefits. Create a 'proud' community.

### 6.18.2 Lighting

- Purpose:
    - The impact of artificial lighting created by roads is relatively unknown and only occasionally considered in impact studies.
    - Artificial lighting (vehicle and street lights) has numerous negative impacts which have only started to be quantified.
- Fauna groups affected:
    - Nocturnal animals.
    - Diurnal species - sleep patterns disturbed by flashes of light.

- Frogs
  - Become immobilised by headlights and vehicular noise, resulting in roadkill.
  - Can be affected by temporary and permanent changes to lighting in terms of reproduction, foraging, predator avoidance and social interactions.
  - May be blinded by artificial light.
  - Species-specific information:
    - Grey tree frog's ability to hunt and eat was significantly impacted when light illumination was above that of bright moonlight.
    - Several frogs of the Hyla genus are more active between 0.00001-0.001lux, a range well below that on roads. Some only conduct particular calls, such as for breeding and mating, between this range.
- Birds
  - Particularly when migrating, may be attracted to bright lights and become trapped within the circle of light (similar to insects and turtles).
  - Singing and reproductive behaviour of some may be affected.
  - May attempt, unsuccessfully, to nest on streetlights.
- Insects
  - Attract a variety of insects and, in turn, their predators (for example, quolls), resulting in roadkill.
  - May affect signal effectiveness for fireflies.
- Marine turtles
  - Attracted to street lighting when emerging from nests leading to roadkill (Ecological Associates 2002).
- Macropods
  - Pademelons are transfixed by car head lights and suffer from temporary blindness, making them easy targets for predators and increasing chance of vehicle collision.
  - Red-legged pademelons are likely to be attracted to lit areas as they preferentially graze on forest edges.
  - Tammar wallabies are attracted to lit areas.
  - Brush-tailed rock-wallabies are particularly sensitive to light. They have been found to become 'unsettled' on moonlit nights when compared to moonless nights.
- Bats
  - Feeding behaviour may be altered, and result in an increased chance of predation and alteration to their community structure.

**a) Vehicle lights**

- Head- and tail-lights can be visible up to 90 metres into the forest and further in open areas.
- Cause anxiety for fauna and alienate habitat areas.
- Cause roadkill related to stunning and disorientation effects.
  - The mouse opossum (Marmosa mitis) is temporarily blinded by light over 20 lux (car high beam headlights are 20 lux at a ten metre distance) (Wilson and Goosem 2007).
- The general pattern of traffic at night mimics the movement times of nocturnal fauna, that is, heavier movement in the early evening and closer to dawn, which may result in increased rates of roadkill.

*Mitigation designs:*

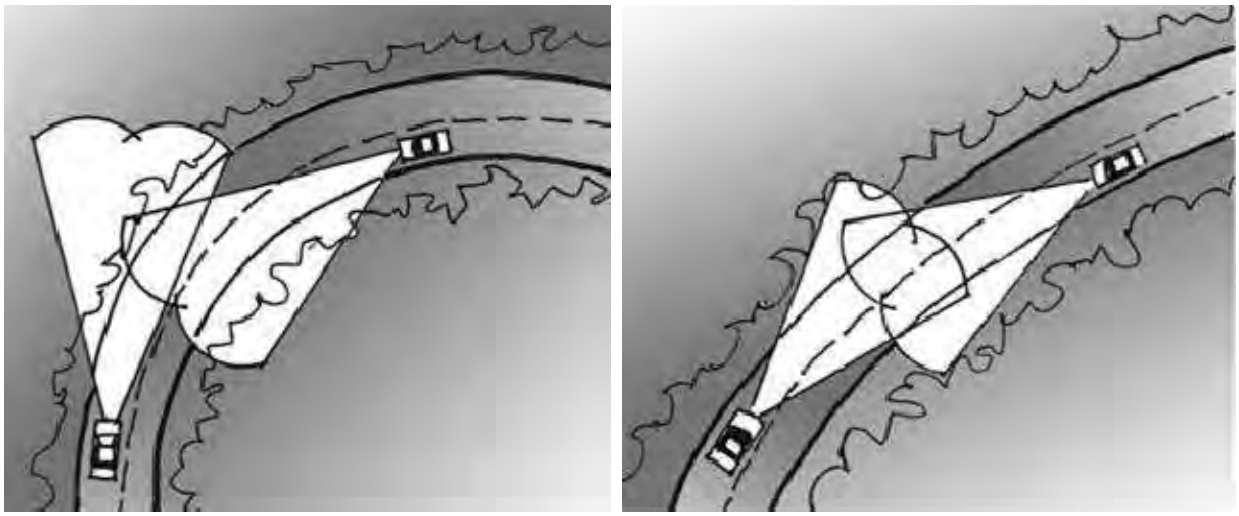
- Light barriers:
    - Solid barriers at the base of fences may reduce blindness or stunning caused by headlights (Figure 6.18.1b).
    - Designed to block light from highset head-lights.
    - Consider in sensitive areas (such as wetlands or other breeding grounds).
        - Specifically, on sections of roads bisecting creeks, gullies and other areas purpose-built for fauna connectivity under or above the road (such as underpasses, fauna-friendly culverts, land bridges).
    - Height:
        - At least 1400 mm, depending on topography (may be able to block light from highset headlights).
        - Barriers of the greatest feasible height (likely to be 1600 mm) should be used on down slope sections of road where headlights may sweep over a greater distance.
- Construction of earth berms may be an alternative where general fauna passage needs to be maintained (Figure 6.18.2).
- Smooth bends on roads to decrease light penetration (Figure 6.18.3). However, this may increase the speed environment leading to fauna roadkill.
- Provision of facilities encouraging the use of low beam headlights (for example, fluorescent road marking, reflectors set at short intervals).
- Lower speed limits encourage the use of low beam headlights.
- Create a vegetative barrier of non-palatable species along the roadside (for macropods, refer to Section 7.8 for additional information on palatable species). This requires careful planting and maintenance.

a)

b)

***Figure 6.18.1 a) Retention of dense vegetation along the roadside can decrease the effect of vehicle lights on the surrounding environment. b) Vehicle headlights disturbance can also be minimised by attaching solid barriers to the base of existing fencing along the road.***

***Figure 6.18.2 The use of dense vegetation and earth berms can reduce vehicle light penetration into the surrounding environment.***



a) b)

***Figure 6.18.3 Sketches showing the effect of headlights caused by bends in roads. a) Less optimal sharp bends cause greater light penetration into the surrounding environment. b) The optional smoother bend, with less illumination of the surrounding environment. Keep speed limits to a minimum to maintain effectiveness.***

**b) Street lighting**

- Traditional lighting can potentially affect fauna's energy budgets through increased stress and changed movement (Figure 6.18.4a).
    - Attracting fauna and possibly even trapping them in an illuminated area; and/or
    - Fauna may actively avoid illuminated areas.
- Ineffective measure for reducing roadkill.
- Reduces habitat quality by illuminating surrounding areas.
- Gliders may avoid crossing in areas which are well-lit but more study is required.
- Lighting adjacent to nesting beaches for marine turtles requires mitigation, as emerging nestlings and breeding females are attracted to lights.

*Mitigation:*

- Reduce intensity of bulbs and pressure of lamps in streetlights.
- Use low pressure sodium lamps.
- Use fewer streetlights and only where necessary for safety.
- Install shields on streetlights to minimise light spill into neighbouring vegetation and to impede birds establishing nests (Figure 6.18.4b).
- Reduce glare from lighting by using a flat glass aeroscreen instead of a refractor glass cover in streetlights (Wilson and Goosem 2007).
- Use barriers, mounds or dense vegetation to stop light infiltration into surrounding habitat. However, ensure habitat connectivity is maintained (Figure 6.18.4c).
- Decrease height of light poles.
- Use alternatives to lighting such as pavement with light-emitting diodes or fluorescent paint.
    - Increasing the reflectivity of signs and road stripping (retro-reflectivity) can increase visibility for drivers.
- Use lighting that turns on when a car approaches or is at a low illumination level until required (Wilson and Goosem 2007).
- Vegetative Barriers:
    - Vegetation can be used to decrease light penetration from street lighting (Figure 6.18.5).
    - In order to perform as a barrier, a vegetative belt must have sufficient height, length and mass. The mass of the vegetation is based upon its maturity and the type of vegetation.
    - The type of vegetation must be evergreen with dense, leafy growth to limit optical penetrability.
    - Recommendations for planting:
        - Individual plants should be spaced to have sufficient room to develop into mature shrubs.
        - At least two to three rows of dense plantings of tall trees and/or dense shrubs increases effectiveness.
        - Row spacing should be maintained to ensure they do not grow together.

a) b) c)

***Figure 6.18.4 Effect of traffic light poles on the surrounding environment***
***a) Traditional lighting methods may penetrate surrounding areas and affect normal fauna behaviour. This effect can be minimised by:***
***b) Installing shields on lights;***
***c) Retaining and/or creating barriers along roadsides***

***Figure 6.18.5 The use of dense vegetation and earthen berms can reduce vehicle light penetration into the surrounding environment.***

## 6.18.3 Noise

- Most noise from highways is produced by engines and tyres as they contact the surface, with noise varying by tyre and surface qualities.
- Noise from vehicular traffic can be of a level to distort territorial bird song, resulting in difficulties in attracting and keeping females (Reijnen and Foppen 1994).
- Increased predation may occur due to the inability of birds to hear predators (Scherzinger 1979).
- Breeding birds appear to be heavily affected by traffic noise (Forman *et al.* 2003).
- Lower bird density has been correlated to traffic noise.
- Typical noise barrier structures may have negative effects on birds.

*Mitigation:*

**a) Elevation of the road surface, and cuts and fills.**

- As most of the noise derives from the road surface a change in the elevation and/or the type of road surface may reduce noise. Cuts and fills can be used to advantage.

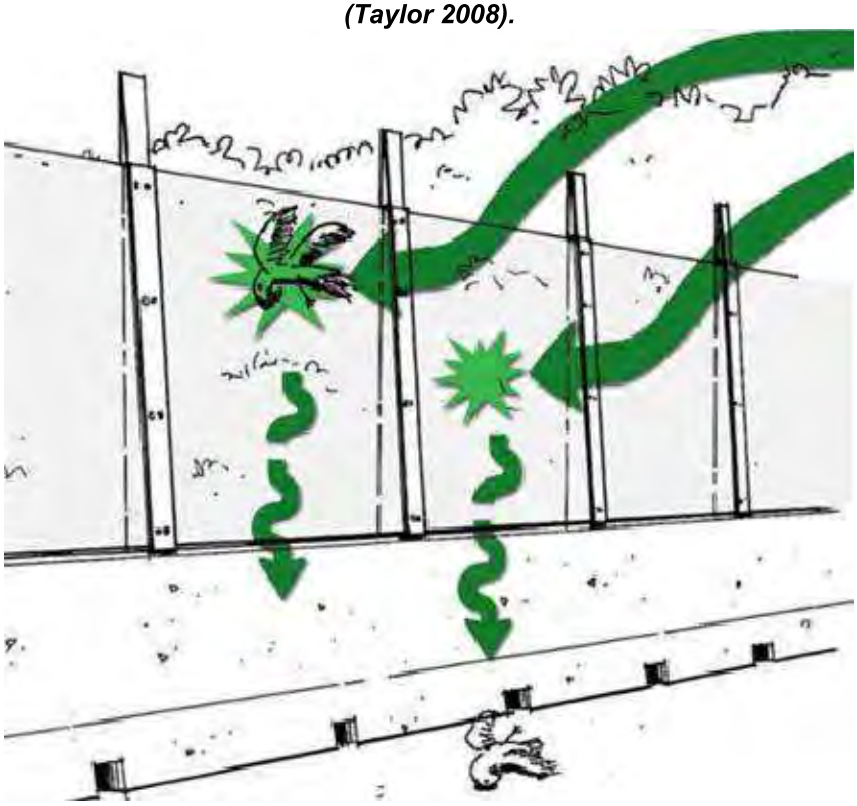
**b) Solid barriers**

- Noise wall barriers are commonly constructed in urban situations along highways and high traffic volume roads using materials such as timber, concrete and steel panels, concrete block and toughened glass (Figures 6.18.6 to 6.18.8).

