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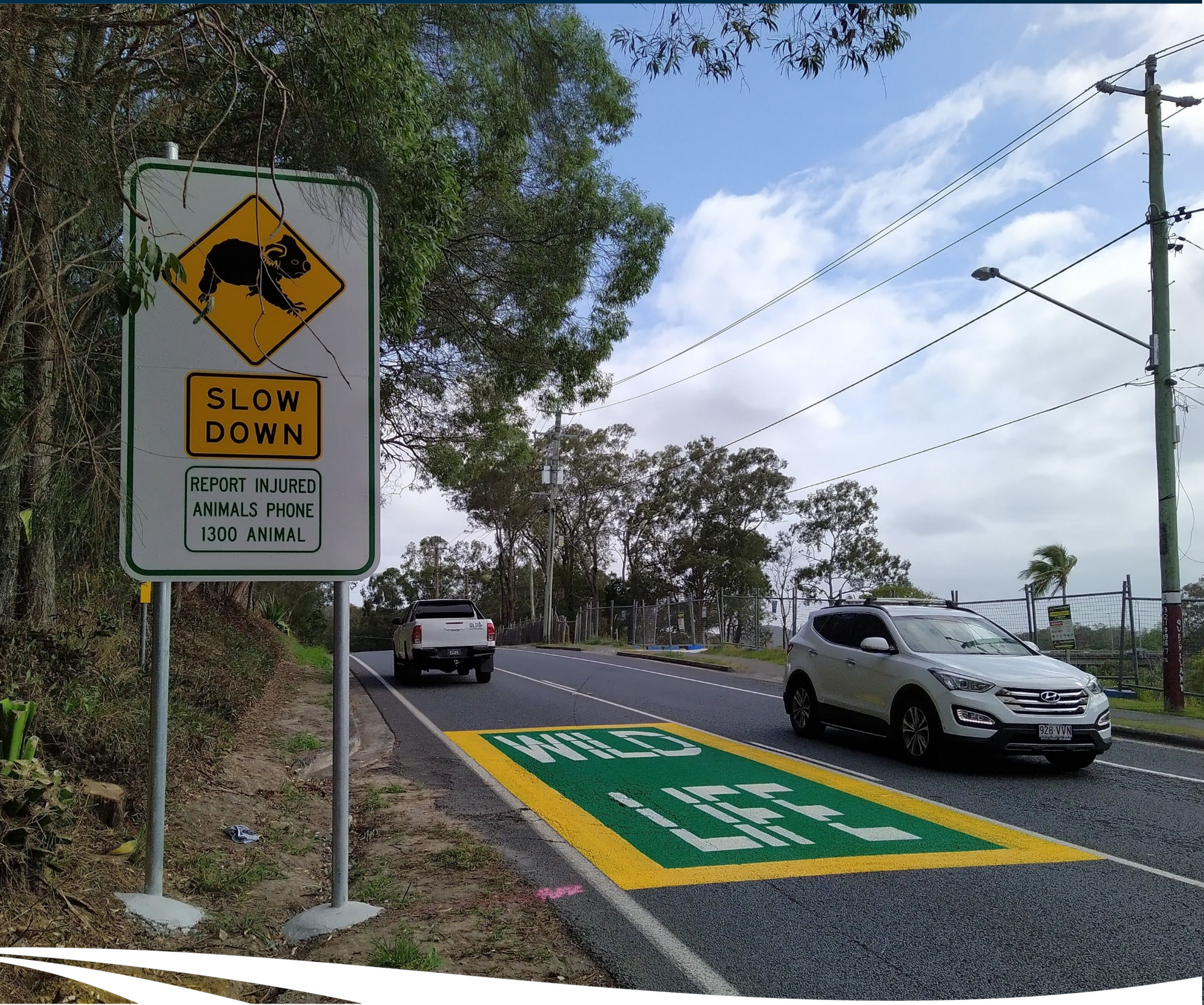

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Manual

Fauna Sensitive Transport Infrastructure Delivery
Chapter 8: Maintenance

June 2024

Queensland Government

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Key Points

- The existing transport network is extensive, and consequently existing conflicts between transport infrastructure and fauna are considerable.
- Maintenance and retrofits help to avoid, minimise, and mitigate the impacts of existing infrastructure on fauna, habitat and ecosystems.
- Retrofits are physical structures or design features that are added to existing transport infrastructure to reduce impacts to fauna. Choosing where to install a retrofit can be decided by identifying priority locations through systematic landscape-scale studies (strategic approach) or by identifying ecological problem areas (ad-hoc approach).
- Maintenance is the work required to maintain the effectiveness and functionality of structural and ecological assets. Some maintenance activities are undertaken routinely, while other maintenance activities only occur when triggered by specific events (e.g. flooding) that may compromise the functionality of the asset.
- Maintenance is necessary to ensure crossing structures, fences and other mitigation measures remain optimally effective.
- Maintenance and retrofits can be key components to adaptive management by providing the opportunity to understand, and subsequently improve, the effectiveness of environmental assets, including retrofits.

