

Waterway technical notes

Practical approaches to waterway management



DairyNZ 



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Waterway management solution finder

This table outlines common problems in waterways. It makes suggestions on what to do and where to go to find solutions.

What's the issue?	What could be causing the problem?	Consider undertaking these actions:
Unstable stream banks	<p>Unstable stream banks can be caused by:</p> <ul style="list-style-type: none"> • Stock trampling • Lack of vegetation to hold the banks together • Land clearance in the upper catchment may mean that stormwater runs off faster and is more erosive. 	<ul style="list-style-type: none"> • Fence stock out. See <i>Waterway Technote: Fencing</i> (pg 11). • Plant stream banks with stabilising grasses, shrubs and trees. See <i>Waterway Technote: Planting</i> (pg 35). • Re-forest steep areas of land in the upper catchment.
Lots of weeds and/or algal growth	<p>Excess nutrients (nitrogen and phosphorus) or increased temperature (lack of shade, over widened drains and/or slow flow). Nitrogen and phosphorus could be coming from:</p> <ul style="list-style-type: none"> • paddock runoff, including soil • stock in the stream • dairy shed effluent • fertiliser application • race and irrigation runoff • eroding stream banks • discharge from tile and mole drains. 	<ul style="list-style-type: none"> • Fence stock out. See <i>Waterway Technote: Fencing</i> (pg 11). • Plant northern stream banks with taller shading vegetation to reduce light and cool the water, reducing weed growth. See <i>Waterway Technote: Planting</i> (pg 35). • Leave a strip of ungrazed vegetation inside the fence or along the edge of cultivated areas to filter runoff. • Plant both stream banks with stabilising grasses, shrubs and trees. See <i>Waterway Technote: Planting</i>. • Protect wetlands and swampy areas so they can filter nitrogen out of groundwater and runoff. • Divert track, race and irrigation runoff away from waterways by creating small bunds. • Re-batter old drains. See <i>Waterway Technote: Drains</i> (pg 18).
No riparian plant cover	<p>All native vegetation has been cleared by flooding, fire, machinery and/or grazing.</p>	<ul style="list-style-type: none"> • Fence off waterways. Give enough space for a grass filter strip to grow and more if you wish to plant trees and shrubs. • Plant up any particularly wet areas to filter surface flow. Many wetlands or boggy soils will naturally return to native plant cover – but watch out for weeds. • Native plant species will also attract birds that will spread more seed and plants. Click here for more information. See <i>Waterway Technote: Planting</i> (pg 35).
Water unsafe for stock to drink or swim in	<p>Faecal pathogens (microscopic organisms) are the cause of unhealthy water for drinking or recreation. Tackling any sources of faecal matter is crucial:</p> <ul style="list-style-type: none"> • stock effluent in paddock, on races/tracks and leaks from irrigation runoff • stock in the stream (all livestock should be excluded from Accord waterways) • dairy shed effluent (check pond is sealed and pumps). 	<ul style="list-style-type: none"> • Fence stock out. See <i>Waterway Technote: Fencing</i> (pg 11). • Leave a strip of ungrazed grass inside the fence to filter runoff – faecal microbes are killed by exposure to direct sunlight. • Improve management of dairy shed effluent. Visit dairynz.co.nz/effluent. • Contour tracks, races and irrigation runoff away from waterways and grow grass filter strips along adjacent waterways.

<p>Stock crossings are not bridged or culverted</p>	<p>All regularly used crossings (>once a month) require bridging or culverting by May 31, 2018.</p> <p>Excluding direct livestock access to waterways applies equally to paddocks as to crossing points.</p>	<ul style="list-style-type: none"> • Install a culvert or bridge or upgrade your existing culvert. See <i>Waterway Technote: Crossings</i> (pg 23). • Ensure culverts and bridges are correctly sized for area drained upstream and high flows. • Ensure culverts are navigable to whitebait and other native migratory fish (not perched, right slope, right size). See <i>Waterway Technote: Crossings</i> (pg 23).
<p>Stock races run along waterway</p>	<p>Races and tracks are super-highways for sediment and bacteria, where flows can increase in speed and carry more material into waterways.</p> <p>Waterways occur on natural low points where races are also often sited.</p>	<ul style="list-style-type: none"> • Realign races to allow for a grass filter strip between waterway and tracks. • Contour races away from waterways. • Construct cut-offs into paddocks at regular intervals along tracks, to channel runoff (and nutrients) into pasture. Alternatively construct small filter wetlands by excluding livestock from boggy areas.
<p>Tile drains flow directly into surface drains or natural waterways</p>	<p>Sediment, nutrients and bacteria bypass filtration in grass strips, wetlands or plantings.</p> <p>Need to filter within subsurface drains (nutrient socks) or direct subsurface drains into sacrifice areas on boggy ground where livestock are excluded and riparian plants can grow.</p>	<ul style="list-style-type: none"> • Construct mini-wetlands at outflows from the tile drains to filter nutrients from water. • Construct artificial wetlands in surface drains by broadening and detaining flow downstream of discharge points (you may need consent – check with your regional council first).
<p>Stock have direct waterway access</p>	<p>All livestock must be excluded from Accord waterways by May 31, 2017.</p> <p>Stock tread banks, damaging soil structure and causing erosion or slumping (increasing sediment loss).</p> <p>Stock defecate into waterways (causing nutrient and bacterial loss).</p>	<ul style="list-style-type: none"> • Fence to exclude stock. See <i>Waterway Technote: Fencing</i> (pg 11).
<p>Drains, streams or other waterways fill up with sediment</p>	<p>Sediment loss to rivers is a natural process but at a relatively infrequent and slow rate.</p> <p>Rapid infilling or the need to clear drains more than once every three to five years indicates banks are collapsing or sediment is being lost to runoff.</p> <p>Causes include livestock treading banks, floods scouring channels, races/tracks aligned incorrectly to waterways, races/tracks too close to waterways, grass strips being too narrow to filter volume of surface flow.</p>	<ul style="list-style-type: none"> • Fence stock out. See <i>Waterway Technote: Fencing</i> (pg 11). • Leave a strip of ungrazed vegetation inside the fence or along the edge of cultivated areas to filter runoff (wider is better). • Stabilise stream banks by planting grasses, shrubs and trees. See <i>Waterway Technote: Planting</i> (pg 35). • Divert and contour track, race and irrigation runoff away from waterways. • Ensure bridges and culverts have bunded edges. • Only spot-spray weeds, this allows the grass or native plantings to reinforce banks. • Batter all drains to <1:1 (<45°) – this ensures faster speeds in low and high flows, suppressing weed growth, while offering native plants and grasses space to grow and stabilise banks.

Examples of well-managed waterways

Fenced to exclude stock



Well-fenced stream with grassy margin to filter contaminants from runoff.

Source: Environment Canterbury Living Streams Handbook Part 1



Carex sedges are excellent low growing native species to plant within narrow waterway margins. They provide a habitat for wildlife as well as filtering nutrients.

Source: Environment Canterbury Living Streams Handbook Part 1

Crossings, bridges and culverts



Bridges with nib walls prevent sediment and nutrient laden runoff directly entering the stream.

Source: Environment Canterbury Living Streams Handbook Part 1



Well-installed culverts prevent nutrients and stock from entering the stream.

Source: Environment Canterbury Living Streams Handbook Part 1

Planting



Planted waterway margins provide a habitat for wildlife, help reduce weeds and assist in filtering nutrients from farm runoff.

Source: Environment Canterbury, A Guide to Managing Waterways on Canterbury Farms



Fenced and planted wetlands provide habitat for wildlife and can remove up to 90 percent of nitrogen from farm runoff.

Source: Bay of Plenty Regional Council Land Management Factsheet #33

Examples of poorly managed waterways

Unfenced waterways



Stock damage to stream banks creates sediment and bank instability. Fencing and planting this waterway would improve water quality and provide a better habitat for birds and stream life.

Source: Environment Canterbury Living Streams Handbook Part 1



Bare soil is prone to erosion and allows contaminants to flow directly into the waterway.

Source: Environment Canterbury Living Streams Handbook Part 1



Unfenced drains allow sediment, bacteria and nutrients to flow into streams.

Source: Environment Canterbury Living Streams Handbook, Part 1.



The right bank of the waterway has been damaged by stock and the absence of any shading is contributing to excess growth of water weeds.

Source: Environment Canterbury, A Guide to Managing Waterways on Canterbury Farms

Tracks and races with runoff entering waterways (no filter strip)



This track is located too close to the stream. Nutrients, sediment and faecal matter can directly enter the stream and stock can damage the stream banks.

Source: Environment Canterbury Living Streams Handbook Part 1

Unfenced wet areas (poorly aligned fencing)



Swampy areas next to the stream should be fenced to reduce sediment, faecal matter and nutrients flowing into the stream.

Source: Environment Canterbury Living Streams Handbook Part 1

Crossings without bridges or culverts (direct stock access to waterway)



Ford crossings are entry points for sediment, nutrients and harmful bacteria from faecal matter.

Source: Environment Canterbury Living Streams Handbook Part 1

Poorly designed drainage (no filter strip before waterway)



Tile drains can be nutrient highways. Tile drain outlets should be diverted through wetland treatment areas before they discharge to waterways.

Source: Environment Canterbury Living Streams Handbook, Part 1.

Planning

Benefits to planning your waterway management

Planning how to manage your riparian zone will help you to prioritise where to start, plan labour requirements and make a budget. Under the Sustainable Dairying Water Accord all farmers must have a riparian management plan to help improve New Zealand's water quality by 2020.

Prioritising waterway management – where to start?

What are your priorities?

Meeting the Sustainable Dairying Water Accord should be a first priority as the dairy industry has set targets designed to improve water quality across New Zealand. By meeting the targets set for dairy farmers in the Accord, it will also improve biodiversity, water quality and aesthetics. This includes:

- Significant wetlands
- Lakes (named lakes as opposed to farm ponds)
- Waterways over one metre wide and 30cm deep that permanently contain water (start at the upstream end where possible)
- Regular crossing points.

After these waterways, move on to (in order of greatest importance):

- 1) Seeps/boggy areas
- 2) Natural waterways less than one metre wide and shallower than 30cm
- 3) Manmade drains less than one metre wide and shallower than 30cm
- 4) Farm ponds.

Also start thinking about what else you want to achieve and look for the most obvious places that will help you fulfil that objective. The other main priorities when managing a waterway are to:

- Improve biodiversity
- Improve water quality
- Improve aesthetics.

These priorities are integrated, so focussing on one aspect will benefit the others.

Start with the best areas or those at most risk

Choose the most cost effective place to start within the best sections, or those areas with the most risk.

In areas where native plants occur:

It's much easier to concentrate on areas that have existing native vegetation than to start planting from scratch. Fencing and weed control can be enough to return these sites to full health. These areas will give you the most benefit for less effort and/or cost.

Eroded areas:

Erosion costs you as grass, valuable land, nutrients and plants are quickly removed from productive areas. Tackle eroding areas early to prevent this from happening. This can be done by increasing your setback, careful planting (see slope stabilising plants from the regional DairyNZ *Getting Riparian Planting Right* guides) and getting help from your regional council. See the erosion section on page 63 for more information.

Weedy areas:

Planting in weedy areas is costly. To do it well and avoid having to replant, it's important to control weeds from the headwaters down, in manageable stretches. Manage weeds ahead of planting (two or more years ahead). If weeds are spreading, tackle these first (willows, blackberries, creepers) and if they are not spreading, tackle them last.

Where do I get the right information?

Throughout DairyNZ's Waterway Technotes you will find a wide range of information that will help you make decisions about waterway management. Answers to common problems can be found as well as links to organisations that will be able to help you further.

Riparian Planner

DairyNZ and Landcare Research have created the Riparian Planner – a flexible, user-driven and comprehensive online tool to automate and regionalise riparian management plans. The Riparian Planner uses intuitive geographic information system tools to capture waterway information and actions on a farm map. It is free and secure, enabling rural professionals and farmers to revisit, review or update any plan.

To easily create your personalised riparian management plan go to dairynz.co.nz/riparianplanner.

Make a plan

Follow these steps to make a plan for managing your priority waterways. Keep it simple – a five year plan is ideal.

Step 1 – Think about what you want to achieve

Ask yourself:

- What do I value about the stream, drain, river, lake, wetland or estuary on my farm?
- Is there anything wrong with the condition of the waterway? If yes, what and how can I improve it?
- How much time have I got to maintain managed waterway margins?
- How much is achievable within five years?
- What assistance (e.g advice, funding) is available to help me with waterway management?
- Where are the areas on the farm that can be improved and will give the biggest benefit for the smallest cost?

Write down some project goals for each of your priority waterways

Examples include:

- Clear flowing water
- Stable stream banks
- More planted areas.

Step 2 – Create a farm map

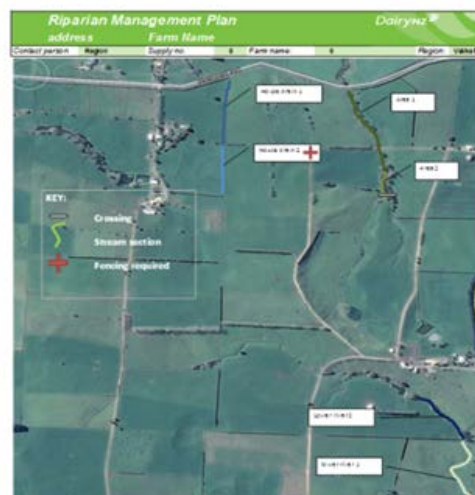
1) Start with a map or aerial photograph of your farm. Aerial photos can be easily sourced from Google Earth. Mark up your priority waterways and any key features you think are important. This might include:

- Existing fence lines
- Buildings

- The farm boundary
- Silage, offall or refuse pits
- Native bush blocks
- Location of native riparian vegetation adjacent to water bodies.

