Works on Waterway Guidelines
Culvert Crossing

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Catchment Management Authority
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Introduction

The key requirements for culvert crossings are:

- Appropriate hydraulic capacity.
- Provision for fish and aquatic fauna passage.
- Low risk of becoming blocked with flood debris.
- Low risk of total failure.

Potential Waterway Impacts

The impacts of culvert access crossings can include:

- Alteration to the stream's natural flow pattern;
- Increase in erosion due to concentration of flow;
- Increased risk of blockage or damage due to debris;
- Reduced capacity for fish and aquatic fauna movement;
- Reduction in wildlife and aquatic fauna habitat in the immediate vicinity of the crossing;
- Adverse impacts on macrophyte communities;
- Reduction in hydraulic capacity of the stream;
- Increased extent of flooding upstream;
- Increased nutrient loads where crossings are used for stock movement on dairy farms;
- Sediment input during construction.

There are a number of arrangements for culverts in waterways as shown in Figure 1.

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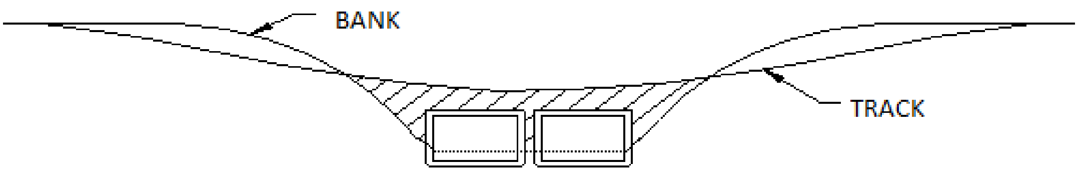
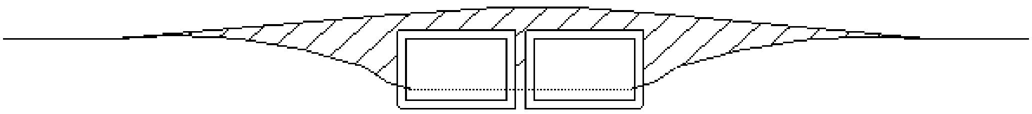
Figure 1: Culvert Arrangements



Box Culvert with Ford



Box culvert without Ford

Assessment Criteria

Fish Passage

Connectivity through a waterway has been identified as an essential component of healthy fish populations as it allows for access to important spawning, dispersal, feeding, refuge, juvenile and adult habitats. Stream barriers such as culvert crossings, can result in a loss of connectivity and has been attributed to the decline in many native fish species in Australian waterways (O'Connor, Stuart & Campbell-Beschorner, 2017).

Table 1 Minimum *preferred* structures for Fish Passage.

Classification	Stream Characteristics	Minimum Preferred Structure
Class 1 - Major fish habitat	Large named permanently flowing stream. Aquatic vegetation present. Known fish habitat.	Bridge
Class 2 – Moderate fish habitat	Smaller named permanently or intermittent flowing stream. Aquatic vegetation present. Known fish habitat.	Large box culvert or bridge
Class 3 – Minimal fish habitat	Named or unnamed watercourse with intermittent flow.	Box culverts
Class 4 – Unlikely fish habitat	Named or unnamed stream with flow during rain events only.	Ford or pipe culverts

Pipe culverts have been identified as the greatest impediment to fish passage and are not recommended for natural streams (O'Connor et al., 2017). This is due to the hydraulic barriers to fish movement and the inability for fish to rest. Many Australian native species of fish are also reluctant to enter a darkened environment that may result from the use of long lengths of pipe. Pipe culvert crossings should only be allowed on Class 4 waterways.

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Track Height

Culvert crossings can be set with the track level at or above the top of bank or some lower level, depending on the frequency of overtopping of the track or roadway that is acceptable to the crossings intended purpose.

A low level ford crossing will be the most cost effective for most farming operations. This type of structure will also normally have no significant effects on the hydraulic capacity of the stream.

For dairy farms, the crossing should be above natural surface so animal wastes are drained away from the waterway.

Culvert Width

For Class 2 streams the recommended width of the box culverts across the bed is 125% of the typical stream bed width. A narrower width may be acceptable for Class 3 and 4 streams.

For pipe culverts on Class 4 streams, the total pipe diameter should be equal to the base stream bed width.

This approach ensures close to natural stream velocities are maintained for aquatic fauna and minimises potential bed erosion.

Culvert Length

Generally culvert length should not exceed 6 metres.

Culverts can also include light grids to allow sufficient light through the culvert so that native fish species are not discouraged by a sudden decrease in light levels (O'Connor et al., 2017).

