Department of Transport and Main Roads

Queensland
Good jobs
Better services
Great lifestyle

Source: © State of Queensland

Manual

Fauna Sensitive Transport Infrastructure Delivery
Chapter 5: Planning and design

June 2024

Queensland Government

Translating and interpreting assistance

The Queensland Government is committed to providing accessible services to Queenslanders from all cultural and linguistic backgrounds. If you have difficulty understanding this publication and need a translator, please call the Translating and Interpreting Service (TIS National) on 13 14 50 and ask them to telephone the Queensland Department of Transport and Main Roads on 13 74 68.

Feedback

Please send your feedback regarding this document to: tmr.techdocs@tmr.qld.gov.au

Key Points

- Commonwealth and State legislation and policy contributes significantly to Fauna Sensitive Transport Infrastructure Delivery (FSTID) in Queensland.
- In order to accurately quantify ecological factors at a project site, an appropriate level of assessment must be completed by suitably qualified and experienced consultants, in accordance with the Department of Transport and Main Roads Terms of Reference and State and Commonwealth targeted species guidelines.
- The ecological impact assessment informs the management hierarchy (i.e. avoidance, minimisation, mitigation, offsetting, and compensation) measures relevant to design of the project.
- Choosing the right management measure for a project is dependent on several factors such as the fauna species present, potential project-related impacts, surrounding landscape and existing vegetation and habitat, local and broad scale ecological connectivity, geology, and land use, as well as the cost to construct and/or maintain the proposed mitigation measure.
- The early development of Specific, Measurable, Achievable, Relevant and Time-framed (SMART) goals is important in monitoring, evaluation, reporting and adaptive management for FSTID now and in the future. It can play a vital role in influencing outcome-based conditions of approval where offsets are conditioned by the Commonwealth Government.

Contents

Tables

Figures

Case Studies

1 Introduction

The assessment of ecological impacts is part of the Transport and Main Roads environmental assessment process (Chapter 1) which starts as early as possible in project lifecycle.

During the concept and development phase of a project it is important to identify ecological factors such as common and threatened fauna species present within the project area, how the project will potentially impact surrounding fauna populations, habitat, and fauna movements, and potential solutions to avoid, minimise, or mitigate these impacts and maximise benefits to fauna.

2 Applicable legislation

2.1 Legislation and policy

All Australian native fauna and vegetation is protected to varying levels under both Commonwealth and State legislation. Species may be listed as threatened under either Commonwealth legislation, State legislation, or both. The Commonwealth and/or State legislative requirements for transport projects varies depending on the legislation, the threatened status of the species affected and the level of impact (e.g. impact assessment, approvals pathway, offset calculations). The following summary (Table 2.1) includes the most relevant pieces of legislation to fauna management and is not a comprehensive list of all the legislation that may be triggered by an infrastructure project.

Table 2.1 – Summary of relevant environmental legislation and policy

Legislation / Policy title	Description
***Environment Protection and Biodiversity Conservation Act* 1999**	The *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) is the key piece of environmental legislation for Australia. It establishes a requirement for Commonwealth environmental assessment and approval for actions that are likely to have a significant impact on any Matter of National Environmental Significance (MNES). There are currently ten MNES listed under the EPBC Act. Those most relevant to FSTID are migratory and threatened fauna, threatened flora, and threatened ecological communities. Under the EPBC Act, species listed as Extinct in the Wild, Extinct, Critically Endangered, Endangered, Vulnerable and Migratory are subject to offset requirements (Section 4.3) when a project results in a significant residual impact. The EPBC Act *Environmental Offsets Policy* (2012) (EO Policy) outlines the Commonwealth Government's approach to the use of environmental offsets under the EPBC Act. This policy provides a framework on the use of environmental offsets under the EPBC Act including when offsets are required, how offsets can be delivered, and the framework under which they operate.

Legislation / Policy title	Description
***Nature Conservation Act* 1992**	The Queensland *Nature Conservation Act 1992* (NC Act) and subordinate legislation including the Nature Conservation (Animals) Regulation 2020 (Animals Reg.) are intended to protect all native fauna occurring in Queensland, as well as providing a framework for the management of protected areas. The Animals Reg. lists species that are threatened (Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, and Near Threatened) in Queensland. <u>Koalas</u> Impacts to koala (*Phascolarctos cinereus*) habitat from state government infrastructure projects in South East Queensland may also need to be offset in accordance with the *State Government Supported Infrastructure – Koala Conservation Policy*. Specific koala management measures are also outlined within the NC Act *Nature Conservation (Koala) Conservation Plan* 2017*,* including additional requirements for koala habitat clearing within South East Queensland (koala district A) as well as Bundaberg, Cherbourg, Fraser Coast, part of Gladstone, Gympie, part of North Burnett, part of South Burnett and part of Toowoomba (koala district B).
***Planning Act* 2016 and *Fisheries Act* 1994**	A waterway is defined in the *Fisheries Act* 1994 and includes a river, creek, stream, watercourse, drainage feature or inlet of the sea. Waterways are fish habitats and include both permanent, ephemeral and periodically inundated fresh and tidal waters. A waterway barrier work is a dam, weir or other barrier across a waterway if the barrier limits fish stock access and movement along a waterway. Further information on waterways and waterway barriers can be found here. Development involving constructing or raising waterway barrier works is assessable under the *Planning Act* 2016 unless it is accepted development. Waterways in Queensland have been categorised into colours to help determine design elements for accepted development for operational work that is constructing or raising waterway barrier works. Where works cannot comply with the accepted development requirements, the works will require a development approval under the *Planning Act* 2016. A development application is required to meet the legislative assessment benchmarks of the State Development Assessment Provisions (SDAP) for State Code 18 to achieve a development approval for constructing or raising waterway barrier works. The performance outcomes of State Code 18 should be addressed in a development application with reference to the SDAP Guideline.

Legislation / Policy title	Description

Transport and Main Road *Environmental Sustainability Policy*	The Transport and Main Roads *Environmental Sustainability Policy* sets a clear vision for environmental sustainable management which aligns with our stakeholder expectations, including reducing our environmental footprint and building increased network resilience to climate change.
	The policy includes the following objectives that are directly relevant to FSTID:
	• Adopt a best practice, cost-effective approach of 'avoid, minimise, mitigate and offset' to manage environmental impacts associated with all aspects of Transport and Main Roads' activities to achieve the benefits of this policy and comply with legislative and policy requirements.
	• Protect the environment by moving beyond compliance in encouraging innovative solutions to minimise Transport Main Roads' environmental footprint and embed environmentally sustainable practices in the ways we work by:
	  ▪ reducing the impacts of our transport operations, both directly and indirectly, on the environment, and
	  ▪ identifying and developing opportunities for restoration and conservation of areas of significant environmental value within the transport network.

Transport and Main Roads *Cassowary Conservation Management Plan*	The *Cassowary Conservation Management Plan* outlines a framework for consistency in project management and public awareness to reduce road strikes and improve cassowary conservation.

The specific environmental factors present at the project site will determine the statutory permits and approvals required under each of the legislative instruments outlined in Table 2.1. Determining and assessing the relevant environmental factors for a project is further discussed in Section 3.

3 How to quantify the ecological factors at a project site

This section provides general information on how to identify the ecological factors present within a project site to inform FSTID. This section does not provide instructions on how to conduct an ecological assessment, but rather outlines:

- What a detailed assessment should include.
- Considerations for the impact assessment.

In the Transport and Main Roads environmental assessment process an initial desktop assessment is completed to determine the level of risk for each environmental factor. The scope of the initial desktop assessment is described in C7557 *Terms of Reference for Preliminary Environmental Assessment*. An output of the Preliminary Environmental Assessment (PEA) is a recommended scope for the detailed assessment. The purpose of the detailed assessment is to gain an understanding of the ecological factors present within a project site. The scope of a detailed assessment is described in C7558 *Terms of Reference for Review of Environmental Factors*.

The scope of detailed assessments is grouped into three levels:

0. Desktop assessment.
1. Standard field assessment.
2. High-risk field assessment.

The report that is prepared for the detailed assessment is referred to as a Review of Environmental Factors (REF). A detailed assessment should be undertaken by a team of suitably qualified and experienced people. Detailed assessments should be conducted as early in the project lifecycle as possible. Constraints that are not identified during the concept and development phase can be financially costly and lead to delays in project approvals and construction, including potentially halting construction once started (Case Study 5.1).

In the Transport and Main Roads environmental assessment process the management measures to address impacts are documented in the Environmental Management Plan (Planning) (EMP(P)). The following are the reasons why the management measures are documented in the EMP(P) rather than in the REF:

- To efficiently document all environmental management actions for the person or team that will be responsible for them.
- To be able to see all recommended management actions in one place as management actions for different environmental factors can often conflict and there will need to be compromise.

The components and methods involved in an ecological assessment and determination of fauna mitigation measures differ based on site-specific factors and are discussed in the remainder of this chapter.

3.1 Desktop assessment

Desktop assessments are searches of existing ecological information, including Commonwealth, State, and local databases, other publicly available records and potentially non-public records. Desktop assessment could also include a literature review including familiarisation of research projects or recent scientific literature relating to fauna in the locality and on the type of project. Detailed literature review and expert consultation may also be sought based on the results of the initial or subsequent field assessments.

3.2 Standard field assessment

Standard field assessment are basic field surveys or observations. The main purpose of standard field assessment is to confirm the accuracy of desktop assessment results and collected additional information to supplement the desktop assessment. Standard field assessments are generally limited in duration and use non-invasive survey techniques.

