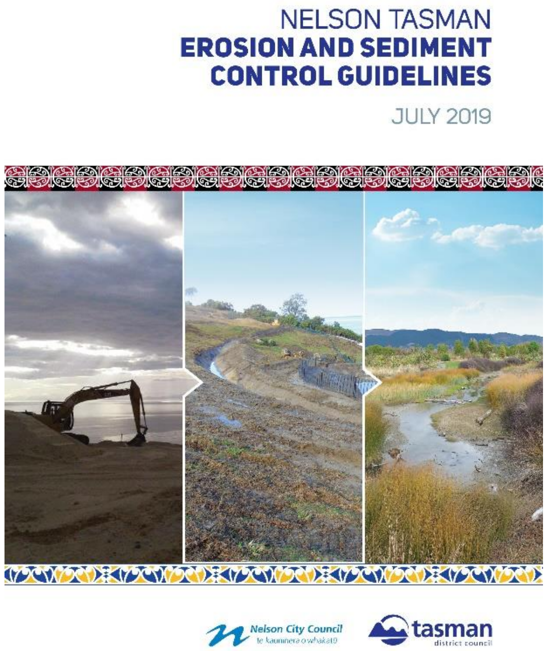
Chapter 11

Activities Within and Around Watercourses



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te kaunihera o whakatū

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11.1 Introduction

Works within or around watercourses have very high potential for erosion and discharge of sediment as they are undertaken in or near flowing water - the major cause of erosion. Flowing water causes ongoing scour and provides the transport mechanism to allow sediment to be dispersed downstream and into other receiving environments.

The potential effects of activities within and around watercourses fall into two categories:

1. Direct effects on the immediate area of works, including the bed, banks and vegetation.
2. Effects on downstream areas from sediments and debris generated by the works degrading water quality, causing habitat change or affecting flood risks.

Works in or around watercourses can have a direct impact on watercourse habitat and ecology, through:

- Direct removal and destruction of substrate habitat by digging out the bed.
- Removing areas used for wildlife spawning or rearing, both in-stream and along the banks.
- Removing cover (eg vegetation, woody material, substrate) used by wildlife for avoiding predation or waiting in prey.
- Removing vegetation that provides food into the stream (eg leaf and insect fall).
- Removing vegetation that provides shading and reduces water temperatures.

Effects on water quality can have far reaching impacts, particularly where fine sediments are generated that may be transported long distances downstream. Unlike contaminants such as nutrients, the ecological response to fine sediment discharges is almost always adverse right from small concentrations (Quinn 2000). Sedimentation during a storm can have significant adverse effects, however sedimentation generated during low flow conditions can have devastating impacts to aquatic resources. Effects of sediment include:

- Destroying aquatic habitats by filling in pool areas and reducing habitat diversity.
- Reducing flow carrying capacity, potentially increasing flooding risks, due to deposition in the stream bottom.
- Smothering of wildlife living in the riverbed.
- Reducing light available for aquatic plants and making it harder for wildlife to see for feeding.
- Damage to aquatic food supplies through loss of biofilms on stream beds and the filling of streambed features, such as crevices, where organic matter would normally collect.
- Damage to the fine gills and mouth parts of macroinvertebrates and fish due to the abrasive suspended sediment and stressing of animals affecting growth and mortality rates.
- Impacts on the reproduction of fish species by inhibiting colonization and migration and the destruction of developing eggs and newly hatched fry.

There are also other effects, such as those on amenity and modification of natural character.

Great care is required for works in and around watercourses to avoid potential effects as much as possible. Where this is unavoidable, specific control measures and methodology are required to minimise potential adverse impacts.

Activities in watercourses mean those within the water or the river bed (refer section 11.3 while works around watercourses mean those in close proximity (eg within 15m) and in particular, works on areas sloping into watercourses. There is also a general requirement for all areas to comply with Part 6 of the TRMP and the NRMP regarding discharges to land, air and water.

All activities in a watercourse, including the placement of structures and diversion of water will need to comply with Parts 4, 5 and 6 of the TRMP and relevant sections of the NRMP may require resource consent.

Depending on the site characteristics and specific activities (eg other structures), there may also be other relevant rules in the TRMP and the NRMP, for example those relating to stormwater or heritage aspects. It is recommended that Council planners are contacted to discuss each site on a case by case basis to ensure all the relevant consents are sought.

Figure 11-1 Bridge construction with a temporary stream diversion using pipe (yellow) and pump (not shown). The pump shown is dewatering the works area to an offline sediment retention pond)

Key aspects considered in the TRMP and the NRMP for activities in and around watercourses include:

- Potential for causing erosion or flooding.
- Potential for obstruction of flood water or navigation.
- Impacts on fish passage and spawning.
- Impacts on habitats and bird nesting.
- Impacts on vegetation or soil, bank stability and water quality.
- Structures in Water Conservation Order areas (eg in the Buller and Motueka catchments – refer Chapter 3, section 3.4.9).
- Diversions in wetlands.
- Impacts on cultural heritage sites and public access.
- Impacts on visual clarity and colour of receiving waters and depth of sediment depositions.
- Removal of all structures and materials and reinstatement of natural bed at decommissioning.

11.2 What constitutes a watercourse?

From a planning and resource consent perspective a watercourse is anything defined as a river under the Resource Management Act (RMA).