Invert Level

The invert of the culverts should be at least 300 mm below the bed of the stream. This will avoid any artificial gradient and allow some sedimentation to occur within the culvert, thus providing a more natural environment for fish and aquatic fauna.

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Culvert Height

A minimum culvert height of 1,200 mm is recommended for low level culvert crossings on Class 2 streams. A lesser height of 900 mm would be acceptable for Class 3 and 4 streams.

This is based on providing at least 600 mm airspace above the typical base flow in the stream to ensure reasonable light within the culvert to encourage fish passage, as well as capacity for minor flows. The recommended height is calculated as follows:

Stream depth at normal low flow	300 mm
Airspace	600 mm
Depth invert below stream bed	300 mm
Culvert height	1200 mm

Hydraulic Assessment

An hydraulic assessment is necessary for all arrangements to check whether or not the works would cause impacts off the applicant's property, would induce erosion damage to the track or the stream and whether velocities through the culverts are acceptable. It is also required to determine any applicable safety criteria for access can be achieved.

Crossing Stabilisation

The crossing must be stabilised to prevent failure during overtopping. As well as loss of access for the owner and the cost of reinstatement, a failure would mean significant sediment input to the stream.

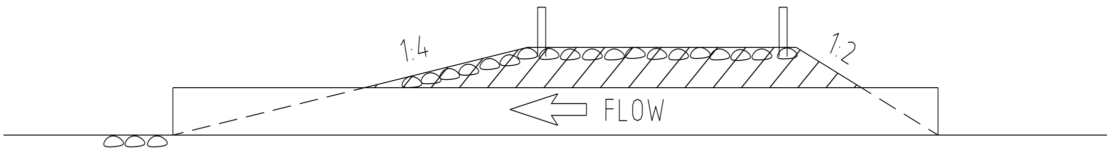
Riprap is required on the downstream batter, bank crest and around the culvert inlet for protection. The rock size should be determined based on the critical flow over the crest before the structure becomes drowned out, after which the velocities over the structure are lower and less critical. The following criteria applies:

- The earth embankment should be compacted to achieve 95% maximum dry density.
- The riprap specification on the downstream batter should be for a well graded hard quarried rock placed 1.5 to 2 times the rock size in thickness. In general a minimum D_{50} of 300 mm would apply. Alternative measures will need to be used where large rock is unavailable. (D_{50} is the median rip rap diameter of the rock mix.)
- The downstream batter to have a maximum slope of 1(v):4(h).

- The crest to be covered with 20 mm to 150 mm diameter rock mix, 200 mm thick (compacted thickness), or sealed with bitumen or concrete.

The upstream batter should not be steeper than 1(v):2(h). Beaching or riprap is not always necessary on the upstream batter but is recommended as good practice if afflux exceeds 300 mm at the point of overtopping. Establishment of a grass cover is desirable to stabilise the batter surface.

Figure 2 Crossing Embankment



Bed and Batter Protection

The need for bed and bank protection depends on the materials at the site. Rock riprap is required on the bed except where the stream bed is rock or consists of stones 150 mm diameter or greater. Rock riprap is also required on the stream banks to protect them during flows over the structure.

For low level crossings, riprap is required on bed and banks to at least 1 metre above track level, extending at least 4 times the culvert height downstream of the culvert. The mean diameter (D_{50}) of the riprap should be based on the Hydrologic and Hydaulic design guidelines from Melbourne Water (https://www.melbournewater.com.au/planning-and-building/developer-guides-and-resources/standards-and-specifications/hydrologic-and). A range of flows needs to be considered to determine the critical flow condition that leads to the largest size rip rap. The quarried rock shall have a minimum D_{50} of 150 mm nominal size.

Local Drainage

In the case of high level crossings, including dairy crossings, local drainage from the site and access tracks should be directed to sedimentation basins or grassed filter zones to trap sediments and nutrients.

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Local drainage from low level crossings should be directed to grassed filter zones to trap sediments and nutrients.

The batters of the access track excavated into the stream bank should be on a slope of 1(v):2(h) or flatter to facilitate the establishment of a grass cover. Table drains at the toe of the batter should be stabilised with graded rock.

Alignment

The culverts should be laid parallel to the main stream flow path. Low level crossings must be aligned with the track perpendicular to the main stream flow path.

References

J. O'Connor, I. Stuart, R. Campbell-Beschorner (2017) Guidelines for fish passage at small structures. Arthur Rylah Institute for Environmental Research Technical Report Series No. 276. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

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