3.3 High-risk field assessment

High-risk field assessments are conducted where detailed information is necessary to determine impacts and develop mitigation measures. As high-risk field assessment must be completed by a suitably qualified person, they are not completed by a Transport and Main Roads Environmental Officer, rather this service is externally procured. The C7558 *Terms of Reference for Review of Environmental Factors* is used as the basis for external briefs for detailed assessments. Briefs for detailed assessments must be customised for projects to ensure that the high-risk field assessments will collect sufficient information to make an assessment for the species that are present in the project area.

Survey techniques, technologies, guidelines, and best practice protocols are constantly evolving as technology improves and greater knowledge is gained. For this reason the C7558 *Terms of Reference for Review of Environmental Factors* makes allowance for service providers to modify the assessment methodology. Service providers of high-risk field assessments are expected to consult with other specialists, review current best practice and confirm current statutory requirements for the work that is requested by Transport and Main Roads. Appendix A of this document can be used as a guide for suitable survey methods for detailed assessments.

Numerous Commonwealth and State survey guidelines have considered the survey method and effort required to be able to calculate the likelihood of detecting a species if it occurs at a site, and these should be used to determine the survey method and survey effort. These guidelines include:

- Department of Climate Change, Energy, the Environment and Water (DCCEEW) Survey Guidelines for Nationally Threatened Species (includes separate guidelines for orchids, bats, birds, frogs, fish, mammals, and reptiles).
- Department of Environment and Science (DES) Terrestrial vertebrate fauna survey guidelines for Queensland.
- DES Targeted species survey guidelines. These survey guidelines complement the federal Survey Guidelines for Nationally Threatened Species, with species specific guidelines available for 27 species listed as threatened under the NC Act.
- Survey Guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the *Environment Protection and Biodiversity Conservation Act* 1999, Department of Sustainability, Environment, Water, Population and Communities, 2011.

Field surveys also provide an opportunity for baseline data collection to support the development of SMART goals for the project (Section 5.1) and ongoing research and monitoring of fauna (see Section 6 and Chapter 3). Reliable evaluation of the impacts of a project and the use and effectiveness of mitigation typically require the collection of data before the impact or mitigation measures has been implemented and often requires the collection of data at sites being impacted and at unimpacted or control sites further away. It is important to carefully plan and undertake surveys if they are to also form part of longer-term monitoring to ensure they are able to reliably answer the aims or questions of long-term monitoring. Chapter 3 describes important study design and methodology considerations to undertake cost-effective research, monitoring and evaluation.

Survey effort (the overall duration of surveys and number of survey visits / traps etc., spent surveying a site or searching for a species) is a critical consideration when planning a field survey. Survey effort is especially relevant for rare or cryptic threatened species because the consequences of concluding that such a species is likely absent, when in fact it is present, are significant (Case Study 5.1).

The survey effort should be primarily based on the survey guidelines listed above, as well as expert consultation where required, to ensure an adequate survey method (see Appendix A) and amount of time has been spent surveying for threatened species. Failing to survey appropriately for threatened species that have been determined to have a moderate or higher likelihood of occurring at a site, without reasonable justification, could result in the State or Commonwealth department applying the precautionary principle to potential project related significant impact determinations. That is, a determination that a threatened species or matter will be significantly impacted may be made because there is insufficient survey effort to conclude it is likely absent and/or not impacted.

The amount of survey effort required to be 90% confident that a species is absent can be estimated and these calculations should be considered when there is uncertainty about the sufficiency of survey effort. Consultation with experienced ecologists with expertise in survey design and statistical analyses will assist in undertaking these calculations.

The required surveys for fish species present at the project site should not be limited to threatened species but to the fish community that will potentially be impacted by the proposed project. Surveys should utilise a comprehensive suite of survey techniques suited to the section of waterway and be undertaken across a representative range of habitats, seasons, and stream flow conditions.

Seasonal surveys may also be required to accurately determine the presence or absence of a threatened species which may be absent or more cryptic during certain times of the year (e.g. migratory birds and fish, amphibian calling periods, plant flowering and fruiting periods). There is no common optimal survey season for all species and surveys should be undertaken during environmental conditions that are most likely to capture the presence of the species, based on knowledge of their behavioural and movement requirements. For example, some waterways have ephemeral or intermittent flows that fish utilise following substantial and prolonged periods of rainfall.

In summary, enough survey effort using suitable survey techniques is required to be reasonably confident in all conclusions about the presence or absence of a rare or threatened species.

3.4 Impact assessment and reporting

The information that is collected in the various assessments should be compiled in the REF. The REF should also include an impact assessment of the project.

The impact assessment should be based upon the potential extent of habitat loss resulting from both the construction and operational phases of the project as well as all other direct and indirect impacts (Chapter 4). The impact assessment should demonstrate a thorough knowledge and understanding of the project and describe how the construction and operational phases of the project may impact fauna over the short and long term, with consideration of:

- Species, guilds, or fauna communities impacted by the project (Section 3.4.1).
- The presence and condition of impacted habitat for each species, guild or community (Section 3.4.2).
- The REZ in terms of current level of habitat degradation and potential changes due to the project (Section 3.4.3).
- Potential disruption of movement along wildlife corridors and fragmentation of populations (Section 3.4.4)
- Risk of impact during construction (e.g. fauna mortality during tree clearing); Risk of operational impacts (e.g. Wildlife-Vehicle Collisions (WVC) (Section 3.4.7).

A thorough impact assessment should discuss the threatened species potentially impacted by the project in addition to discussing impacts to least-concern species groups and breeding habitats.

Impacts on unlisted species should also be assessed and included in reporting because those species may play important ecological roles that could result in flow-on effects to listed species.

The impact assessment needs to identify the importance of the impacts to allow for the prioritisation of management actions. The relative importance of different threatening processes on species is often identified in impact assessment guides for the species and should inform management actions. For example, the mitigation for a transport project will differ if the primary threat to a species is increased mortality due to WVC, climate change impacts, barrier effects or disease. Recommended management options must be documented in the EMP(P) not the REF. Choosing management actions and documenting them is further discussed in Section 5.

The impact assessment may include calculations of impacts to a quantifiable area (e.g. in hectares) for each habitat type.

Where possible, cumulative impacts for a committed program of works should be considered. Very large projects, such as a major highway realignment, may be broken into smaller projects which will be designed and constructed separately. In this case, the cumulative impact of the larger project should be considered. Cumulative impacts should not be considered for uncommitted projects.

Case Study 5.1 – Emergency translocation of the Purple Copper Butterfly during a road realignment project

In 2004, the purple copper butterfly (*Paralucia spinifera*) was unexpectedly discovered during the advanced stages of a road realignment project near Lidsdale in the Central Tablelands of New South Wales, leading to the requirement for emergency translocation of the population[1].

The presence of the EPBC Act listed species was not identified during the Review of Environmental Factors. It is unclear why they were not detected, but the species is small and only active during certain times of year and under specific climatic conditions. The presence of a population of the butterflies was found by an ecologist doing a landscaping assessment during construction.

The Roads and Traffic Authority (now Transport for New South Wales) implemented a stop works protocol, halting construction while a butterfly management plan was prepared and implemented. The management plan involved a complex multi-staged approach including:

- Translocating caterpillars and an associated ant species to a new site.
- Provisioning of ‘bridging habitat’ involving short term replacement of larval food plant in the disturbed area while a relocation method could be developed.
- Rehabilitation at the new site to improve habitat quality for the species.

The translocation program was considered a success for the species, however construction was delayed with significant cost implications. Although a large portion of the road realignment had already been constructed, late-stage design changes were implemented including moving an intersection, shortening an overtaking lane, and steeper road batters to reduce further clearing of the butterfly habitat by approximately one third of what was initially planned.

[1] (Mjadwesch and Nally 2008)

Figure 3.4 – The purple copper butterfly

Source: Mjadwesch and Nally (2008).

3.4.1 Identifying the target species, guild, or community impacted by the project

The detailed assessment will typically include a list of all the species that have been observed during the detailed assessment or that are likely to be present based on the habitat that has been identified. Other species occurring further from the project but could be impacted when they traverse the project area, such as when migrating or when they visit the area in response to flowering or fruiting events should also be identified. This list of species needs to be prioritised to aid the development of management actions. The species profiles in Chapters 9 to 21 provide a useful way to group species as each profile includes specific impact and management discussion.

Rare and threatened species are typically priorities for management actions as they are generally the focus of environmental legislation. However common species, particularly those that perform important ecological functions, need to be considered in the development of management actions. Focusing on a single species can result in management actions that exacerbate impacts to other species and thus impacts to all fauna species should be considered to ensure the best overall outcome.

There are situations where the priority species is uncommon or even extirpated at the project site. Where this occurs, it is important to assess if the rarity of such a species is due to the ongoing presence of the transport infrastructure, perhaps due to decades of mortality from WVC. Management measures at the project site as well as retrofits (Chapter 8) elsewhere should be considered if they support the recovery of the species.

3.4.2 Presence and condition of fauna habitat

The presence and quality of habitat should be considered during the impact assessment, as the presence of habitat is an indicator of fauna species presence or potential future presence. For example, arboreal mammals (e.g. possums and gliders) prefer areas of mature woodland and forest with connected canopy (Chapter 14) while many small terrestrial mammals (e.g. bandicoots, antechinus, native mice) and reptiles prefer a groundcover of shrubs, grasses, logs and woody debris, or leaf litter (Chapters 15 and 17).

Desktop assessments can help to identify vegetated areas and modelled fauna habitat that may support wildlife and their movement which can then be avoided. These areas can be identified using:

- State mapped regulated vegetation (regional ecosystems) to identify remnant vegetation.
- State mapped regulated vegetation essential habitat layers.
- State mapped connectivity corridors.
- State mapped waterways.
- Aerial and/or satellite imagery.

The following datasets may also be available for specific local government areas:

- Local mapped connectivity / biodiversity / wildlife corridors.
- Local mapped waterway corridors.
- Local mapped wetlands.
- Local mapped environmental management areas.
- Local mapped fauna habitat models.