2) Look at your project goals to work out some actions you need to undertake to improve your waterways. Your actions should align with the project goals. For example, if your goal is to stabilise stream banks, you may choose to move your current fencing further back from the stream and plant erosion control tree species on the bank.

Mark on the waterway management plan the actions you wish to undertake for each of your identified priority waterways (e.g new fencing, planting, weed control, new crossing).



A farm map could be hand written or drawn on a software program such as Google Earth or Microsoft Word

Step 3 – Write down what you plan to do

Think back to what you have marked on your map. Write down what you plan to do for each waterway and when. You can also put some costs next to each action. Below is an example.

Location (as marked on your map)	Description of issue	Work Required	Estimated Cost	Schedule
Stream 1	Stock eroding drain bank	Fencing Fence to exclude stock (2 wire electric)	500 metres of 2 wire electric fence @ \$4 per metre = \$2000	Summer 2014/15
House paddock stream	Nutrient runoff, weedy and looks ugly	Pest control, planting Undertake plant pest control and riparian planting within fenced area	500 plants @ \$3 per plant = \$1500 500 plants at \$2 each labour to plant = \$1000 Weed control and plant releasing = \$400 Total - \$ 2900	Pest control – summer 2015 & spot spray July 2015 Plant – Aug 2015
Farm track (section next to stream 1)	Race runoff goes directly into the stream	Earthworks Re-contour race and create cut-offs to divert water into the paddock.	Digger time - \$500	2015
Wetland 1	Stock getting stuck, pugging	Fencing Fence to exclude stock and carry out weed control	Fencing - \$ 4000 Weed control - \$500	Summer 2015/16
Crossing 1	Stock polluting stream when crossing the ford	Culvert construction Build culvert across stream	Needs further investigation	2016

Note: Don't forget to factor in costs associated with weed control, especially if you are undertaking planting. Good weed control is key to a successful planting.

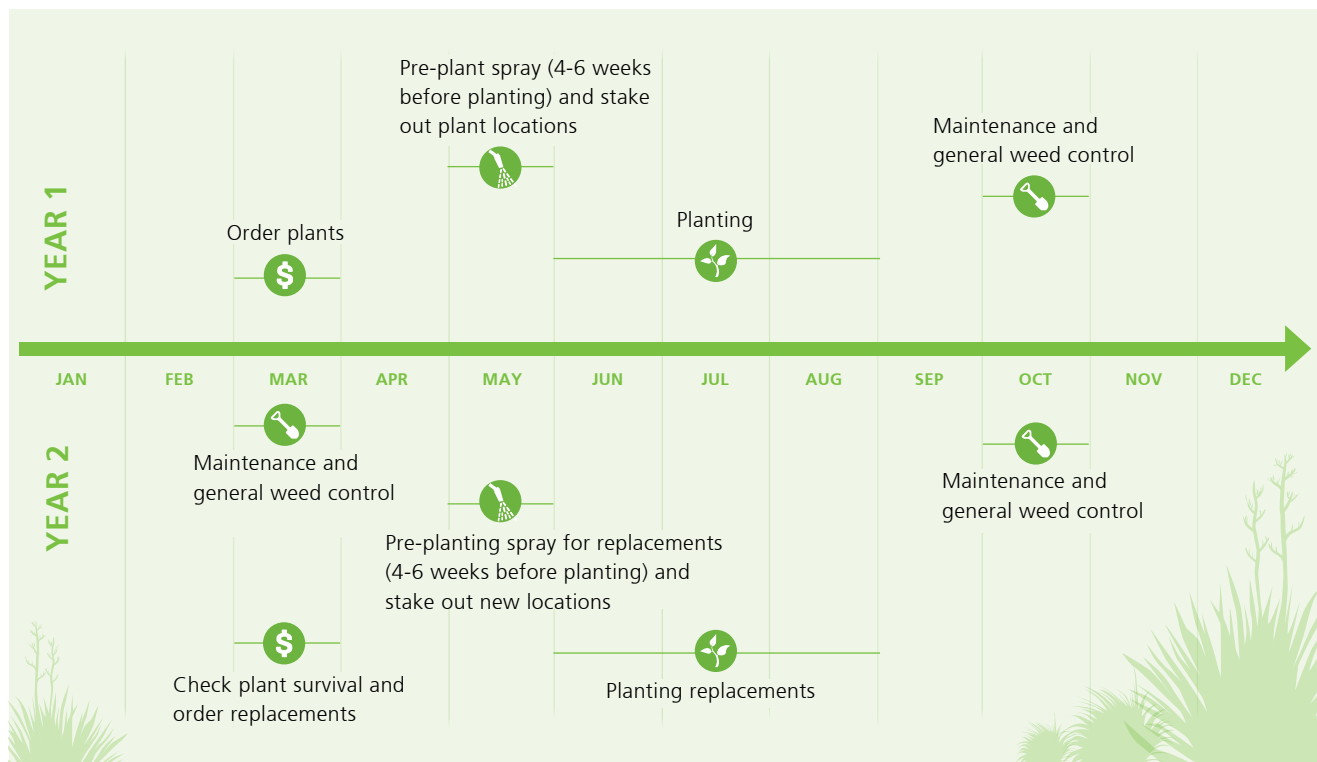
Step 4 – Create an annual work plan

Below is an example of how you might plan your annual works.

Year 1 - 2015												
Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stream 1												
- Fencing				✓								
House paddock stream												
- General herbicide spraying	✓	✓										
- Order plants			✓									
- Spot spraying							✓					
- Planting								✓				
Farm track												
- Organise digger										✓		
Wetland 1												
- Fencing				✓								
- Herbicide spraying											✓	

Keep in mind that there are suitable times for planting and maintenance work. See the regional *Getting planting right* guides on the DairyNZ website. Below is an example of the Waikato region planting timeline.

Riparian planting calendar – two year plan



Fencing

Under the Sustainable Dairying Water Accord:

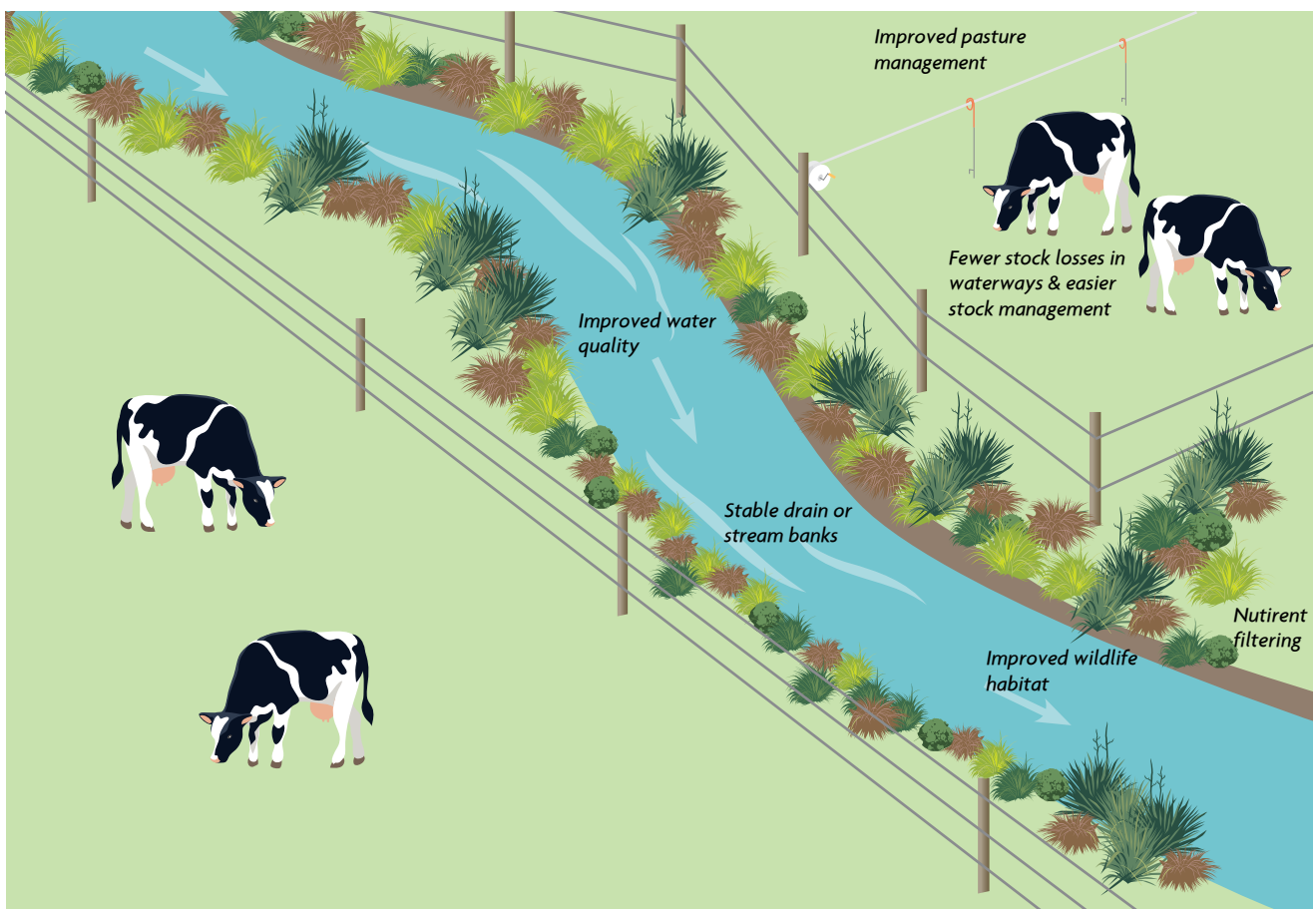
- All stock must be excluded from any permanently flowing rivers, streams, drains and springs, more than a metre wide and 30cm deep by May 2017
- All lakes must have all stock permanently excluded by May 2017
- Any significant wetlands, as identified in your regional plan or policy statement must also have stock permanently excluded by May 2017. Check with your dairy company to see if you have one on your property.

This means that the fencing of waterways should be a priority on your farm.

See the *Sustainable Dairying Water Accord* at: dairynz.co.nz/wateraccord.

Benefits of fencing waterways

Fencing waterway margins is an important step in protecting freshwater from nutrients, faecal matter and sediment. It creates a buffer between the water and the land. Fencing riparian zones will create a habitat for birds and freshwater species and will also help maintain and improve water quality.



Key messages/quick links

- Plan what you want to do before fencing.
- Fence back far enough to allow for movement of the waterway.
- Consider farm layout when putting new waterway fences up.
- Plan where crossings will go.
- Once fenced, the riparian area will probably need some management. You may require weed or pest animal control.

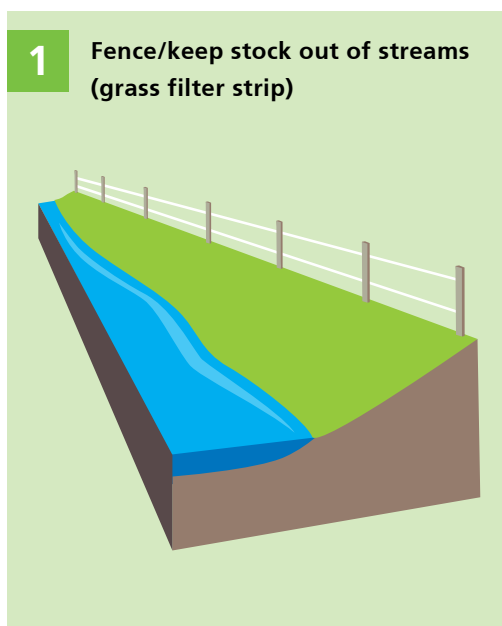
Planning

Consider the overall layout of your farm when planning for waterway fences. Along with protecting waterways, new fencing could improve grazing management and stock control¹.

The setback for your fence will depend on how you are going to manage the area between the fence and the stream. Do you want to maintain it as a grassy strip to filter nutrients and sediment from runoff or do you want to plant it with trees?

How to determine where your fence should go

Where you locate your fence will depend on how you intend on managing the zone. There are four major ways to manage your riparian zones:²



Benefits

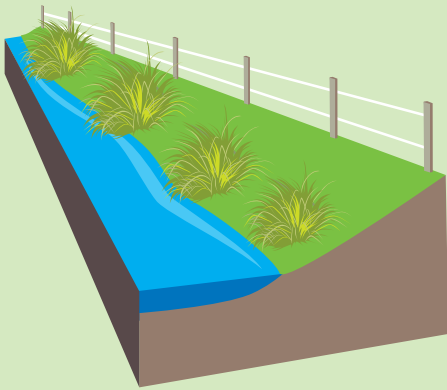
- Reduces phosphorus and sediment from entering the waterway
- Cheapest option
- Small loss of grazing land
- More stable banks
- Excludes stock therefore direct faecal pollution and treading damage.

Limitations

- Needs weed control
- Limited shading of waterway
- Minimal habitat for bird and aquatic life
- Banks can become unstable without deeper rooted vegetation.

¹ Dairy NZ. Fencing factsheet.

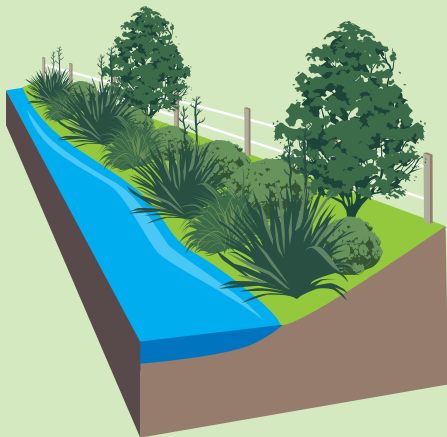
² DairyNZ: Riparian Planner – Understanding and managing your riparian margins

2**Low planting – plant low growing sedge species and fence****Benefits**

- Stock exclusion
- Stream bank stability
- Reduces phosphorus and sediment from entering the waterway
- Only small loss of grazing land
- Helps control weed growth
- Shade and cover for fish and insect life
- Can make use of sprays targeted to broadleaf species.