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1 Introduction

Transport infrastructure in Queensland often has significant detrimental impacts on native fauna (Chapter 4). There are many opportunities to avoid, minimise, mitigate, offset, and/or compensate the negative impacts of this existing infrastructure on fauna and these should be implemented when feasible and appropriate. These opportunities range from relatively simple actions such as routine maintenance to targeted efforts to retrofit mitigation measures to existing roads and crossing structures.

1.1 Impact assessment of retrofits and maintenance

While maintenance and retrofits are of a smaller scale than construction activities, they still require potential impacts to be assessed and managed. The Transport and Main Roads environmental assessment process must be used to assess all retrofits and maintenance activities.

2 Retrofits

2.1 What are retrofits?

Retrofits are physical structures or design features that are added to existing transport infrastructure to reduce impacts to fauna. Retrofitting can include:

- Installing ledges to existing drainage culverts, waterway bridges, or other underpasses to increase accessibility or suitability for fauna.
- Replacing existing culverts and bridges with larger or different structures to improve fauna connectivity.
- Building new wildlife crossing structures on existing transport infrastructure to increase fauna connectivity.
- Installing a new fauna exclusion fence or modifying an existing fence, or other structure, to exclude fauna and prevent or reduce the likelihood of fauna from accessing the road or railway, thereby reducing the rate of wildlife-vehicle collisions (WVC).
- Installing physical structures along existing roads and railways, such as noise and light walls, to reduce the intensity of noise and light entering habitat adjacent to transport infrastructure.
- Changing existing lights or light fixtures to reduce the wavelength, direction or intensity of light at crossing structures and in adjacent habitats.
- Fill gaps around large erosion-control rocks under bridges or on approaches to underpasses with poured concrete to increase accessibility for fauna.
- Installing fauna furniture (i.e. logs, rocks, hollow logs, koala refuge poles) to existing underpasses to increase accessibility for fauna.
- Undertaking earthworks at entrances to existing underpasses to:
  - Decrease ponding and improve accessibility for fauna that prefer dry crossings.
  - Eliminate perched culverts and facilitate upstream movement of fish.
- Installing baffles and other devices within existing culverts to reduce water velocity and improve the movement of fish.

- Installing a rocked fish ramp on the downstream side of a perched culvert or a rock ramp fishway on the downstream side of an existing causeway structure to improve fish passage up to and through / over the structure during low flow conditions. Note that where retrofits are made to improve fish passage at existing structures, removal or upgrade of the barrier should always be considered as the first option.
- Converting a regular asset into an environmental asset and adding it to the Transport and Main Roads environmental asset database (Refer to Section 3.6.1). This could include undertaking revegetation at a bridge or culvert to encourage animal movement and thereby converting a standard drainage structure into an environmental asset. The types of works include:
  - Planting trees to provide arboreal fauna with cover.
  - Digging a pond to allow amphibians to access a flooded culvert.
  - Removing dense stands of weeds at entrance to a drainage culvert to improve accessibility for fauna.

2.2 What is not a retrofit?

Retrofits do not include routine or regular maintenance, often referred to as 'business as usual' activities. For example, the following would not be classified as retrofitting:

- Regular maintenance (e.g. weeding, reducing ponding) of environmental assets.
- Upgrades to already existing environmental assets (e.g. adding koala rails to a wildlife crossing that is already included in the department's environmental asset database).

2.3 Why consider retrofits?

The existing transport network is extensive, and consequently existing conflicts between transport infrastructure and fauna are considerable.

WVC can result in high rates of serious injury and death to motorists and repair costs to cars and trains[1]. In addition, trains may need to be taken from service for cleaning and inspection after collision with large animals, with subsequent delay costs. Retrofit designs and features that reduce WVCs can reduce injury, damage costs, and delays on roads and railways. In addition, retrofits can be a cost-effective solution, with studies in the USA[2] finding that fencing and crossing structures on roads can pay for themselves in a few years through reductions in injury and damage costs. When there is an existing concern about WVC on an existing road or railway but there are no planned upgrades to it, a stand-alone retrofit can address this concern, saving money, time, and human lives.

[1] (Klocker et al. 2006, Rowden et al. 2008, Visintin et al. 2018)
[2] (Huijser et al. 2009)

Wildlife crossing structures installed on new transport infrastructure may be less effective if a parallel road or railway lacks safe crossing opportunities for wildlife. Where this occurs, retrofitting the existing road or railway with a wildlife crossing structure is important to optimise overall landscape connectivity and the effectiveness and usage of the new crossings. This can occur when Transport and Main Roads manages the parallel transport infrastructure, or when local government or other agencies manage that infrastructure. Collaboration among multiple land managers will likely be required to achieve landscape-scale biodiversity benefits.