High quality remnant vegetation with low levels of disturbance and weeds and containing diverse microhabitats such as leaf litter and logs, is typically high value habitat and can provide connectivity for fauna. Additionally, vegetation in larger patches or wider strips and when contiguous with adjacent areas of native vegetation is also highly likely to be utilised by fauna. Riparian vegetation along rivers and other waterways are also highly important as they often support habitat of a higher quality and higher productivity than elsewhere in the landscape and are especially important as refuges during drought. These areas of field-verified habitat are likely to be suitable for locations to install wildlife crossing structures for both threatened and common fauna species.

The detailed assessment should include maps of habitat for priority species as well as common species groups identifying both high quality habitat and degraded habitat.

The assessment should include known areas of quality habitat, such as National Parks and conservation reserves. As a minimum these areas should be identified on maps because habitat quality is linked to fauna movement which is further discussed in Section 3.4.4. Detailed assessments in known areas of quality habitat may be useful to inform species density which will in turn help identify the REZ for species in the project area.

3.4.3 Consideration of the road- and railway-effect zone

The road- and railway-effect zone (REZ) is the distance or area over which the effects of the road or railway extend into the surrounding landscape and impact wildlife[2]. Descriptions of the size of the REZ and factors contributing to it are discussed in detail in Chapter 4. Currently there is a lack of published information on the REZ for specific species.

The REZ can be estimated using a range of data, such as estimates of WVC rates, modelling of noise and light impacts, and other descriptions of habitat degradation. Modelling of lighting impacts should include fixed lighting and vehicle headlights. By necessity, any noise modelling would be based on

[2] (van der Ree et al. 2015b)

human perception of noise but take into account understanding of fauna responses to different frequency and volume of noise. The REZ should be overlaid with habitat mapping to identify areas of habitat that are degraded due to REZ impacts.

It is important to consider the REZ for threatened species during the impact assessment of a project, because the long-term indirect loss of habitat may be easily overlooked.

It is easier to apply the REZ to new projects than to upgrades of existing roads or railways. In these contexts, it can be difficult to calculate the proportion of the REZ that is caused by the upgrade compared to what was existing. However, analyses which relate the severity or scale of the REZ to design parameters of the project (e.g. number of lanes, traffic volume etc) can be used to calculate the proportional increase in the REZ. Nonetheless, recognising that the REZ exists and impacts fauna and ecosystems far from the infrastructure is helpful to calculate impacts and inform mitigation options, including for programs to mitigate existing impacts.

3.4.4 Fauna movement patterns

One of the major impacts of transport infrastructure is reducing or preventing the movement of fauna across the landscape (Chapter 4). Fauna movement patterns should be considered and assessed for priority species and common least-concern species.

The impact assessment should identify the types of movement (Chapter 2) that needs to occur and the likely pathways for that movement. The importance of different movements needs to be mapped and prioritised to assist in the development of management actions. Mapping of WVC will assist in identifying areas where movement is being attempted, however lack of WVC records should not be used as evidence that a movement pathway is low priority.

The impact of fragmenting populations needs to be discussed to provide context for the need to maintain movement patterns.

There are numerous approaches to identifying and prioritising movement corridors, including:

- ‘Eyeballing’ the landscape and identifying obvious ‘corridors’, such as wherever suitable habitat (Section 3.4.2) crosses the project. This simple approach may be appropriate for single-species problems and where sufficient information about that species is known. This approach can be quite subjective, especially when multiple species are involved.
- Use already identified and mapped ‘bioregional’ or local corridors across the study area as part of the desktop assessments.
- Undertake an objective, evidence-based approach using Geographic Information System (GIS) to identify and prioritise important movement corridors for fauna connectivity.

3.4.5 Existing corridor mapping

State and local government mapping of corridors should be identified during the desktop assessments as primary movement pathways as these routes represent both actual and strategic objectives for wildlife movement. Corridors mapped by local government consider future planned land use so maintaining connectivity along those routes should be a priority for management actions. Where there is a conflict between local and state government corridor mapping, local government mapping should be prioritised as it considers future land use.

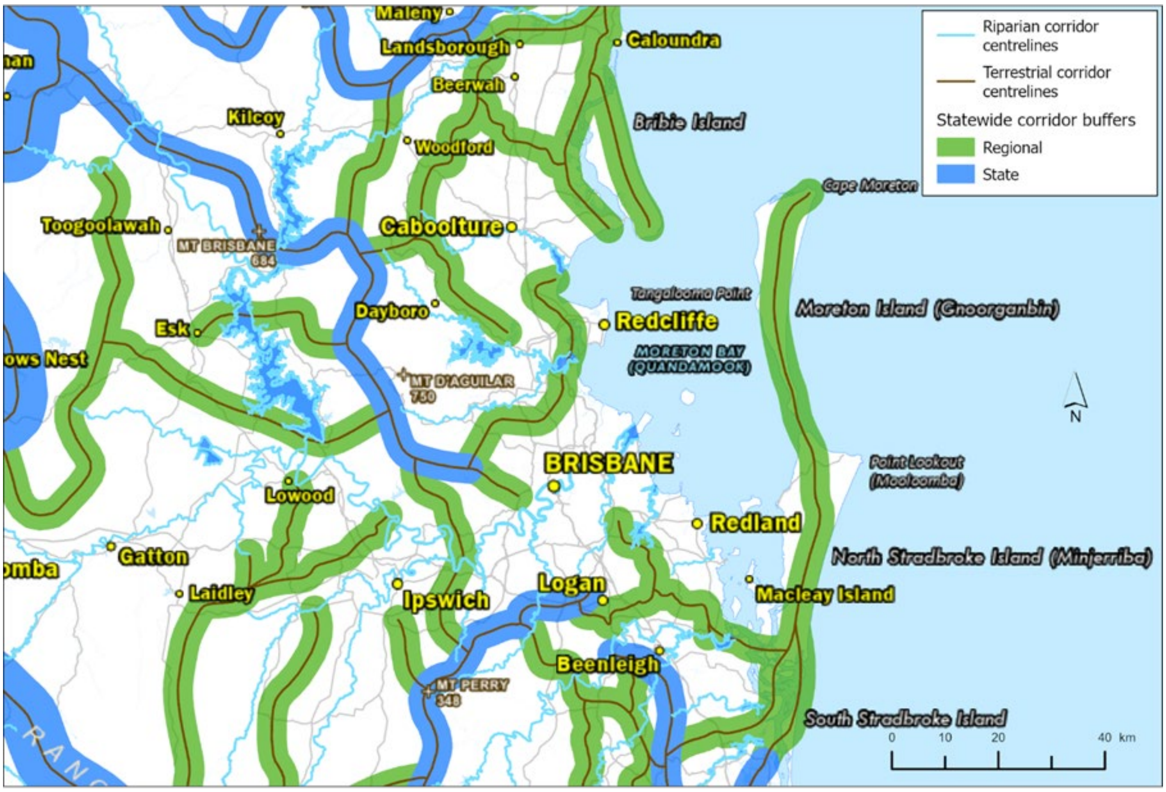
However, the efficacy of these corridors for supporting the movement of all target species should be assessed prior to adopting them because their suitability for all target species is dependent on the methodology used to identify the corridors and the specific requirements of each species. In addition, these corridors are based to a large extent on habitat remaining after clearing, which may not be suitable for the movement of all species.

Biodiversity corridors have been identified for riparian and terrestrial habitat across Queensland (i.e. Queensland Statewide Corridors) and for many local areas throughout Queensland[3]. A project that intersects a state-mapped biodiversity corridor is likely to have a significant impact on the movement, dispersal, and migration of fauna at regional spatial scales. This mapping indicates major fauna connectivity areas and can assist in locating higher-priority areas for maintaining fauna movement. However, this mapping is primarily designed to be used at a regional scale and does not necessarily consider local landscape features that may affect fauna movement. Therefore, the importance of these corridors for fauna movement needs to be assessed for the project using a combination of:

- GIS data.
- Desktop and field verified vegetation mapping.
- Desktop and field verified fauna occurrence and distribution.
- Connectivity and fauna movement modelling.

[3] Queensland Globe, State Government of Queensland. Queensland Globe (information.qld.gov.au)

Figure 3.4.5 – State-mapped bioregional biodiversity corridors in South East Queensland



Source: © *State of Queensland 2024 Based on [Dataset – Queensland statewide corridors] (Department of Environment and Science) and other state government datasets.*

3.4.6 Connectivity modelling

There are several ways of conducting connectivity modelling that vary in approach, methods, and complexity (Table 3.4.6). However, they should all provide an objective, transparent, and repeatable method to test the reliability of existing corridor mapping and/or identify and prioritise new linkages. This is important because it enables the underlying assumptions to be tested and critiqued, including the source and destination patches, the ease with which species can move across different land uses, the role of different types of barriers, and the size of gaps that a species can cross.

The use of a modelling approach to identify connectivity is recommended in situations where multiple linkages exist and need to be prioritised.

Transportation agencies rarely have control over adjacent land and the tenure and management of such areas should be considered in the development of connectivity strategies. This is important because future land-use changes can have serious implications for the management of the transportation reserve and the movement of fauna. For example, land use changes in neighbouring properties can inadvertently direct more fauna to cross the road or railway, resulting in increased rates of WVC. Similarly, changes to adjacent properties may lower the size of fauna populations and reduce the rate of use of crossing structures.

Local government planning schemes should be reviewed to confirm current and future land use. This will help to ensure the long-term success and viability of fauna mitigation structures.

