New Zealand
Fish Passage
Advisory Group

Considering fish passage in the design of new instream structures

Why is fish passage important?

New Zealand is home to more than 50 species of native freshwater fishes and several species of sports fishes. Around 70% of our native fishes are threatened or at risk. Many of these fishes, such as eels, whitebait, trout and salmon, spend part of their life in fresh water and part of their life at sea, making access between habitats essential. In addition, some fishes and other freshwater species, such as frogs, shrimps and aquatic invertebrates, also need to move within waterways to access food and spawning grounds. If the movement of these species upstream and downstream is delayed or prevented, they may not be able to reach the necessary habitats to complete their life cycle, resulting in their numbers being reduced or the species being lost completely from the stream.

Instream structures can block or impede the movement of our native freshwater and valued introduced fish species. Structures such as tide and flood gates, road crossings, culverts, weirs, fords and dams can slow or stop fish from migrating to upstream and downstream habitats if they are not designed, installed and maintained correctly. Fish can also be sucked into intake structures that lack suitable fish screens, resulting in their removal from their habitats and loss from populations.

There are very few situations where the installation of intentional barriers to fish passage will be appropriate in New Zealand. Therefore, you can help our freshwater species by ensuring that structures in waterways are designed and constructed to provide appropriate fish passage by adhering to the *New Zealand Fish Passage Guidelines* (https://niwa.co.nz/freshwater-and-estuaries/research-projects/new-zealand-fish-passage-guidelines).

Planning considerations

The Department of Conservation (DOC) and regional councils have specific responsibilities to manage fish passage in New Zealand's waterways.

DOC is responsible for enforcing the Freshwater Fisheries Regulations 1983, under which culverts, fords, dams and diversion structures in a natural river, stream or other body of water may need approval.[1] This includes considering permits if a culvert or ford impedes fish passage, approving any structural change to fish facilities, and assessing whether proposed dams and diversion structures require a fish facility.

Regional councils are responsible for controlling the environmental effects of construction under the Resource Management Act 1991, including enforcing the **Resource Management (National Environmental Standards for Freshwater) Regulations 2020** that has set rules that apply whenever someone is installing or altering a culvert, weir, flap gate, dam or ford. Rules in councils' regional plans include providing fish passage and protecting places that provide important habitat for native species. Other statutory requirements apply in some cases and should be considered when designing and managing physical structures (see Appendices A & B of the *New Zealand Fish Passage Guidelines* for further explanation).

Before deciding on the best design for a proposed structure, it is important to:

- check which species are in the waterway
- identify objectives and performance standards (see section 3 of the *New Zealand Fish Passage Guidelines*)
- plan for maintenance and monitoring to ensure that fish passage is maintained and the structure is working (see section 7 of the *New Zealand Fish Passage Guidelines*).

[1] For information on the modification of existing structures, see the *How to fix fish barriers in existing instream structures* resource (www.doc.govt.nz/nature/habitats/freshwater/fish-passage-management/resources/) or information on approvals required, see www.doc.govt.nz/fish-passage-authorisations.

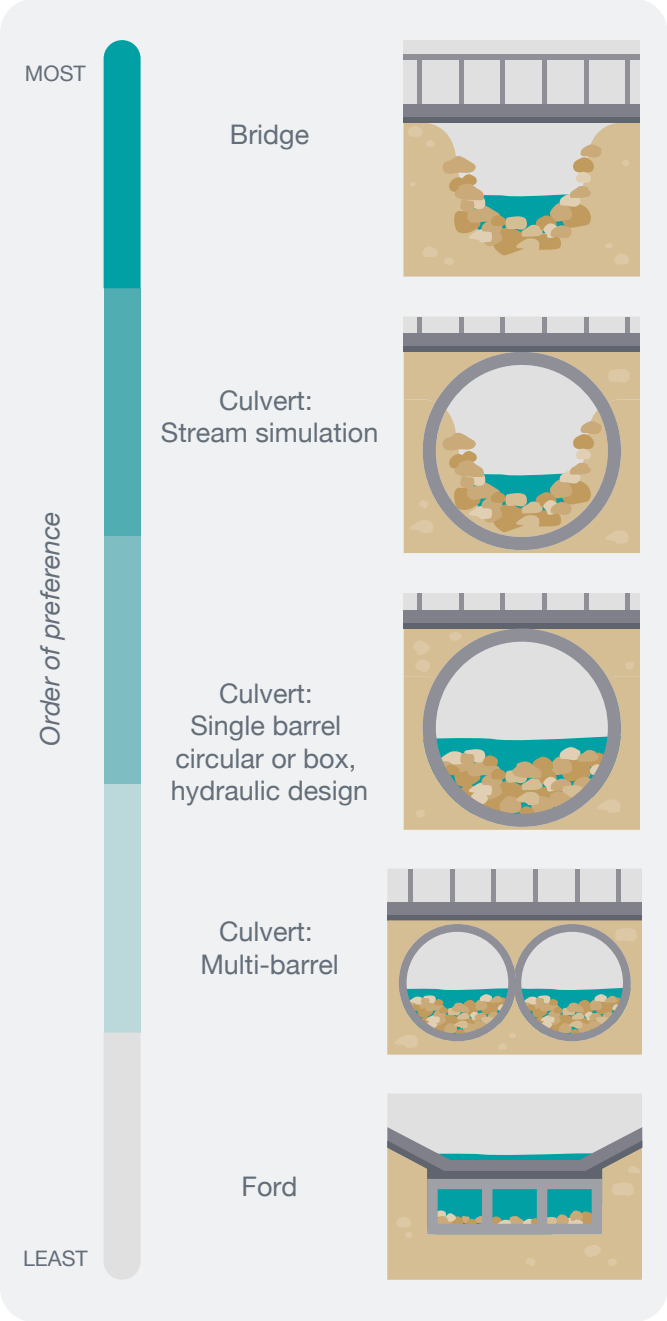
Department of Conservation
Te Papa Atawhai