Limitations

- Needs weed control
- Minimal habitat for birdlife.

3**Full planting - fence and plant the riparian margin****Benefits**

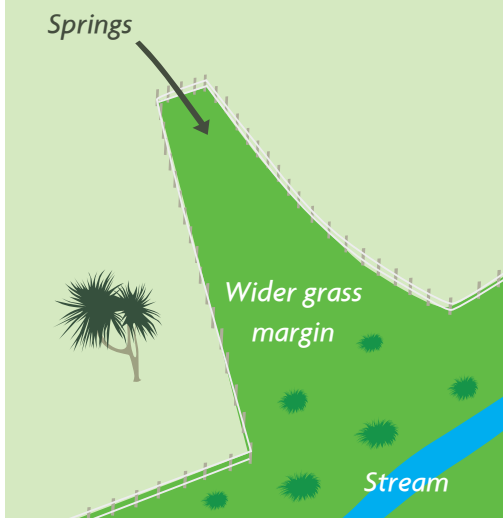
- Reduces drain maintenance
- Attractive asset for your farm
- Provides shade and keeps water cool for fish, etc
- Increases habitat for birds
- Reduces phosphorus and sediment from entering the waterway
- Some nitrogen removed by plants
- Improves stream bank stability.

Limitations

- Can be expensive
- May result in loss of grazing land
- Needs weed control for at least two to three years
- Animal pest control may be required.

4

Fence stock out of seeps/ wetlands/swamps and springs



Benefits

- Reduces stock losses
- Reduces faecal bacteria in water
- Filters out nutrient and sediment from runoff
- Reduces phosphorus entering the waterway
- May provide habitat for bird life
- Denitrifies water before it enters the stream.

Limitations

- May result in loss of grazing land
- Needs weed control
- May be expensive if planting is required
- May affect stock flow.

See *Waterway Technote: Planting* for information on planting options.

What is your waterway like?

Surrounded by rolling land/ flat land

Fence set back needs to allow for a grass margin and changes in stream shape and size.

On flat land you are more likely to come across adjacent wetlands, so include them in fenced areas where possible.



An example of the minimum fencing setback on flat land.

Source: Waikato Regional Council



A five-metre setback allows for several rows of native plants.

Source: Waikato Regional Council



A wider riparian margin has been provided on the left side of the stream where the slope is rolling.

Sourced from: <http://news.ecocentre.co.nz/posts/streambank-work-goes-mainstream-in-taranaki-so-what-about-north/>

Surrounded by steep land

Steep areas generate fast runoff and the margin required to capture it will be wider than that used for rolling or flat land. Allow for a grass strip on the fence side of the riparian zone. The larger the zone, the more likely runoff will be captured before it reaches the stream.

Erosion prone banks

Fences will need to be set back further on erosion prone banks. Allow for some erosion and changes in stream meander, particularly on the outside of bends. Erosion is a natural process and in some areas will be hard to stop or slow without appropriate planting or structures. Your regional council will be able to give you ideas and advice on how to fix it.

Consider how far the stream moves during large storm or erosion events and how many events occur yearly.

Vegetation will not protect the stream straight away, so fence back far enough to allow for three years of erosion. For more information on erosion management see *Waterway Technote: Erosion*, page 63.

Surrounded by poorly drained soils

Poorly drained soils require a wide setback. Water does not easily infiltrate the soil resulting in overland flow directly into waterways. Wetlands can be used to remove nutrients and sediment, so try to fence these off too. Dense riparian plantings will slow flow and also act as a filter before runoff enters the waterway. Your setback should allow for several rows of trees and a grassy margin.

Surrounded by free draining soils

Free draining soils will require a riparian area large enough to accommodate deep rooted plants. In well-drained soils water will easily move through the soil into groundwater and then potentially into surface water. Roots of riparian plants help to filter this, removing nutrients and other contaminants. Plants with strong roots will also help to stabilise banks and prevent erosion.

Weed management

Weed growth can be a problem in fenced grass margins if not managed early on. For information on identifying and controlling specific types of weeds see *Waterway Technote: Pest plants*, page 48.

Type of fence

Invest in a robust, stock proof, good quality fence that provides the best waterway protection and minimises maintenance issues long term. Ensure your fence is suitable for all classes of stock that will be near waterways.

Requirements

Different milk suppliers have different minimum requirements around fencing, so it is best to check with your milk supplier before finalising your choice of fence.

Waterways that are required to be fenced due to a resource consent condition, may have specific fencing requirements and fence setbacks. Ensure you comply with any regional council requirements.



A wide riparian margin has been provided as steep slopes feed into the waterway.

Source: <https://www.niwa.co.nz/publications/wa/vol11-no4-december-2003/photo-survey-do-people-like-riparian-management-on-farm-streams>

Funding

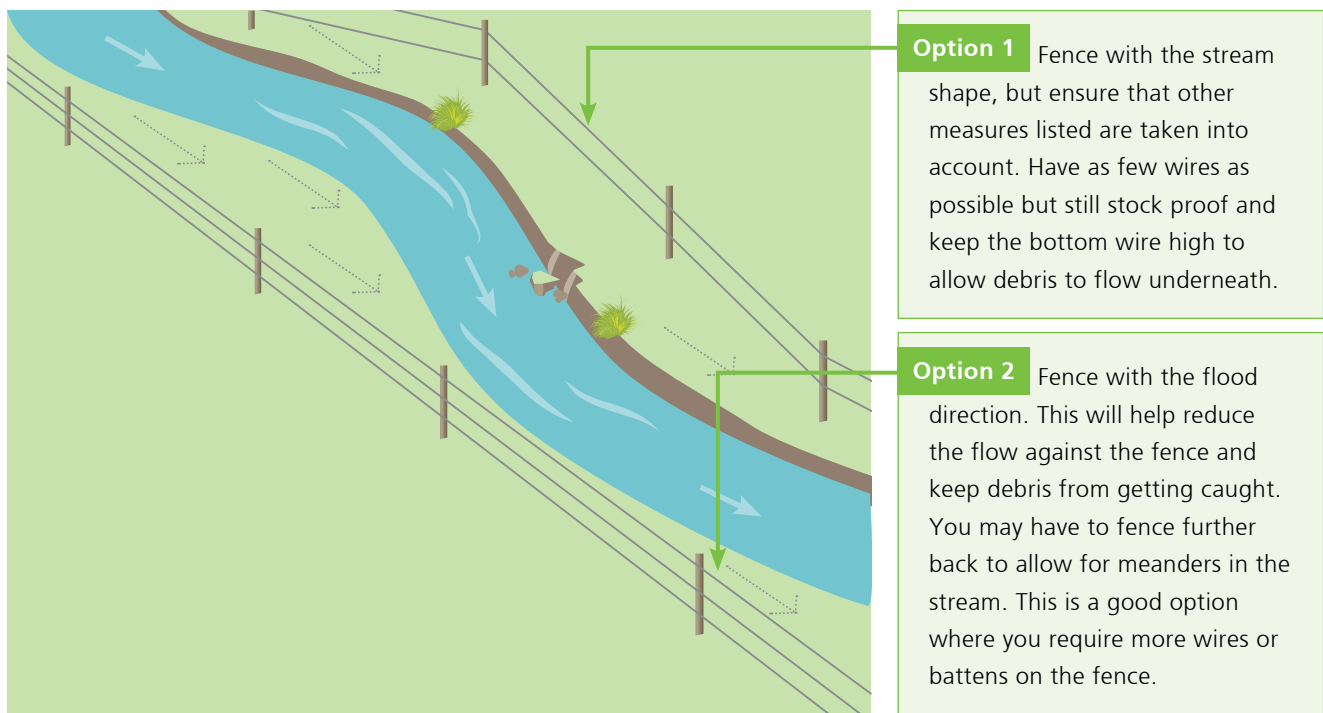
Funding may be available from regional councils or QEII Trust. Usually it is for fencing above the minimum standard, for example fencing an environmentally significant waterway or wetland. In these circumstances, specific fencing standards may apply.

For further information on fencing design and what materials to use visit openspace.org.nz.

Fencing in flood prone areas

These areas may need a wider set back than others to ensure that the fence is not subjected to high velocity flows. Where possible erect fences above any flood prone areas or leave a good setback from the waterway. This is particularly important on the outside of bends of rivers and streams where there is greatest potential for banks to break and erosion to occur. Think about what the stream does in regular high flow events before fencing.

Use the techniques outlined below to help reduce the impact of flooding on your fence.



When fencing flood prone areas:

- Use fewer uprights and less wire – that way less debris will catch on the fence. Do not use netting as it will trap debris³
- Put wires on the downstream side of posts so the staples pop and the wire drops rather than pulling out the posts and strainers¹
- Use un-barbed staples so wires can pop off more easily¹
- Erect fences parallel with the way the stream floods so the fence does not collect debris¹
- Have fences further back where active erosion is occurring
- Construct separate 'blow-out' sections across flood channels.⁴

You should also:

- Avoid using battens in flood prone sections to reduce snagging²
- Use insulators that can be dropped before a flood event
- Consider using tape instead of wire as it's easy to repair after a flood has gone through
- If flow levels are usually low, think about where the bottom wire is in relation to the flood levels and move it slightly higher.²

³ Environment Canterbury: Living Streams Handbook – Part 2: Improving the stream environment. Environment Canterbury. Christchurch.

⁴ Waikato Regional Council, 2004: Clean Streams: A Guide to Managing Waterways on Waikato Farms. Waikato Regional Council. Hamilton.

Maintaining access

If you need to maintain access for machinery to clean weeds, silt or debris from your waterway, consider these options:

- Check that you do not require regional council consent
- Build an electric fence that can be dropped or removed to allow access.
- Use pinlock insulators so that the wires can easily be lowered for machinery to cross
- Position the fence so that a long reach digger can reach over the top
- For wide waterways, place a fence far enough back to allow a digger to work between the fence and the bank. This approach still allows for a wide grassy margin and you can plant low growing plants on the waterway margin if you wish. Do not cut off gateways that give diggers access to neighbouring paddocks.⁵

For information on what can be planted along drains where access is required see *Waterway Technotes: Drains*, page 18.



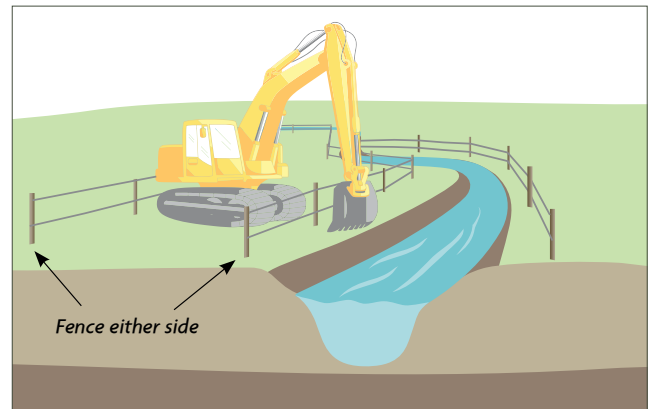
Pinlock insulator.

Source: <http://intelligentfencing.com/shop/category.php>



Fence positioning that allows a long digger to reach over the top.

Source: Environment Canterbury. A Guide to Managing Waterways on Canterbury Farms. Environment Canterbury. Christchurch.



Example of a wide riparian strip that allows for digger access.

Source: Environment Canterbury: Living Streams Handbook – Part 2: Improving the stream environment. Environment Canterbury. Christchurch.

⁵ Environment Canterbury. A Guide to Managing Waterways on Canterbury Farms. Environment Canterbury. Christchurch.

Drains

The Sustainable Dairying Water Accord

The *Sustainable Dairying: Water Accord* is a dairy industry commitment to good management practices around freshwater. This affects your drains. All drains should be included in your farm riparian plan, whether natural, straightened-natural or artificial. Drains require fencing by May 31, 2017 – the only exceptions are drains less than a metre wide and a foot deep.

See the *Sustainable Dairying: Water Accord* at dairynz.co.nz/wateraccord.

Benefits of good drain practice

Drains include natural or artificial channels to lower the water table and/or reduce surface flood risk. They often make up the majority of lowland waterways, acting as highways for nutrients, sediment and bacteria lost on-farm.