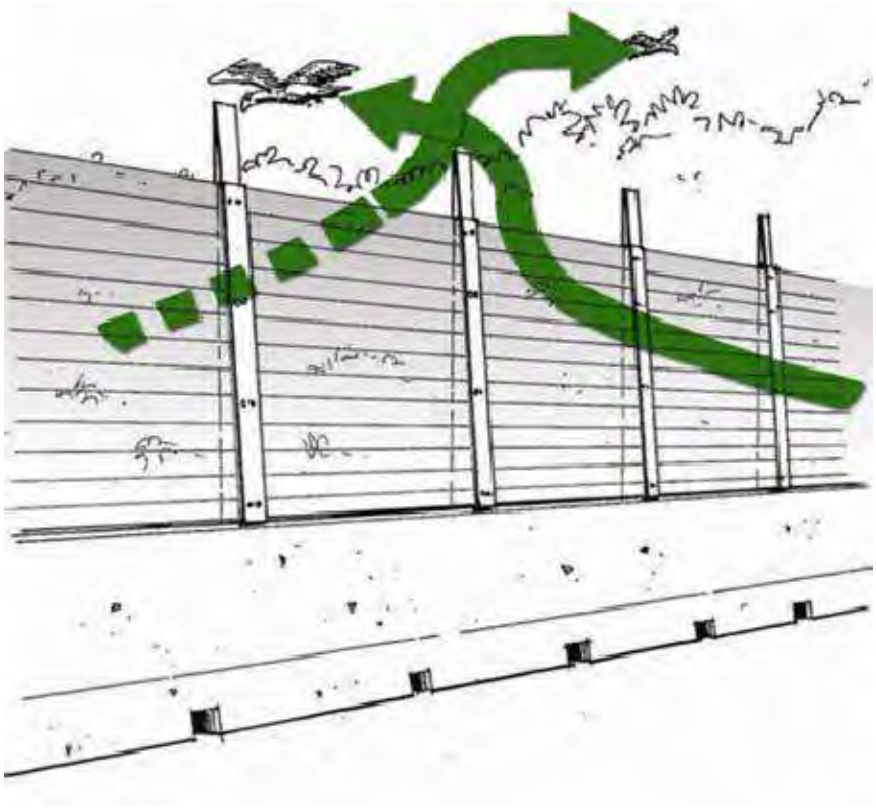
- While this effectively reduces noise in lower vegetation layers, it also eliminates permeability for many terrestrial fauna groups, reduces light penetration at low levels and is expensive.
- TMR guidelines provide information on planting in conjunction with solid noise walls:
    - Re-planted vegetation: a minimum of three-quarters the height of the barrier; vegetation should be stratified (i.e. start with groundcover, shrubs, small trees and then larger trees against the barrier) and extend from the barrier at least 1.5 times the height of the barrier (Queensland Department of Main Roads 2004).
- Considerations of transparent noise wall barrier (Figure 6.18.8).
    - Birds have trouble seeing transparent noise walls and this can result in bird strikes.
    - Constructed from acrylic or glass.
    - Install glass that is treated with a UV reflective coating. Glass coated in UV- reflective coating is clearly visible to birds and virtually transparent to humans (Ambrose 2008).
    - Embed mesh in acrylic transparent noise walls.
        - This treatment stops bird strike and does not disturb the driver's view.
        - Lines should be 50 mm apart if oriented horizontally, and 100 mm if oriented vertically.
    - Horizontal line etchings, five centimetres apart on clear noise wall barriers is the optimal treatment to avoid bird strikes and minimise disturbance to drivers (Figure 6.18.8b).
    - Other markings on noise walls have also been used (Figure 6.18.7).

***Figure 6.18.6 Solid noise wall barrier (Taylor 2008).***

***Figure 6.18.7 Transparent noise wall with etchings to reduce bird strike along the Tugun Bypass (Taylor 2008).***



a) Transparent noise wall design without consideration of potential bird strike.

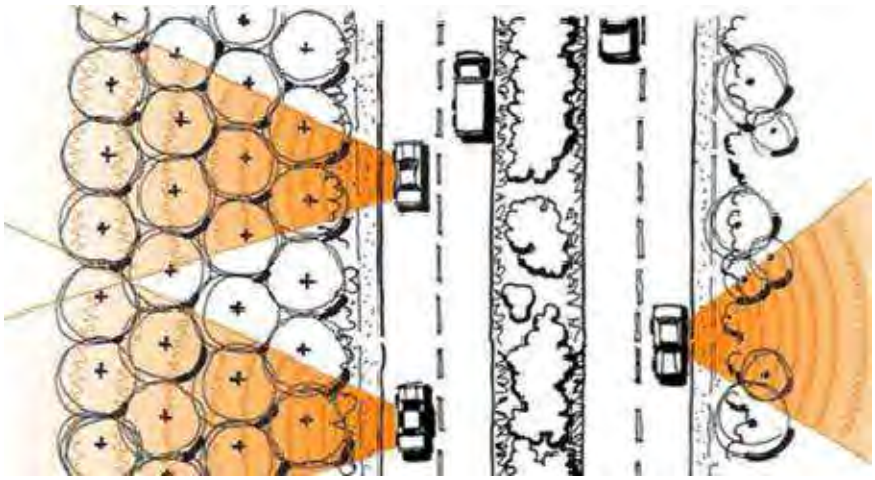


b) Transparent noise wall design with horizontal etchings incorporated to minimise bird strike.

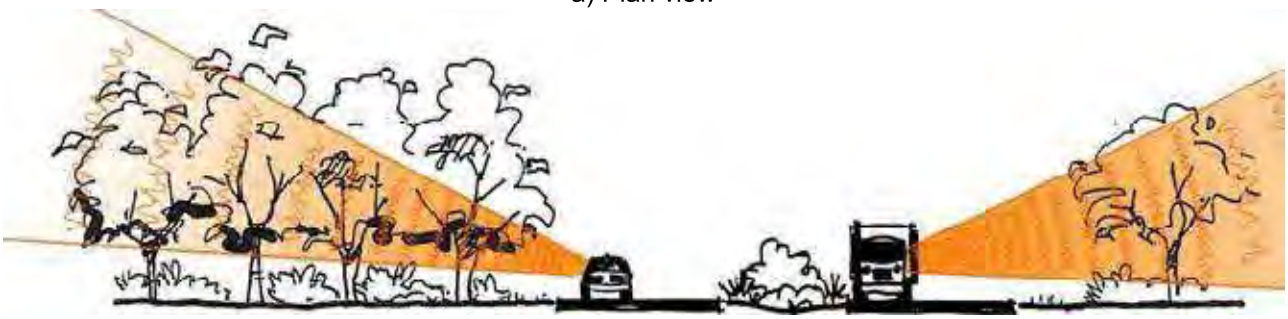
***Figure 6.18.8 Transparent noise wall barriers need to consider the issue of bird strike.***

**c) Vegetative barriers**

- Vegetation can be used as an alternative noise (and light) abatement measure when substantial reductions in noise levels are not required (Figure 6.18.9).
- In order to perform as a barrier, a vegetative belt must have sufficient height, length and mass. The length and height requirements are analogous to those of a conventional freestanding noise wall (Harris 1986).
- The mass of the vegetation is based upon its maturity and the type of vegetation.
- The type of vegetation must be an evergreen with dense, leafy growth that will limit optical and sound penetrability.
- Recommendations for planting:
    - Individual plants spaced to ensure sufficient room for the development of mature shrubs.
    - At least two to three rows of dense plantings of tall trees and/or dense shrubs increases effectiveness.
    - Correct row spacing to be maintained, ensuring rows do not grow together.
- Vegetative barriers will not provide the same noise reduction as a free standing noise wall.
- For a vegetative barrier to provide a 3dB reduction, it needs to be at least 30 metres wide and 4.6 metres high (depending on the type of planting and maintenance).
- Effectiveness is dictated by the planting scheme and the maintenance schedule.
- Consider dense vegetation where noise walls would cause a greater level of disturbance and fragmentation than a dense hedge of vegetation.



a) Plan view



b) Cross-sectional view

***Figure 6.18.9 Drawing highlighting the effectiveness of vegetation as a noise barrier.***

**d) Road surface**

- Smooth surfaces have been developed to reduce noise while retaining safe traction control; in addition some tyres are less noisy than others. Road authorities need to consider road surface design when upgrading or constructing highways.

## 6.18.4 Design Speed

A reduction in road speed may be a cost effective way to reduce fauna roadkill.

## 6.18.5 Road Safety Barriers

Road safety barriers potentially increase road mortality by trapping fauna on the road.

Safety barrier design may need to be modified to enable fauna to climb over or under such structures.

Temporary structures may be attached to these barriers to assist fauna to pass over these structures.

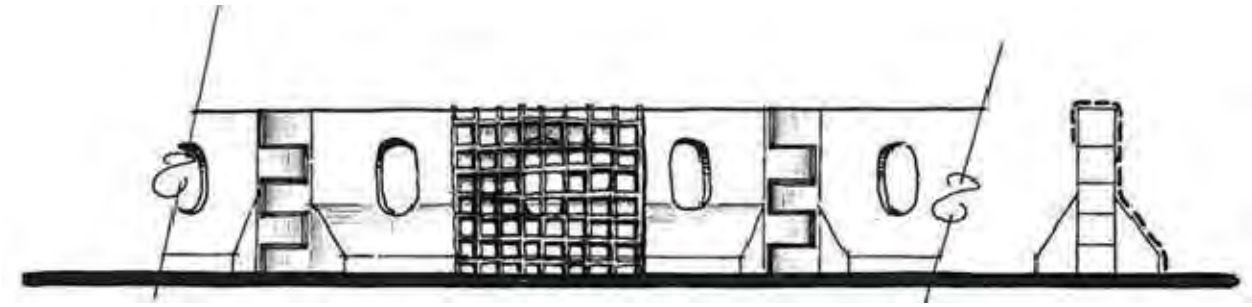
*Plastic Road Safety Barriers:*

To enable fauna to cross under the barrier, a 400 mm x 400 mm arch cut-out at the base is suggested.