The RMA defines River as:

***"River** means a continually or intermittently flowing body of fresh water; and includes a stream and modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal:"*

Any activities within or around watercourses that meet the definition of river will need to comply with parts 4, 5 and 6 of the TRMP and the NRMP regarding activities in beds, water takes, diversions and discharges. Further information on Tasman's perennial and intermittent rivers and streams can be found in Chapter 5.4.

A drain or a stream?

Many streams in Tasman and Nelson, particularly in lowland areas have been highly modified, including channel straightening, channel lining and armouring and changes to riparian vegetation. Many are also referred to as 'drains', but these are still legally classed as rivers (refer Case Law 2003 and 2009). This is also the case for diversions of previous water bodies – including streams, rivers and wetlands – effectively if there was a water body there previously, then any subsequent channel formed to divert the water (even if completely man-made) is still considered a river under the RMA (Case Law 2002, Case Law 2009). This makes a distinction between an artificial channel and an artificial watercourse - the former is still a river; the latter is not.

If there is any doubt about the nature of a watercourse on site, it is prudent to consider it as a natural watercourse (river), even when highly modified. If you are unsure about a watercourse or identifying where the bed of the river is for consenting purposes, seek advice from Council.

The TRMP further defines artificial watercourses as:

***"Artificial Watercourse** means a constructed watercourse that contains no natural portion from its confluence with a river or stream to its headwaters and includes any:*

(a) irrigation canal;
(b) water supply race;
(c) canal for the supply of water for electricity power generation;
(d) roadside drain (or water table or culvert) that is constructed alongside or under roads used by vehicles and has as its primary function the drainage of surface water from the road;
(e) farm drainage canal."

Artificial watercourses still contain water and are subject to rules in Parts 5 and 6 of the TRMP regarding water takes, diversions and discharges. In considering erosion and sediment control it is important to remember that most artificial watercourses flow into other receiving environments (rivers, lakes and wetlands, etc) or water is taken for specific end uses, and it is therefore important to minimise the generation of sediment and its transport into downstream areas.

In addition, some artificial watercourses, although not legally classed as rivers (or streams), may still function as streams, providing both good habitat and water quality that could be retained with some forethought.

11.3 Where is the bed of a river?

The RMA defines the bed of a river and lake as:

***"Bed** means,—*

(a) In relation to any river—

(i) For the purposes of esplanade reserves, esplanade strips, and subdivision, the space of land which the waters of the river cover at its annual fullest flow without overtopping its banks:

(ii) In all other cases, the space of land which the waters of the river cover at its fullest flow without overtopping its banks; and

(b) In relation to any lake, except a lake controlled by artificial means,—

(i) For the purposes of esplanade reserves, esplanade strips, and subdivision, the space of land which the waters of the lake cover at its annual highest level without exceeding its margin:

(ii) In all other cases, the space of land which the waters of the lake cover at its highest level without exceeding its margin; and

(c) In relation to any lake controlled by artificial means, the space of land which the waters of the lake cover at its maximum permitted operating level; and

(d) In relation to the sea, the submarine areas covered by the internal waters and the territorial sea."

For activities in watercourses a[ii] (or b[ii] and c (in the case of lakes) applies. This can be difficult to identify for small shallow streams or those in steep gullies, as there may be no readily defined edge of bank. Contact Council for assistance in identifying your obligations.

11.4 Types of Activities and Methods of Protection

The types of activities which may cause erosion and sediment generation issues in and around watercourses includes:

- Earthworks, recontouring and construction of roads or tracks.
- Sediment removal from streams, stream reprofiling or re alignment.
- Temporary passage across or along watercourses to access other parts of sites during construction.
- Removal and planting of vegetation alongside or within watercourses.
- Piping and infilling of watercourses (this should only occur where a resource consent has been obtained).
- Installation of temporary and permanent structures, such as culverts, bridges and utility pipes.
- Installation of protection structures for bank stability and erosion control (retaining walls, rock rip-rap, etc).
- Installation of temporary or new outlets (eg sediment retention pond outflows or stormwater pipes) that discharge into watercourses.
- Stock access.
- Cultivation (crops and forestry).

Erosion and sediment control measures are not to be constructed in channels having permanent flow. This is because the catchments are too large, the permanent flows limit the effectiveness of any controls, they can impede fish passage and they cause their own effects because of the degree of construction disturbance. Instead the aim is usually to divert flows temporarily around the area of works, allowing for activities to be done 'in the dry'.

The following sections cover the typical methods used when undertaking activities in or around watercourses including:

- Temporary waterway crossings.
- Temporary diversion by damming and piping.
- Temporary diversion by new temporary channel.
- Outlet protection.

Some situations may also require a range of other control measures in additional to those discussed, including those outlined in Chapters 8 and 9. Specialist help may be required in some circumstances. For example, fish and eel recovery may be required for many stream and river works. This process is outlined in the following section.

11.5 Eel and fish recovery

Eel and fish recovery is required in all situations where flowing watercourses are diverted during works. In addition, eel and fish recovery will also be required in intermittent watercourses that have ceased flowing and where residual pools are present.

In situations where works are being undertaken in wetted channels, but diversion is not practicable, eel and fish recovery may also be required depending on the site characteristics and the nature of the works.

These situations require differing methodologies for eel and fish recovery which are outlined in the sections below.

In all cases recovery operations should be overseen by an appropriately qualified ecologist and undertaken by persons holding relevant permits to transfer fish (from the Ministry of Primary Industries (MPI) and the Department of Conservation).