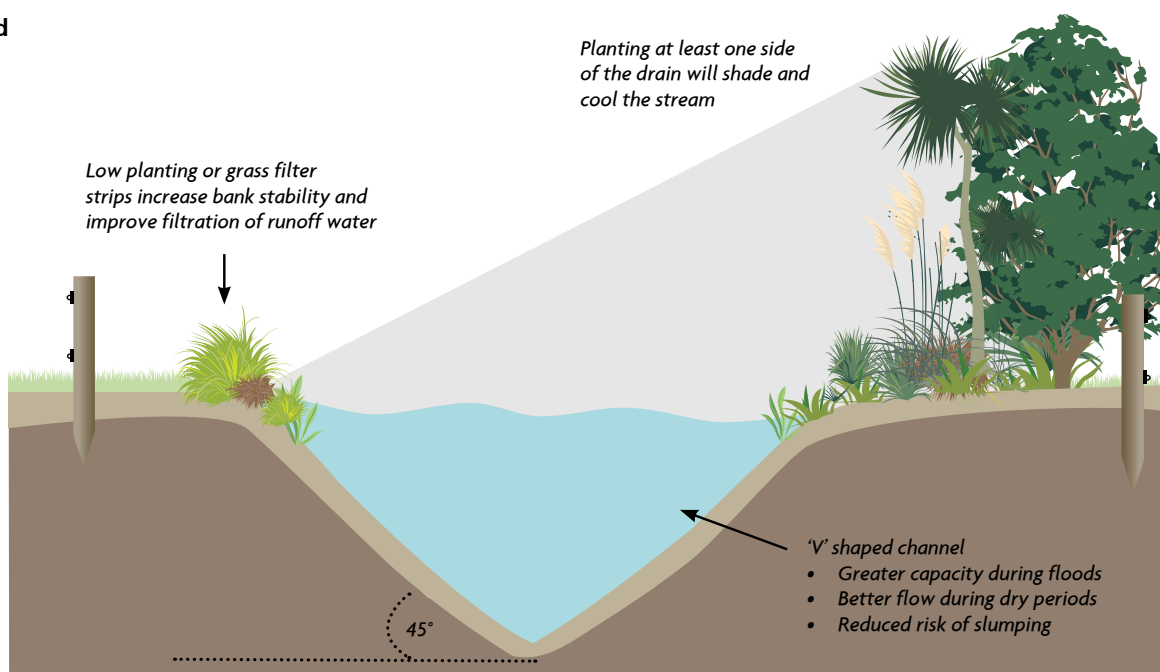
Good management of drains benefits your farm by:

- Optimising soil moisture
- Improving pasture production
- Improving stock health and production by reducing waterborne illness and losses
- Enhancing water quality by reducing nutrient, sediment and bacterial concentrations
- Improving habitat for fish and insects by cooling water, enhancing flow and increasing oxygenation.

Are your drains healthy?

- | | | |
|--|---|--|
| <input type="checkbox"/> Fenced | <input type="checkbox"/> Grassed or planted along banks | <input type="checkbox"/> Gently sloping (1:1 or 45°) |
| <input type="checkbox"/> No ponding or pugging | <input type="checkbox"/> Outlets run well after rain | <input type="checkbox"/> Have little sediment build-up |

Good

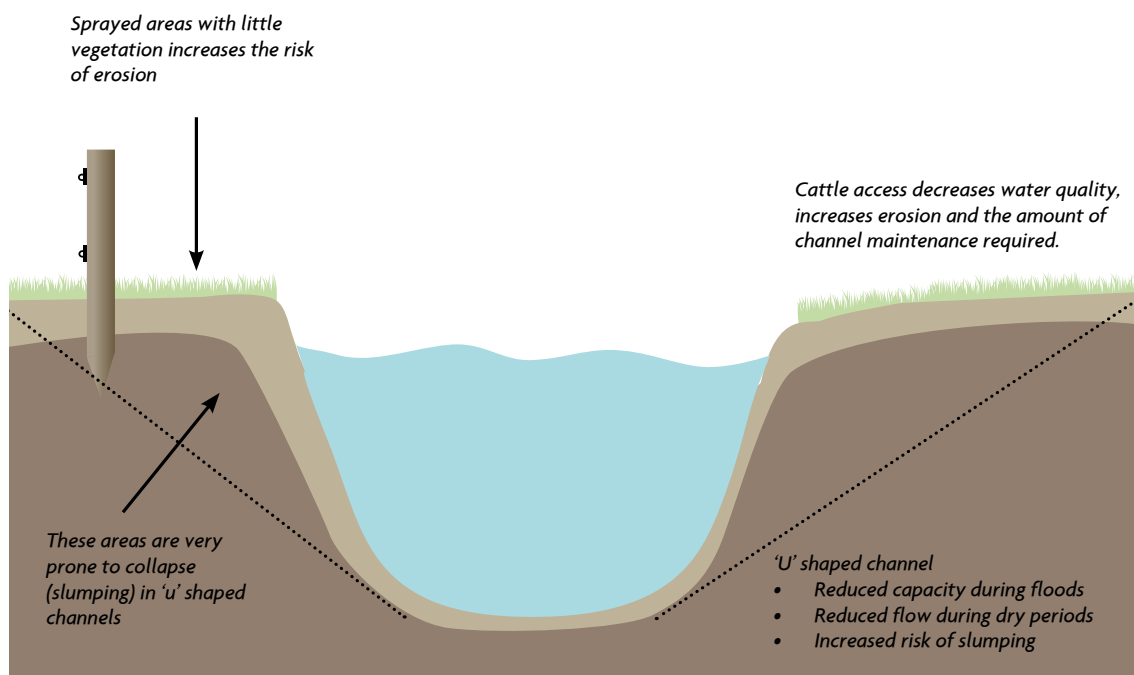


Bank shaping (battering)

Avoid excavating drains in the shape of digger buckets – doing so makes them prone to collapse, requiring more frequent clearing, encouraging more weed growth and offering less protection from flooding.

- Batter banks to a 1:1 slope (45°).
- Gentle slopes are easier to grass, offering more opportunity to strip sediment, nutrients and bacteria from runoff.
- Gentle slopes collapse less frequently, reducing the need to clear drains and improving drainage capacity.
- A V-shaped channel (as opposed to a U-shape) increases low-flow water speeds, helping to control weeds.

Not so good



Example of a poorly-managed drain



Bank erosion caused by stock.

Source: Environment Waikato Best Practice Guidelines for Land Drainage

Example of a well-managed drain



A stable drain bank fenced from stock with a grassy margin.

Source: Environment Waikato Best Practice Guidelines for Land Drainage

Planning drain maintenance

Take the time to plan your drain maintenance by reading through the rest of these topics.

- Contact your regional council to identify what conditions apply to farm drainage structures (culverts, weirs & bridges) and activities (clearing & spraying) in your region, and whether or not you are in a council maintained drainage scheme area.
- With the exception of peatland, the goal is to lower the water table 30cm below the soil surface within 24 hours, or 50cm within 48 hours of rain halting (a one-year return period, 24-hour storm is the design event). Any more or less can reduce pasture health.
- Peat soils are subject to stricter controls in your regional plan as they require a higher moisture content to prevent their loss to compaction or microbial action.
 1. Optimal depths to the water table for pasture and forage crops range from 30-45cm on peat. (WRC, 2006)
 2. Avoid deep or closely spaced drains. Do not dig through into underlying soil types when cleaning.
 3. For more information read *For Peat's Sake* see waikatoregion.govt.nz.

Fencing and clearing

Excluding livestock helps protect banks from slumping and collapsing, while protecting pasture during floods and improving water quality.

- Permanently exclude livestock from any drains one metre or more wide and 30cm deep.
- Find out if you need consent. Ensure you have consent if required (call your regional council if in doubt).
- Walk drains with the digger operator beforehand to avoid clearing any shallow stony areas known as riffles – clearing these can require consent under the Conservation Act (1987).
- Clean diggers thoroughly to avoid spreading weeds.
- Use a weed rake or stream-cleaning bucket on diggers to minimise spoil and better protect banks from collapsing (also leave spoil near the drain so that fish can easily return to the water).
- Clear from upstream down – leave downstream drains undisturbed until last to help trap sediment released by the digger upstream.
- Clear sediment from the southern bank – this limits damage to the other bank and enables planting for shade in summer, which enhances water quality.
- Clean and break – aim to clear no more than a fifth of your drains per year, rotating between years.

Grass filters (pasture and native sedge)

Grass filters are a cheap and effective way of protecting banks and improving water quality

- Grass strips can filter up to 90 percent of suspended sediments, 80 percent of particulate phosphorus and 60 percent of dissolved phosphorus (if 3m or more wide). (WRC, 2006)
- By removing nutrients and sediment, grass strips improve water quality and suppress weed growth.
- Grasses, especially native sedges (*Carex* species), improve bank stability through their roots and reduce the need to clear drains of slumped banks.



A stable drain bank fenced with a grassy margin.

Source: Environment Waikato Best Practice Guidelines for Land Drainage

Planting drains

Maintaining digger access is crucial to drain management, but shading the channel in summer is also important to keep down aquatic weeds and cool the water for native wildlife.

- Check with your regional council to see if you are in a council maintained drainage scheme area – conditions apply for planting these.
- Where you can, plant both sides of the drain. This will help stabilise the bank and shade the water.
- Planting up the northern bank ensures summer shade and access for clearing from the southern bank. (See *Waterway Technote: Planting*, page 35).
- Cutting out sunlight reduces weed growth and cools water. This helps drains remain well-oxygenated for fish and insects as well as enabling them to carry more water.



Planting shades water and helps prevent weed growth. Cleaning is made easy for a long reach digger by only planting sedges (Carex species).

Source: Environment Canterbury: Living Streams Handbook – Part 1: Investigations and planning. Environment Canterbury. Christchurch

Spraying

Drains are like any other waterway, they require ongoing weed maintenance.

- Always inform neighbours and check if resource consent is needed (call your regional council).
- Check your calendar – only spray drains from October to January, any later or earlier risks interrupting native fish breeding and migration.
- Only use glyphosate-based herbicides over water and avoid spraying within a foot of the bank edges.
- Spot-spray banks – never blanket spray for weeds, which can kill grass filter strips and/or plantings.
- Follow manufacturer’s guidelines for correct concentration and application (i.e avoid high winds, wet weather or excessive application rates).
- Willows (grey, crack) often become problematic if not regularly cut-back. Treatment varies by type and also distance infested, so talk to your regional council about suitable options for foliar, trunk or stump poisoning. (See *Waterway Technote: Pests*, page 48).



If you need to clear weeds, spray only the centre of the drain.

Source: Environment Waikato Best Practice Guidelines for Land Drainage



A weed-choked drain.

Source: A guide to managing your drains: Selwyn-Waihora



Bank erosion resulting from spraying the drain edge.

Source: Environment Waikato Best Practice Guidelines for Land Drainage

Land drainage areas

Regional councils have responsibilities under the Resource Management Act (1991) to manage the effects and use of watercourses or bodies, and of drainage and stormwater runoff. Territorial or district authorities also have responsibilities to manage stormwater under the Local Government Act (2002). Any artificial, natural or straightened natural drains in drainage schemes are therefore subject to strict conditions of consent for clearance, fencing and planting. (Call your regional council and district authority if unaware whether or not you farm in a council maintained drainage area or are unsure of conditions).

Where to go for more information

DairyNZ's sustainability team member (0800 4 DairyNZ or 0800 4 324 7969) can answer your questions on drain maintenance, as can your regional council land or catchment management officer. Your milk supply company will be able to answer any questions on farm obligations to The Sustainable Dairying Water Accord.

Crossings

The Sustainable Dairying Water Accord

As part of the Sustainable Dairying Water Accord, by May 31, 2018 all dairy farmers will be required to have bridges or culverts on regular stock crossing points used more than once a month. See: dairynz.co.nz/wateraccord.

Remember to also check with your regional council about further stock exclusion and crossing requirements that may be in place.

Benefits of well-planned and well-constructed crossings

Benefits to your farm:

- Makes travel times faster for you and your stock
- Improves stock health by reducing stress, lameness and the potential of liver fluke
- Provides easier access for stock and farm vehicles when streams are running high
- Prevents damage to the stream bed
- Protects stream habitat for fish and insects
- Reduces the amount of sediment and bacteria getting into waterways
- Improves health and safety for farm staff, owners and any visitors to the farm.



If you have places on the farm where stock and vehicles regularly cross through streams or rivers, it's time to start thinking about alternatives.

Plan before you construct

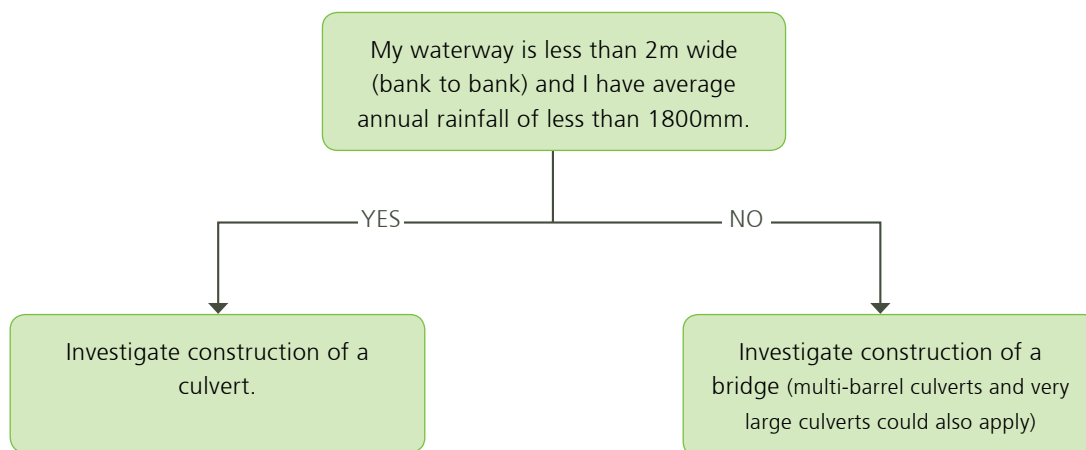
Planning the type of crossing and its location is important to avoid damaging waterway banks and disrupting streams. It will also help reduce maintenance or refitting costs. The initial considerations when installing a crossing are:

- Taking the time to properly plan any new crossings or crossing upgrades
- Consulting with your regional council to find out what their rules are around constructing crossings
- If your proposed crossing is on a waterway managed by your regional council for flood protection purposes, you will also need to talk to them as restrictions on what you can do may apply.

- Prioritise crossings on waterways that have the most use. Where dairy cows cross to access the milking shed and return after milking more than once per month, the accord requires constructed crossings.
- Understand there may be other crossings e.g forded crossings, in-paddock crossings, and intermittent waterways which would benefit from a constructed crossing.

Culvert or bridge?