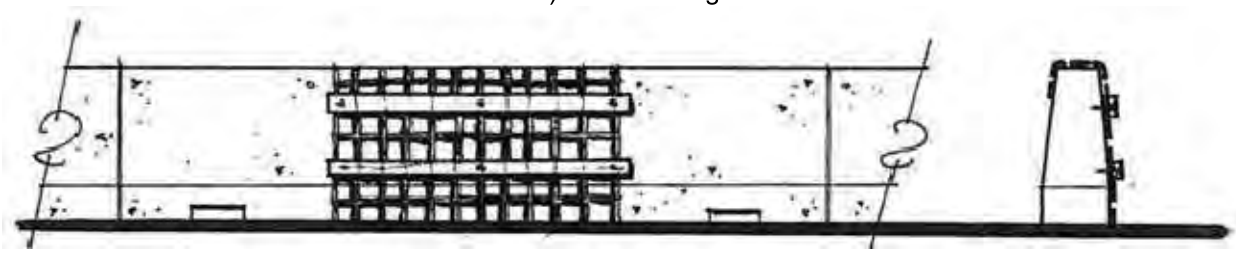
- Every second barrier requires a cut-out.
- Smaller size cut-outs currently prohibit use by large koalas (Queensland Department of Main Roads 2009).

Can be modified by placing plastic mesh (parawebbing) or wooden planks on the sides of these barriers. This assists koalas to climb over the barriers and may also prove useful for some small mammal species (although untrialled for the latter fauna group) (Figures 6.18.10 and 6.18.11).

The current forklift holes within these barriers may provide some level of permeability for small mammals depending on climbing capabilities.



a) Parawebbing



b) Wooden planks attached to thick parawebbing

***Figure 6.18.10 Modifications that can be placed over barriers to assist fauna to more easily escape road corridors.***

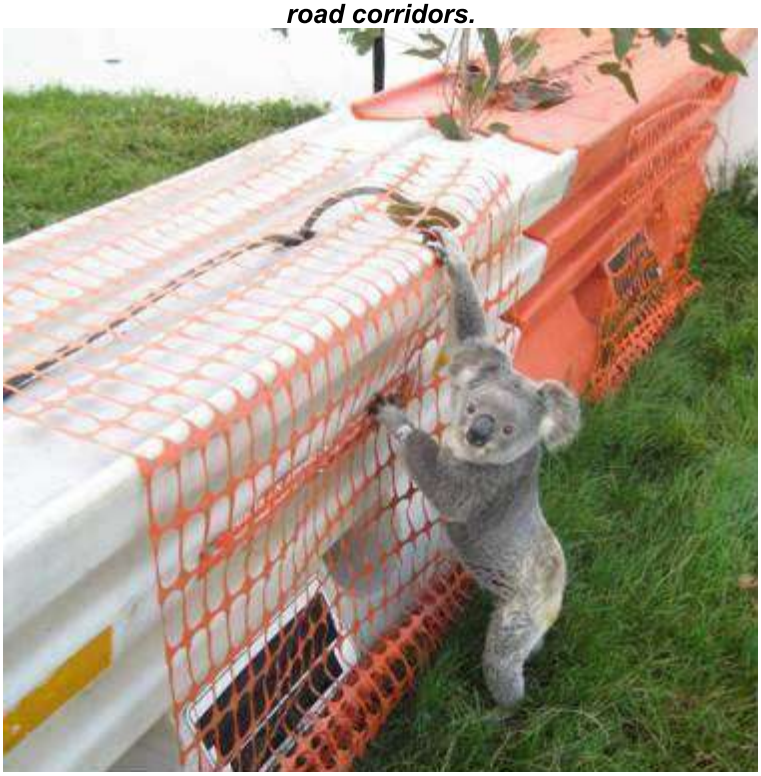


***Figure 6.18.11 Koala barrier trial at the Australian Wildlife Hospital, Queensland. Some koalas were able to use parawebbing to climb over the barrier (Scott 2008).***

*Concrete Safety Barriers:*

To enable fauna to cross over concrete barriers wooden poles placed horizontally along barriers may be installed.

- Maximum of 500 mm apart to suit koalas' reach.

Can also be modified by placing plastic mesh (parawebbing) or wooden planks on the side of these barriers. This may assist koalas to climb over the barriers.

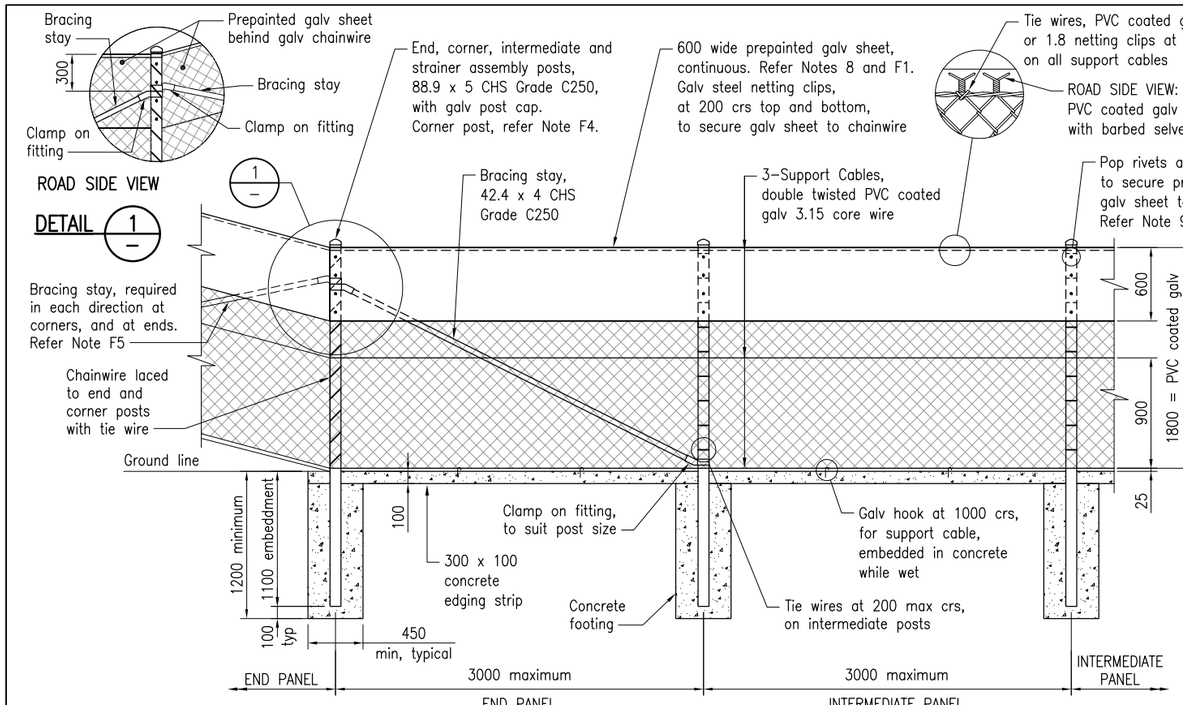
Currently studies indicate that modifications may still be inadequate to enable safe fauna passage (Figure 6.18.12).

***Figure 6.18.12 Koala barrier trials at the Australian Wildlife Hospital in Queensland. This koala was able to use wooden logs to climb over the simulated concrete barrier (Scott 2008).***

# Attachment E

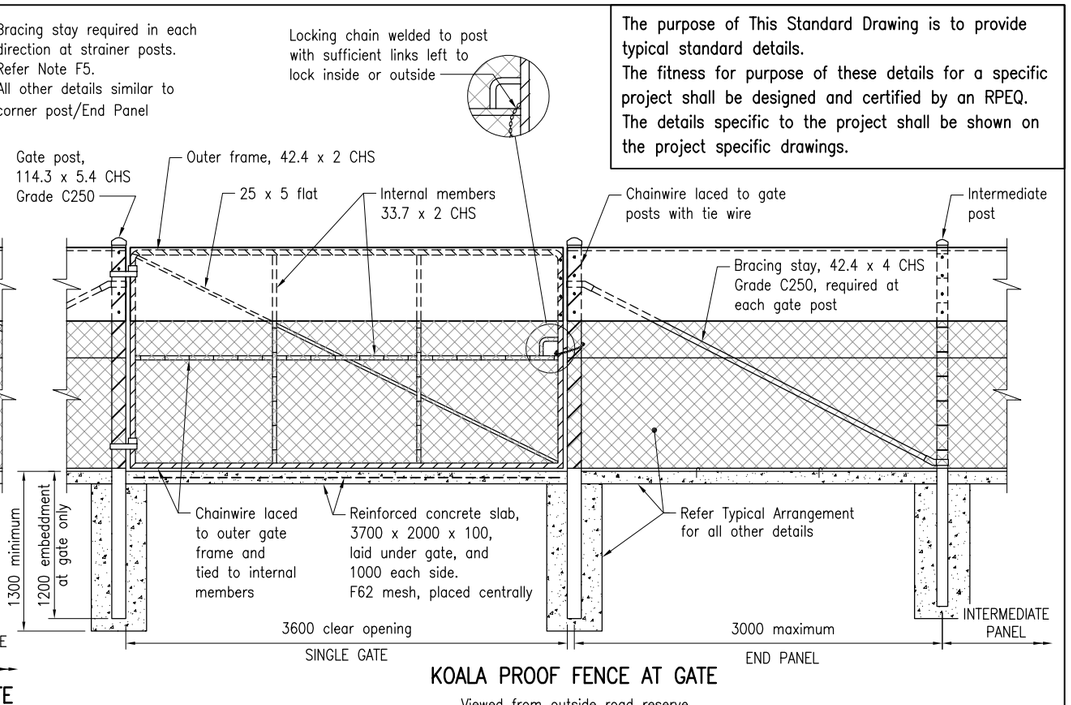
## Department of Transport and Main Roads Koala proof fence and gate standard drawing 1603

The purpose of This Standard Drawing is to provide typical standard details.
The fitness for purpose of these details for a specific project shall be designed and certified by an RPEQ.
The details specific to the project shall be shown on the project specific drawings.




## KOALA PROOF FENCE – TYPICAL ARRANGEMENT

Viewed from outside road reserve




## KOALA PROOF FENCE AT GATE

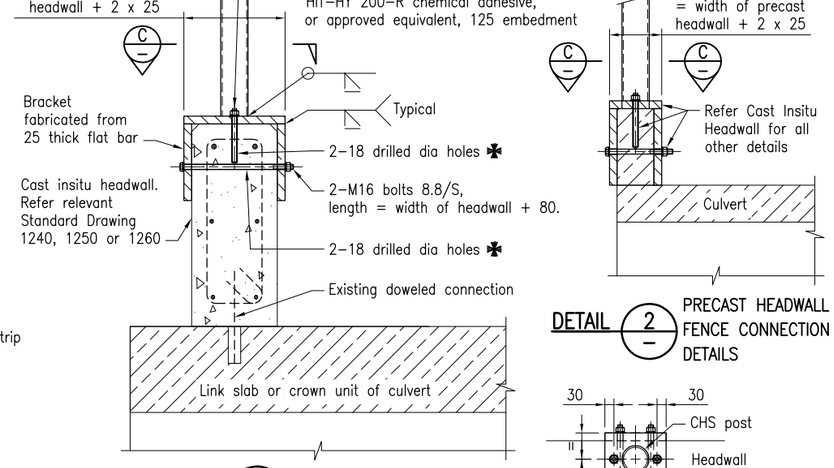
Viewed from outside road reserve

## KOALA PROOF FENCE:

F1. PREFINISHED/ PREPAINTED GALVANIZED STEEL SHEET shall be coloured on both sides. The nominated colour to face the road, which shall be approved by the Project Administrator, shall be "Cottage Green" or "Nightsky Black".
F2. SELVEDGES: Barbed selvedges shall be used at top except on gates where knuckled selvedges are used top and bottom.
F3. TIE/LACING WIRE shall be green PVC coated galvanized wire unless specified otherwise.
F4. CORNER POSTS shall be adopted where the change in angle in horizontal alignment exceeds 20 degrees.
F5. STRAINER POST: Provide bracing stays in each direction at strainer post between 2 intermediate panels at 150 intervals on straight lengths of fence.
F6. FENCE INSTALLATION REQUIREMENTS:
Chain wire and prepainted galvanized steel sheet shall be located on the opposite side of the posts to the roadway to prevent koalas climbing the CHS posts, stays, and bracing.
Connection to culvert headwalls:
All dimensions shall be verified on site prior to fabrication of steel components. Connection to bridges shall be as detailed in the bridge drawings.