Retrofits to existing drainage structures that are barriers to fish movement (i.e. typically small and/or old bridges and culverts) can be beneficial to improve fish passage at the site. However these should be considered after first considering whether removal of the structure, or replacement in accordance with best practice fish passage provision, is not feasible. The removal of a single strategically-located waterway barrier (Chapter 19) and replacement with a structure that enables fish movement can restore migrations of fish over many hundreds of kilometres.

2.4 Where to implement retrofits?

There are likely many locations where retrofits could be beneficial. There are two ways to identify where to implement retrofits:

1. The strategic approach.
2. The ad-hoc approach.

The strategic approach identifies priority locations through systematic landscape-scale studies and investigations (Section 2.4.1). A benefit of the strategic approach is that locations can be assessed objectively to prioritise the most important and cost-effective options. For waterway barrier works in Queensland, there are several barrier prioritisation reports that have already been undertaken to identify such sites. Retrofits can also be scheduled to occur during already planned road works, such as bridge replacement programs and infrastructure upgrades. This can be preferrable to a stand-alone retrofit which may be more expensive, may not have separate funding, or may be redundant if there are plans to change the design of the road in the future.

The ad-hoc approach identifies ecological problem areas often through local conservation advocates, road maintenance crews, police crash statistics, and/or targeted local information. A benefit of the ad-hoc approach is that stand-alone retrofits may be possible to implement quickly if concern (e.g. risk of human injury or species extinction) is high. The potential disadvantage of this approach is that the location of concern may not be the most important or cost-effective option. Ad-hoc requests for mitigation should be assessed within a larger-scale analysis, even if not as rigorous as the strategic approach, to enable an objective assessment and decision to be made.

If the retrofit is required urgently in a location that has already been prioritised for works, the ad-hoc approach may be the most suitable. In other situations, the strategic approach is recommended. The implementation of both approaches (e.g. undertaking a large-scale strategic approach and also retrofitting key problem areas immediately) is also an option.

2.4.1 Strategic approach to retrofitting

For the strategic approach, potential locations for retrofits are identified through systematic landscape-scale studies and investigations. Several local governments in South East Queensland have undertaken such studies (e.g. Moreton Bay Regional Council, Gympie Regional Council, and others). In these contexts, managers use a range of information sources to identify and rank priority locations for retrofit works. These information sources include:

- WVC records from local government and state government databases, police records, wildlife carer databases, wildlife hospital databases and systematic data collected by researchers. This data should include information about the fauna involved in collisions, as well as the number and seriousness of collisions for motorists.
- Wildlife occurrence data, including from wildlife databases, First Nations knowledge, and targeted surveys. This data identifies fauna species in adjacent habitat that are at risk of WVC.
- Fauna habitat and vegetation mapping. The identification of fauna habitat is important because it can be used as a proxy for animal presence. Alternatively, it also describes potential habitat, which may be re-colonised if the cause of the decline (i.e. WVC) is rectified.
- Identified biodiversity corridors (Chapter 5).
- Road and traffic data, such as road width, traffic volume and speed. This information represents barriers to movement and risk of WVC.
- Existing infrastructure, including culverts, bridges, fencing, underpasses and public utilities plant such as powerlines, pipelines, telecommunication cables, etc. These may represent additional barriers to movement, or restrictions to implementing retrofits.
- Current and planned land-use and tenure of adjacent land. Mitigation adjacent to conserved public land may represent a more viable long-term security option compared to mitigation adjacent to private land that may be developed in the future.

This information is then combined using simple spatial overlays or more complex wildlife connectivity modelling approaches (Chapter 5) to identify locations where wildlife and the transport infrastructure networks intersect. Once the ecological priority of the intersected locations has been ranked, a physical inspection is then required to identify reasonable and feasible retrofit solutions.

Case Study 8.1 – Interpreting a Lack of WVC Data

A lack of WVC records for a certain location on a road or railway can indicate that there is little conflict between fauna and vehicles or trains. A lack of WVC records where a road or railway passes through fauna habitat can also mean:

- There is no-one collecting WVC data or the data has been collected and not been published or made available.
- The fauna getting struck are:
  - too small to detect
  - thrown off the road or railway upon impact, or
  - scavenged too quickly in order to be detected reliably.

- Historically high rates of WVC and/or other threatening processes have reduced the density of the local population to the extent that fauna populations are low, so corresponding WVC rates are currently low.
- WVC data represents those animals that unsuccessfully attempt to cross the road or railway. It is important to assess whether the WVC data represents a small proportion of the local population (i.e. most individuals make it across successfully) or a large proportion of the local population (i.e. most individuals do not make it across) attempting to cross. In the case of the latter situation, retrofit works may be required.