The type of crossing that is suitable in your situation is dependent on a range of variables which include: waterways size, high flow levels, the size and shape of the waterway and the types of vehicles that need to cross. However as a general guide, the following can be adhered to:



Selecting the location of your crossing

Ideally a crossing point should be at a narrow point of a waterway stream with flat approaches on either side, or approaches that slope away from the waterway.

Avoid locating crossings where there are steep slopes leading down to it. This is safer for farm vehicles, reduces the risk of stock slipping over and will reduce sediment and nutrient runoff into the waterway.

Choose a straight stretch of stream with a low gradient (bends in the stream near culverts are more likely to cause erosion).

General design considerations for crossings



Crossings should be constructed so that storm water runoff from the track leading to and from the crossing can be diverted away from the stream (using earth cut-off drains) into a grassy area. This can be harder if the crossing has steep entries leading onto the crossing.

Raised edges (often called nib walls) on the crossing will help prevent direct runoff from entering the water.

Which crossing type to use?

Ensure you have the right crossing for each waterway. Below is a summary of common crossing types.

Type of crossing	Where suitable	Key considerations
<p>Single barrel arch culvert</p> 	<p>Waterway <2m wide, average rainfall <1800mm.</p>	<ul style="list-style-type: none"> • Have been widely and successfully used. • When sized correctly allows for good water flow in high and low flow periods as well as enabling some in-stream habitat and good fish passage. • Can accommodate the full width of a small stream and some of the natural bank. • Use culverts that are at least 300mm in diameter. • Install the outlet below the level of the waterway to prevent a waterfall from forming.
<p>Single barrel circular culvert</p> 	<p>Waterway <2m wide, average rainfall <1800mm.</p>	<ul style="list-style-type: none"> • The most common form of culvert. • A good option if installed using good practice. • Bridges and arched culverts will generally provide greater capacity for flows and be able to maintain a more natural stream bed. • Ensure a good size culvert is installed to accommodate the full width of the stream. • Use culverts that are at least 300mm in diameter. • Install the outlet below the level of the waterway to prevent a waterfall from forming.
<p>Box culvert</p> 	<p>Waterway <2m wide, average rainfall <1800mm.</p>	<ul style="list-style-type: none"> • Can be effective if constructed correctly. • Box culverts often accommodate the full width of a waterway. Install on a slight angle to allow for fish to swim through in low flows. • Use culverts that are at least 300mm across. • Install the outlet below the level of the waterway to prevent a waterfall from forming.
<p>Multi barrel circular culvert</p> 	<p>Dependent on the catchment area, but can be used in a higher rainfall area or larger catchment than a single barrel culvert of the same size.</p>	<ul style="list-style-type: none"> • Used to accommodate larger flows, and can be a far cheaper option than installing bridges across large waterways; but they will collect more debris than bridges and require more maintenance. • Installation should include having some culverts at different heights to allow for variations in flow. • Install the outlet below the level of the waterway to prevent a waterfall from forming.

Type of crossing	Where suitable	Key considerations
<p>Single span bridge</p> 	<p>Good for streams <10m wide and will be suitable for larger streams in many cases.</p>	<ul style="list-style-type: none"> • A long term option when constructed well with quality materials. Engineering advice is usually required. Consent is almost always required. • Try to avoid using recycled materials such as car bodies or trailer parts. • Avoid installing a bridge in the flow path of flood events.
<p>Multiple span bridge</p> 	<p>Large river systems.</p>	<ul style="list-style-type: none"> • Not common on farms, and expert advice is required. • Ensure resource consent is sought and engineers are involved.

Culverts

Culverts are usually installed on smaller streams rather than bridges, and are significantly cheaper and easier to put in. Correct size and installation will generally save money in the long term by reducing the likelihood of failure and the need for replacement. Poor design often results in erosion and damage to the stream.

Install a bridge instead of a culvert when:

- Overtopping of the culvert could cause flooding to nearby infrastructure
- High debris loads are likely, e.g. significant gravel bed load, flood debris such as trees or logs
- Overtopping the culvert could cause embankment failure with significant consequences
- In steep hill catchments which are prone to flash floods
- The catchment is larger than 500ha.

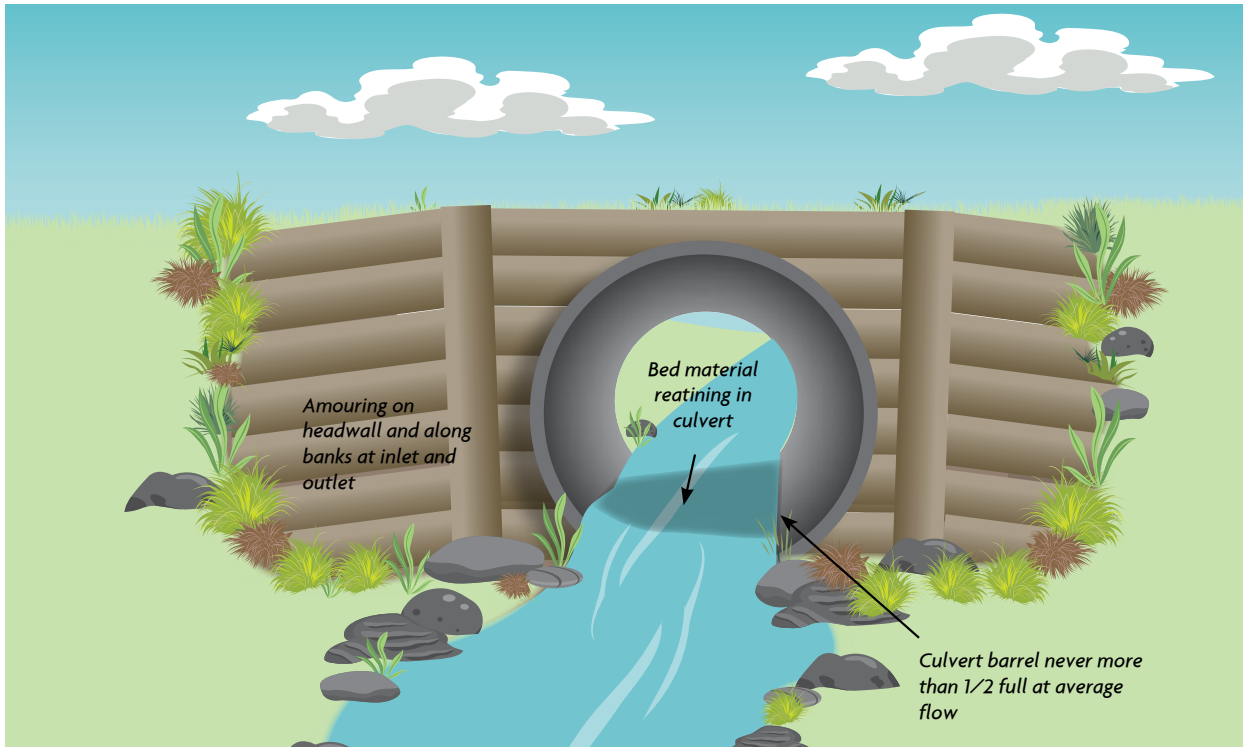
Good management practices for culverts

In general, when building, replacing, or upgrading a culvert, consider the following good management practices:

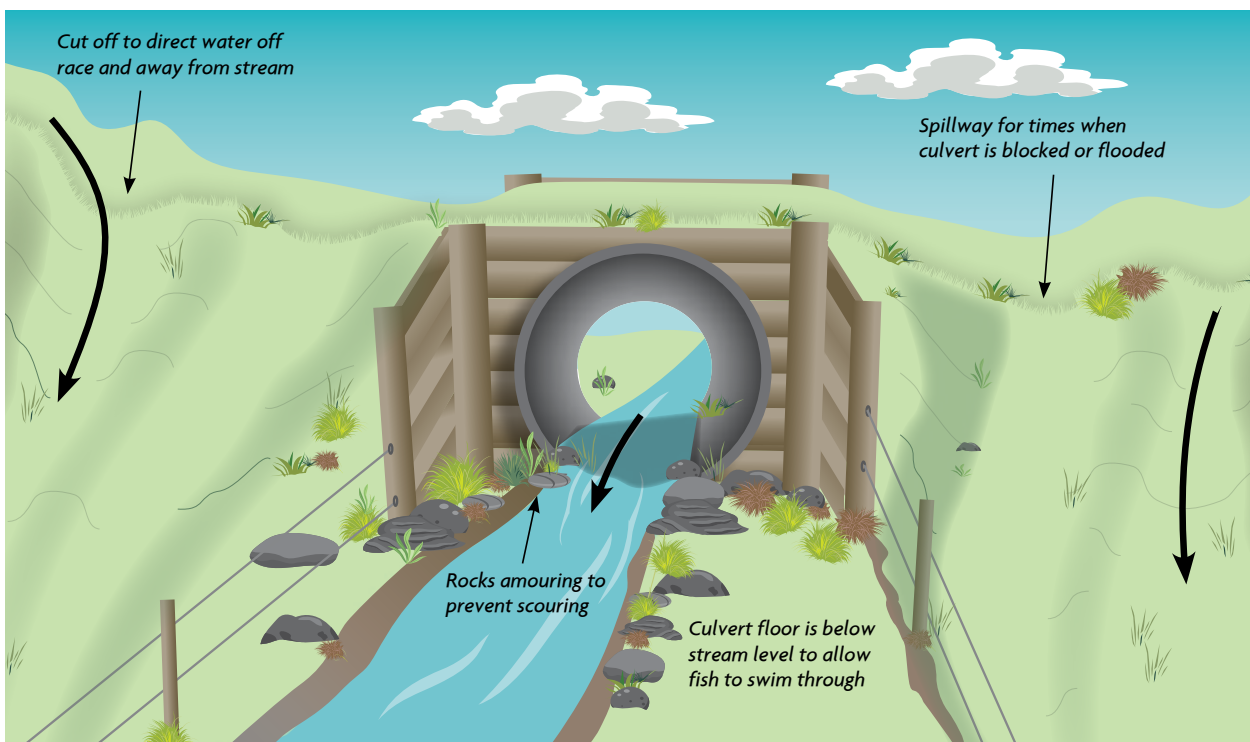
- When choosing a culvert, bigger is generally better if you are concerned about blockages, erosion from overtopping or if high downstream water levels restrict water flow.
- Make sure the width of the culvert is the same as, or wider than the average width of the stream. This will help avoid bypassing or blow-outs in floods. A good rule to follow is $1.2 \times \text{channel width} + 0.5\text{m}$.
- Position the culvert so that the gradient and alignment are the same as the stream.
- Set the floor of the culvert below streambed level to avoid vertical drops at the downstream end. Do not create a waterfall, as this increases the chance of erosion and restricts fish movement upstream.
- Use armouring materials such as rocks or concrete around the culvert and especially below the outlet to reduce erosion.
- Check the culvert manufacturers' recommendations about the depth of fill to put over your pipe to make sure it can withstand loads.

- Consider building a spillway to cope with extreme flood events. A spillway is an area to the side of a culvert where water can flow if the culvert overtops. It should be wide and level across the path of the flow and grassed to prevent scouring. Talk to your regional council or an engineer for advice about good design for your site.
- Allow natural streambed material to settle on the culvert floor along its length so that it is easier for fish to swim through.
- Make sure the culvert is not altering the natural gradient and bed of the stream.
- Take care to minimise the amount of sediment entering the waterway when installing the culvert. Use silt fences or hay bales downstream and minimise soil disturbance where possible. Keep machinery out of the waterway.

Good practice circular barrel culvert installation



Good practice culvert design



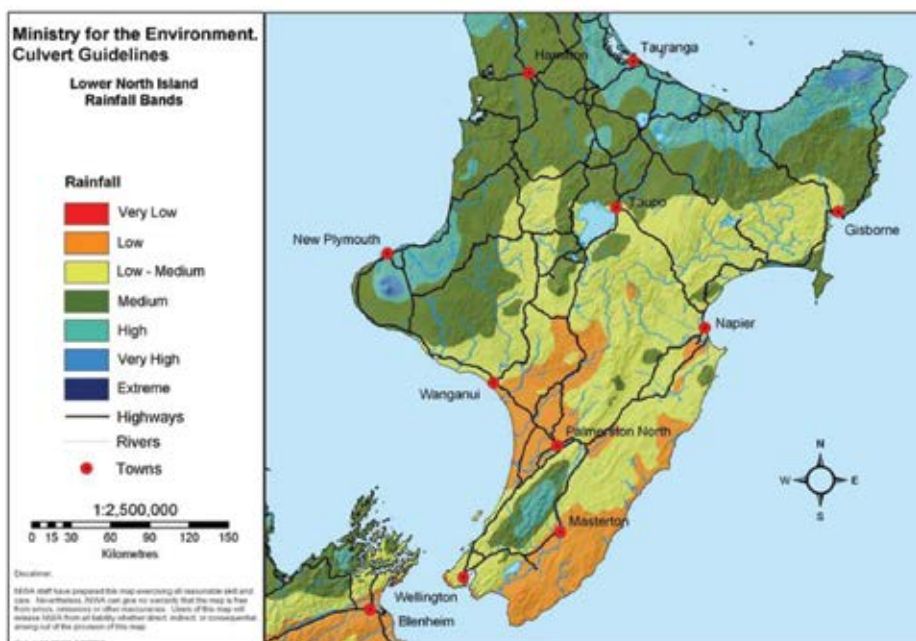
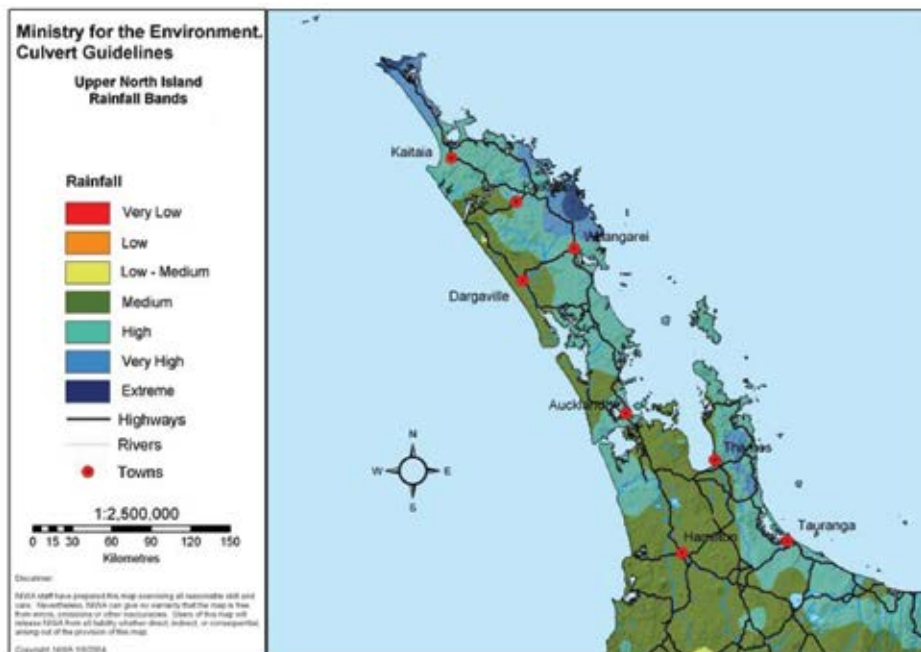
Culvert sizing guidelines