In addition, those undertaking electric fishing will also typically be required to hold a licence certifying completion of a NIWA electric fishing training course under health and safety requirements.

11.5.1 Eel and fish recovery for watercourse diversions

It is important with any stream work that fish, including eels, are recovered from the intended work area before work begins.

The basic recovery process involves:

1. Isolating the subject stream reach with stop nets or silt fences at upstream and downstream ends prior to damming and pumping or channel diversion
2. Electric fishing the isolated section with 2-3 passes. Use two machines for waterways over 3m wide
3. Once the dams are placed within the isolated area, over-pumping the stream water from the dammed section and electric fishing of any residual ponds, collecting any stranded fish. This process may

need to be repeated depending on the specific project and stream characteristics to maximize fish recovery. This process may involve iwi monitors

4. Avoid predation by eels while holding the recovered fish for transfer by keeping fish and eels over 400mm in separate tanks from those under 400mm long
5. Fish should be kept in suitably large containers, kept shaded and cool, and transferred as soon as possible. Fish should be kept no longer than 6hrs in summer or 12hrs in winter, unless water is kept cool and well aerated. If fish show signs of distress, such as gasping at surface, they should be released immediately.
6. Fish should be released to a suitable location in flowing water in the same waterway where possible. This transfer needs to be overseen by personnel with a licence from the Ministry of Primary Industries.
7. When work is complete and the watercourse bed is reinstated, return the water to the stream by removing the dams and then remove the stop nets/silt fences to allow fish passage back into the isolated area.

Figure 11-2 Fish recovery in Reservoir Creek using electric fishing technique and a recovered eel awaiting transfer

11.5.2 Eel and fish recovery and mitigation for works in wetted channels

In some situations diversion of waterways and undertaking works in the dry are not practicable due to waterway size or site characteristics. Ecological sampling should be undertaken to determine the type and abundance of fish populations in the works area to assist in identifying appropriate mitigation methods.

Methods that may be employed to minimise impacts on fish populations include:

- Minimising the area of wetted channel that is disturbed.
- Fish recovery immediately before the works are carried out, including electric fishing and installation of fish stop-nets up and downstream to prevent fish re-entering the work zone.
- Installing sediment curtains or silt fences to minimise sediment transport downstream (refer Chapter 8, section 8.2).
- Using an excavator with a weed rake attachment to allow fish chance to escape back into the water.

- Avoiding the compaction of excavated sediments for at least 24hours to allow for eel escape or recovery.
- If excavated stream bed sediments are disposed of near or along the channel, benching of disposed sediments towards the watercourse to encourage fish and eel movement back towards the watercourse (eels can move effectively over wetted ground for some distance). Do not place such bed sediment on the landward side of a stopbank as fish will generally only move down-slope.
- If excavated bed sediments are disposed of away from the channel (ie at a designated dump site) – carefully spreading out excavated bank and bed materials at the disposal site to allow for eel and fish search and recovery and transfer back to the watercourse for release.
- Records of fish recovered including basic size classes should be kept and provided to the Resource Scientist responsible for river ecology monitoring.

11.6 Temporary watercourse crossings

11.6.1 Definition and purpose

A temporary bridge or culvert installed across a watercourse for short term use by construction vehicles.

Temporary watercourse crossings provide a means for construction vehicles to cross watercourses without moving sediment into the watercourse, causing turbidity, or damaging the bed and channel.

Figure 11-3 Temporary culvert crossing

11.6.2 Conditions where practice applies

Where heavy equipment is required to be moved from one side of a watercourse to the other, or where traffic crosses the watercourse frequently for a short period of time.

11.6.3 Key design criteria

If a watercourse crossing is required, select a location where the potential effects of the crossing (including its construction) are minimised, such as old or existing crossings or areas where the bed is firm aggregates or cobbles rather than muds.

Plan watercourse crossings well before you need them and if possible, construct them during periods of dry weather. Complete construction as rapidly as possible and stabilise all disturbed areas immediately during and following construction. Fish and eel recovery may also need to be undertaken in waterways that are flowing at the time of construction (refer Chapter 11.5).

As well as erosion and sediment control measures, structural stability, utility and safety should also be taken into account when designing temporary watercourse crossings. In addition, consents may be required for the construction of the proposed crossing. Any temporary crossing should be consistent with the technical requirements outlined in the Council's Nelson Tasman Land Development Manual (NTLDM) document.

Do not build a watercourse crossing during the fish migration (particularly upstream migration) or spawning periods for the watercourse. In Tasman the main upstream migration period is in spring from August to November. Inanga spawning occurs from February to May near where streams meet the coast and trout spawning occurs from May to August in inland waterways. For further information refer to Tasman District Council Report # 11001 on Tasman fish species (TDC 2011). The migration and spawning calendars for particular species from the report are reproduced in Appendix 13.12.

The two main types of crossing considered to be good practice are bridges and culverts. Crossings using fords may be applicable in certain circumstances.

11.6.3.1 Bridges

Bridges are the preferred temporary watercourse crossing method. They provide the least obstruction to flow and fish migration, cause little or no modification of the bed or banks and generally require little maintenance.

It should be noted, however, that bridges can be a safety hazard if not designed, installed and maintained appropriately. Materials and designs should be adequate to bear the expected loadings.