Table 3.4.6 – Common modelling approaches to identify connectivity linkages

MODEL TYPE	DESCRIPTION
Least-cost path	Estimates the surface area of the least-cost movement path from one location to another that an individual or process would likely take, assuming knowledge of the source and destination location and the ecological 'cost' or 'difficulty' of traversing the intervening area. The ecological cost is a combination of the energetic cost to pass through an area and the risk of dying while doing so.
Circuit theory	Adapted from electrical circuits, circuit theory identifies the degree of connectivity provided by a landscape by modelling random walks of individuals across a range of surfaces (e.g. habitat types, different land uses) with varying levels of resistance.
Graph theory	The study of graphs that represent a network of interconnected objects, and is used in many approaches to connectivity modelling, including least-cost path and circuit theory. Graph theory can be used to prioritise landscape linkages.
Individual-based modelling	Simulates the movement path of individuals many hundreds or thousands of times following a series of 'decision' rules that are based on empirical field data or expert knowledge. The relative frequency of use of certain areas over many runs is calculated and preferred movement paths are identified.

Source: Hilty et al. (2020) and references therein.

3.4.7 Identifying wildlife-vehicle collision hotspots

The location of WVC hotspots identifies where fauna are currently unsuccessfully attempting to cross the road, but not where they are:

- Successfully crossing, or
- Where animals would attempt to cross but the local population has declined to a level where there are insufficient animals in the population attempting to cross.

WVC and mortality data can be obtained from a variety of sources, including:

- Systematic surveys commissioned by transportation agencies to identify roadkill hotspots and quantify collision rates for a variety of reasons, such as project planning, baseline data, and in response to community concerns.
- Systematic and/or incidental observations made by community members, including from fauna rescue and wildlife care organisations.
- Species specific databases such as KoalaBase.
- Clean up records from road and rail maintenance crews.
- Local government observations or customer reports.
- Collision data reported by train drivers.
- Insurance claims records from insurance companies (for those collisions where claims are made).
- Police records (usually just for those collisions resulting in serious injury or fatalities to motorists).

- Targeted and systematic surveys conducted as research projects, often by academic researchers or postgraduate students[4].
- Inferring mortality via population surveys using capture-mark-recapture or resight to estimate survival or longevity in different populations, such as near and far from a road or railway[5].

There is high variability in the spatial extent, target species, temporal, and spatial accuracy of the data among the different sources. The limitations and biases inherent in each data set should be carefully considered before drawing conclusions from the data.

A range of statistical methods are available to identify WVC hotspots and the optimal approach for each situation is primarily influenced by the amount and accuracy of the WVC dataset. The simplest methods calculate the density of collisions over time and space, which can then be correlated with various landscape, habitat, and infrastructure variables to identify features that best explain or cause WVC. In the absence of such data for the specific section of road or railway being investigated, it may be feasible to use patterns obtained from other locations and apply them to the area without adequate data. In these situations, an understanding of the relationship between rates of WVC and relevant explanatory variables can be used to model and predict what is likely to occur in the unstudied area.

WVC can also occur during construction from collision with construction vehicles and on adjacent roads and railways (Chapter 7), and these impacts should also be identified and assessed in the REF and the EMP(P).

WVC hotspots can also be used to prioritise WVC as an impact to be managed. The rate of WVC should be considered with respect to the abundance or density of the local fauna population, other threatening processes, and changes in fauna movement patterns caused by the proposed transport project.

4 The management hierarchy

The management hierarchy (also often referred to as the mitigation hierarchy) should be applied to manage the impacts of transport infrastructure.

For all projects, adjacent existing land use and future planned development should be considered to the extent possible when planning or implementing the management hierarchy, as current and future land-uses will greatly influence the efficacy of many mitigation measures.

The management hierarchy (Figure 4) should be applied in the following order to achieve no net loss and ideally a net gain in biodiversity:

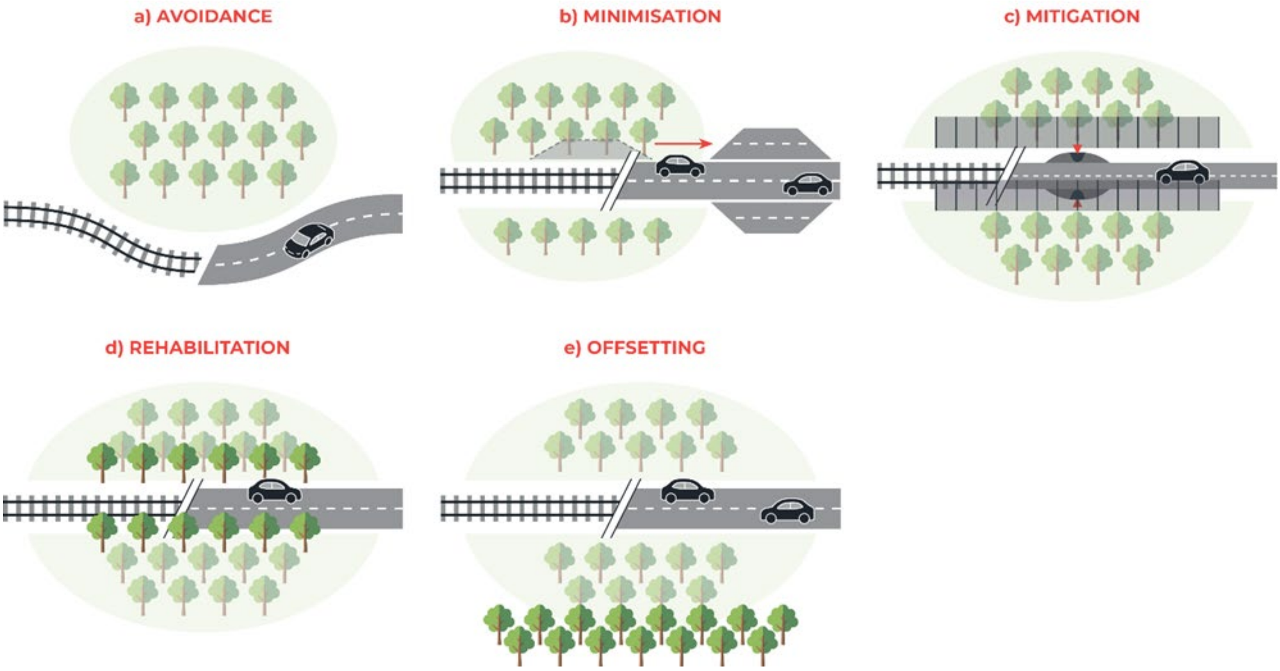
a) Avoidance: can the sensitive area or important ecological feature be sufficiently avoided to result in no impact?
b) Minimisation: if the sensitive area or important ecological feature cannot be avoided, can the potential impact be reduced through design, such as a reduced clearing footprint, re-aligning the project, or moving interchanges or overtaking lanes to another location?

[4] (e.g. Dique et al. 2003, Taylor and Goldingay 2004, Ramp et al. 2006, Nguyen et al. 2019)
[5] (e.g. McCall et al. 2010)

c) Mitigation: for impacts that are unable to be avoided or minimised, can design features be added to reduce the impact? These can include under- or over-passes for wildlife, fencing to prevent wildlife accessing the transport corridor, one-way gates to allow trapped wildlife to leave the fenced transport corridors, and/or wildlife detection and deterrent systems.
d) Rehabilitation or restoration: can the severity or extent of any remaining impacts be lessened through restoration or rehabilitation at the site of impact? Does the size and severity of the REZ mean that rehabilitation should occur away from the project?
e) Offsetting: any residual impacts that remain after working through the previous steps can be offset, where habitat elsewhere is bought and/or managed to achieve conservation gains. Residual impacts can also be compensated – where funds are provided to support activities that can indirectly benefit the impacted entity, such as research. In Queensland, proponents can either deliver State environmental offsets as a land-based offset, a financial settlement offset (monetary payment), or a combination of both.

While the management hierarchy should be implemented sequentially from (a) to (e) (i.e. avoidance first, and lastly offsetting), the final combination of measures for a project will typically include all aspects in the final design.

Figure 4 – Representation of the management hierarchy for transport projects



4.1 Avoidance

Avoidance should always be considered when planning and designing a project and prior to developing minimisation and mitigation strategies. Avoidance also applies across a range of scales, including re-routing the entire alignment to avoid matters of State environmental significance and/or significant areas of biodiversity value, or micro-siting to avoid smaller but still significant habitat features, such as a large old tree or small wetland. The retention of a single large tree could significantly improve the success of mitigation for arboreal mammals (see Chapter 6 and Chapter 14). Maximising the degree to which impacts are avoided can significantly reduce the extent to which impacts need to be minimised, mitigated, offset, or compensated, potentially also reducing costs.

4.2 Minimisation and mitigation

Minimisation and mitigation aim to reduce the severity of impacts of transport infrastructure that are unable to be avoided.

Minimisation focuses on modifications to the design to lessen the overall impact, such as reductions in the project footprint on the impacted matter. Minimisation can also include aspects such as fewer streetlights or lower wattage lighting in sensitive habitats, installation of crash barriers to reduce clearing for safety zones, and the use of road surfaces that produce less noise, and using a bridge rather than culverts for waterway crossings.

Mitigation measures are typically structural features that address specific impacts, such as underpasses that allow fauna movement or noise walls that reduce the REZ. The broad types of mitigation appropriate for transport infrastructure projects are outlined in Section 5, and described in detail in Chapter 6.

Minimisation and mitigation measures should be pragmatic and achievable, as well as appropriate for the level of impact and importance of the species and location. Wherever possible, all efforts to minimise and mitigate impacts should be made prior to considering offsets.

4.3 Rehabilitation and restoration

Rehabilitation and restoration refers to reversing the impacts of a project at the location where it occurred, such as replanting vegetation cleared during construction or restoring the conditions of a waterway after bridge or culvert works. These measures are typically focussed on remediating the specific actions of a project, but can also address existing impacts from previous projects or activities. Rehabilitation and restoration can also be used to enhance the effectiveness of mitigation measures, such as planting vegetation or restoring waterway channels to improve access to wildlife crossing structures.