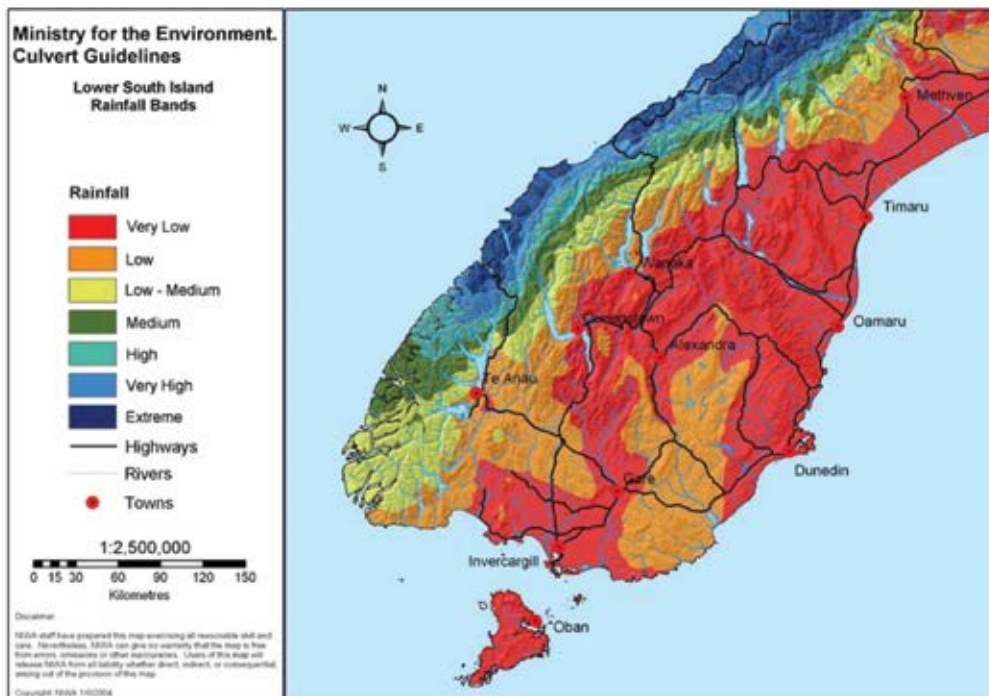
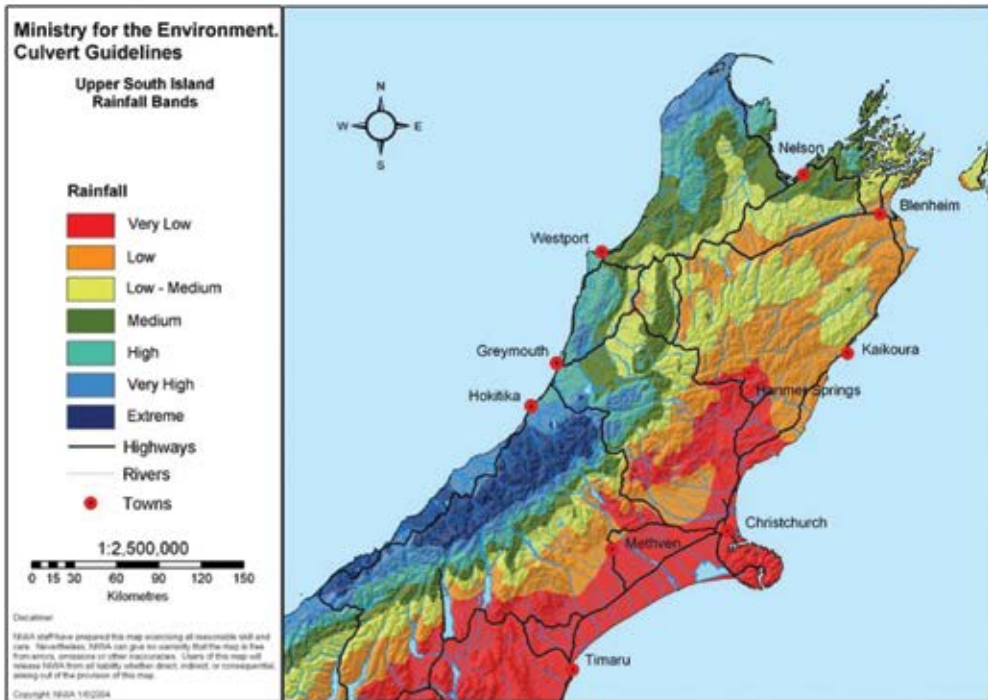
Look near your proposed crossing site to see if there are any other culverts on the same stream which work well in high flows (i.e do not flood upstream in smaller floods and do not regularly overtop). This may give you a guide to an appropriate culvert size, although be wary as, in many cases, culverts already in place may not be appropriately sized.

When choosing a culvert, make sure the width is the same as, or wider than, the average width of the stream. This will help avoid water bypassing or causing blow-outs in floods.

To size a culvert:

1. Determine the catchment area above the crossing point. If using NZMS 1:50,000 maps note that one square on the map equals 100ha.
2. Locate the catchment on the rainfall map below and identify the rainfall band. Note: If the catchment lies across two rainfall bands, use the higher band.
3. Refer to the culvert sizing tables for the relevant rainfall band and choose the catchment area closest to yours. This will give you a recommended culvert diameter. Using 300mm pipe as a minimum will help prevent blockages and overtopping.





Culvert sizing tables for catchment area:

Very low	
5 ha	300 mm
10 ha	375 mm
15 ha	450 mm
20 ha	525 mm
30 ha	600 mm
40 ha	675 mm
50 ha	825 mm
100 ha	975 mm
150 ha	1200 mm
200 ha	1350 mm
250 ha	1600 mm
300 ha	1600 mm
350 ha	1600 mm
400 ha	1800 mm
450 ha	1800 mm
500 ha	1950 mm

Low	
5 ha	300 mm
10 ha	450 mm
15 ha	525 mm
20 ha	600 mm
30 ha	675 mm
40 ha	825 mm
50 ha	900 mm
100 ha	1200 mm
150 ha	1350 mm
200 ha	1600 mm
250 ha	1800 mm
300 ha	1800 mm
350 ha	1800 mm
400 ha	1950 mm
450 ha	2100 mm
500 ha	2100 mm

Low-medium	
5 ha	375 mm
10 ha	450 mm
15 ha	600 mm
20 ha	675 mm
30 ha	825 mm
40 ha	900 mm
50 ha	975 mm
100 ha	1350 mm
150 ha	1600 mm
200 ha	1800 mm
250 ha	1950 mm
300 ha	1950 mm
350 ha	2100 mm
400 ha	2100 mm
450 ha	2550 mm
500 ha	2550 mm

Medium	
5 ha	375 mm
10 ha	525 mm
15 ha	600 mm
20 ha	675 mm
30 ha	825 mm
40 ha	975 mm
50 ha	1050 mm
100 ha	1350 mm
150 ha	1600 mm
200 ha	1950 mm
250 ha	2100 mm
300 ha	2100 mm
350 ha	2550 mm
400 ha	2550 mm
450 ha	2550 mm
500 ha	n/a

High	
5 ha	450 mm
10 ha	600 mm
15 ha	675 mm
20 ha	750 mm
30 ha	900 mm
40 ha	1050 mm
50 ha	1200 mm
100 ha	1600 mm
150 ha	1800 mm
200 ha	2100 mm
250 ha	2550 mm
300 ha	2550 mm
350 ha	2550 mm
400 ha	2550 mm
450 ha	n/a
500 ha	n/a

Very high	
5 ha	450 mm
10 ha	600 mm
15 ha	675 mm
20 ha	825 mm
30 ha	975 mm
40 ha	1200 mm
50 ha	1200 mm
100 ha	1600 mm
150 ha	1950 mm
200 ha	2550 mm
250 ha	2550 mm
300 ha	2550 mm
350 ha	2550 mm
400 ha	n/a
450 ha	n/a
500 ha	n/a

Extreme	
5 ha	525 mm
10 ha	675 mm
15 ha	825 mm
20 ha	975 mm
30 ha	1200 mm
40 ha	1350 mm
50 ha	1600 mm
100 ha	1800 mm
150 ha	2550 mm
200 ha	2550 mm
250 ha	n/a
300 ha	n/a
350 ha	n/a
400 ha	n/a
450 ha	n/a
500 ha	n/a

For catchments in excess of 500ha – contact an engineer as you may require a bridge not a culvert.

- The minimum recommended culvert size is 300mm in all situations. This is because smaller culverts are easily blocked by debris.
- In some cases, a large single culvert may not be the most practical option. The table below gives equivalent multiple barrel culvert installations, which will provide the required culvert capacity.
- The culvert sizes provided will in most cases, pass storm flows equating to about a one in five year storm. Therefore from time to time they can be expected to overtop and in very large storms may scour out. If you wish to have a higher level of storm protection, or gain a more site-specific understanding of your risk, you will need to get advice from your regional council or a suitably experienced consulting engineer.

Equivalent pipe diameters when using multiple culverts

Pipe diameter	Equivalent to		
300 mm			
375 mm	2 x 300 mm		
450 mm	2 x 375 mm	3 x 300 mm	
525 mm	2 x 450 mm	3 x 375 mm	4 x 300 mm
600 mm	2 x 450 mm	3 x 375 mm	4 x 375 mm
675 mm	2 x 525 mm	3 x 450 mm	4 x 375 mm
750 mm	2 x 600 mm	3 x 450 mm	4 x 450 mm
825 mm	2 x 675 mm	3 x 525 mm	4 x 450 mm
900 mm	2 x 675 mm	3 x 600 mm	4 x 525 mm
975 mm	2 x 750 mm	3 x 600 mm	4 x 525 mm
1050 mm	2 x 825 mm	3 x 675 mm	4 x 600 mm
1200 mm	2 x 900 mm	3 x 750 mm	4 x 675 mm
1350 mm	2 x 1050 mm	3 x 825 mm	4 x 750 mm
1600 mm	2 x 1200 mm	3 x 975 mm	4 x 900 mm
1800 mm	2 x 1350 mm	3 x 1200 mm	4 x 975 mm
1950 mm	2 x 1600 mm	3 x 1200 mm	4 x 1050 mm
2100 mm	2 x 1600 mm	3 x 1350 mm	4 x 1200 mm
2550 mm	2 x 1950 mm	3 x 1600 mm	

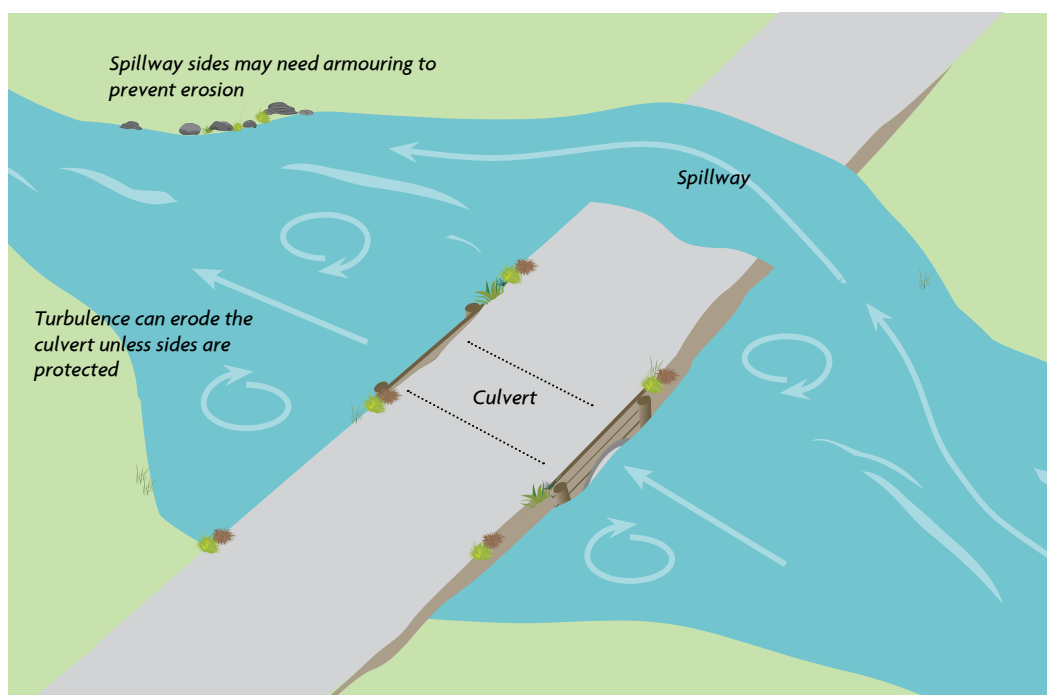
Images from <http://www.mfe.govt.nz/publications/land/culvert-and-bridge-construction-guidelines-farmers/2-culvert-guidelines>

Installing a spillway

The culvert sizes provided in these tables allow for low flood flows. An allowance needs to be made for larger flood flows to prevent damage to the culvert and track. The best way to achieve this is to create a lowered spillway (approx 0.5m deep) to the side of the culvert to allow controlled overtopping. The spillway should be wide and level across the track and away from culvert fill material. The outlet side of the spillway should gently slope back to the stream and grassed or rock armoured to prevent erosion.