New Zealand Government

New structure design

The most suitable structure at a given location will depend on its purpose (eg to provide a crossing over a natural waterway without affecting the stream), the species that use the waterway (eg the species' different abilities and habitat requirements) and local conditions (eg high versus low gradient). A bridge is the most preferred option, while a ford is the least preferred.

Good practice guidelines for the design of culverts, weirs, and flood and tide gates are summarised below. (See section 4 of the *New Zealand Fish Passage Guidelines* for further detail.)



Culverts

Culverts are commonly used to convey water beneath roads, tracks, and other crossings of waterways. There are two approaches to culvert design that allow fish passage.

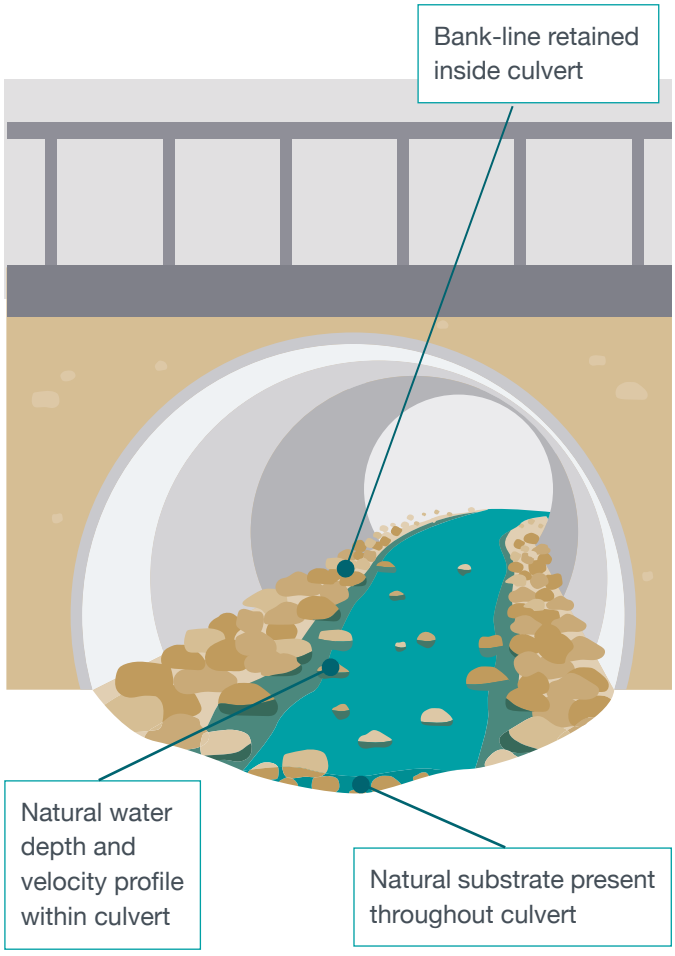
- The **stream simulation approach** represents best practice for allowing passage for a wide range of organisms (sizes, ages and species) and uses more holistic design thinking that integrates geomorphic, engineering and ecological approaches.
- The **hydraulic approach** represents minimum design standards that will provide passage.