4.4 Offsetting

Offsetting is implemented when the project results in an acceptable significant residual impact even after avoidance, minimisation and mitigation measures have been implemented. This process is shown in Figure 4.4. Offsets should not be considered until all reasonable avoidance, minimisation and mitigation measures have been considered and implemented.

Offsets should not usually be established adjacent to transport infrastructure if there is a reasonable likelihood that the infrastructure will be expanded in the future, which will require the establishment of a new offset elsewhere. Similarly, the presence of an offset can complicate the future installation of fauna crossing structures if they require vegetation clearing on the approaches, such as ramps leading to a vegetated land bridge. The effectiveness of offsets that are located within the REZ should also be considered.

The project may be subject to mandatory statutory offsets as a condition of project approval when significant impacts to threatened species (or other protected matters) cannot be avoided, or adequately minimised or mitigated.

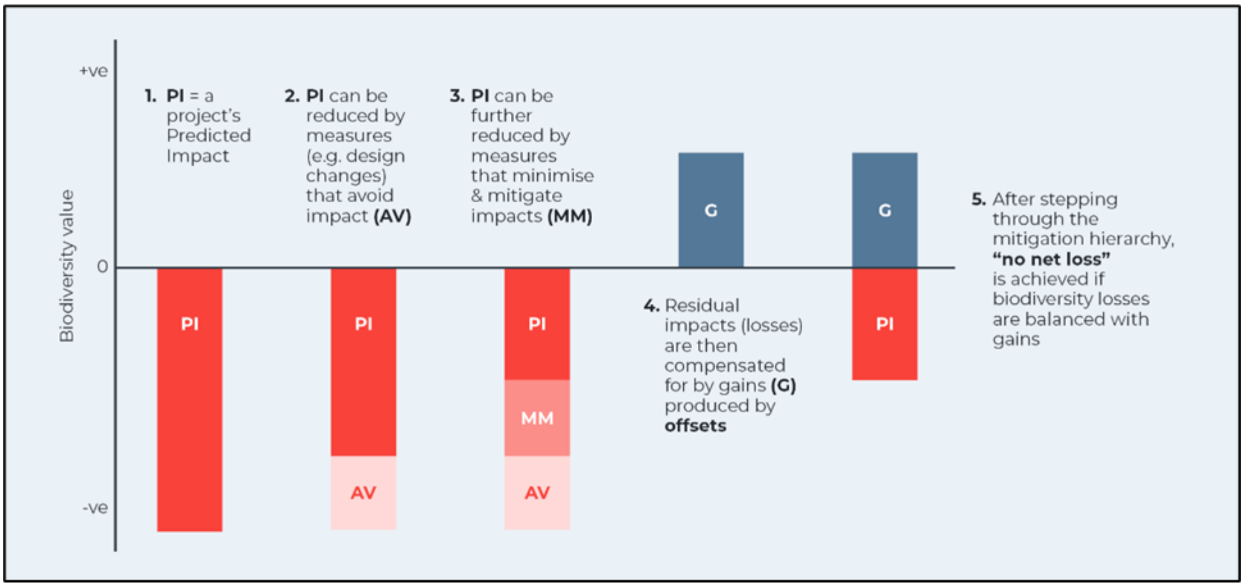
There are different requirements and rules for offsets required under State and Commonwealth legislation and which vary depending on the scale and severity of the impact, the type and threatened status of the impacted entity. Projects should seek expert advice to ensure offsets comply with current requirements.

Implications with offset delivery

The potential challenges of delivering offsets for projects include:

- Identifying suitable land for committing land-based offsets.
- Confirming the availability of offsets (field verification), preparing an offset strategy and offset management plan, and legally securing the land.
- Managing contractors and costs associated with offset protection (e.g. fencing), offset management (e.g. weed control) and offset monitoring and reporting.
- Ensuring sufficient funding for the management of the offsets for up to 20 years or until offset completion criteria are met.
- Ensuring the offsets adequately meet completion criteria to ensure an ecological gain or additional benefit.

Figure 4.4 – The steps of applying the management hierarchy (left to right) and the role of offsets in ensuring 'no net loss'



Source: Chee (2015).

4.5 Enhancing ecological outcomes using sustainability rating tools

Transport and Main Roads aims to be an industry leader in environmental sustainability and protect the environment by moving beyond compliance and encouraging innovative solutions to improving the sustainability of transport infrastructure[6]. Transport and Main Roads currently mandates that all projects over $100 million in value must undertake a sustainability assessment which incorporates climate change criteria. FSTID is a key component of sustainability and embedding FSTID in a project provides opportunities to improve the sustainability rating by considering ecosystem impacts and enhancement during a project.

[6] Environmental sustainability policy (Department of Transport and Main Roads) (tmr.qld.gov.au)

It is important to note that 'chasing sustainability scores' can lead to perverse outcomes by focusing on trivial solutions that don't specifically address the ecological impacts of a project. Nevertheless, when considered and implemented carefully, sustainability rating tools can enhance ecological outcomes and should be considered.

The Infrastructure Sustainability Council (ISC), have developed a widely adopted tool that encompasses numerous economic, social, and environmental criteria based on performance of infrastructure across the concept, development, and implementation project phases. For example, rehabilitation and offsetting can contribute to the ISC Eco-1 rating (Ecological Value), and improvements in connectivity could contribute to the ISC Eco-2 rating (Habitat Connectivity) which rewards maintenance or enhancement of habitat connectivity in the landscape.

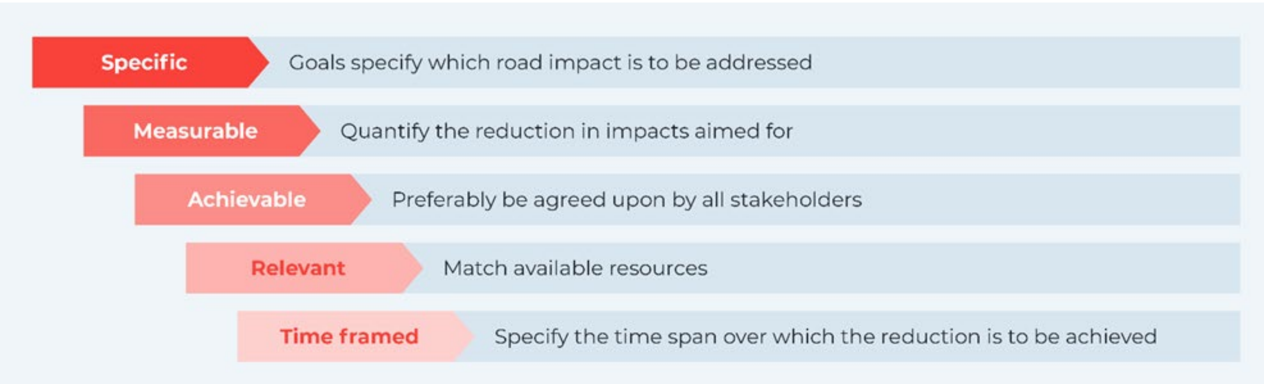
The recent M1 Pacific Motorway upgrade between Burleigh and Palm Beach (B2PB) on the Gold Coast successfully obtained an ISC rating of level 3 (out of 3) for Ecology. B2PB was one of four sections of the Varsity Lakes to Tugun upgrade, all of which involved FSTID for ISC ratings. This rating was awarded due to design initiatives including dedicated fauna underpasses, innovation in noise barrier fauna exclusion devices, inclusion of fish microhabitat structures in fish passageways, and offsets and revegetation targeted to threatened species including the koala, Richmond birdwing butterfly (*Ornithoptera richmondia*), and varied swordgrass brown butterfly (*Tisiphone abeona*). Details on the innovative fauna sensitive road design features are presented in Section 7.

5 How to choose the right fauna sensitive transport infrastructure delivery solution for the project

5.1 Identify priority impacts

An important step during impact assessments is to identify and prioritise impacts to guide the choice of management actions. In early project phases the impacts will only be broadly defined but during the detailed assessment the species-specific impacts are identified and prioritised for management. The highest priority impacts should be refined into SMART goals to assist with developing management action and to measure the success of FSTID. SMART goals are Specific, Measurable, Achievable, Relevant and Time-framed (Figure 5.1).

Figure 5 1 – The key elements of SMART goals for transport projects



Source: Van der Grift et al. (2015).

The ability to set meaningful SMART goals for a project, or a specific part of a project, relies on a comprehensive assessment, knowledge of the likely impacts, and the formulation of sensible and relevant targets. It is important to realise that while SMART goals should be measurable, an absence of data now should not preclude the development and adoption of a specific goal. For example, a lack of knowledge about the current rate of movement, gene flow, or survival of a species does not mean it is not possible to set SMART goals for related impacts.

Example SMART goals for a specific section of a project may include:

- No mortality of koalas (or species X) due to WVC over a specified time period.
- No reduction in the movement of fauna that leads to a demonstrable decline in gene flow of any species within 10 years of the operation of the transport project.
- The target species of fauna are using all suitable crossing structures at rates commensurate with their local abundance and for specific purposes (e.g. home range use, migration, dispersal) within X years of construction.
- Within X years of construction and throughout the operation of the project the home range / dispersal pathway / migration routes of species X will encompass both sides of the road or railway.

The setting of SMART goals is an important process and should be undertaken at a spatial and temporal scale that is relevant for the impact and the solution. In most cases, SMART goals will be applicable to an overall project and to specific parts of a project where there are discrete and unique challenges to overcome. For example, different goals may be applicable to sections of a project which pass through largely cleared farmland compared to another section that passes through a patch of high-quality remnant vegetation. SMART goals can also apply to specific mitigation measures or suites of mitigation measures.