If there is no suitable location for a spillway adjacent to the culvert, the spillway can be over the culvert. In this case, special care must be taken in the construction of the culvert headwalls to protect the fill material from being washed out.

An example of how a spillway should operate.

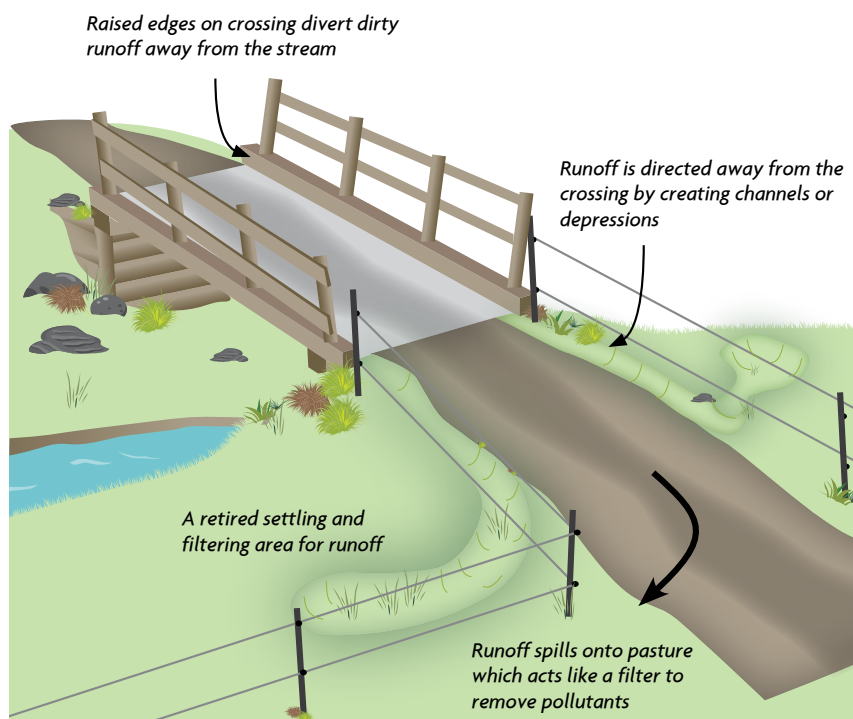


For further information and design details to simplify the process, see the Culvert and Bridge Construction Guidelines prepared by the Ministry for the Environment.

Bridges

In general, when building bridges, consider the following good management practices:

- Use standardised plans and materials to reduce time and cost of design
- Try to minimise the number of piers (if any) in the waterway to avoid impeding water flow and creating eddies which could contribute to bank erosion
- Avoid locating your bridge on a bend in a waterway, as sediment will build up on the inside
- Construct your bridge to ensure that high stream flows are not impeded
- If possible, minimise your bridge span to keep costs down
- Construct raised lips on the deck and edges to prevent runoff entering the waterway
- Raising the bridge above its approaches will also help to reduce runoff from tracks and races entering the waterway
- Channel runoff from the bridge into grassy or planted areas
- Construct a spillway.



Building safe bridges

For information and design details to simplify the process, see the Culvert and Bridge Construction Guidelines prepared by the Ministry for the Environment.

You may also want to contact your bridge builder and engineer to discuss designs and costs to suit your situation. You will need to take into account things such as flood flows, bridge use, stream bank material, stream bed profile and preferred construction materials.

Safe bridges will have:

- Railings to ensure vehicles, stock and people will be able to cross safely
- Race surfaces which are maintained and constructed from a durable and sturdy surface

- Crossings that shed water into paddocks will ensure that surfaces are not slippery during wet periods
- Wide entries onto and off of the crossing to allow larger vehicle access and reduce problems in cow flow
- Been built using sturdy and durable materials able to withstand high flows and flood levels.

Common types of bridges on dairy farms

Single span bridge

A single span bridge constructed according to good practice is the best type of waterway crossing on-farm. The waterway environment remains largely unchanged, flood flows can easily be accommodated and stock can move freely.

Single span bridges have for a long time been the most popular choice of crossing on farms. While there are many historic ways of constructing bridges, nowadays it is important to ensure that construction methods make use of trustworthy long-lasting materials and bridges are located in appropriate areas.



Good practice single span farm bridge. (Note that the footing of the bridge is well away from the water's edge at normal flow so that the natural river bank is retained under the bridge.)

Multiple span bridge

Multiple span bridges are common where large river crossings are required and where a single span bridge is not practical. Consent and professional engineering will almost always be required.

Multiple span bridges are also prone to debris build-up on the piers, particularly during high flow events, which may result in bed erosion and channel restriction. This is particularly important in flood prone rivers and streams where bridges with small spans and multiple piers can act as funnels for flood water, creating areas of higher velocity and increasing the flood water's erosive impact.



A multiple span road bridge during a high flow event. (Note the debris build-up on the bridge piers.)

Maintenance of bridges and culverts

Inspect your bridges and culverts regularly and especially after heavy rain events. Remove any debris or blockages as this reduces flow capacity, resulting in additional flooding and possible damage. Regional councils can often provide assistance and advice around removing large blockages.

It is important to ensure regular upkeep of the general area around bridges and crossings. In particular, paying attention to areas where sediment and effluent accumulate to prevent these washing into waterways during rain events. These areas include:

- Cut-off drains
- Crossing surfaces
- Hollows around bridge surfaces
- Nib wall edges.

In some cases, filling with race material or fill is enough to stop this accumulation. In others, scraping of crossing surfaces might be a better option and this can be pushed into paddocks where it can be filtered before entering water.

Crossings requiring upgrades

In some cases, old crossings require upgrades. This can be because materials wear out or because of incorrect initial installation. In most cases, quick fixes may mean some simple patching of old crossings or possible slight adjustment to the site of the crossing. In other cases, an entire re-build/re-think will be required.

Examples of moderate fixes to improve your crossing might include:

- Redesigning cut off areas to divert water off the raceway away from the stream
- Armouring around the base of bridges and culverts to reduce erosion
- Installing a new top to the bridge or culvert that directs runoff away from water.

Examples of when a rebuild may be required:

- The culvert is perched and creates a waterfall
- The culvert is too small
- The culvert gets overtopped
- At crossings where animals are walking through water.



Ford crossings are entry points for sediment, nutrients and faecal bacteria. Good practice means upgrading this type of crossing to a bridge or culvert.



An example of a badly installed culvert, which has been placed too high above the stream bed, which increases erosion and prevents fish passage.

Planting

Benefits of planting

Planting around waterways has many benefits, including:

- Improving stream bank stability
- Filtering nutrients and sediment from overland flow
- Enhancing bird habitat and biodiversity
- Lowering stream temperature and reducing waterweed growth
- Improving habitat for aquatic life
- Improving aesthetics on farm.



With good planning, riparian planting can be very effective and simple to implement.

Planning your planting

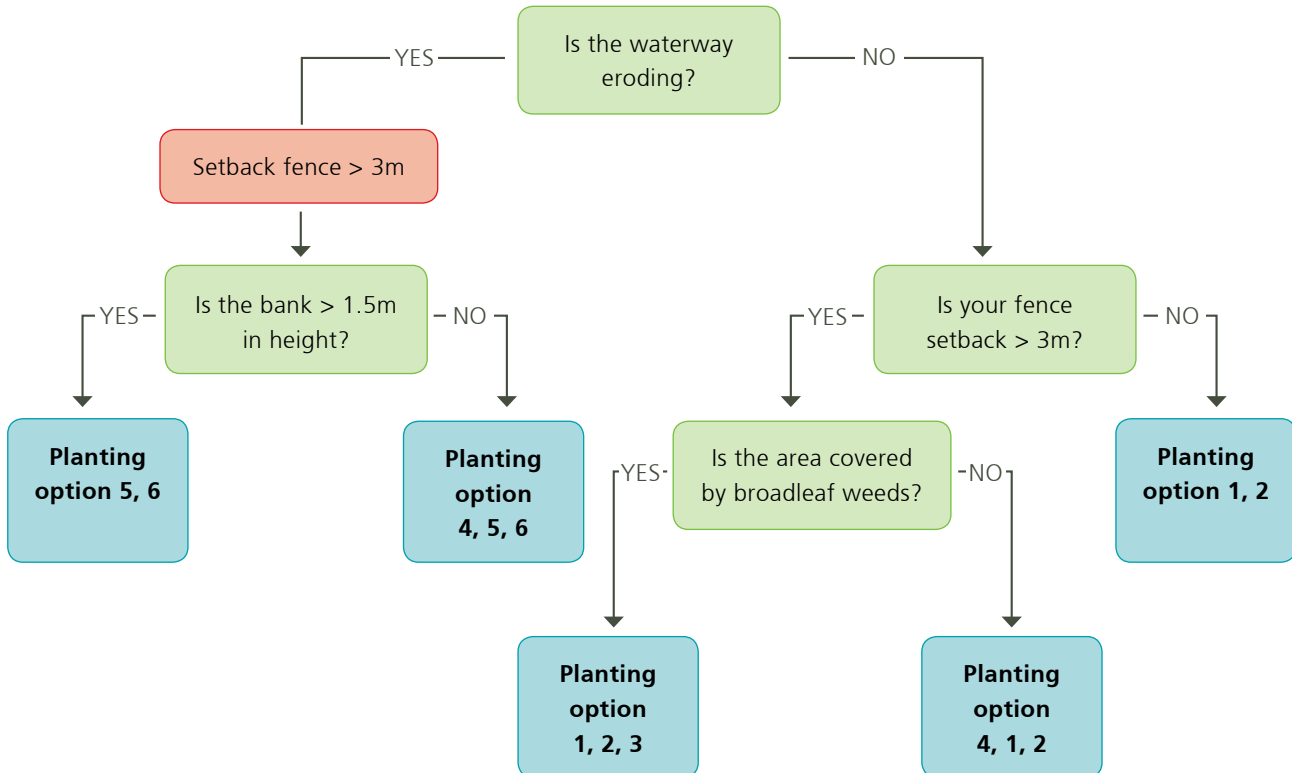
Step 1 – Plan your waterway management first

Before planting can occur, you need to plan where fences and crossing will go, how much you intend to spend, how much time you have and where to start. To find out more see the planning section on page 8.



Step 2 – Work out what type of planting is suitable for your waterway

Planting will be different depending on what type of waterway you have, e.g. wetland, swamp, drain or stream, and what you're planning to achieve. Use the decision tree below to help plan which planting option is best for your site.

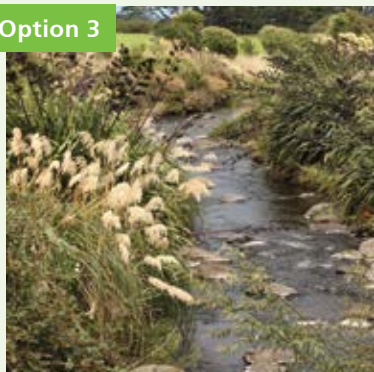
PLANNING YOUR PLANTING



General planting options

<p>Option 1</p> 	<p>No planting (grass only) - Pasture grass Requires: Weed control in many cases (try to use a selective broadleaf herbicide). 1m+ width</p>	<p>Pros: Inexpensive, will shade small streams and drains, filters overland flow, great for narrow riparian margins. Cons: Not good for erosion prone sites, low biodiversity value.</p>
<p>Option 2</p> 	<p>Native sedge/rush only - E.g <i>Carex</i>, <i>Juncus</i> Requires: Some weed control (try to use a selective broadleaf herbicide). 1.5m+ zone width Rushes and sedges are resistant to most broadleaf sprays.</p>	<p>Pros: Works in small riparian areas, will shade small waterways, filters overland flow, stabilises bank more than grass. Cons: Plant cost, not as much shade generated as tree planting, less habitat for birds.</p>

Option 3



Native monocot planting (grass like plants)

- E.g *Carex*, toetoe, flax, cabbage tree

Requires: Weed control in many cases (try to use a selective broadleaf herbicide).

These plants are resistant to most broadleaf sprays.

Pros: Works in small riparian areas, will shade small waterways, filters overland flow, stabilises bank more than grass. Can selectively spray broadleaf weeds without risk to native planting.

Cons: Plant cost, not as much shade generated as tree planting, less habitat for birds.

Option 4



Full native planting

- General native species suitable to riparian sites

Requires: Weed control in most cases.

3m+ zone width

Pros: Gives the stream shading, bank stability, generates seed bank of native plants, improved biodiversity benefits.

Cons: Plant cost, retirement area required. Not an ideal option in a large or steep catchment.

Option 5



Willow and poplar erosion control

- A range of willow or poplar can be used

Requires: Regular maintenance; regional council input.

3m+ zone width

Pros: A very good erosion control option, provides some shading.

Cons: Regular maintenance required. Can be an issue when fully grown if planted too close to the waterway.