Alteration of the natural stream channel alignment, gradient and substrate should be avoided or minimised with either approach.

Stream simulation approach

The aim of the stream simulation design approach is to create a channel within the structure that is as similar as possible in both structure and function to the adjacent natural stream channel.

The following best practice design criteria should be used.



- The culvert span is greater than the bankfull width. The stream bed inside the culvert should be 1.2 x bankfull width + 0.6 m.
- Open bottom culverts are used or the culvert invert is embedded by 25–50% of the culvert height.
- Natural water depth, velocity, bank margins and substrate are present within culvert. The composition and stability of the substrate in the natural stream is matched throughout the full length of the culvert bed.
- The 84th percentile of the particle size distribution (D_{84}) is the recommended benchmark grain size for bed mobility.

Hydraulic approach

The following design criteria should be used when site constraints (eg existing infrastructure) prevent the use of a stream simulation approach.

- The culvert span is:
  - 1.3 x stream bankfull width for streams ≤ 3 m wide
  - 1.2 x stream bankfull width + 0.6 m for streams > 3 m wide.
- Open bottom culverts are used or the culvert invert is embedded by 25–50% of the culvert height.
- Well-graded substrate is present throughout the full length of the culvert bed.
- The substrate within the culvert is stable at the high fish passage design flow[2].
- The mean cross-sectional water velocity in the culvert over the fish passage design flow range is equal to or less than the greater of:
  - the mean cross-sectional water velocity in adjacent natural stream reaches, or
  - the maximum allowable water velocity calculated from fish swimming speeds of agreed target fish species and/or life stages.
- The minimum water depth in the culvert at the low fish passage design flow is the lesser of:
  - 150 mm for native fish passage, or
  - 250 mm where adult salmonid passage is also required, or
  - the mean cross-sectional depth in adjacent natural stream reaches.

[2] Fish passage design flow – the range of flows over which fish passage is required.

[3] For further information see www.doc.govt.nz/fish-passage-authorisations

Weirs

Weirs are structures that are used to control water levels. The construction of new weirs should be avoided where possible. However, if unavoidable, a full width rock-ramp fishway should be used to provide the same water level control function as a weir while maintaining fish passage.

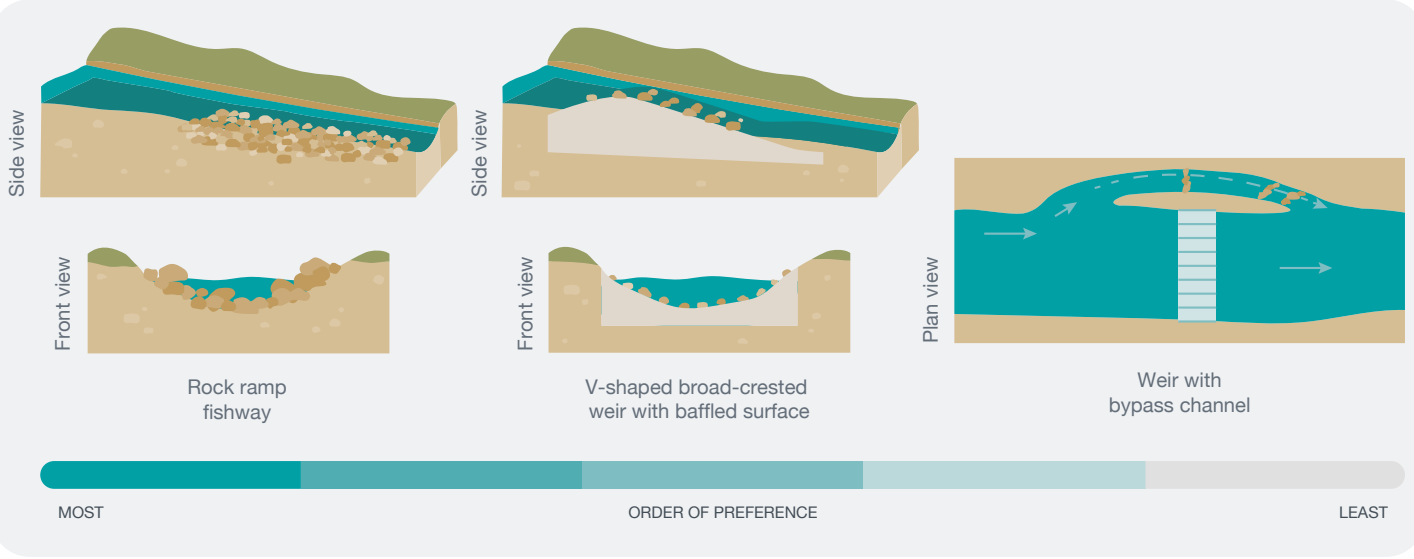
The following design criteria should be used for a rock-ramp weir.