Figure 11-4 Temporary Bridge Crossing

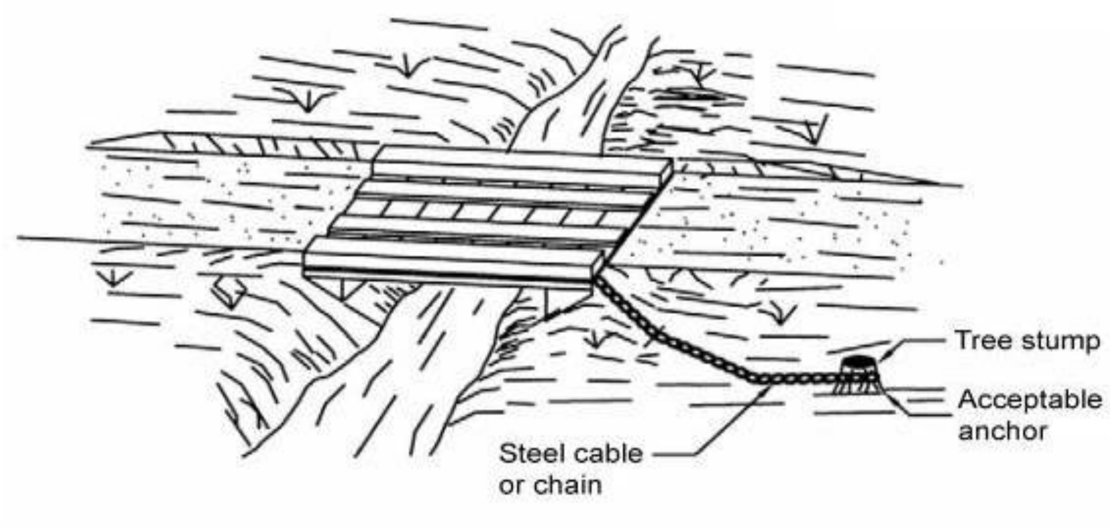

Figure 11-5 Temporary bridge example for small streams (with anchor to retain bridge components during floods)

11.6.3.2 Culvert crossings

Culverts are the most commonly used type of temporary watercourse crossing and can be easily adapted to most site conditions.

The installation and removal of culverts can cause damage to watercourses and can also create obstruction to flood flows and fish passage.

When installing a temporary culvert, sizing is important as storm flows could cause erosion or overtop the culvert causing failure of the temporary access.

Figure 11-6 Temporary culvert crossing with the rock protection at the outfall to reduce stream erosion

The sizing of temporary culverts should be determined by following the risk based approach in Appendix 13.7 through selecting an appropriate design storm from Table 13-12 based on works duration and type of receiving environment. For very short duration works (less than two weeks) with Category B or C receiving environments culvert size can be determined using 85% of the channel width at bank full providing appropriate provision is made for overtopping. Consideration should be given to overland flow paths to ensure that larger flows do not cause safety or environmental impacts.

All temporary watercourse culvert crossings should have a contingency plan in place, in the event that a larger than design storm occurs. The plan should include consideration of the following:

- Where feasible removal of the culvert and stabilization of the channel bed to reinstate full channel flows prior to storm events.
- Understanding the flood flow paths around the site, including the potential for flows to take unusual flow paths due to the culverts - if these are retained in place -which may affect adjacent properties differently than normal.
- Scour protection to ensure the integrity of the crossing in the event of overtopping.
- Ensuring all loose building materials and machinery are out of the channel and any flood flow paths prior to storm events occurring.

Even though the culverts are temporary, they need to ensure that fish passage is not impeded during the period of time that the culvert is in the stream -particularly on perennial streams.

This will typically include:

- Placing the invert of the culvert below the bed level and maintaining the same grade in the pipe as the stream channel to avoid changes in bed level and water depth which may create a barrier to fish.
- Using velocity dissipation structures along the culvert invert to provide low velocity areas to allow for fish passage.

Figure 11-7 Culvert with Energy Dissipation Baffles

- For multiple pipe crossings, one pipe should be lower than the rest to maintain deeper water during low flows.
- The invert (base) of box culverts should be sloped to one side to provide a deeper water zone, rather than a thin film of water at low flows.

See the Council's Best Practice Guidelines for Waterway Crossings (TDC 2009) further design guidance on providing fish passage.

Figure 11-8 Temporary culvert crossings with box culvert and multiple culverts

11.6.3.3 Ford crossings

Crossings using constructed ford structures (low water crossings) are not generally considered best practice for temporary or permanent crossings, however in situations where streams are wide and shallow (eg 10m wide and less than 0.5m deep), with rock or gravel substrates, direct fording of the watercourse by vehicles may occur providing adequate sediment control is used to achieve the required water quality standards. For example, a suitable wheel and truck wash facility provided on each bank to remove excess sediment prior to the crossing and stabilisation of the roads entering into and out of the watercourse with aggregate.

Where bed substrates contain more fine sediments and the crossing of the bed is likely to generate sediment discharges, consideration should be given to methods to temporarily stabilise the bed and banks and approval for this obtained from Council. Fords that are unlikely to comply with the permitted activity conditions in the TRMP and NRMP will need resource consent.