The road and railway effect zone (REZ) (Chapter 4) may be preventing fauna from accessing the road or railway. Hence, it is important to understand the ecological relevance of a particular rate of WVC and use this to inform management decisions.

2.5 Challenges to installing retrofits

A major challenge of retrofitting mitigation measures to existing roads and railways is the often complicated and contested spaces around the location of the proposed retrofit. These challenges could include:

- Private land at the entrances to crossing structures that may prevent the removal of fences or alterations to drainage to improve underpass use by wildlife.
- Existing overhead or underground powerlines, telecommunication cables, or pipelines that could interfere with crossing structures.
- High-quality and endangered native vegetation adjacent to roads or railway that may require clearing to install a fence or approach ramps, resulting in significant habitat loss and potentially offset requirements.
- Narrow reservations between the transport infrastructure and adjacent private land that may physically prevent retrofit solutions being built solely on Transport and Main Roads land, resulting in ownership, maintenance, and long-term security of land tenure issues.
- Topography and vertical geometry of the road or railway that may prevent the construction of underpasses (where the road is in a cutting) or overpasses (where the road is on large amounts of fill).
- Areas that provide insufficient space for laydown areas, truck access, etc.

Other challenges of retrofitting may include:

- Cost – it is always more expensive to retrofit a solution on an existing road or railway than it is to install the same structure during standard construction projects and upgrades.
- Funds – funding will require prioritisation to allocate funds to the highest priority actions.
- Constructability – traffic control to retrofit a structure will have cost implications. A compromise that reduces traffic control requirements may be the only viable solution (e.g. installing a pipe culvert is quicker than box culverts).

2.6 Business case for retrofits

The first step in implementing retrofits is to build a business case to provide to decision makers, which could include:

- Collecting information on the number of WVC, vehicle damage costs, and human safety costs / impacts.
- Exploring possible mitigation options and costing them out.
- Investigating if future upgrades, which could otherwise deliver the required structures, are planned or likely.
- Seeking collaborative funding or support from adjacent land managers and user groups e.g. National Parks, wildlife recovery teams, other government agencies, and/or not-for-profit groups.
- Establishing a working group to explore options and garner community support.

If a retrofit is funded, the project should undergo the same planning, design and approval processes (Chapter 5), construction (Chapter 7), maintenance (Section 3) as well as monitoring, evaluation, reporting and adaptive management (Chapter 3).

3 Maintaining environmental assets

3.1 What is maintenance?

Maintenance is the recurrent day-to-day, periodic, or scheduled work required to preserve, restore, or replace a mitigation measure or other environmental asset to maintain effectiveness and functionality[3]. Structural maintenance includes work to prevent damage or deterioration that, if left unchecked, would eventually progress to structural damage and may otherwise be more costly to restore. While maintenance budgets are often limited, it is important to ensure sufficient funds are allocated when required to ensure the mitigation measures remain effective and that the ecological conditions of approval for the project are not compromised, potentially resulting in a breach of approval conditions.

Ecological maintenance is conducted to ensure the environmental asset continues to achieve its functional goals over its full lifespan. Transport and Main Roads environmental infrastructure inspections record structural integrity and ecological functionality separately because structural integrity and ecological function may not be the same. Examples of conflicts between structural integrity and ecological function are provided in Section 3.5.

Even though structural maintenance and ecological maintenance are separate considerations, they should be co-ordinated, assessed at the same inspection, and repaired together to minimise costs. However, different skills may be required to assess structural maintenance and ecological functionality. For example, while an Environmental Officer may be capable of assessing the ecological functionality of a glider crossing, they are unlikely to be able to conduct an engineering assessment of the structure's integrity. Hence qualified engineers are also likely to be required for structural inspections.

[3] (van der Ree and Tonjes 2015)

Structural maintenance activities to achieve Fauna Sensitive Transport Infrastructure Delivery (FSTID) include:

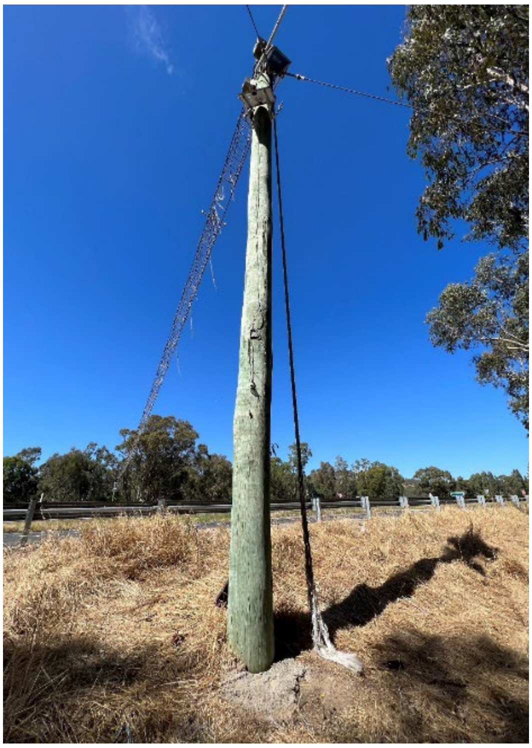
- Replacing rotten timber structures, such as timber ledges, Koala refuge and escape poles, and poles that hold up canopy bridges or glider poles.
- Replacing rope on canopy bridges that have been degraded by ultraviolet (UV) light, or damaged feeder ropes that connect canopy bridges to adjacent trees (Figure 3.1).
- Repairing holes in wildlife fencing or holes under wildlife fencing / at gates (Figure 3.2(a)).
- Assessing steel, concrete and other components of structures.