- Slope is gentle (1:15 to 1:30). A slope of 1:30 is suitable where weakly swimming species such as īnanga and smelt require passage.
- The lateral profile is V-shaped, sloping up at the banks and providing a low-flow channel in the centre. 5–10° is a suitable slope for the lateral cross-section.
- The weir should create a hydraulically diverse flow environment including continuous low velocity wetted margins and resting areas in all flows.
- Backwatering of upstream habitats should be minimised.

Where site conditions prevent the use of a rock-ramp fishway in place of a weir, broad-crested weirs with rounded crests are preferred. Vertical weirs with sharp or overhanging downstream edges must be avoided. If a weir is proposed, you will need to apply to DOC to determine if a fish facility (eg fish ramp) will be required[3].

The following design criteria should be used for conventional weirs.

- Slopes on the downstream side are gentle, with continuous low-velocity wetted margins provided up the weir. Suitable slopes are:
  - ≤ 1:10 for a conventional weir where the fall height is ≤ 1 m
  - ≤ 1:15 for a conventional weir where the fall height is 1–4 m.
- The lateral profile is V-shaped, sloping up at the banks and providing a low-flow channel in the centre. 5–10° is a suitable slope for the lateral cross-section.
- No smooth concrete is used on the downstream face of the weir.
- Roughness elements are added to the whole weir face, such as embedded mixed-grade rocks (150–200 mm diameter). These rocks should be closely (70–90 mm) and irregularly spaced to create a diverse flow structure across the weir.
- Backwatering of upstream habitats because of the weir must be minimised.
- Downstream edge should be rounded where possible.



Fords

Fords are constructed to provide crossings over waterways. The use of fords should be avoided or minimised. However, where they are required, the following design criteria should be used.

- Reduction in the cross-sectional area of the channel at the ford is avoided or minimised over the fish passage design flow range.
- Culverts are incorporated and meet the minimum design standards.
- Where multiple culvert barrels are required, box culverts are used – circular culverts must be avoided.
- Substrate is maintained throughout the full length of the culvert(s) and remains stable across the fish passage design flow range.
- Alteration of the natural stream channel alignment and gradient is avoided or minimised.
- The surface of the ford is roughened (eg by embedding rocks) to facilitate the passage of fish when flows overtop the structure.
- The lateral profile is V-shaped to ensure that wetted margins are maintained across the ford when it is overtopped during high flows.

Flood and tide gates

Flood and tide gates are primarily used to prevent low-lying lands from becoming flooded during high-flow periods. Both types of structures should be avoided if possible, as they can significantly disrupt the movements of freshwater species and alter upstream habitats. However, if gates are required, best practice is to install automatic gates that operate based on the water level and only close when needed for flood protection. Minimum standards for fish passage require self-regulating 'fish-friendly' gates that maximise the opening duration and aperture, particularly on the incoming tide when most juvenile fish are migrating upstream.

Stormwater management ponds

Stormwater management ponds/wetlands are designed to reduce downstream flooding and erosion in urban or modified waterways. Recommended best practice is to utilise dry detention ponds or to develop an 'off-line' wet pond system. Since dry detention ponds do not provide suitable habitat for fish, their passage does not need to be considered. Where an 'online' wet pond design is required, good practice would be to design a wetland in which the water levels are controlled by a weir at the outlet, following the minimum design standards for weirs outlined above. Vertical risers are not recommended for water level control as they exclude both swimming and climbing fish.

Resources

- **New Zealand Fish Passage Guidelines**

  Franklin, P.; Gee, E.; Baker, C.; Bowie, S. 2018: New Zealand Fish Passage Guidelines for structures up to 4 metres. Version 1. NIWA Client Report 2018019HN. 226 p. https://niwa.co.nz/static/web/freshwater-and-estuaries/NZ-FishPassageGuidelines-upto4m-NIWA-DOC-NZFPAG.pdf

- **How to fix fish passage barriers in existing instream structures**

  Department of Conservation 2020: How to fix fish passage barriers in existing instream structures. Department of Conservation, Wellington. 7 p. www.doc.govt.nz/nature/habitats/freshwater/fish-passage-management/resources/

Need further help?

Check out **www.doc.govt.nz/fishpassage** or contact your local council or DOC office.

JULY 2020 | R182206