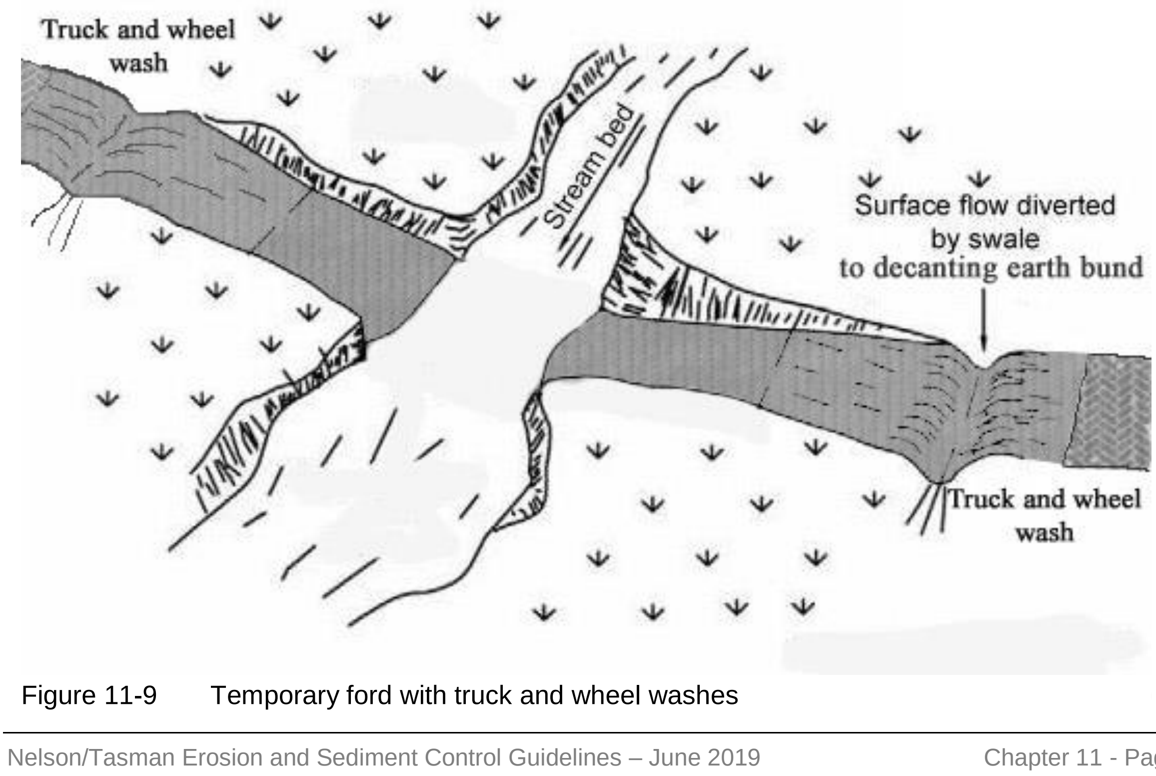

Figure 11-9 Temporary ford with truck and wheel washes

11.6.4 Maintenance of temporary crossings

Inspect temporary watercourse crossings after rain to check for blockage in the channel, erosion of the banks, channel scour or signs of instability. Make all repairs immediately to prevent further damage to the installation.

11.6.5 Decommissioning of temporary crossings

When the structure is no longer needed, remove the structure and all material from the site. Immediately stabilise all areas disturbed during the removal process by revegetation and if required, using artificial protection as a short-term control measure until vegetation has established. If possible, keep machinery clear of the watercourse while removing the structure.

11.7 Diversion by coffer dam

11.7.1 Definition and purpose

Diversion by coffer dam involves a temporary enclosure built within a body of water to allow the enclosed area to be pumped out, creating a dry work environment for the work to proceed. A sufficient width of watercourse is retained to allow normal flows past the works.

Figure 11-10 Aquadam used on the Ruby Bay bypass to isolate an estuary work site

11.7.2 Conditions where practice applies

Diversions by coffer dam are generally suitable for most small, short duration works. They can be used to allow works to be undertaken within permanent and ephemeral watercourses and on the edges of lakes and estuaries.

They allow for continued water flow past the works site without the need for continuous high-volume pumping or a new temporary channel. This can reduce costs in terms of fuel or power for pumping and allows for fish passage throughout the duration of the works.

11.7.3 Limitations

- Not suitable in areas of high velocity flow unless specifically designed and built of appropriate materials.
- May still require ongoing over pumping if groundwater rises into dammed area or coffer dam leaks (eg when made of sandbags).
- Consideration is required for disposal of sediment laden water from over pumping.
- Works may be difficult to undertake due to the small confined area.

11.7.4 Key design and construction criteria

Coffer dams design and construction will depend on the site and situation. Dams can be constructed with stabilised materials such as sandbags, large rock with geo-textile support or other suitable construction materials eg sheet metal or a suitable proprietary (off the shelf) device may be used. The design of the dam should be capable of holding back the incoming flows.

Where fish and eel recovery is required, stop nets or silt fences should be located upstream and downstream to isolate the area to be dammed and initial fish recovery undertaken (refer section 11.5 for the fish recovery process).

Dams are constructed around the area to be worked starting from the upstream side and working progressively downstream to complete the dam. Deployment of proprietary devices should follow the manufactures' instructions. Water remaining within the dammed area is then over pumped to an appropriate dewatering facility (refer 9.6).
If required, the pump intake is retained inside the dammed area to remove water entering the dammed area from leakage through the coffer dam or upwelling from groundwater.