Ecological maintenance includes:

- Mowing grass and slashing vegetation on roadsides or railway verges to increase the detectability of wildlife, provide wildlife with better views of oncoming traffic, and reduce the suitability of vegetation adjacent to roads and railways for use by wildlife. This will typically lower rates of WVC (Chapter 4).
- Clearing out built-up silt from the entrances to underpasses and within the underpass (Figure 3.2(b)).
- Removing vegetation that have grown through or against wildlife fencing.
- Removing overgrown vegetation at underpass entrances.

In Transport and Main Roads, major maintenance activities are triggered by an inspection report that identifies a shortcoming that requires attention. Consequently, maintenance is a critical consideration when planning or designing fauna infrastructure.

Figure 3.1 – Canopy bridge with degraded rope that requires replacement



Source: © Rodney van der Ree, WSP

3.2 Why is maintenance just as important as construction?

Adequate maintenance regimes are critical because:

- Poorly maintained structures are unlikely to meet the conditions of approval of a project, placing Transport and Main Roads in breach of its legislative obligation.
- Human safety may be compromised if animals can breach a broken fence or if they are unable to use a crossing structure. If animals access the road or railway to cross over, the risk of WVC and injury or death of motorists increases.
- Poorly maintained structures could result in the decline and extinction of local fauna populations and other detrimental ecosystem impacts.
- The money spent on building crossing structures is wasted if functionality is not maintained. For instance, if fauna fencing is not maintained and has holes, then the effectiveness of the fence is greatly diminished.

Figure 3.2(a) – Damage to fauna exclusion fencing that needs repairing

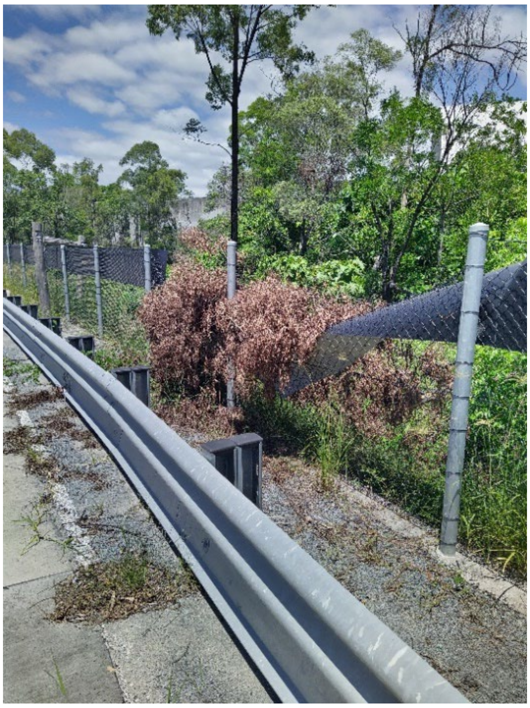


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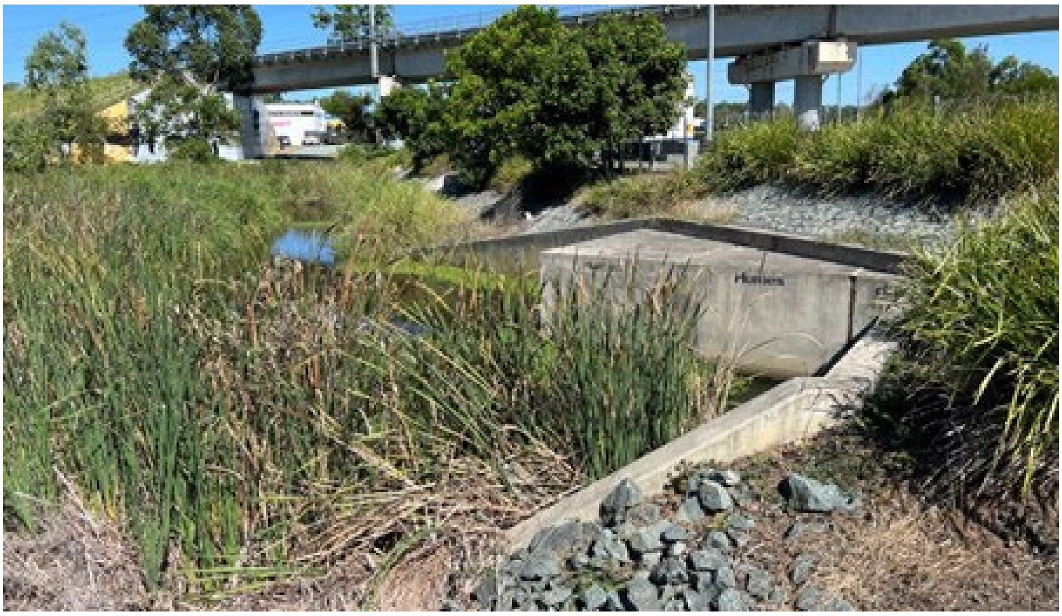
Figure 3.2(b) – Entrance to culvert that is overgrown and requires earthworks and weeding to improve functionality