## TYPICAL INTERMEDIATE STRAINER POST ASSEMBLY

Viewed from outside road reserve

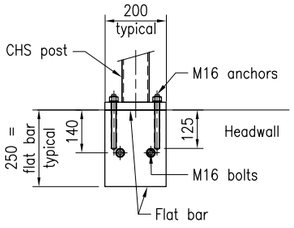



DETAIL 2 – CAST INSITU HEADWALL FENCE CONNECTION DETAILS

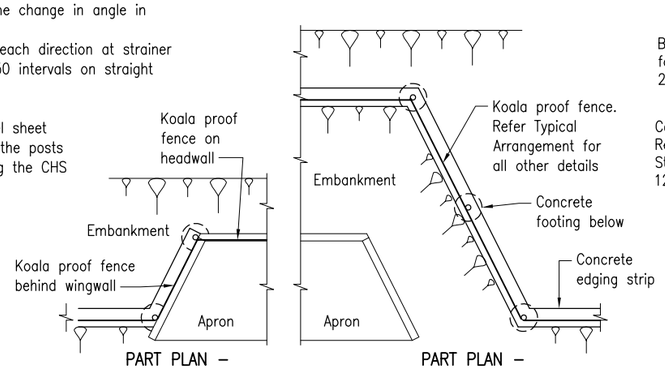
DETAIL 2 – PRECAST HEADWALL FENCE CONNECTION DETAILS




SECTION C – TYPICAL DETAILS – PART PLAN

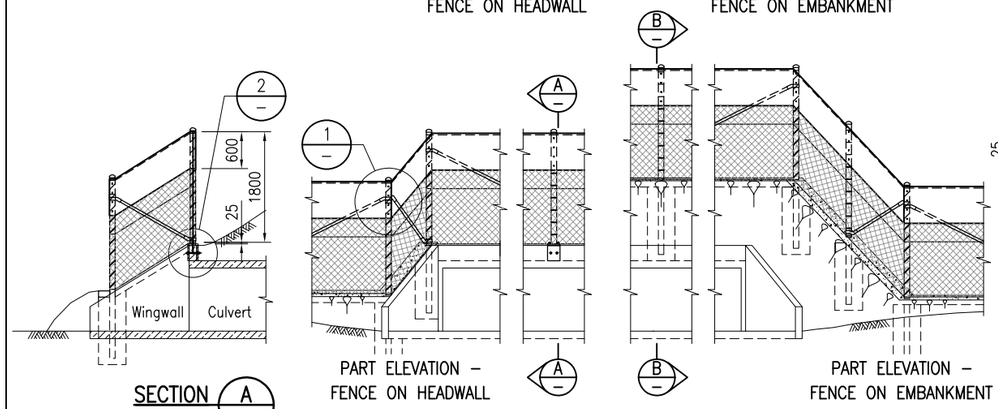



PART ELEVATION
FENCE CONNECTION TO HEADWALL




PART PLAN – FENCE ON HEADWALL

PART PLAN – FENCE ON EMBANKMENT




SECTION A

PART ELEVATION – FENCE ON HEADWALL

PART ELEVATION – FENCE ON EMBANKMENT

SECTION B

## KOALA PROOF FENCE AT CULVERTS

Viewed from outside road reserve

## NOTES:

1. SCOPE: This Standard Drawing provides details of koala proof fencing for TMR projects, and shall be constructed in accordance with MRTS14.
2. WIND DESIGN LOADS shall comply with AS/NZS 1170.2.
   Design ultimate wind load V = 51 m/s.
3. CONCRETE shall be in accordance with MRTS70. Concrete strength N32/20.
4. REINFORCING STEEL shall be in accordance with MRTS71, Standard Drawing 1044 and AS/NZS 4671.
   Mesh Grade D500L.
5. STEELWORK shall be fabricated to the requirements of MRTS78.
   CHS shall be Grade C350, or as noted on the drawing, to AS 1163.
   Flat bar shall be Grade 300 to AS/NZS 3679.1.
   Bolts Class 8.8, nuts Class 8 and washers for Class 8.8 bolts to AS/NZS 1252.
   All nuts shall be snug tight in accordance with AS 4100.
   Galvanized fencing wire, tie/lacing wire and galvanized chainwire shall conform to AS 2423.
   All bolts and nuts shall be hot dip galvanised to AS 1214.
   All other steelwork shall be hot dip galvanized to AS/NZS 4680.
   Prior to galvanizing all weld splatter and welding slag shall be removed.
7. WELDING symbols to AS 1101.3. All welding shall be to AS/NZS 1554.1.
   All welds except tack welds shall be SP category.
   Welding consumables shall be controlled hydrogen type G493 to AS/NZS ISO 14341–B or T493 to AS/NZS ISO 17632–B.
8. PREFINISHED/ PREPAINTED GALVANIZED STEEL SHEET shall be 0.4mm BMT to AS 2728.
9. POP RIVETS with aluminium shell, steel stem (large flanged) maximum grip 9.5mm, drill bit No 11 (4.9mm), shall be used.
10. DIMENSIONS are in millimetres.

REFERENCED DOCUMENTS:
Departmental Specifications and Technical Notes:
MRTS14 Road Furniture
MRTS70 Concrete
MRTS71 Reinforcing Steel
MRTS78 Fabrication of Structural Steelwork