Priority impacts should be identified in the REF and related SMART goals documented in the EMP(P). The environmental assessment process requires that both documents are prepared by suitably qualified people. The annual cost for monitoring needs to be identified so that it can be included in project and program budgets. The cost estimate should be documented in the EMP(P).

5.2 Choosing the optimal management strategy

The optimal solution for a project will address the highest priority impacts within the constraints of the project objectives and budget. The optimal solution for mitigation at a site is typically a compromise of numerous factors, including:

- Whether multiple species and/or ecosystem services can also benefit from the mitigation.
- The cost to construct and/or maintain the proposed mitigation measure(s).
- The net benefit of constructing more less-expensive mitigation measures or fewer more-expensive measures for the same total cost, such as a single vegetated land bridge or multiple terrestrial fauna culverts.
- The distribution and abundance of the priority species and its preferred habitat.
- The mode and speed of movement of the priority species and their sensitivity to noise, light, and other disturbances.

- Topography and whether the road is to be built at grade, in a cutting, or on a structure such as a culvert or bridge – as this influences what can feasibly be built. For example, it is rarely feasible to install an underpass for fauna where the road is in a cutting. Similarly, building an overpass is more difficult where the road is above grade as feasibility depends on the type of overpass and the relative height of the road.
- The tenure and long-term security of the land adjacent to a crossing structure and other types of mitigation (e.g. fauna fencing).
- The degree of certainty that the proposed mitigation measure will be effective and/or can be adaptively modified if ineffective.
- Whether the design already includes structures (e.g. bridges and culverts) for drainage that can be cost-effectively modified to also facilitate the movement of fauna.
- The degree to which the management strategy improves conservation outcomes for the target species relative to other threats on the population.

While avoidance, minimisation, and mitigation measures may increase the construction cost, they can result in a positive cost-benefit over time. For example, studies from North America have demonstrated that the installation of large crossing structures and fauna fencing can be cost-neutral after a few years through avoided repair costs to vehicles and injury and death of motorists and wildlife[7].

5.3 Balancing transport and ecological objectives

The primary objective for transport infrastructure projects is to provide for the safe and efficient transport of goods and people. FSTID requires balancing the primary objectives of transport infrastructure projects with the need to achieve better outcomes for fauna.

There are times when user safety and fauna safety are complementary. For example preventing large (e.g. kangaroos) or threatened (e.g. cassowaries and koalas) species from entering the road or railway can reduce the rate of WVC and damage to vehicles, motorist injury, and fauna mortality.

In other situations, additional engineered safety features, such as guard rail, are required to enable the construction of ecological mitigation measures and achieve motorist safety standards.

5.4 Topographical features

An assessment of the project design, landscape design drawings, topographical maps, and spatial GIS layers from the broader landscape is essential to ensure that management measures are appropriate and cost effective. Identification of topographical constraints from mapping should be verified with site inspections to determine whether proposed fauna infrastructure is feasible once topography and the design of the infrastructure is considered.

Careful planning can increase the likelihood that structures are located to complement topographical features. For example, the cost of excavation may be decreased by using natural undulating areas for fauna underpasses and/or overpasses, where these sites also correspond with animal movement pathways and suitable habitat. In addition, excess fill removed from one area of the project could be

---

[7] (Huijser et al. 2009)

cost-effectively used to build up the height of the road or railway and enabling larger underpasses to be installed.

5.5 Single or multi-species solutions

Avoidance, minimisation, and mitigation solutions that benefit multiple species or communities of species are always preferrable over single-species solutions because they address multiple impacts from the construction and operation of transport infrastructure.

Multi-species solutions are also often more cost-effective than numerous single species solutions. For example, with the right design and inclusion of appropriate furniture, a single bridge underpass or vegetated land bridge can facilitate the movement of birds, bats, amphibians, reptiles, arboreal species, and terrestrial mammals at the one crossing structure.

Perhaps more importantly, solutions that benefit communities and ecosystems will facilitate the persistence and healthy functioning of the whole ecosystem, and not just the survival of a few threatened species. A broad perspective should be adopted when evaluating the suite of alternative management measures.

5.6 How many terrestrial fauna crossing structures are required?

The ecology of the priority species largely influences the number, location, and type of crossing structures required. For example, species with small home ranges and those that require access to resources on opposite sides of the road or railway will require more crossing structures than species with larger home ranges and those that require infrequent crossing. Arboreal mammals that predominantly move through the tree canopy are likely to attempt to cross a road in more wooded areas (Chapter 14). In such cases, the use of connectivity mapping or vegetation mapping discussed in Section 3.4.4 may assist in identifying optimal locations of crossing structure.

The specific ecology of all target species then needs to be considered. For example, possums and gliders readily utilise canopy bridges (Chapter 14) while koalas are more likely to utilise land bridges or underpasses due to differences in their movement patterns and habits (Chapter 13).

In contrast, fauna preferring grassland or very open woodland such as large kangaroos, or reptiles that bask in open areas, may cross the road in areas containing little vegetation. For common and widespread species, such as eastern grey kangaroos (*Macropus giganteus*), methods such as WVC hotspot analysis (Section 3.4.5) may be useful to identify where crossing structures and fencing for these species should be located.

Where possible, crossing structures should be installed as part of a crossing zone, where two or more crossing structures are in relatively close proximity to each other within each zone. This is important because the rate of use of the same types of crossing structures can vary significantly[8], and the reasons for this variation in use are generally unknown. Similarly, the rate of use can vary over time as animals occupy different areas of the adjacent habitat or as habitat conditions change. Therefore, the use of crossing zones builds in some redundancy to ensure that sufficient crossing structures in each area of habitat are available for use over time.

Crossing zones should also ideally include multiple types of crossing structures whenever there is some uncertainty about the effectiveness of different crossing structure types or designs. For example,

[8] (e.g. Soanes et al. 2013, Soanes et al. 2018)

crossing zones for gliders should consider both canopy bridges and glider poles (Chapter 6). An advantage with this approach is that the rate of use of each method can be evaluated after construction and the results can provide a reliable evidence-base to inform future projects (Chapter 3).

6 Why should monitoring, evaluation, reporting, and adaptive management be considered during project planning?

Monitoring, evaluation, reporting, and adaptive management during the delivery and operational phases of transport projects is critical to building a scientifically robust evidence-base to inform the design of future projects. Guidance on how and when to undertake monitoring and evaluation is given early in this manual (Chapter 3) because it can apply to assessing impacts (Chapter 4), planning (Chapter 5), mitigation (Chapter 6) and construction (Chapter 7).

There are many different contexts or situations where research, monitoring, and evaluation may be required during the planning stage of projects, including:

- Identifying WVC hotspots on existing roads, understanding the contributing factors, and applying this knowledge to proposed transport projects to inform mitigation strategies.
- Identifying key connectivity linkages in the landscape to inform the placement and type of crossing structures.
- Understanding the movement requirements and behaviour of fauna to inform the design of crossing structures.
- Evaluating the use and effectiveness of different mitigation measures, such as wildlife crossing structures, fauna exclusion fencing and fauna escape mechanisms, and determining optimal designs, placement and density.
- Developing and testing novel mitigation techniques, such as crossing structures for new species, wildlife detection and deterrent systems and new fencing designs.
- Assessing the size of a population to inform the impact assessment and estimating population viability before and after mitigation.

The planning stage of a project is where many knowledge gaps and uncertainties are identified and represent an optimal time to initiate and commence research, monitoring and evaluation programs. Refer to Chapters 3 and 4 for detailed guidance to undertake cost-effective and scientifically robust research and monitoring that maximises information learnt and maximally informs the planning of transport infrastructure projects.

7 Case Study – Burleigh to Palm Beach Fauna Sensitive Transport Infrastructure Delivery

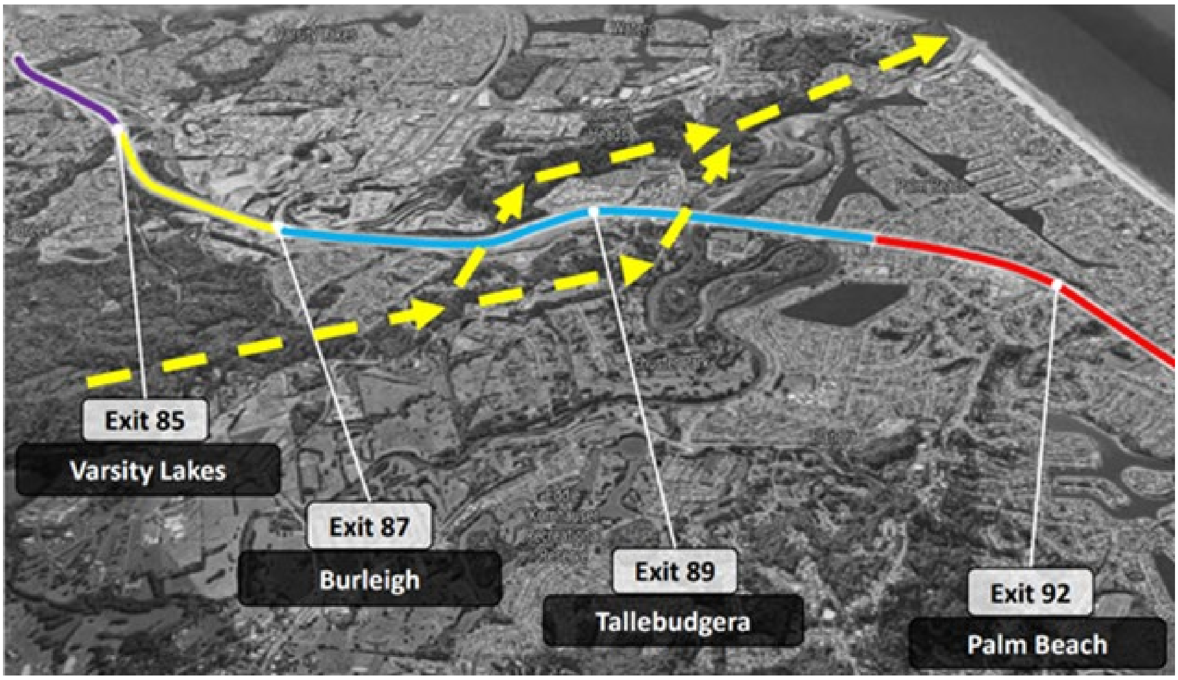
Figure 7(a) – Artist impression of fauna underpass on Burleigh to Palm Beach upgrade of the Pacific Motorway