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3.3 Routine and triggered inspections

Inspections of Transport and Main Roads Environmental Infrastructure Assets are principally the responsibility of the department’s Maintenance, Preservation and Operations Element 2 (Nature Conservation) Program. Element 2's routine maintenance schedules depend on a range of factors including staff availability, budgets and asset type.

Inspections can also be triggered by specific local- or large-scale events, usually wildfire or flood / storm, to ensure the environmental asset is not damaged and will continue to function effectively. Inspections can also be triggered after collisions with the structure itself (e.g. car collides with fauna fence, noise wall or glider pole) or a sudden increase in WVC that may indicate damage to a fence. For example, where a dead animal is found on a fenced motorway, it is common practice for the fence to be inspected for one kilometre in each direction of where the animal was found to check for any breaches in the barrier.

While the Element 2 Program is responsible for the maintenance of Environmental Infrastructure Assets, such as a fauna movement pole in a culvert, other Transport and Main Roads programs are responsible for the maintenance of the actual structures, which may include environmental assets. For example, Element 19 (Bridge and Culvert Servicing and Rehabilitation) is responsible for the inspection, servicing and rehabilitation of road bridges and major culverts. These programs have their own maintenance schedules and guidelines, including the Transport and Main Roads *Structures Inspection Manual*, *Routine Maintenance Guidelines* and *Bridge / Culvert Servicing Manual*.

3.4 Maintenance considerations during planning and design

Careful consideration of maintenance requirements during planning and design of the project can significantly reduce ongoing maintenance costs and increase the efficiency of maintenance. For example, planning that ensures assets are constructed in areas which can be easily and safely inspected, are cheaper and easier to inspect and maintain compared to areas which may require road closures or traffic management to ensure safe access. Effectively planning and designing asset maintenance improves the likelihood that assets will be regularly inspected and maintained.

Things to consider during the planning and design phase include:

- Are there other equally effective mitigation measures that have lower maintenance requirements?
- Can high-maintenance items on structures be engineered / designed out so that maintenance can be less frequent (e.g. using materials with longer life) and less costly (e.g. without needing traffic control)? For example, using treated timber for poles and structures compared to untreated salvaged timber which may degrade rapidly, requiring replacement soon after construction.
- Has the long-term cost of the mitigation measure been considered? Installing cheaper infrastructure may require more maintenance or may fail sooner, requiring larger amounts of money over the life of the asset.
- Does the structure require special maintenance or equipment which may cost more or require specialist skills? For example, engineering inspections of rope ladders which requires an engineer and an elevated work platform.
- Has ease of access been considered? For example, providing a hard stand at the base of glider poles and rope bridges, and installing poles outside clear zones will enable maintenance with an elevated work platforms (EWP) during wet weather and without the need for traffic control.
- Have maintenance engineers been involved in the planning and design of the mitigation measures? This is important to include because the maintenance engineers and crews have first-hand experience of the difficulties and solutions to effective maintenance.
- Has sufficient budget been allocated to undertake maintenance?
- Have the mitigation measures been designed for the local conditions or climate? For example, fauna fencing that collapses during floods may be required in high flood risk areas.

3.5 Managing conflict between standard Transport and Main Roads maintenance and ecological effectiveness

Standard routine road and rail maintenance programs have developed over many years with the primary aims of user safety, maintaining asset longevity and reducing maintenance costs. This approach has resulted in some maintenance practises that are incompatible with FSTID. Some maintenance practices utilised by standard road and rail maintenance programs could be in conflict with the requirements of environmental assets, and vice versa.

Standard maintenance measures that conflict with ecological effectiveness may include:

- Removing and not replacing soil and organic matter from the base of a fauna culvert as part of routine inspections of structural integrity.