11.7.4.1 Contingency Planning

All watercourse diversions should have a contingency plan in place, in the event that a larger than design storm occurs. The plan should include consideration of the following:

- Where feasible removal of the dam to reinstate complete channel flows prior to storm events.
- Understanding the flood flow paths around the site, including the potential for flows to take unusual flow paths due to the dam - if these are retained in place - which may affect adjacent properties differently than normal.
- Provision for temporary stabilization of the works area prior to any flooding based on forecast warnings. This includes having suitable stabilization materials readily available.
- Ensuring all loose building materials and machinery are out of the channel and any flood flow paths prior to storm events occurring.

11.7.5 Maintenance

Any diversion of a watercourse will require ongoing and vigilant maintenance to minimise erosion and sediment generation.

Key aspects to consider include:

- Integrity of the dam – ensure no erosion or undercutting is occurring.
- Leakage from dams or groundwater into works area.
- Regular monitoring and maintenance of any pump used to dewater the dammed area to ensure continued function at the required capacity.

11.7.6 Decommissioning

Once the works have been completed, the bed in the works area should be reinstated including stabilisation and reshaping of any bare sections of channel to match the cross-section immediately upstream and downstream, reinstatement of similar bed substrate and removal of all materials not required for any installed structures.

Once the bed has been reinstated, progressively remove the coffer dam from the downstream side to allow flows to slowly re-enter the dammed area to minimize erosion and flushing effects or follow the manufactures’ instructions for proprietary devices.

11.8 Diversion by damming and piping

11.8.1 Definition and purpose

Diversion by damming and piping is temporarily used to convey surface water from above a construction activity downstream of that activity. This assists in providing dry working conditions for works within the existing channel.

Damming a stream and pumping the flows around the work site or diverting flows through a gravity fed pipe, back to the stream minimises disturbance considerably compared with diversion by constructing a new temporary channel (refer section 11.9).

Figure 11-11 Temporary Culvert Crossing

11.8.2 Conditions where practice applies

Damming and piping diversions are generally suitable for most small streams with relatively low flows. They have less potential effects on the environment and are relatively simple to carry out when compared to temporary waterway diversions using channels (section 11.9).

11.8.3 Limitations

The key limitation with damming and pipe diversions is that the stream flow able to be diverted is dependent on the pump size and pipe capacity used. In addition, failure of the pump through malfunction or running out of fuel if the pump is unattended (eg at night) could result in flooding of the works area and generation of considerable sediment. There can also be issues with fish passage affecting the allowed duration or timing of the works (refer to the TRMP and NRMP for relevant rules).

Figure 11-12 Reservoir Creek diversion with intake pipe (upper right) and outlet with energy dissipation (lower right)

11.8.4 Key design and construction criteria

Where fish and eel recovery is required, stop nets or silt fences should be located upstream and downstream to isolate the area to be dammed and initial fish recovery undertaken (refer section 11.5 for the fish recovery process).

Dams are constructed across the watercourse upstream and downstream of the proposed works area. Dams can be constructed with stabilised materials such as sandbags, large rock with geo-textile support or other suitable construction materials. The dam should be capable of holding back the incoming flows.

If required a pump intake is installed in the upper dam and sufficient hose/pipe length should be available to reach below the extent of instream works. The pump intake should be placed in a drum with a screen placed on the inlet to ensure that the velocity over the screen is less than 0.3m/sec to prevent sucking up aquatic life and minimise the possibility of sucking sediment from the bottom of the dam.

The pump and pipe should be sized following the risk-based approach in Appendix 13.7 through selecting an appropriate design storm from Chapter 13, Table 13-12 based on works duration and type of receiving environment.

The outlet should be directed to a stabilised area with an energy dissipater, such as riprap boulders or similar to avoid scour of soft banks or bed.

Eel and fish recovery should be undertaken as the isolated area of works is pumped dry. The recovery process is outlined in section 11.5.

Figure 11-13 Pipe diversion during Ruby Bay Bypass (D.Shaw)

For projects longer than five days duration, works will need to cease and flows be reinstated down the main channel to allow for fish passage to occur, unless resource consent has been obtained (refer the diversion of water by structures rule in the TRMP which requires that diversions do not reduce the capacity for fish and eels to migrate past any structure for periods exceeding five days per any 20-day period).

11.8.4.1 Contingency Planning

All watercourse diversions should have a contingency plan in place, in the event that a larger than design storm occurs. The plan should include consideration of the following:

- Where feasible removal of the dams and pumps to reinstate channel flows prior to storm events.
- Understanding the flood flow paths around the site, including the potential for flows to take unusual flow paths due to the dams - if these are retained in place -which may affect adjacent properties differently than normal.
- Provision for temporary stabilization of the works area prior to any flooding based on forecast warnings. This includes having suitable stabilization materials readily available.
- Ensuring all loose building materials and machinery are out of the channel and any flood flow paths prior to storm events occurring.

11.8.5 Maintenance

Any diversion of a watercourse will require ongoing and vigilant maintenance to minimise erosion and sediment generation. This is particularly important where pumps are used to maintain the diversion flow.

Key aspects to consider include:

- Integrity of the dams – ensure no erosion or undercutting is occurring.
- Regular monitoring and maintenance of the pump to ensure continued function at the required capacity.
- Scour occurring where the piped flow re-enters the original channel.
- Leakage from pipes back into works area.