Department of Transport and Main Roads

FENCING

KOALA PROOF FENCE AND GATE

Queensland Government

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A3 | Not to Scale

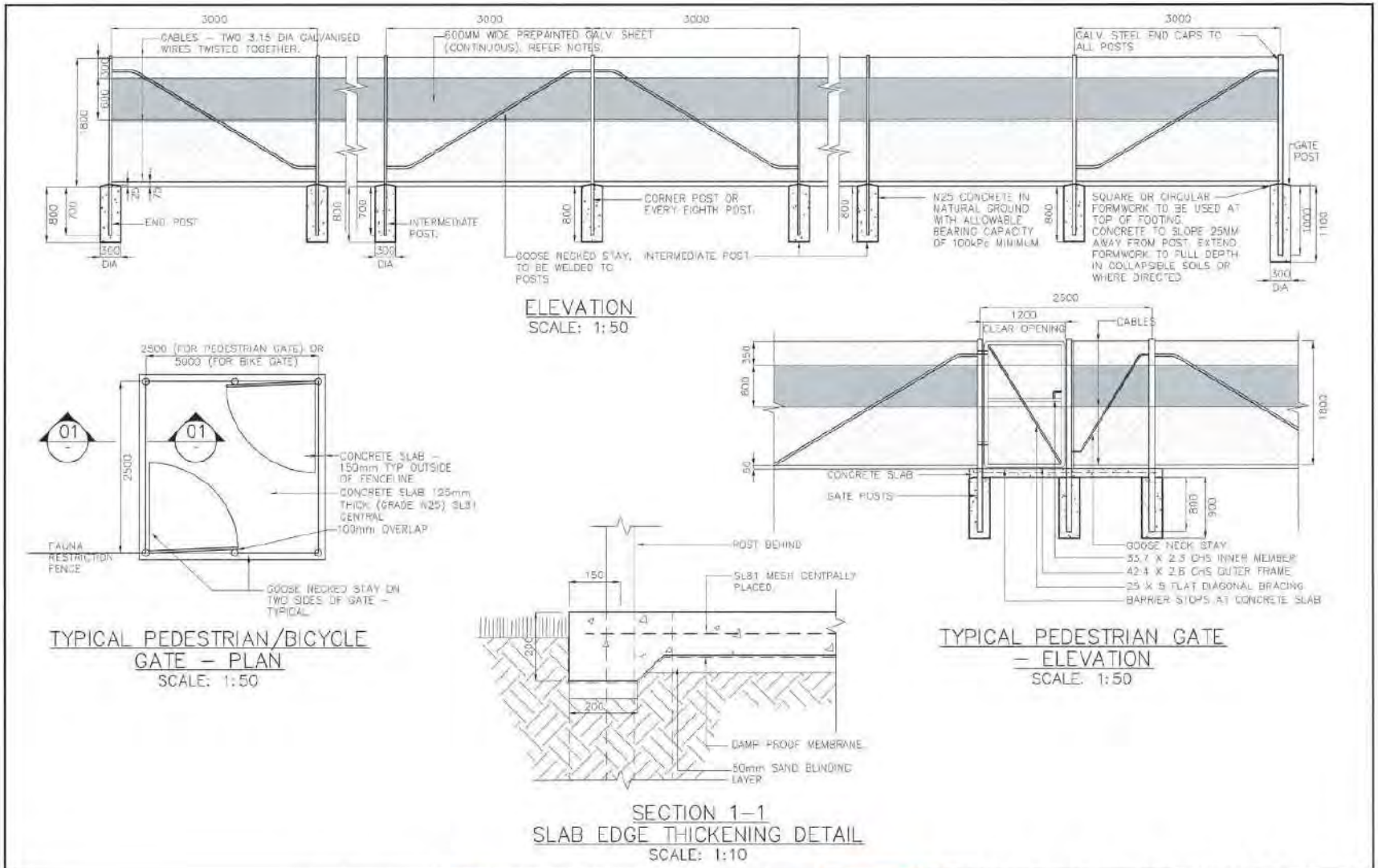
Standard Drawing No 1603

Date 7/19

A | B

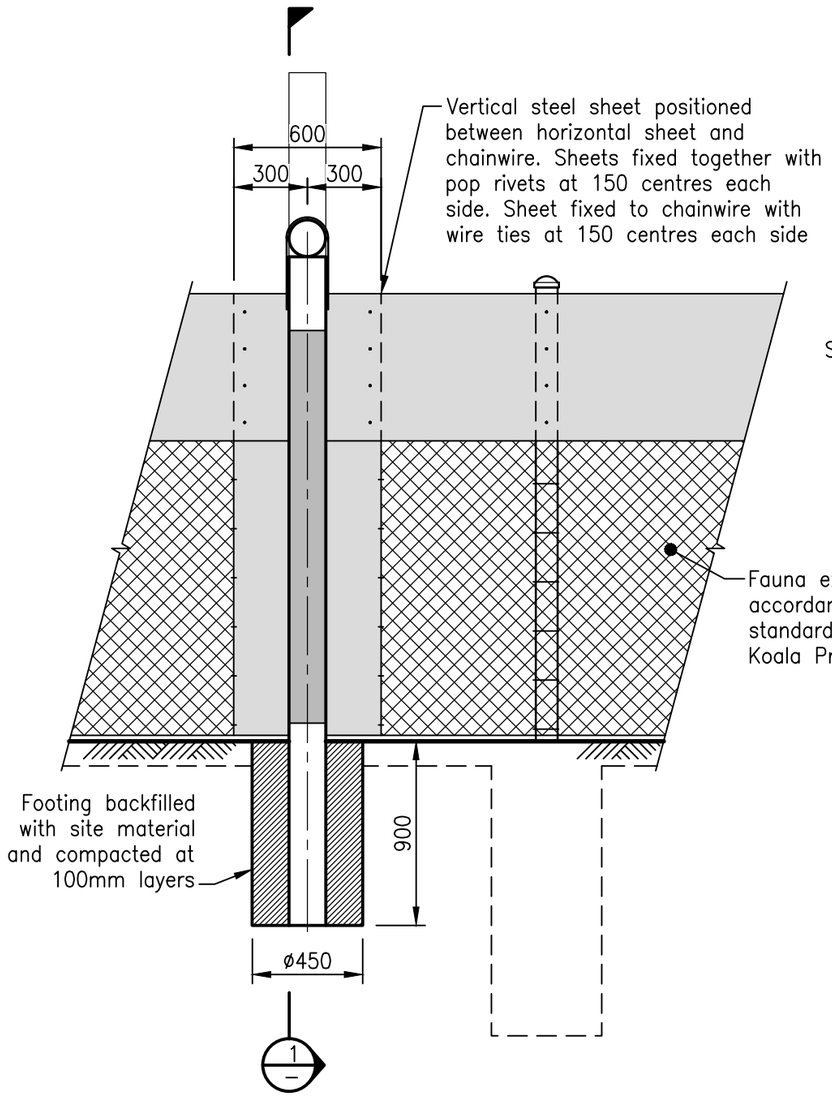
# Attachment F

## Brisbane City Council fauna exclusion fence standard drawing BSD-7009


3000
3000
3000
3000
CABLES – TWO 3.15 DIA GALVANISED WIRES TWISTED TOGETHER.
600MM WIDE PREPAINTED GALV. SHEET (CONTINUOUS). REFER NOTES.
GALV. STEEL END CAPS TO ALL POSTS
GATE POST
1800
600
300
800
700
END POST
INTERMEDIATE POST.
CORNER POST OR EVERY EIGHTH POST.
N25 CONCRETE IN NATURAL GROUND WITH ALLOWABLE BEARING CAPACITY OF 100kPa MINIMUM
SQUARE OR CIRCULAR FORMWORK TO BE USED AT TOP OF FOOTING. CONCRETE TO SLOPE 25MM AWAY FROM POST. EXTEND FORMWORK TO FULL DEPTH IN COLLAPSIBLE SOILS OR WHERE DIRECTED.
1000
1100
300 DIA
GOOSE NECKED STAY. INTERMEDIATE POST TO BE WELDED TO POSTS
ELEVATION
SCALE: 1:50
2500 (FOR PEDESTRIAN GATE) OR 5000 (FOR BIKE GATE)
01
01
2500
CONCRETE SLAB – 150mm TYP OUTSIDE OF FENCELINE
CONCRETE SLAB 125mm THICK (GRADE N25) SL81 CENTRAL
100mm OVERLAP
FAUNA RESTRICTION FENCE
GOOSE NECKED STAY ON TWO SIDES OF GATE – TYPICAL
TYPICAL PEDESTRIAN/BICYCLE GATE – PLAN
SCALE: 1:50
2500
1200 CLEAR OPENING
CABLES
350
600
50
1800
CONCRETE SLAB
GATE POSTS
800
900
GOOSE NECK STAY
35.7 X 2.3 CHS INNER MEMBER
42.4 X 2.6 CHS OUTER FRAME
25 X 5 FLAT DIAGONAL BRACING
BARRIER STOPS AT CONCRETE SLAB
TYPICAL PEDESTRIAN GATE – ELEVATION
SCALE: 1:50
POST BEHIND
150
SL81 MESH CENTRALLY PLACED
200
200
DAMP PROOF MEMBRANE
50mm SAND BLINDING LAYER
SECTION 1–1
SLAB EDGE THICKENING DETAIL
SCALE: 1:10
A ORIGINAL ISSUE DEC '16 DEC '16 DEC '16
ISSUE AMENDMENT DRAWN DATE CHK'D DATE APPR'D DATE
DRAWING NO LONGER FOR PUBLICATION
ASSET ENGINEERING MANAGER STRATEGIC ASSET MANAGEMENT
DESIGN APPROVED
SENIOR CO-ORDINATOR NATURAL ENVIRONMENT ASSET SERVICES/BRISBANE INFRASTRUCTURE
DESIGN CPD – PSD DATE DEC '16
DRAWN CPD – PSD DATE DEC '16
CHECKED BI – FSG – AS DATE DEC '16
DRAWING FILENAME BSD-7009-Sheet 2 of 2.dwg
ASSOCIATED PLANS BSD-7009-Sheet 1
BRISBANE CITY
BRISBANE CITY COUNCIL STANDARD DRAWING
FENCE – NATURAL AREA – CHAINWIRE FAUNA EXCLUSION FENCE – SHEET 2 OF 2
SCALE AS SHOWN
BSD-7009
DRAWING SIZE A3
STATUS A

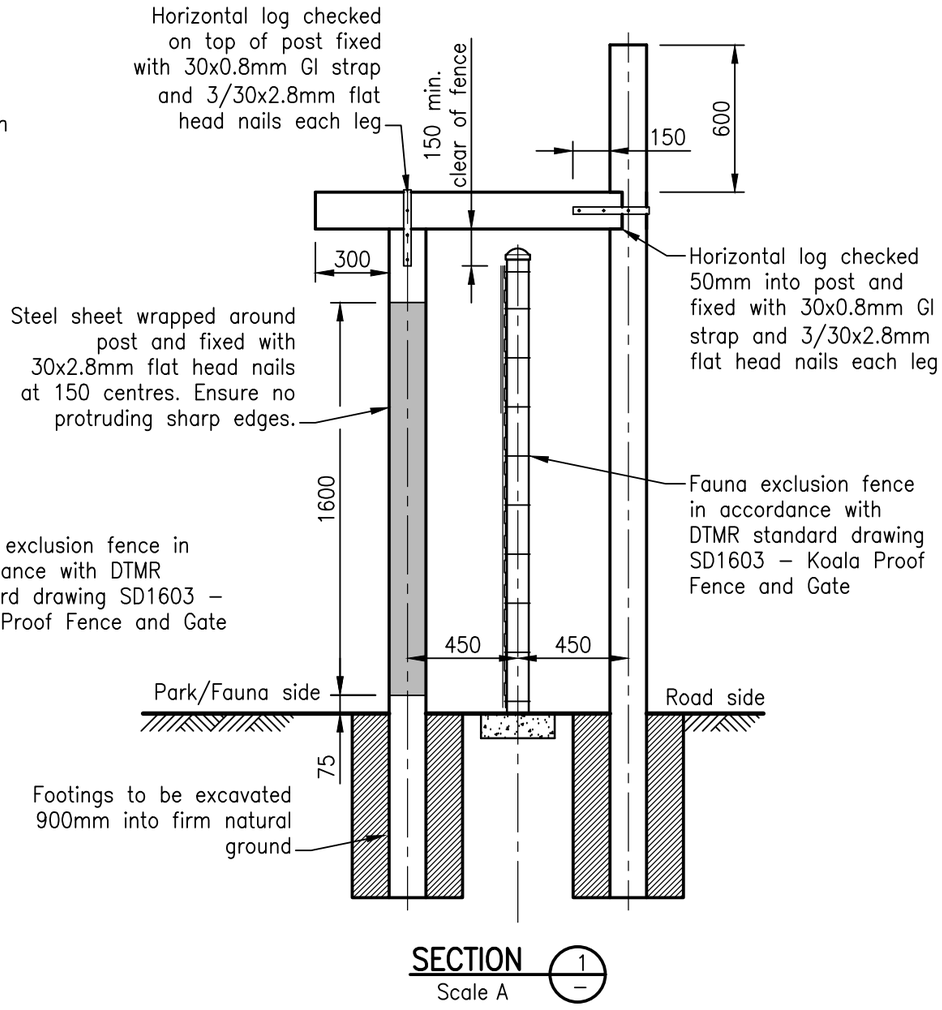
# Attachment G

## Moreton Bay Regional Council fauna escape pole standard drawing GI-0520




## FAUNA EXCLUSION FENCE ESCAPE POLE ELEVATION

Scale A




## SECTION

Scale A

## EXAMPLE PHOTO

Not to scale

The structural work shown on this drawing is considered to be structurally sound, and suitable for the design loads.

All construction to be as per current Australian Standards and Building Codes, in accordance with MBRC requirements, and in a professional and tradesmanlike manner

IAN BARNES & ASSOCIATES P/Ltd
CONSULTING ENGINEERS
P.O. Box 1378
CABOOLTURE 4510
ABN 70 057802490
Office : 07 5495 8444
Mobile : 0418 873 320
RPEQ 3333
Date : 13/09/2017

## NOTES:

1. Pine logs to be ø150 and preservative treated to hazard class H4 to AS1604.1 and have a durability class 4 to AS5604.
2. Galvanised steel sheet to be powdercoated or pre–painted to AS2728, the colour shall be 'Mist green' or 'River gum' subject to final approval by superintendent. Sheets shall be 0.42mm BMT.
3. Nails to be treated with 'Zenith–Tufcote' or 'Buildex–Climacoat' or approved equivalent (unless noted otherwise).
4. Pop rivets with aluminium shell and steel stem (large flanged) maximum grip 3.2mm, drill bit No.11 (4.9mm) shall be used.
5. Tie wire shall be 1.57mm green PVC coated galvanised wire unless specified otherwise.

| REVISIONS | | INIT | DATE |
|---|---|---|---|
| E | | | |
| D | | | |
| C | | | |
| B | Endorsed by Structural Engineer | TC | 7/17 |
| A | Structural Design Note Changed | RH | 11/16 |
| X | ORIGINAL ISSUE | BW | 07/16 |

SCALES

A 0mm 100 200 300 400 500 1:25

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| Drawn | BW | Date | 07/16 |
| Coordinator | PP | Date | 07/16 |

AUTHORISED

SYD JERRAM
07/07/16

Manager Integrated Transport Planning & Design
RPEQ 6872

# FAUNA ESCAPE POLES

Moreton Bay Regional Council

DRG No. GI-0520

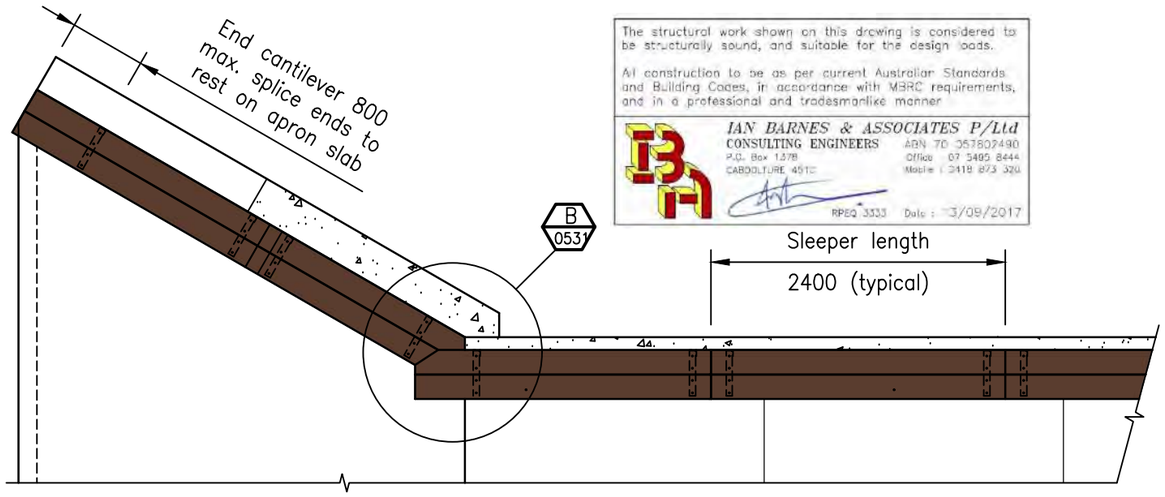
ORIGINAL SIZE A3

REVISION B

File name: I:\User_Group\Design_Services\Projects\MBRC Standard Drawings\AutoCAD Files\02 – Green Infrastructure\GI–0520b – Fauna Escape Poles.dwg Date: Sep 28, 2017 – 11:07am

# Attachment H

## Moreton Bay Regional Council fauna movement shelf standard drawing GI-0530 and GI-0531




The structural work shown on this drawing is considered to be structurally sound, and suitable for the design loads.