- Clearing all vegetation from approaches and entrances to a fauna underpass because it was mistaken as a drainage culvert, or the target species was mistaken.
- Allowing too much vegetation to grow at approaches and entrances to an underpass when clear lines of sight are required.
- Removing all aquatic vegetation around waterbodies that require a minimum percentage of fringing vegetation as frog habitat.

Ecological effectiveness measures that conflict with standard maintenance may include:

- Allowing tall trees to grow on the edge of a land bridge, improving passage for arboreal fauna, but also increasing risk to passing motorists underneath.
- Allowing tall trees to grow adjacent to bridge structures, improving passage for birds and bats, but also increasing the risk of damage to the bridge if a tree falls.
- Installing fish passage solutions, like baffles, which reduce water velocity, encouraging fish passage, but also reduce hydraulic capacity, potentially causing culvert sedimentation and upstream flooding.
- Fencing or gating minor waterways as part of wider exclusion fencing efforts to reduce WVC, but also increasing the likelihood of sediment or rubbish accumulation.

Ways to avoid or minimise conflict include:

- Ensure maintenance requirements are considered during infrastructure planning and design and that a suitably qualified landscape specialist is consulted for plant species selection and positioning.
- Undertake hand-over from construction to operational / maintenance teams and include a specialist ecologist in that hand-over.
- Ensure the operational and maintenance teams have ecologists on the team or ecologists they can refer to.
- Ensure sufficient resources are available to undertake maintenance properly.
- Ensure the Transport and Main Roads environmental asset database is updated after construction is completed (Section 3.6.1).
- All environmental assets should be physically labelled and uniquely numbered to minimise the risk of misidentifying an asset during inspections and maintenance activities and undertaking maintenance activities that may compromise the objectives of the asset.
- When conflict is unable to be avoided or resolved, the operational risk (e.g. the risk of injury to motorists and/or damage to infrastructure) should be weighed against the ecological risk (e.g. the risk of local extinction to threatened species) and a final decision made.

3.6 Establish a maintenance program for environmental assets

Effective maintenance requires the development and implementation of an environmental asset maintenance program. Actions in the program should include:

- Adding the asset to the Transport and Main Roads environmental assets database (Section 3.6.1).
- Determining the inspection frequency (e.g. periodic, after flood / storm).

- Setting operational or maintenance standards such as the requirements of the inspection (drive by, walk through, structural test) and what to look for and how to measure it.
- Specifying who will undertake the maintenance (engineer, ecologist, etc.).

3.6.1 Transport and Main Roads environmental asset database

All environmental assets must be added to an asset database to trigger routine and exceptional inspections. For Transport and Main Roads, this is the Environmental Assets ECHO (Environment and Cultural Heritage Observation) database.

Transport and Main Roads environmental assets database captures:

- A description of the asset (e.g. culvert type and size, type and dimension of fencing, type of furniture in a crossing structure).
- The location of the asset. Note that fauna fencing is recorded in 100 metre – long sections.
- Attachments, including design drawings which identify the maintenance standard (a description of what the asset should look like to ensure it is effective).
- The targeted species or group.
- Date of installation and which project was responsible.
- Details of relevant permits and objectives of the asset which dictate maintenance standards or requirements.

Environmental assets that have been installed by other agencies, or are the management responsibility of other agencies, should also be captured in ECHO and the agency responsible for asset maintenance identified. The inclusion of other assets ensures they can be considered and managed appropriately when Transport and Main Roads plan future asset delivery.

4 Inspection and maintenance checklist

This section outlines typical inspection and ecological maintenance requirements for fauna mitigation measures. Suitably qualified engineering staff are required to inspect the structural integrity of most assets. However, inspections of ecological functionality conducted by an ecologist can still identify potential structural issues which should then be escalated to relevant maintenance programs for more detailed assessments.

Table 4 – Checklist for inspecting and maintaining ecological function

STRUCTURE TYPE AND FREQUENCY OF ECOLOGICAL INSPECTION	COMPONENT	DESCRIPTION
Canopy bridge. **Inspect once every two years.**	Canopy ladder	• Both sides of the ladder are approximately level. • The ladder is the required minimum height above the road or railway. • Connections to cross are arms strong and secure.
	Approaches and entrances to the canopy bridge	• Feeder ropes are securely attached to trees at both ends. • Tree health is not being compromised by feeder ropes. • Trees are being allowed / encouraged to grow through feeder ropes and around poles. • There is no obvious wear or damage to feeder ropes.