11.8.6 Decommissioning

Once the works have been completed, the bed in the works area should be reinstated including stabilisation and reshaping of any bare sections of channel to match the cross-section immediately upstream and downstream, reinstatement of similar bed substrate and removal of all materials not required for any installed structures.

Once the bed has been reinstated the following steps should be taken to decommission the diversion:

1. Retain upstream and downstream fish nets and silt fences in place during decommissioning
2. While still pumping flows past the isolated area, remove the downstream dam
3. Remove the upstream dam and reduce the rate of pumping to achieve low flows through the works area to minimize erosion and flushing effects (if decommissioning is done during a period of low flows reduced pumping may not be needed)
4. Once water is flowing through the site, turn off the pump and remove all equipment from the watercourse, including the upstream and downstream fish nets / silt fences.

11.9 Diversion by temporary channel

11.9.1 Definition and purpose

Waterway diversion by temporary channel creates an alternative flow path for the waterway that allow works to occur within the original watercourse channel under dry conditions.

11.9.2 Conditions where practice applies

Diversions by temporary channel can be used to allow any works to be undertaken within permanent and ephemeral watercourses.

They are particularly useful where longer duration works are undertaken and maintaining fish passage for the duration of the works is important or where waterway flows are in excess of practical pumping capacities or the costs of powering pumping are too high.

11.9.3 Key design criteria

Divert all flow via a stabilised system around the area of works and discharge it back into the channel below the works to avoid scour of the channel bed and banks.
The stabilised system can include an excavated channel, marine ply flume or similar structure.

The diversion channel or structure should be sized following the risk-based approach in Appendix 13.7 through selecting an appropriate design storm from Table 13-12 based on works duration and type of receiving environment.

Figure 11-15 Use of Marine Ply flume as a Stream Diversion

The process for excavating a temporary channel is outlined below:

11.9.3.1 Step 1

The diversion channel should be excavated leaving a plug at each end so that the watercourse does not breach the diversion while it is being constructed.

The diversion channel should be appropriately stabilised to ensure it does not become a source of sediment. Suitable geotextile cloth (refer Section 8.3.5) should be anchored in place to the manufacturers' specifications, which will include trenching into the top of both sides of the diversion channel to ensure that the fabric does not rip out.

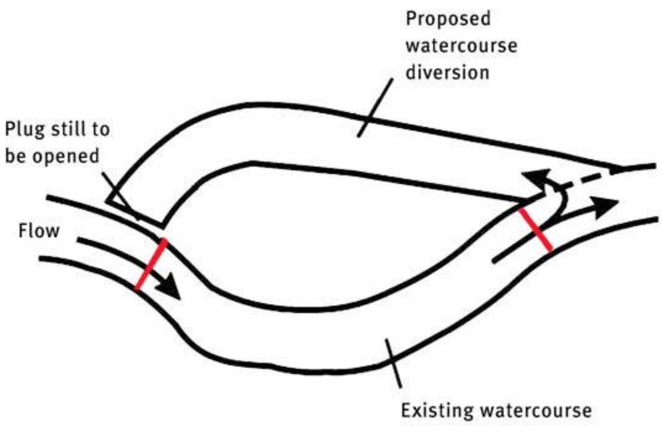

Figure 11-16 Diversion channel prior to upstream plug removal with fish stop nets (red)

Where fish recovery is required, stop nets or silt fences (refer Figure 11-16 should be located upstream and downstream to isolate the area to be dammed and initial fish recovery undertaken (refer section 11.5 for the fish recovery process).

The downstream plug is then opened to allow water to flow up the new channel, keeping some water within the channel to reduce problems when the upstream plug is excavated. Open the upstream plug and allow water to flow into the new channel.

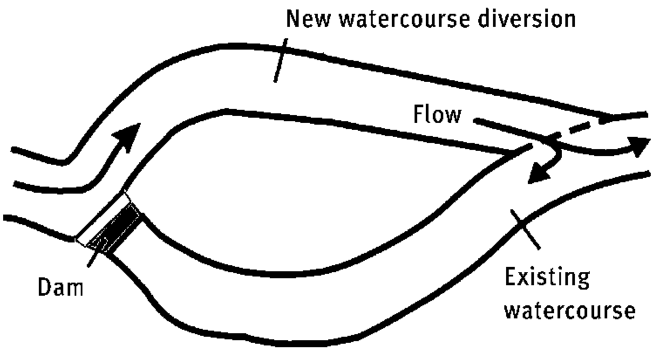

Figure 11-17 Opening up bypass channel and damming off existing one

11.9.3.2 Step 2

A non-erodible dam should be immediately placed in the upstream end of the original channel. The dam should be constructed as specified in Figure 11-17, or use an approved proprietary device.

11.9.3.3 Step 3

A non-erodible downstream dam should then be installed in the original channel to prevent backflow into the construction area.

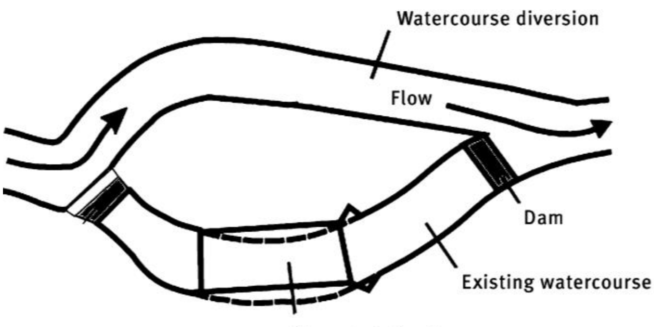

Figure 11-18 Temporary Watercourse

If there are fish trapped in the original watercourse as a result of the diversion, those fish should be captured and relocated to the live section of the watercourse (refer section 11.5).

