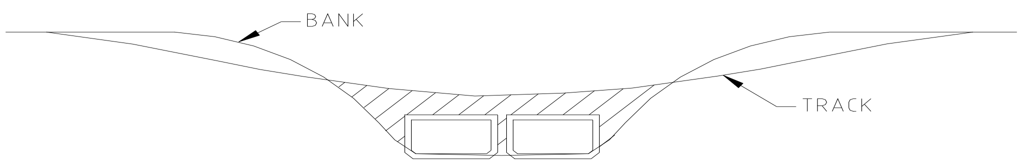
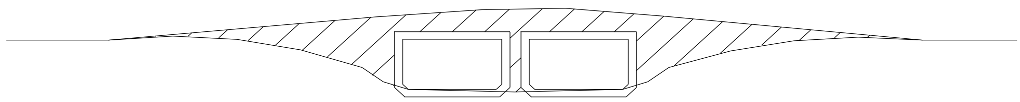
Works on Waterways Notes – Culverts

There are several arrangements for culverts in waterways as shown in Figure 1.

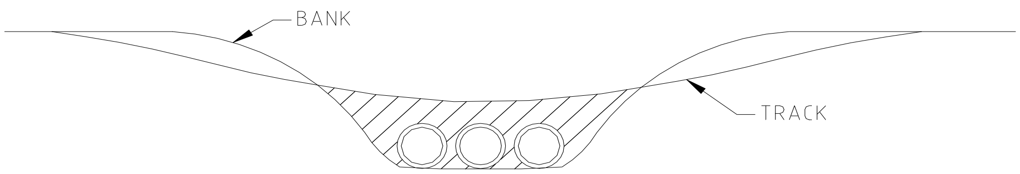
Figure 1: Culvert Arrangements



Box Culvert with Ford



Box culvert without Ford



Pipe Culvert with Ford

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.

Assessment Criteria

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 owner.

A low-level 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 provided the top of the track is less than about 50% of the depth of the stream channel.

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

Culvert Type and Width

Generally, box culverts should be used in the Class 2 streams (see Table 3). Pipe culverts may be considered for class 3 and 4 streams. Note: a combination of box and pipe culverts could be considered to provide additional waterway area if requested.

For Class 2 streams, the recommended width of the box culverts across the bed is 75% of the typical stream bed width. A narrower width of 50% may be acceptable for Class 3 and 4 streams.

For pipe culverts on Class 3 and 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. Where the proposal does not meet this criterion, a wider structure should be a condition of approval.

Invert Level

The invert of the culverts should be at least 150 mm below the bed of the stream. This will allow some sedimentation to occur within the culvert, thus providing a more natural environment for fish and aquatic fauna.

Culvert Height

A minimum culvert height of 1,200 mm is recommended for low level culvert crossings on Class 2 streams as described in **Table 3** 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:

Table 1. Culvert height calculation

Stream depth at normal low flow	300 mm
Airspace	600 mm
Depth invert below stream bed	150 mm
Culvert height	1050 mm (say 1200 mm)

Hydraulic Assessment

A 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.

Crossing Stabilisation

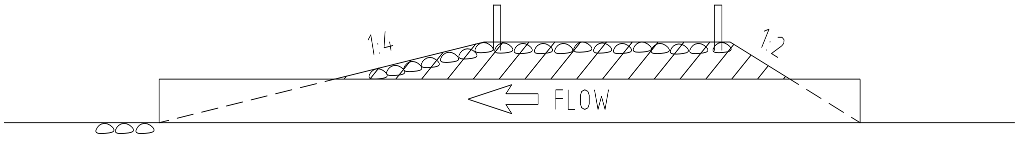
The crossing must be stabilised to prevent failure during overtopping. As well as loss of access for the owner and the cost of reinstatement, a failure would mean significant sediment input to the stream.

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 can be determined in accordance with SCRC (1991). 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.

Table 2. Rock Rip Rap Gradation Size:

Spherical Diameter	% of rip rap smaller (i.e., % of rip rap passing through sieve)
1.5 – 2.0 D50	100%
D50	50%
0.3 – 0.4 D50	10-20%

D50 = median rock rip rap size

That is: there should be no rock greater than 2 x D50. 50% of the rock should be evenly graded from D50 to 2 x D50. 40% of the rock should be evenly graded from D50 to 0.3 – 0.4 D50. And the final 10% of rock will be less than 0.3 D50 to fill the gaps.

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 rather than discharging directly to the stream. Where outfall directly to the waterway cannot be avoided, piped or rock chute outfalls may be needed.

The culvert surface should be graded to sedimentation basins or grassed filter zones to trap sediments at each end of the bridge, with the return flow either overland or by pipe to the stream.

On dairy farms, the culvert surface and tracks are to be graded away from the waterway to a drainage recycling system to prevent animal wastes directly discharging to the waterway.

There should be no direct connection of any dairy track to a stream or connected drain. 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 and Location

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. Culverts should be located on a stable reach of the stream.

Fish Passage

The type of structure recommended to provide fish passage depends on the characteristics of the stream. The minimum preferred structure type is shown in **Table 3** and based on a report by NSW Fisheries (1999). This methodology can be used for access crossings and other in-stream structures such as drop structures, to quickly determine whether provision for fish passage is required.

Pipe culverts are generally not recommended for natural streams as they inhibit the passage of fish. (NSW Fisheries, 1999). This is due to the narrow effective bed width and greater flow concentration compared with box culverts. Some fish species are also reluctant to enter the darkened environment resulting from the use of long lengths of pipe and thereby creating a barrier to fish movement. Pipe culvert crossings should only be allowed on Class 3 and 4 waterways.

Table 3. 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 / pipe culverts
Class 4 – Unlikely fish habitat	Named or unnamed stream with flow during rain events only.	Ford or culverts