All construction to be as per current Australian Standards and Building Codes, in accordance with MBRC requirements, and in a professional and tradesmanlike manner

IAN BARNES & ASSOCIATES P/Ltd
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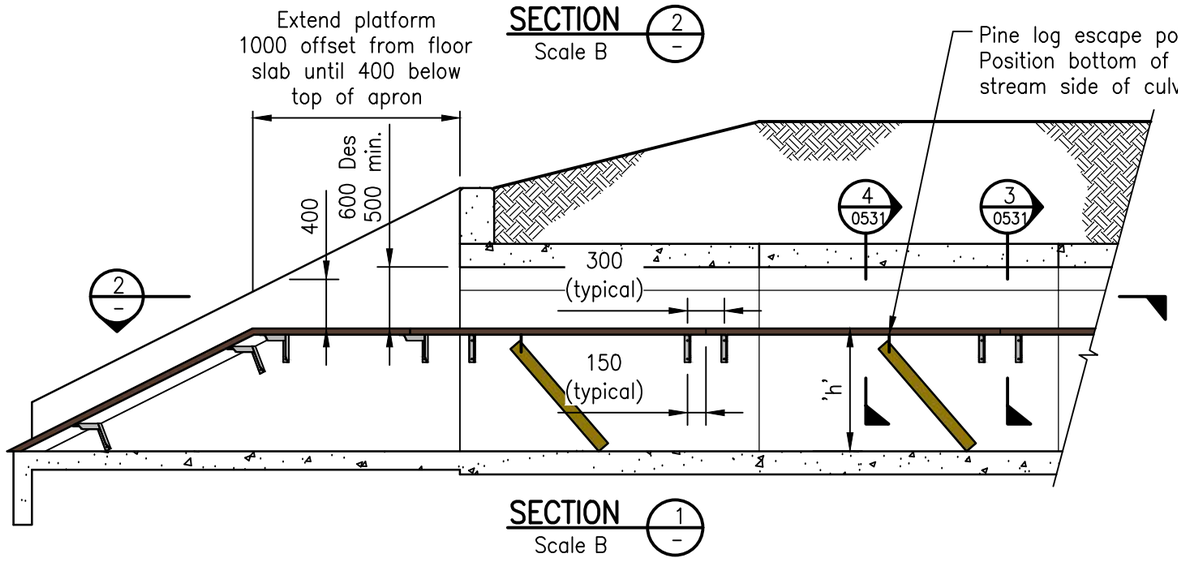
RPEQ 3333 Date : 13/09/2017

## SECTION
Scale B 2 –

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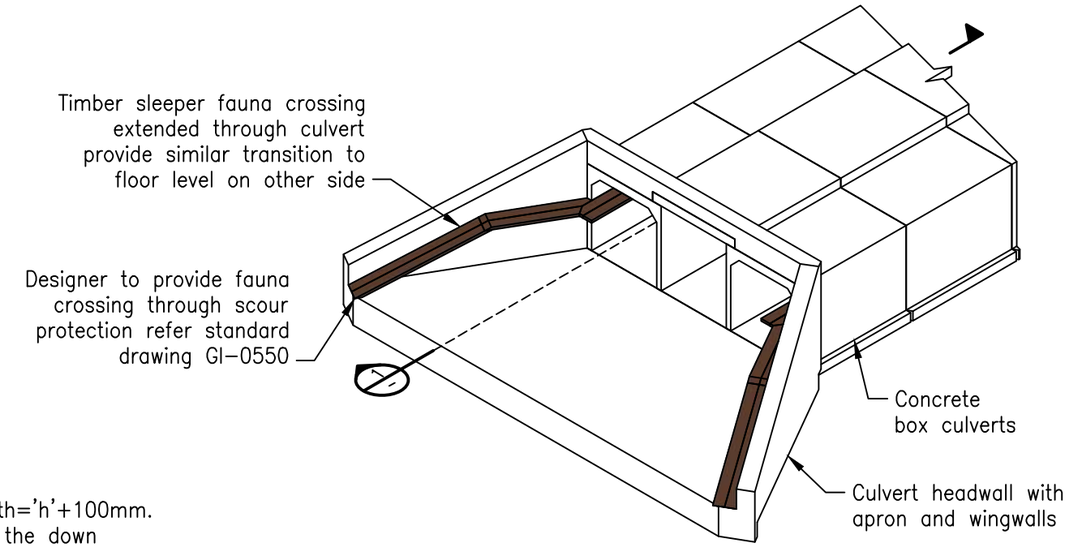



## ISOMETRIC VIEW
Scale A

## NOTES:

1. Fauna movement shelf and access poles allow wildlife to move through the culvert and avoid or escape ground level predators at each end and at key points through the culvert.
2. Ensure existing vegetation is retained as close as practical to both ends of the culvert to provide shelter for crossing fauna.
3. Where vegetation removal is undertaken for construction, designers should incorporate revegetation planting to support biodiversity and encourage crossing by wildlife.
4. Adequate culvert size is influenced by target fauna species and geographical location. Designers should consult an ecologist or suitably qualified professional with regards to appropriate culvert size for target species.
5. Culverts with heights ≥1800 cater for a greater range of native species and should be used as a minimum for koala. Larger culverts are preferable.
6. Escape poles should be placed at intervals of approximately 3.0m commencing at the ends of the culvert.
7. Timber sleepers shall be 200x50 pine or hardwood and treated to hazard level H5 in accordance with AS1604.
8. Pine logs to be ø100 and preservative treated to hazard class H5 to AS1604.1 and have a durability class 4 to AS5604.
9. Steel sections grade 300 material and hot dipped galvanised after manufacture.
10. Welds to be effected with E48xx or W50x electrodes but not less than that required by AS4100.
11. Bolts, washers, nuts and screws to be treated with 'Zenith–Tufcote' or 'Buildex–Climacoat' or approved equivalent (unless noted otherwise).
12. All bolts shall be fixed with one washer under the turned part.
13. Where double nut has been specified tighten first nut against structure then lock nuts together by tightening in opposing directions

| REVISIONS | | INIT | DATE |
|---|---|---|---|
| E | | | |
| D | | | |
| C | | | |
| B | | | |
| A | Endorsed by Structural Engineer | TC | 7/17 |
| X | ORIGINAL ISSUE | BW | 07/2016 |

SCALES
A 0mm 500 1000 1500 2000 1:100
B 0mm 250 500 750 1000 1:50

| | | | |
|---|---|---|---|
| Drawn | BW | Date | 07/16 |
| Coordinator | PP | Date | 07/16 |

AUTHORISED
SYD JERRAM
07/07/16
Manager Integrated Transport Planning & Design
RPEQ 6872

# FAUNA MOVEMENT SHELF

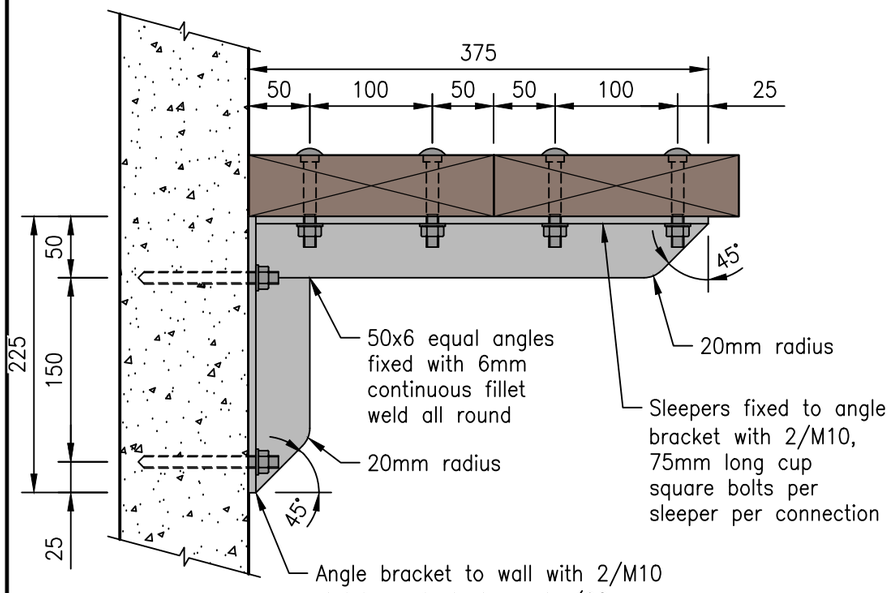
Moreton Bay Regional Council

DRG No. GI-0530

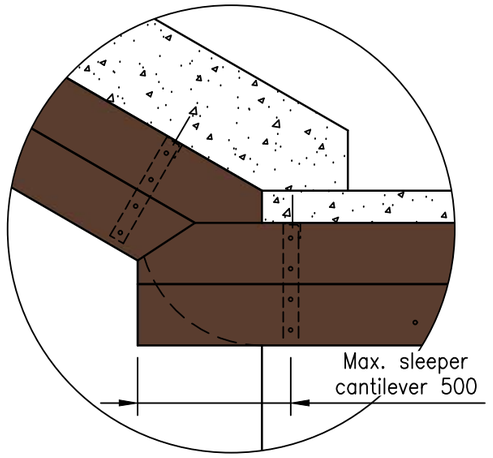
ORIGINAL SIZE A3

REVISION A

File name: I:\User_Group\Design_Services\Projects\MBRC Standard Drawings\AutoCAD Files\02 – Green Infrastructure\GI–0530–GI–0531 – Fauna Movement Shelf.dwg Date: Sep 28, 2017 – 11:10am

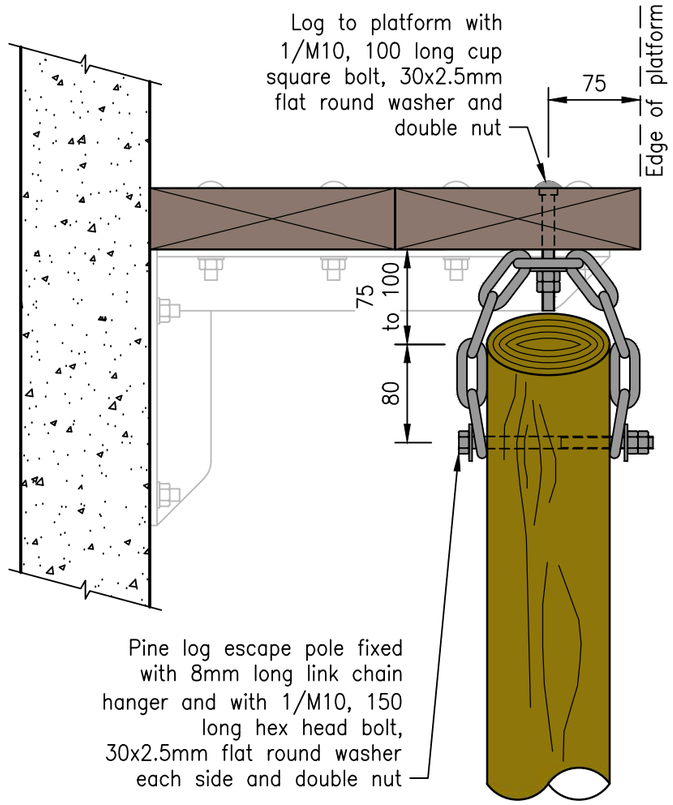



SECTION 3 / 0530
Scale B




DETAIL B / 0530
Scale A

EXAMPLE PHOTO
Not to scale




SECTION 4 / 0530
Scale B

The structural work shown on this drawing is considered to be structurally sound, and suitable for the design loads.