Source: © State of Queensland

The M1 Pacific Motorway Varsity Lakes to Tugun (VL2T) program upgraded 10 km of the M1 between the Varsity Lakes interchange (Exit 85) and the Tugun interchange (Exit 95). Improvements included:

- Increase from two lanes to a minimum of three lanes in both directions.
- Widening the Tallebudgera Creek and Currumbin Creek bridges.
- Constructing a new 2-way western service road between Tallebudgera (Exit 89) and Palm Beach (Exit 92) and a new bridge over Tallebudgera Creek connecting the new western service road.
- Extending all entry and exit ramps to interchanges, and significant improvements to:
  - Burleigh Interchange (Exit 87).
  - Tallebudgera Interchange (Exit 89).
  - Palm Beach Interchange (Exit 92).
- Installing bike and pedestrian paths to improve active transport connections.

Figure 7(b) – State Significant Biodiversity Corridors (yellow) intersecting the B2PB M1 Project footprint (blue and red).



Source: © State of Queensland

The Burleigh to Palm Beach (B2PB) upgrade project from the Burleigh Interchange (Exit 87) to Palm Beach (Nineteenth Avenue) forms one of three sections of the Varsity Lakes to Tugun (VL2T) Pacific Motorway (M1) upgrade program.

Prior to construction, several environmental assessments were undertaken to inform the project design, including:

- Desktop reviews of existing information including species databases, aerial photographs, and previous reports.
- A series of field surveys to examine the flora, fauna, and aquatic environments within the project corridor.

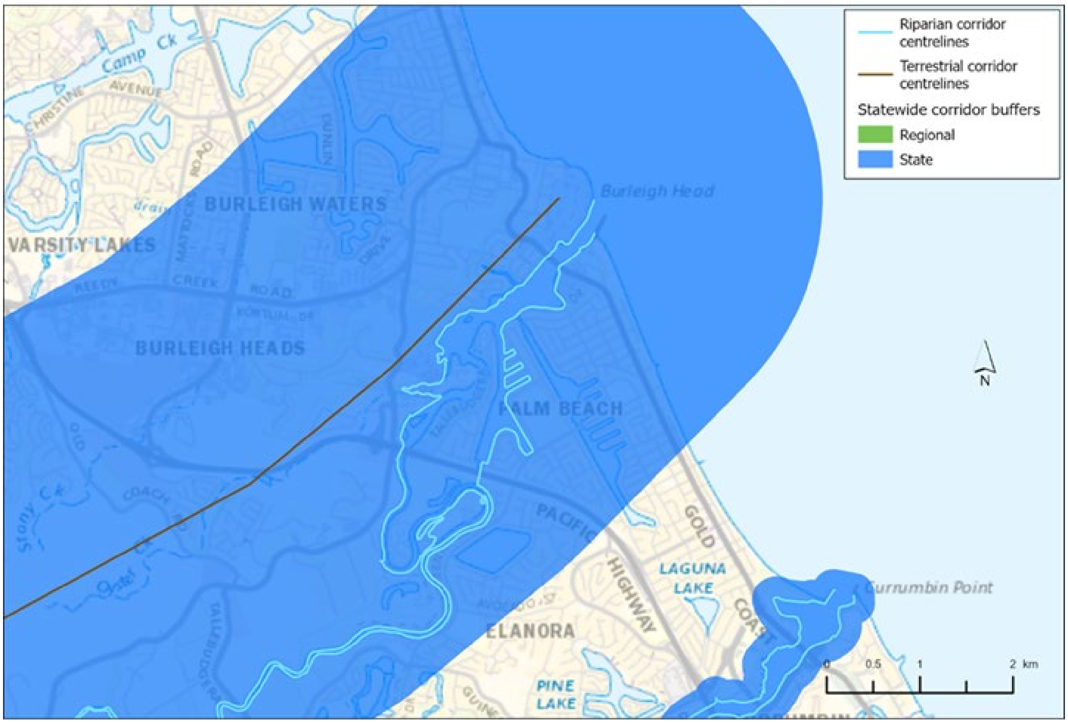
These surveys and assessments showed that the project extent included ecologically sensitive habitats, such as patches of remnant vegetation, habitat for protected plants, habitat for conservation significant species such as koala and echidna, waterways mapped as being significant for fish passage, and other fauna connectivity areas.

Throughout the design phase, ecologists worked in collaboration with the engineering design team to apply an 'avoid, minimise, rehabilitate and offset' hierarchy to ecological amelioration. Following this approach, management measures and proposed future actions were identified, implemented, and summarised in an Ecological Management Plan. This plan identified ecological and habitat management objectives and management measures to achieve the objectives.

Importantly, fauna connectivity areas, including the State significant Burleigh Heads to Springbrook Biodiversity Corridor, were identified early in the ecological assessment phase and subsequently, mitigation measures such as fauna exclusion fencing, and wildlife underpasses were recommended.

BURLEIGH HEADS TO SPRINGBROOK BIODIVERISTY CORRIDOR

Figure 7(c) – State-mapped Wildlife Corridor.



Source: © State of Queensland 2024 Based on [Dataset – Queensland statewide corridors] (Department of Environment and Science) and other state government datasets.

The Burleigh Heads to Springbrook Biodiversity Corridor provides wildlife connectivity in an East-West direction providing linkages between large patches of isolated remnant vegetation and habitat, and between coastal and inland areas. The corridor ultimately connect to Springbrook National Park – one of Queensland's five World Heritage Properties supporting high wildlife diversity, including more than 1,700 species of flowering plants and 500 vertebrate animals.

The Pacific Motorway M1 including the B2PB section of the Project was a major barrier to wildlife movement prior to construction, with opportunities for wildlife movement limited to riparian areas along Oyster Creek and Tallebudgera Creek.

TERRESTRIAL FAUNA INFRASTRUCTURE DESIGN FEATURES

Transport engineering designs and the Environmental Design Report (EDR) included the construction of a 15 metre single span bridge to the north of Oyster Creek (Figure 7(d)) as a fauna crossing underpass. The underpass was designed to be permanently dry and facilitate fauna movement between the northern and southern sides of the motorway.

Design features for the underpass included:

- Bridge span of 15 metres long, 55 meters wide, and five metres high.
- A four metre gap between each carriageway, enabling natural light and rainfall.
- Fauna furniture such as hollow logs, three and four chamber microbat boxes, and vegetation within and surrounding the underpass.

- Construction of a nest platform for eastern osprey (*Pandion cristatus*) located adjacent to Tallebudgera Creek.
- Fauna exclusion fencing to encourage fauna movement towards the underpass and away from the highway, as well as fauna exclusion fencing along the highway. This includes concrete barriers with acrylic strips designed specifically to prevent koalas accessing the motorway (Figure 7(d)).

Figure 7(d) – Stylised graphic of the proposed fauna crossing underpass (indicated in purple)

Source: © State of Queensland

Figure 7(e) – Acrylic panels on concrete barrier designed to be a fauna exclusion barrier.

Source: © State of Queensland

REVEGETATION

Several landscape design planting considerations were included in the preliminary design and followed through to the detailed design, targeted at providing revegetated habitat for threatened fauna including:

- Revegetation surrounding the fauna crossing to enhance connectivity with surrounding existing vegetation.
- Revegetation species mix including koala feed trees, such as Eucalyptus, Corymbia, Lophostemon, Melaleuca and Angophora species.
- Design plans including trellised Richmond birdwing vine (*Pararistolochia praevenosa*), the host plant for the threatened Richmond birdwing butterfly.
- Revegetation species mix including tall saw-sedge (*Gahnia clarkei*), the host plant for the varied sword-grass brown butterfly (*Tisiphone abeona morrisi*) and painted sedge-skipper butterfly (*Hesperilla picta*), species that are in decline and locally extinct within the project locality. The establishment of host plants are aimed at encouraging dispersal and increasing local population sizes should these species be present in the locality.

KOALA HABITAT OFFSETS

The *State Supported Infrastructure Koala Conservation Policy* required three new koala habitat trees to be established for every non-juvenile koala habitat tree (NJKHT) removed in southeast Queensland. Transport and Main Roads collaborated with the City of Gold Coast to utilise land nearby and within Eddie Kornhauser Recreational Park to plant the required 4785 NJKHTs. In total, 10,000 koala habitat trees (Figure 7(f)) and 4000 other native trees were planted over 5.5 hectares to ensure the vegetation communities of each site match the pre-clearing Regional Ecosystems.

Koala habitat trees were also incorporated into the revegetation design adjacent to the fauna underpass, to link the underpass to surrounding vegetated areas and provide habitat for koalas and other native fauna.