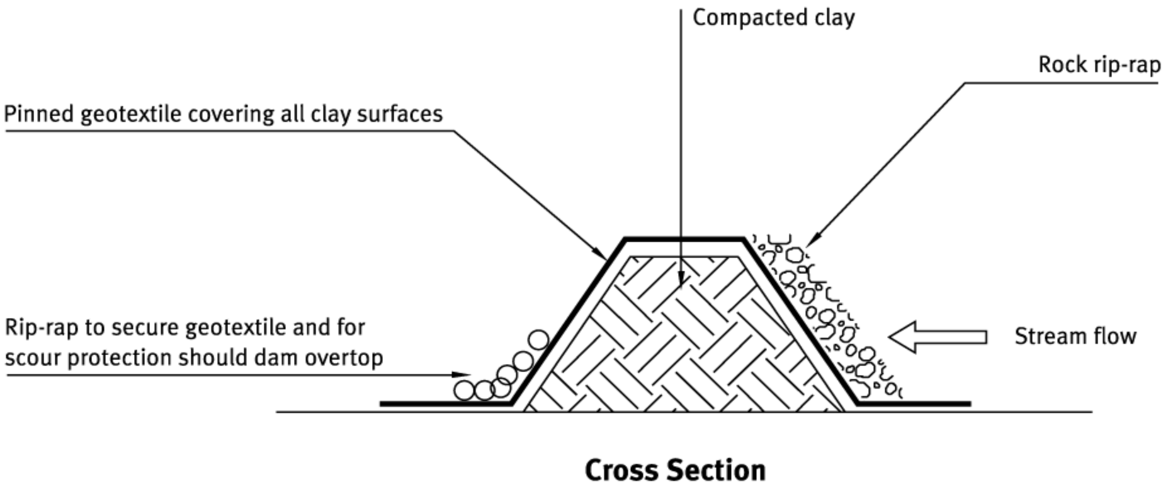

Figure 11-19 Downstream damming of original watercourse to isolate works area

11.9.3.4 Step 4

The isolated area of works on the original watercourse is then drained by pumping to a sediment retention pond where treatment of the ponded water can occur prior to discharge to the live section of the watercourse.

Works can then be undertaken 'in the dry' within the isolated works area.

11.9.3.5 Contingency Planning

All watercourse diversions should have a contingency plan in place, in the event that a larger than design storm occurs. The plan should include consideration of the following:

- Where feasible removal of the dams and reinstatement of flows in the original channel prior to storm events.
- Understanding the flood flow paths around the site, including the potential for flows to take unusual flow paths due to the dams or temporary channel - if these are retained in place -which may affect adjacent properties differently than normal.
- Provision for temporary stabilization of the works area prior to any flooding based on forecast warnings. This includes having suitable stabilization materials readily available.
- Ensuring all loose building materials and machinery are out of the channels and any flood flow paths prior to storm events occurring.

Figure 11-20 Temporary diversion and culvert while a new permanent culvert is constructed

11.9.4 Maintenance

Any diversion of a watercourse will require ongoing and vigilant maintenance to minimise erosion and sediment generation. Take particular notice of the following signs of potential problems developing and make repairs immediately:

- The geotextile lining in the temporary channel ripping.
- Scour occurring where the flow re-enters the original channel.
- Undercutting of the diversion lining.
- Leaking or erosion of the dams.

11.9.5 Decommissioning

Once the works have been completed, the bed in the works area should be reinstated including stabilisation and reshaping of any bare sections of channel to match the cross-section immediately upstream and downstream, reinstatement of similar bed substrate and removal of all materials not required for any installed structures.

Once the bed has been reinstated, the downstream dam should be removed first, allowing water to flow back into the original channel.

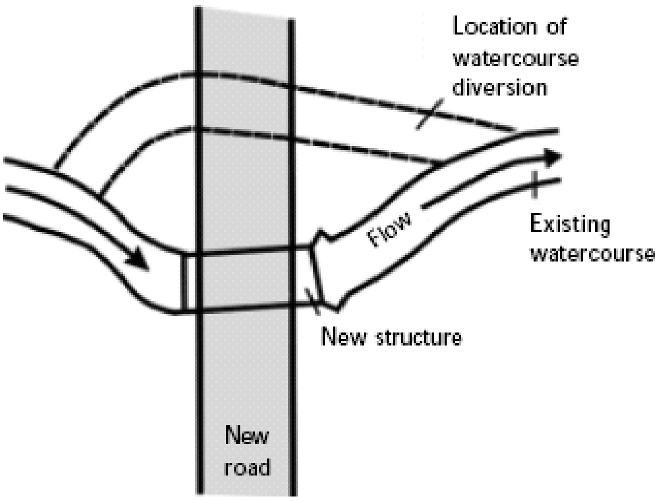

Figure 11-21 Re-establishment of flow in original channel

The upstream dam is then removed, and both ends of the diversion channel filled in with non-erodible material to prevent flows going back down the diversion.

Any sediment-laden water in the temporary diversion channel should be pumped to a sediment retention pond for treatment. The diversion channel should then be filled in and stabilised.