All construction to be as per current Australian Standards and Building Codes, in accordance with MBRC requirements, and in a professional and tradesmanlike manner

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RPEQ 3333
Date : 13/09/2017

| | REVISIONS | INIT | DATE |
|---|---|---|---|
| E | | | |
| D | | | |
| C | | | |
| B | Approved by Structural Engineer | TC | 7/17 |
| A | MINOR DRAFTING CHANGE | TC | 4/17 |
| X | ORIGINAL ISSUE | BW | 01/2016 |

SCALES
A 0mm 100 200 300 400 1:20
B 0mm 25 50 75 100 1:5

| | | | |
|---|---|---|---|
| Drawn | B.W | Date | 07/16 |
| Coordinator | | Date | |

AUTHORISED
SYD JERRAM
07/07/16
Manager Integrated Transport Planning & Design
RPEQ 6872

# FAUNA MOVEMENT SHELF
# SHEET 2 OF 2

Moreton Bay Regional Council

DRG No. GI-0531

ORIGINAL SIZE A3

REVISION B

File name: I:\User_Group\Design_Services\Projects\MBRC Standard Drawings\AutoCAD Files\02 - Green Infrastructure\GI-0530-GI-0531 - Fauna Movement Shelf.dwg Date: Sep 28, 2017 - 11:12am

# Attachment I

## Baseline raw data from SAT surveys

# Koala Spot Assessment Technique Results

The Scat meander-SAT method is an assessment of Koala activity involving a search for any Koalas and signs of Koala usage. The Scat meander-SAT involves actively searching for Koala scats and then identifying the tree where a Koala or scats was found. The nearest suitable Koala habitat tree is then identified and the same data recorded. The next closest habitat tree to the first tree is then assessed and so on until 30 trees have been recorded. The number of trees showing evidence of Koalas is expressed as a percentage of the total number of trees sampled to indicate the frequency of Koala usage. Assessment of each tree involves a systematic search for Koala scats beneath the tree within 1 m radius of the trunk. After approximately 2 person minutes of searching for scats, the base of the trunk is observed for scratches and the crown for Koala.

| 2016 SAT 1 | | | | |
|---|---|---|---|---|
| **Date:** | **5th August 2016** | | | |
| **No.** | **Species Name** | **Common Name** | **DBH** | **Scats** |
| 1 | *Corymbia intermedia* | Pink Bloodwood | 340 | Yes |
| 2 | *Eucalyptus racemosa* | Scribbly Gum | 740 | Yes |
| 3 | *Eucalyptus racemosa* | Scribbly Gum | 560 | No |
| 4 | *Corymbia intermedia* | Pink Bloodwood | 170 | No |
| 5 | *Corymbia intermedia* | Pink Bloodwood | 500 | No |
| 6 | *Eucalyptus racemosa* | Scribbly Gum | 400 | No |
| 7 | *Eucalyptus racemosa* | Scribbly Gum | 350 | No |
| 8 | *Corymbia intermedia* | Pink Bloodwood | 180 | No |
| 9 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 260 | No |
| 10 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 150 | No |
| 11 | *Eucalyptus racemosa* | Scribbly Gum | 490 | No |
| 12 | *Corymbia intermedia* | Pink Bloodwood | 180 | No |
| 13 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 240 | No |
| 14 | *Angophora leiocarpa* | Smooth-barked Apple | 140 | No |
| 15 | *Eucalyptus racemosa* | Scribbly Gum | 130 | No |
| 16 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 420 | No |
| 17 | *Corymbia intermedia* | Pink Bloodwood | 120 | No |
| 18 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 210 | No |
| 19 | *Lophostemon suaveolens* | Swamp Box | 190 | No |
| 20 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 200 | No |
| 21 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 530 | No |
| 22 | *Corymbia intermedia* | Pink Bloodwood | 330 | No |
| 23 | *Corymbia intermedia* | Pink Bloodwood | 280 | No |
| 24 | *Corymbia intermedia* | Pink Bloodwood | 180 | No |
| 25 | *Corymbia intermedia* | Pink Bloodwood | 300 | No |
| 26 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 790 | Yes |
| 27 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 500 | No |
| 28 | *Corymbia intermedia* | Pink Bloodwood | 190 | No |
| 29 | *Corymbia intermedia* | Pink Bloodwood | 210 | No |
| 30 | *Eucalyptus racemosa* | Scribbly Gum | 730 | No |
| Percent trees with scats | | | | 10.00 |

| 2016 SAT 2 | | | | |
|---|---|---|---|---|
| **Date:** | **5th August 2016** | | | |
| **No.** | **Species Name** | **Common Name** | **DBH** | **Scats** |
| 1 | *Eucalyptus tereticornis* | Forest Red Gum | 660 | Yes |
| 2 | *Corymbia intermedia* | Pink Bloodwood | 130 | No |
| 3 | *Corymbia intermedia* | Pink Bloodwood | 100 | No |
| 4 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 250 | No |
| 5 | *Corymbia intermedia* | Pink Bloodwood | 160 | No |
| 6 | *Corymbia intermedia* | Pink Bloodwood | 190 | No |
| 7 | *Corymbia intermedia* | Pink Bloodwood | 100 | No |
| 8 | *Corymbia intermedia* | Pink Bloodwood | 100 | No |
| 9 | *Lophostemon suaveolens* | Swamp Box | 250 | No |
| 10 | *Eucalyptus tereticornis* | Forest Red Gum | 620 | No |
| 11 | *Lophostemon suaveolens* | Swamp Box | 250 | No |
| 12 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 300 | No |
| 13 | *Lophostemon suaveolens* | Swamp Box | 190 | No |
| 14 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 220 | No |
| 15 | *Eucalyptus tereticornis* | Forest Red Gum | 520 | Yes |
| 16 | *Lophostemon suaveolens* | Swamp Box | 180 | No |
| 17 | *Corymbia intermedia* | Pink Bloodwood | 180 | No |
| 18 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 220 | Yes |
| 19 | *Lophostemon suaveolens* | Swamp Box | 220 | No |
| 20 | *Corymbia intermedia* | Pink Bloodwood | 270 | No |
| 21 | *Eucalyptus tereticornis* | Forest Red Gum | 450 | No |
| 22 | *Eucalyptus tereticornis* | Forest Red Gum | 600 | No |
| 23 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 24 | *Lophostemon suaveolens* | Swamp Box | 260 | No |
| 25 | *Acacia concurrens* | Black Wattle | 130 | No |
| 26 | *Eucalyptus tereticornis* | Forest Red Gum | 410 | No |
| 27 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 200 | No |
| 28 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 260 | No |
| 29 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 180 | No |
| 30 | *Lophostemon suaveolens* | Swamp Box | 210 | No |
| Percent trees with scats | | | | 10.00 |

| 2016 SAT 3 | | | | |
|---|---|---|---|---|
| **Date:** | **5th August 2016** | | | |
| **No.** | **Species Name** | **Common Name** | **DBH** | **Scats** |
| 1 | *Eucalyptus siderophloia* | Grey Ironbark | 300 | Yes |
| 2 | *Eucalyptus tereticornis* | Forest Red Gum | 340 | No |
| 3 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 180 | No |
| 4 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 5 | *Eucalyptus siderophloia* | Grey Ironbark | 320 | No |
| 6 | *Eucalyptus siderophloia* | Grey Ironbark | 350 | No |
| 7 | *Eucalyptus siderophloia* | Grey Ironbark | 200 | No |
| 8 | *Eucalyptus siderophloia* | Grey Ironbark | 240 | No |
| 9 | *Eucalyptus tereticornis* | Forest Red Gum | 190 | No |
| 10 | *Eucalyptus siderophloia* | Grey Ironbark | 500 | No |
| 11 | *Eucalyptus tereticornis* | Forest Red Gum | 300 | No |
| 12 | *Eucalyptus siderophloia* | Grey Ironbark | 260 | No |
| 13 | *Eucalyptus siderophloia* | Grey Ironbark | 410 | No |
| 14 | *Eucalyptus siderophloia* | Grey Ironbark | 300 | No |
| 15 | *Lophostemon suaveolens* | Swamp Box | 120 | No |
| 16 | *Eucalyptus tereticornis* | Forest Red Gum | 250 | No |
| 17 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 209 | No |
| 18 | *Eucalyptus siderophloia* | Grey Ironbark | 300 | No |
| 19 | *Eucalyptus siderophloia* | Grey Ironbark | 260 | No |
| 20 | *Eucalyptus siderophloia* | Grey Ironbark | 450 | No |
| 21 | *Eucalyptus siderophloia* | Grey Ironbark | 380 | No |
| 22 | *Eucalyptus siderophloia* | Grey Ironbark | 300 | No |
| 23 | *Eucalyptus tereticornis* | Forest Red Gum | 380 | No |
| 24 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 180 | No |
| 25 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 180 | No |
| 26 | *Lophostemon suaveolens* | Swamp Box | 150 | No |
| 27 | *Eucalyptus siderophloia* | Grey Ironbark | 230 | No |
| 28 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 190 | No |
| 29 | *Corymbia intermedia* | Pink Bloodwood | 210 | No |
| 30 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 170 | No |
| Percent trees with scats | | | | 3.33 |