STRUCTURE TYPE AND FREQUENCY OF ECOLOGICAL INSPECTION	COMPONENT	DESCRIPTION
	Pole, cross arms, stays	• Poles and cross arms are not damaged or leaning. • Wire stays and attachments are not loose.
	Furniture	• Refuge pipes are securely attached to poles and canopy bridge.
	Fencing	• If present, see fencing below.
Dedicated fauna culvert. **Inspect once every two years.**	Approaches and entrances	• Dry passage is available, small temporary puddles are OK. • Vegetation type, coverage, and connectivity is appropriate for the target species. • No rubbish or debris (car tyres, shopping trolleys etc.) is blocking the entrance. • Signs of use by the intended species, as well as signs of use by non-target species (i.e. foxes) which could negatively impact the intended functionality of the culvert.
	Furniture	• Logs, branches, rocks, shelters etc. are appropriate for target species and are in good condition. • Wooden structures do not contain termites / mounds or termite damage. • Substrate suits target species, typically 5–10 centimetres of soil, leaf litter etc.
	Fencing	• See fencing below.
	Structure	• There is no visible damage to the structure (e.g. cracks or leaks).
Fencing. **Inspect annually.**	Vegetation	• No trees are leaning on the fence. • Vegetation near the fence is maintained to prevent target species from climbing over (e.g. tall grass and shrubs at frog fences, and trees extending over Koala fences, are not present).
	Structure	• No holes are present in the fence. • No significant gaps are evident under the fence. • The fence is not leaning or falling over. • Gates or other designed openings are operational. Locks are functional and there are no gaps between or under gates. • Escape mechanisms are not damaged or impeded. • There is no build-up of debris along frog fencing allowing them to jump up and over. • Secondary features are still in place and functional (e.g. lips on frog fence, skirt to prevent burrowing animals getting underneath, Perspex or metal panel on Koala fence). • Refer to Transport and Main Roads *Fauna Fence Inspection Guideline* for common issues impacting fauna exclusion fencing.

STRUCTURE TYPE AND FREQUENCY OF ECOLOGICAL INSPECTION	COMPONENT	DESCRIPTION
Bridge underpass. **Inspect once every two years.**	Approaches and entrances	• Dry passage is available, small temporary puddles are OK. • Vegetation coverage and connectivity is appropriate for the target species. • A species-specific fauna pathway is present (not washed away). • Large erosion control rocks are not obstructing fauna movement.
	Furniture	• Ledges, Koala rails, etc. are functional and not obviously damaged.
	Fencing	• See fencing above.
	Structure	• Co-located crossing structures (e.g. under-bridge glider poles and canopy bridges) are present and functional according to criteria for those structures.
Noise and light walls. **Inspect once every two years.**		• There are no gaps underneath the walls that fauna may pass through. • There is no evidence of bird strike. • Decals (stencils or patterns that improve visibility of the structure to reduce bird collisions) are still attached.
Frog ponds. **Inspect once every two years.**		• The frog ponds contain appropriate levels of water, vegetation cover and shade for the target species. • There is no obvious damage or degradation (e.g. water pollution, weeds).
Light fixtures. **Inspect once every two years.**		• The movement sensor is functioning as intended. • The fixtures are still attached.

5 Retrofits and maintenance as part of monitoring, evaluation, and reporting

A collaborative effort is required between the maintenance and operation crews and the research and monitoring teams to ensure both programs operate effectively. The most successful outcomes will occur when there is clear communication between both parties about what works are being undertaken and when. For example, if there is research or monitoring underway, the maintenance team might inadvertently disrupt or destroy years of research or monitoring data if they are not made aware that it is occurring. Maintenance teams should be aware of this risk and the monitoring and evaluation that is occurring at each site before they undertake maintenance tasks. Advance notice of proposed works will allow researchers time to collect their equipment or to adjust their methods to account for changed conditions.

Maintenance and operation teams can also facilitate and support research and monitoring. If maintenance is required, this might be an excellent opportunity to do an experiment and learn while doing (Chapter 3). For example, eight dedicated fauna culverts are frequently observed to be flooded or filled with sediment, rendering them impassable by terrestrial fauna. Rather than remove the sediment in all eight culverts, it could be informative to remove sediment from half of the culverts and leave the sediment in the other half and measure the response by fauna before and after the maintenance. This would provide important information to inform future management regimes. The list of available structures and their maintenance details should be made available to researchers so they can develop monitoring and evaluation programs (Chapter 3) utilising maintenance activities.

The needs of monitoring and evaluation equipment should also be considered in the design and maintenance of structures. For example, maintaining cameras on canopy bridges and poles is cheaper and easier if it can be done by climbing (install rope attachment points) or if an elevated work platform can be parked without needing traffic control.

Maintenance and retrofits can be key components to adaptive management. Maintenance provides the opportunity to understand the effectiveness of environmental assets, including retrofits, and the opportunity to improve current or future structures according to this effectiveness. For example, maintenance records may find that a rope bridge design has been failing maintenance due to UV degradation of the rope. Adaptive management could include using a different design or rope type in the future. Retrofits may also be a form of adaptive management themselves. If monitoring or maintenance identifies a problem WVC area, retrofitting fauna crossing structures may be the chosen adaptive management.

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