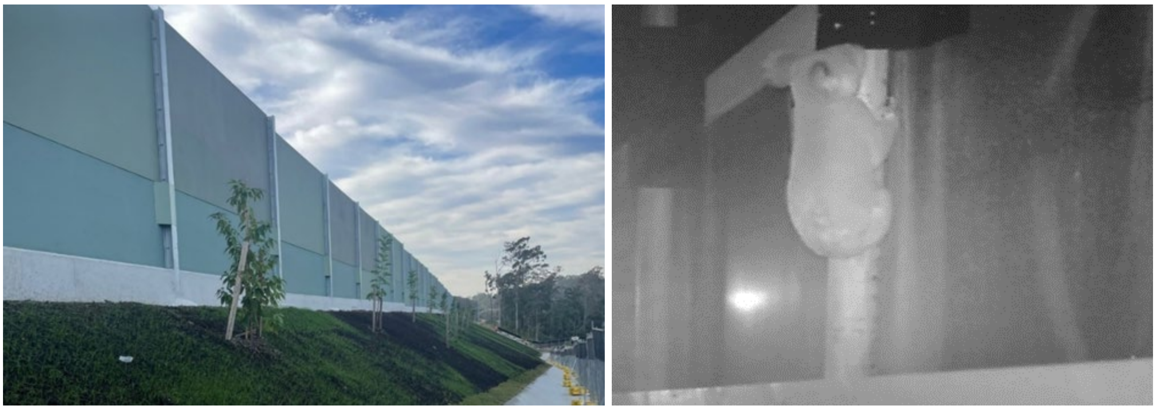
Figure 7(f) – Growth of koala habitat offset vegetation from January 2020, June 2022 to June 2023.

Source: © Courtesy of City of Gold Coast

INNOVATIVE FAUNA EXCLUSION FENCING

In an Australian-first initiative, fauna exclusion devices were fitted to noise walls to prevent arboreal mammals, including koalas, from climbing over and onto the road. This innovation was researched in collaboration with Currumbin Wildlife Sanctuary, who provided design advice, and David Fleay Wildlife Park, who conducted trials with their captive koalas.

Figure 7(g) – Koala exclusion devices installed on the B2PB noise barriers (left), and a koala being successfully thwarted by the device during trials at David Fleay Wildlife Park (right).



Source: © State of Queensland and © David Fleay Wildlife Park CCTV.

AQUATIC FAUNA INFRASTRUCTURE DESIGN FEATURES

Waterways within the project area supported a variety of complex instream habitat features such as overhanging vegetation, marine plants including mangroves and associated pneumatophores, as well as abundant fish cover features such as undercut banks, snags and overhanging vegetation.

The Environmental Design Report included transforming the existing modified Oyster Creek to have natural river features. This included installing structures to allow effective fish passage and creating fish micro-habitats within the areas of Oyster Creek altered by previous development, such as the:

- Inclusion of seven 2.4 metre x 1.4 metre wooden LUNKER (Little Underwater Neighbourhood Keepers Encompassing Rheotactic Salmonids) structures undercut into each of the three new ponds.
- Placement of large woody debris as fish habitat within each pond.
- Installation of cross vanes to facilitate upstream fish passage.
- Increasing the area of marine aquatic and terrestrial habitat.

This in turn encourages fish movement within these waterbodies by enhancing aquatic habitat, creating a preferable environment for fish to move through and improving on pre-construction connectivity within Oyster Creek.

INFRASTRUCTURE SUSTAINABILITY COUNCIL

For all transport infrastructure projects over $100 million, Transport and Main Roads is required to undertake sustainability assessments. For the M1 Upgrade (B2PB), an Ecological Impact Assessment in accordance with the Infrastructure Sustainability Council manual V1.2 was undertaken to determine the level of enhancement in ecological value (Eco-1) and habitat connectivity (Eco-2) possible for the project.

This was calculated by quantitatively assessing the level of ecological impact of the project before and after infrastructure development. The overall results of this assessment determined that the B2PB project positively enhanced both the ecological value (terrestrial and aquatic), and the habitat connectivity of the site compared to existing conditions. This was achieved through several ecological improvement measures and implementation of fauna sensitive road infrastructure design strategies. The B2PB ISC Ecological Impact Assessment took into consideration the following ecological design features:

- Increased connectivity for terrestrial fauna due to the construction of a significant fauna underpass, including fauna furniture, daylighting, and vegetation to provide terrestrial fauna movement underneath the M1 Motorway along the Burleigh Heads Springbrook Biodiversity Corridor.
- Fauna exclusion fencing to prevent access onto the M1 Motorway and channel fauna movement towards the underpass.
- Improved aquatic habitat and increased connectivity for aquatic fauna due to the enhancements to Oyster Creek.
- Direct land-based koala habitat offset (revegetation) at Eddie Kornhauser Recreational Park including the re-establishment of ‘Endangered’ regional ecosystem 12.3.20 – *Melaleuca quinquenervia, Casuarina glauca +/- Eucalyptus tereticornis, E. siderophloia, M. styphelioides* open forest on low coastal alluvial plains.
- Revegetation of part of the Burleigh Heads Springbrook Bioregional Corridor within the Oyster Creek revegetation area adjacent to the fauna underpass.
- Direct land-based offset (revegetation) at a private property revegetation area for threatened plant species removed during vegetation clearing.
- Establishing host plants for threatened Richmond Birdwing Butterfly and Varied Sword-grass Brown Butterfly within the Oyster Creek revegetation area.
- The development and implementation of Ecological Management Plans specific to managing the offsets.
- Installing artificial roosting places for bird species (including osprey), arboreal mammals and microbats.
- Planting saplings propagated from seed collected from a First Nation Peoples' culturally significant scarred tree.

The change in ecological value was calculated as a percentage based on the baseline (pre-construction) value and predicted design value, with an outcome of:

- **Eco – 1** (**Level 3** out of 3) – **45% enhancement** achieved.
- **Eco – 2** (**Level 3** out of 3) – there was a low or moderate degree of existing habitat connectivity identified AND the existing / new degree of habitat connectivity is enhanced (with no offsetting).

Figure 7(h) – Oyster Creek in 2017 prior to construction commencing

Source: © State of Queensland

Figure 7(i) – Oyster Creek during construction (March 2023)

Source: © State of Queensland

References

Chee, Y. E. 2015. *Principles underpinning biodiversity offsets and guidance on their use*.in R. van der Ree, D. J. Smith, and C. Grilo, editors. Handbook of Road Ecology. Wiley and Blackwell, London.

Commonwealth of Australia. 2016a. *Outcomes-based conditions guidance*.in D. o. t. Environment, editor.

Commonwealth of Australia. 2016b. *Outcomes-based conditions policy*.in D. o. t. Environment, editor.

DAF. 2018. *Accepted development requirements for operational work that is constructing or raising waterway barrier works.*

Department of Transport and Main Roads. 2023. C7558 *Terms of Reference for Review of Environmental Factors*.in D. o. T. a. M. Roads, editor. Queensland Government, Queensland.

Forman, R. T. T., and R. D. Deblinger. 2000. *The ecological road-effect zone of a Massachusetts (USA) suburban highway.* Conservation Biology 14:36-46.

Gadd, M. E. 2015. *Expected effects of a road across the Serengeti*. Pages 455-464 in R. van der Ree, D. J. Smith, and C. Grilo, editors. Handbook of Road Ecology. John Wiley & Sons, Oxford, UK.

Hilty, J. A., G. L. Worboys, A. Keeley, S. Woodley, B. Lausche, H. Locke, M. Carr, I. Pulsford, J. Pittock, J. W. White, D. M. Theobald, J. Levine, M. Reuling, J. E. M. Watson, R. J. Ament, and G. M. Tabor. 2020. *Guidelines for conserving connectivity through ecological networks and corridors.* IUCN, Gland, Switzerland.

Huijser, M. P., J. W. Duffield, A. P. Clevenger, R. J. Ament, and P. T. McGowen. 2009. *Cost-benefit analysis of mitigation measures aimed at reducing collisions with large ungulates in the United States and Canada: a decision support tool.* Ecology and Society 14:15.

Infrastructure Sustainability Council of Australia. 2016. *IS Technical Manual v1.2.*

Mjadwesch, R., and S. Nally. 2008. *Emergency relocation of a Purple Copper Butterfly colony during roadworks: Successes and lessons learned.* Ecological Management & Restoration 9:100-109.

Smith, D. J., R. van der Ree, and C. Rosell. 2015. *Wildlife crossing structures.* Pages 172-183 in R. van der Ree, D. J. Smith, and C. Grilo, editors. Handbook of Road Ecology. John Wiley & Sons, Oxford, U.K.

Soanes, K., M. Carmody Lobo, P. A. Vesk, M. A. McCarthy, J. L. Moore, and R. van der Ree. 2013. *Movement re-established but not restored: inferring the effectiveness of road crossing mitigation for a gliding mammal by monitoring use.* Biological Conservation 159:434-441.

Soanes, K., A. C. Taylor, P. Sunnucks, P. A. Vesk, S. Cesarini, and R. van der Ree. 2018. *Evaluating the success of wildlife crossing structures using genetic approaches and an experimental design: lessons from a gliding mammal.* Journal of Applied Ecology 55:129-138.

Van der Grift, E. A., J. A. G. Jaeger, and R. van der Ree. 2015. *Guidelines for evaluating the effectiveness of road mitigation measures.*in R. van der Ree, D. J. Smith, and C. Grilo, editors. Handbook of Road Ecology. Wiley-Blackwell, London.

van der Ree, R., J. W. Gagnon, and D. J. Smith. 2015a. *Fencing: a valuable tool for reducing wildlife-vehicle collisions and funneling fauna to crossing structures.* Pages 159-171 in R. van der Ree, D. J. Smith, and C. Grilo, editors. Handbook of Road Ecology. John Wiley & Sons, Ltd, Oxford, UK.

van der Ree, R., C. Grilo, and D. J. Smith. 2015b. *The ecological effects of linear infrastructure and traffic: Challenges and opportunities of rapid global growth*. Pages 1-9 in R. van der Ree, D. J. Smith, and C. Grilo, editors. Handbook of Road Ecology. Wiley-Blackwell, London.