| 2016 SAT 4 | | | | |
|---|---|---|---|---|
| **Date:** | **5th August 2016** | | | |
| **No.** | **Species Name** | **Common name** | **DBH** | **Scats** |
| 1 | *Eucalyptus siderophloia* | Grey Ironbark | 960 | Yes |
| 2 | *Corymbia intermedia* | Pink Bloodwood | 200 | No |
| 3 | *Corymbia intermedia* | Pink Bloodwood | 260 | No |
| 4 | *Corymbia intermedia* | Pink Bloodwood | 290 | Yes |
| 5 | *Allocasuarina littoralis* | Black She-oak | 190 | No |
| 6 | *Eucalyptus acmenoides* | White Mahogany | 180 | No |
| 7 | *Corymbia intermedia* | Pink Bloodwood | 200 | No |
| 8 | *Corymbia intermedia* | Pink Bloodwood | 210 | No |
| 9 | *Eucalyptus acmenoides* | White Mahogany | 220 | No |
| 10 | *Corymbia intermedia* | Pink Bloodwood | 270 | No |
| 11 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 12 | *Allocasuarina littoralis* | Black She-oak | 150 | No |
| 13 | *Corymbia citriodora* | Spotted Gum | 310 | No |
| 14 | *Eucalyptus acmenoides* | White Mahogany | 320 | No |
| 15 | *Eucalyptus acmenoides* | White Mahogany | 160 | No |
| 16 | *Corymbia intermedia* | Pink Bloodwood | 220 | No |
| 17 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 160 | No |
| 18 | *Corymbia intermedia* | Pink Bloodwood | 300 | No |
| 19 | *Eucalyptus siderophloia* | Grey Ironbark | 210 | No |
| 20 | *Corymbia intermedia* | Pink Bloodwood | 200 | No |
| 21 | *Eucalyptus acmenoides* | White Mahogany | 180 | No |
| 22 | *Corymbia citriodora* | Spotted Gum | 290 | No |
| 23 | *Eucalyptus acmenoides* | White Mahogany | 180 | No |
| 24 | *Corymbia citriodora* | Spotted Gum | 650 | No |
| 25 | *Corymbia citriodora* | Spotted Gum | 230 | No |
| 26 | *Allocasuarina littoralis* | Black She-oak | 190 | No |
| 27 | *Allocasuarina littoralis* | Black She-oak | 180 | No |
| 28 | *Allocasuarina littoralis* | Black She-oak | 110 | No |
| 29 | *Corymbia citriodora* | Spotted Gum | 140 | No |
| 30 | *Corymbia intermedia* | Pink Bloodwood | 260 | No |
| Percent trees with scats | | | | 6.67 |

| 2017 SAT 1 | | | | |
|---|---|---|---|---|
| **Date:** | **22nd June 2017** | | | |
| **No.** | **Species Name** | **Common Name** | **DBH** | **Scats** |
| 1 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 450 | Yes |
| 2 | *Corymbia intermedia* | Pink Bloodwood | 290 | Yes |
| 3 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 170 | No |
| 4 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 300 | No |
| 5 | *Acacia leiocalyx* | Early Black Wattle | 120 | No |
| 6 | *Acacia concurrens* | Black Wattle | 110 | No |
| 7 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 390 | No |
| 8 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 350 | No |
| 9 | *Corymbia intermedia* | Pink Bloodwood | 150 | No |
| 10 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 11 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 160 | No |
| 12 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 280 | No |
| 13 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 260 | No |
| 14 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 200 | No |
| 15 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 270 | No |
| 16 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 170 | No |
| 17 | *Corymbia intermedia* | Pink Bloodwood | 390 | Yes |
| 18 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 200 | No |
| 19 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 180 | No |
| 20 | *Acacia leiocalyx* | Early Black Wattle | 100 | No |
| 21 | *Corymbia intermedia* | Pink Bloodwood | 340 | No |
| 22 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 520 | No |
| 23 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 260 | No |
| 24 | *Corymbia intermedia* | Pink Bloodwood | 120 | No |
| 25 | *Corymbia intermedia* | Pink Bloodwood | 230 | No |
| 26 | *Acacia leiocalyx* | Early Black Wattle | 130 | No |
| 27 | *Acacia leiocalyx* | Early Black Wattle | 150 | No |
| 28 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 160 | No |
| 29 | *Melaleuca quinquenervia* | Broad-leaved Paperbark | 150 | No |
| 30 | *Acacia disparrima* | Hickory Wattle | 110 | No |
| Percent trees with scats | | | | 10.00 |

| 2017 SAT 2 | | | | |
|---|---|---|---|---|
| **Date:** | **22nd June 2017** | | | |
| **No.** | **Species Name** | **Common Name** | **DBH** | **Scats** |
| 1 | *Corymbia intermedia* | Pink Bloodwood | 410 | Yes |
| 2 | *Eucalyptus racemosa* | Scribbly Gum | 240 | No |
| 3 | *Eucalyptus racemosa* | Scribbly Gum | 230 | Yes |
| 4 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 5 | *Corymbia intermedia* | Pink Bloodwood | 150 | No |
| 6 | *Eucalyptus racemosa* | Scribbly Gum | 130 | No |
| 7 | *Acacia leiocalyx* | Early Black Wattle | 150 | No |
| 8 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 9 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 10 | *Acacia leiocalyx* | Early Black Wattle | 180 | No |
| 11 | *Eucalyptus racemosa* | Scribbly Gum | 200 | No |
| 12 | *Corymbia intermedia* | Pink Bloodwood | 180 | No |
| 13 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 14 | *Eucalyptus racemosa* | Scribbly Gum | 190 | No |
| 15 | *Corymbia intermedia* | Pink Bloodwood | 130 | No |
| 16 | *Corymbia intermedia* | Pink Bloodwood | 120 | No |
| 17 | *Corymbia intermedia* | Pink Bloodwood | 120 | Yes |
| 18 | *Acacia leiocalyx* | Early Black Wattle | 120 | No |
| 19 | *Eucalyptus racemosa* | Scribbly Gum | 140 | No |
| 20 | *Corymbia intermedia* | Pink Bloodwood | 290 | No |
| 21 | *Corymbia intermedia* | Pink Bloodwood | 280 | No |
| 22 | *Eucalyptus racemosa* | Scribbly Gum | 110 | No |
| 23 | *Eucalyptus racemosa* | Scribbly Gum | 190 | No |
| 24 | *Corymbia intermedia* | Pink Bloodwood | 120 | No |
| 25 | *Eucalyptus racemosa* | Scribbly Gum | 120 | No |
| 26 | *Angophora woodsiana* | Rough-barked Apple | 210 | No |
| 27 | *Corymbia intermedia* | Pink Bloodwood | 280 | No |
| 28 | *Eucalyptus racemosa* | Scribbly Gum | 210 | No |
| 29 | *Eucalyptus racemosa* | Scribbly Gum | 200 | No |
| 30 | *Eucalyptus racemosa* | Scribbly Gum | 120 | No |
| Percent trees with scats | | | | 10.00 |

| 2017 SAT 3 | | | | |
|---|---|---|---|---|
| **Date:** | **22nd June 2017** | | | |
| **No.** | **Species Name** | **Common Name** | **DBH** | **Scats** |
| 1 | *Corymbia intermedia* | Pink Bloodwood | 600 | Yes |
| 2 | *Eucalyptus siderphloia* | Grey Ironbark | 900 | Yes |
| 3 | *Acacia leiocalyx* | Early Black Wattle | 160 | Yes |
| 4 | *Corymbia intermedia* | Pink Bloodwood | 340 | No |
| 5 | *Acacia leiocalyx* | Early Black Wattle | 160 | No |
| 6 | *Acacia leiocalyx* | Early Black Wattle | 200 | No |
| 7 | *Corymbia intermedia* | Pink Bloodwood | 710 | No |
| 8 | *Pinus elliottii* | Slash Pine | 600 | No |
| 9 | *Corymbia intermedia* | Pink Bloodwood | 110 | No |
| 10 | *Corymbia intermedia* | Pink Bloodwood | 130 | No |
| 11 | *Corymbia intermedia* | Pink Bloodwood | 190 | No |
| 12 | *Corymbia intermedia* | Pink Bloodwood | 170 | No |
| 13 | *Eucalyptus siderphloia* | Grey Ironbark | 140 | No |
| 14 | *Corymbia intermedia* | Pink Bloodwood | 160 | No |
| 15 | *Corymbia intermedia* | Pink Bloodwood | 160 | No |
| 16 | *Corymbia intermedia* | Pink Bloodwood | 150 | No |
| 17 | *Corymbia intermedia* | Pink Bloodwood | 140 | Yes |
| 18 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 19 | *Eucalyptus siderphloia* | Grey Ironbark | 130 | No |
| 20 | *Eucalyptus siderphloia* | Grey Ironbark | 160 | No |
| 21 | *Corymbia intermedia* | Pink Bloodwood | 150 | No |
| 22 | *Acacia concurrens* | Black Wattle | 140 | No |
| 23 | *Corymbia intermedia* | Pink Bloodwood | 160 | No |
| 24 | *Corymbia intermedia* | Pink Bloodwood | 180 | No |
| 25 | *Eucalyptus siderphloia* | Grey Ironbark | 150 | No |
| 26 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| 27 | *Eucalyptus siderphloia* | Grey Ironbark | 140 | No |
| 28 | *Acacia leiocalyx* | Early Black Wattle | 200 | No |
| 29 | *Eucalyptus siderphloia* | Grey Ironbark | 130 | No |
| 30 | *Corymbia intermedia* | Pink Bloodwood | 140 | No |
| Percent trees with scats | | | | 13.33 |

| 2017 SAT 4 | | | | |
|---|---|---|---|---|
| **Date:** | **22nd June 2017** | | | |
| **No.** | **Species Name** | **Common Name** | **DBH** | **Scats** |
| 1 | *Eucalyptus acmenoides* | White Mahogany | 380 | Yes |
| 2 | *Eucalyptus siderophloia* | Grey Ironbark | 240 | No |
| 3 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 200 | No |
| 4 | *Corymbia intermedia* | Pink Bloodwood | 450 | No |
| 5 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 300 | No |
| 6 | *Eucalyptus acmenoides* | White Mahogany | 400 | No |
| 7 | *Corymbia intermedia* | Pink Bloodwood | 370 | No |
| 8 | *Lophostemon suaveolens* | Swamp Box | 200 | No |
| 9 | *Angophora leiocarpa* | Smooth-barked Apple | 200 | No |
| 10 | *Corymbia intermedia* | Pink Bloodwood | 180 | No |
| 11 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 300 | No |
| 12 | *Eucalyptus siderophloia* | Grey Ironbark | 450 | No |
| 13 | *Lophostemon suaveolens* | Swamp Box | 120 | No |
| 14 | *Lophostemon suaveolens* | Swamp Box | 160 | No |
| 15 | *Corymbia intermedia* | Pink Bloodwood | 190 | No |
| 16 | *Corymbia intermedia* | Pink Bloodwood | 230 | No |
| 17 | *Corymbia intermedia* | Pink Bloodwood | 190 | No |
| 18 | *Corymbia intermedia* | Pink Bloodwood | 350 | No |
| 19 | *Corymbia intermedia* | Pink Bloodwood | 260 | No |
| 20 | *Eucalyptus acmenoides* | White Mahogany | 230 | No |
| 21 | *Lophostemon suaveolens* | Swamp Box | 200 | No |
| 22 | *Eucalyptus acmenoides* | White Mahogany | 270 | No |
| 23 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 110 | No |
| 24 | *Corymbia intermedia* | Pink Bloodwood | 170 | No |
| 25 | *Eucalyptus siderophloia* | Grey Ironbark | 220 | No |
| 26 | *Eucalyptus acmenoides* | White Mahogany | 440 | No |
| 27 | *Eucalyptus acmenoides* | White Mahogany | 250 | No |
| 28 | *Eucalyptus seeana* | Narrow-leaved Red Gum | 270 | No |
| 29 | *Eucalyptus acmenoides* | White Mahogany | 400 | No |
| 30 | *Eucalyptus acmenoides* | White Mahogany | 320 | No |
| Percent trees with scats | | | | 3.33 |