Option 6



Willow and poplar with native planting

- General native species with willow and poplar

Requires: Maintenance of willow and poplar, regular weed control.

3m+ zone width

Pros: A good erosion control option. This option also allows for native plants to replace willow and poplar in time.

Cons: Poplars and willows require regular maintenance.

Keep in mind:

- If you want to use native plants that will grow greater than three metres in height, your planting area will need to be at least five metres wide (a five metre strip will allow room for a grassy margin next to the water's edge and one or two rows of trees or shrubs).¹
- Planting zone sizes will differ depending on the shape of your stream. There is no specific guide for the width of each planting zone.

¹ Collier KJ, Cooper AB, Davies-Colley RJ, Rutherford JC, Smith CM and Williamson RB, 1995: Managing riparian zones: A contribution to protecting New Zealand's rivers and streams (2 volumes). Department of Conservation, Wellington.

Work out what you want the planting to achieve

Planting to:

Improve stream bank stability

Most suitable options: 3 and 4 for moderate erosion; 5 and 6 for risk of severe erosion

Plants will improve the stability of stream banks. Plants with flexible growth forms such as Carex grasses should be used on the margins at the waterway's normal flow level. Plant larger plants further back.

Planting to:

Filter nutrients and sediment from overland flow

Most suitable options: 1 and 2; and 3 and 4 with filter strip on fenced side of riparian zone

To adequately filter nutrients and sediment from overland flow, you need to make sure your fencing is setback far enough to slow down the water as it passes through the riparian zone. On rolling or steep land, the fence will need to be further back from the waterway than it would be on flat land.

Grasses, sedges and rushes, such as pasture grass or native Carex sedges, are great for filtering nutrients from overland flow. You can also combine these with taller plantings to make your riparian strip wider.

Tile and mole drains bypass riparian areas. If you can, allow these drains to run through a wide riparian margin, or a constructed wetland.

Planting for:

Bird habitat and biodiversity

Most suitable options: 3 and 4 will also provide benefit

Where possible link your planting areas to other existing native vegetation such as forest remnants. If you want your riparian plantings to become a self-sustaining area of native bush where weed management is minimal, you will need to make your planted area at least 10 metres wide.²

Riparian plantings can provide habitat and food for a range of bird and insect species. Insects living in riparian vegetation provide food for fish and birds. Select tree species native to your area that are known for attracting birds. Some examples include flax, kowhai, titoki, karamu, kahikatea and cabbage.

Planting to:

Reduce stream temperature and waterweed growth

Most suitable options: ALL – dependent on the stream size. Shade plants need to be at least the same height as the width of the stream.

Sunlight speeds up weed growth and heats up the water, especially in summer. Providing shade is an important way to keep water temperatures down, improve in-stream life and reduce weed growth.³

Fish also benefit from cooler water temperatures. In general, fish can be harmed when water temperatures increase above 25°C and many aquatic insects need the water to be less than 20 degrees. Aquatic insects have huge ecological importance because they break down organic matter and are food for fish, like trout.⁴



This photo illustrates how shade can reduce water weed growth.⁶

² Parkyn SM, Shaw W and Eades P, 2000: Review of information on riparian buffer widths necessary to support sustainable vegetation and meet aquatic functions. NIWA Client Report ARC00262.

³ Waikato Regional Council, 2004: Clean Streams: A Guide to Managing Waterways on Waikato Farms. Environment Waikato, Hamilton.

⁴ Greater Wellington Regional Council, 2009: Mind the Stream – A guide to looking after streams in the Wellington Region. Wellington.

If you want to replant your stream bank with native plants while also preventing erosion, you will need to maintain a good cover of grasses on the bank edge.

Keep shade levels between 50 to 70 percent to make sure grasses and sedges are not shaded out. Fifty to 70 percent shade occurs where your combined bank and vegetation height is about equal to the stream's channel width.⁵

Planting to:

Improve fish habitat

Most suitable options: 3 (Native monocot planting) and 4 (Full native planting)

Plant a native riparian strip to enhance fish habitat. This will provide stream shade and shelter. Leaf litter and small twigs that fall into the water from riparian plants will provide food for invertebrates on which fish feed. Fish will also feed on insects that fall into the stream from riparian plantings.

In tidal areas, create grassy waterway margins as this will provide spawning habitat for whitebait.

Where practical, leave woody material in the stream as it will provide sites for fish to spawn and hide.

Planting to:

Prevent further erosion

Most suitable options: 5 and 6

Willows and poplars can be ideal for erosion control. They have excellent soil binding characteristics provided by their fibrous roots. This is important for stabilising river margins, as the banks are often formed from non-cohesive silts, sands and gravels. Willows and poplars grow rapidly, even in relatively poor soils and can handle conditions ranging from dry sites to very wet, partially submerged sites.

Willow and poplars for soil conservation

Hybrid sterile willows have been bred specifically for soil conservation. Unlike weed willows (crack and grey) they will not spread easily or cause blockages and erosion. For information on poplars and willows see:

poplarandwillow.org.nz

Contact your local regional council for information on the most suitable varieties for your areas and where to source them.

Propagation

- Willows and poplars can be propagated relatively easily and cheaply. They can be planted out from small cuttings, stakes, branches or even whole trees. Do not propagate weed species.
- A wide range of specially selected and bred varieties are available.



Poplar pole planting along a waterway. In a dairy situation these trees need to be fenced from stock. This will improve the survival rate.

Source: Gibbs, 2007: Best Practice Guidelines for Vegetation Management and In Stream Works. Waikato Regional Council Technical Report 2007/41.

⁵ Davies-Colley RJ and Rutherford JC, 2001: Some Approaches to Measuring and Modelling Riparian Shade. In Proceedings of the International Ecological Engineering Conference, 25-29 November 2001, Lincoln University.

⁶ Environment Canterbury, 2005: A guide to managing waterways on Canterbury farms. Environment Canterbury. Christchurch.

How to plant poplars and willows

Poplars and willows are planted as stakes (less than one metre) or poles (one-and-a-half to three metres). A poplar pole is a young tree cutting which roots and sprouts when planted in the ground.

The spacing between willow and poplar trees is important. Plant tree species at least three metres back from the top of the stream bank and six to 10 metres apart. At this spacing, by the time your trees are five years old, they will have formed a solid mass of roots along the bank of the waterway.

Shrub (Osier) willows are medium-sized willows that often have flexible branches which are unlikely to break off in high river flows (e.g. Irette). They will bush out into the water helping to deflect the current away from the eroding area and slow water flow which results in deposition of sediment helping to rebuild eroded banks.⁹

Plant shrubby willows on wide meandering streams at one to two metre spacing at the base of eroding banks or on top of steep banks that are eroding to prevent scouring and reduce future slumping.

Planting poles and stakes

The key to healthy survival of poles and stakes is planting them deep and firm. The most effective ways of planting poles is ramming and digging.¹⁰ To ensure survival, don't let large animals graze around the pole plantings for the first two years.

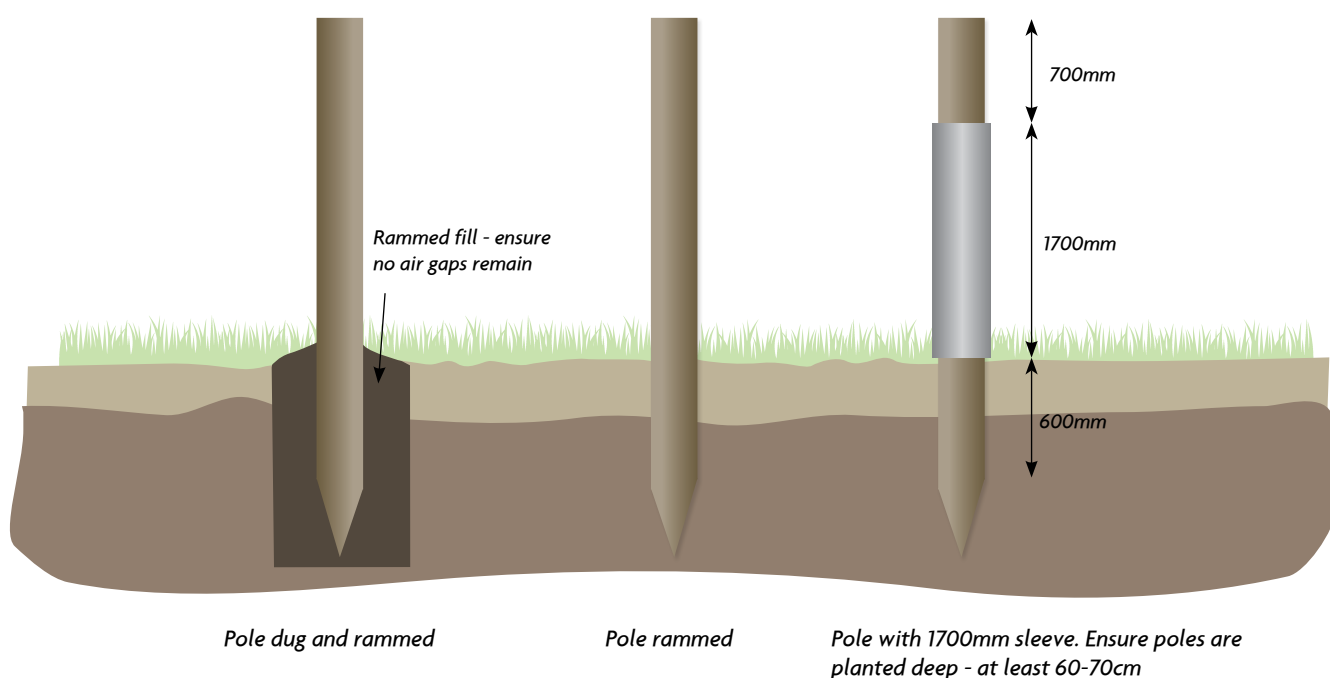


Diagram showing how to plant poplar and/or willow poles.

Source: Hawkes Bay Regional Council, Land Management Factsheet. Retrieved from <http://www.hbrc.govt.nz/HBRC-Documents/HBRC%20Document%20Library/Planting%20Poplars.pdf>

Ramming

A pole rammer or pole bar can be used to drive the pole as tightly as possible into the ground, with the base of the pole anchored into undisturbed soil.

It may be helpful to prepare a pilot hole with a hand auger, crow bar or attachment on a rammer which should be slightly smaller than the diameter of the pole.

Using the rammer, drive approximately a third of the pole into the ground. If the pole is 2.3m long, drive it at least 60cm into the ground.

⁹ Waikato Regional Council. Poplar and willow planting: A guide to planting poplar and willow on your property

¹⁰ Waikato Regional Council. Poplar and willow planting: A guide to planting poplar and willow on your property

Digging or using a post hole borer

A post hole borer or spade can also be used to create a hole. However, ensure poles are rammed tightly into the bottom of the hole. It is recommended that during summer, the soil around the pole is rammed/compacted to prevent the pole from loosening.

Timing

The best time to plant poplar and willow poles and stakes is during the winter months when willows are generally dormant.

Maintenance

Before planting poplar and willow, bear in mind that they are large and vigorous trees that will require silviculture maintenance over their 15-35 year lifespan. They need to be monitored and managed to ensure their ongoing effectiveness. This will include thinning the trees to 10 to 12 metre spacings at 10 to 20 years old, form pruning, and coppicing.

The Taranaki Regional Council has produced a factsheet that details maintenance requirements for poplar and willow poles. See trc.govt.nz¹¹

Combining native plants with willows and poplars

Willows and poplars require extensive long term maintenance so planting native plants should always be considered in the first instance. Native plants are slower growing, but have a longer life span than willows and poplars. Unfortunately, native shrubs and trees are not always appropriate as a direct alternative to willows and poplars for erosion control. Some native species exhibit many of the attributes listed above but none have all of them.

In most situations native vegetation can be inter-planted between willows and poplars and once mature, the willow and poplar trees can be removed.

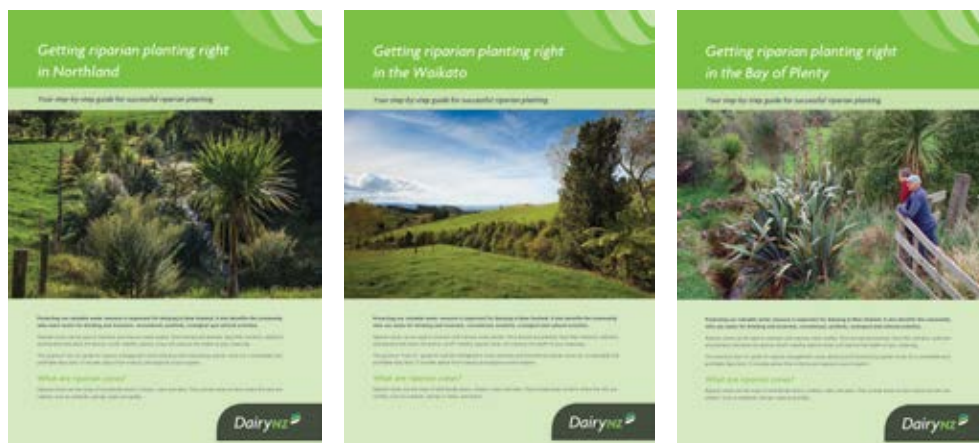
Root spread and depth in native plants

Integrated native planting with willow and poplar species is often the best option. You can plant a range of natives as the willows and poplars will usually provide all the stability required to prevent further erosion.

Step 3 – follow the steps in the planting guide specific to your region

DairyNZ has produced riparian planting guides for a number of regions in New Zealand.

See dairynz.co.nz



¹¹ Taranaki Regional Council: Pole planting – maintenance (Pamphlet). Taranaki Regional Council, Stratford.

Working out how many plants you need

- Sketch out your planting area showing the different planting zones and the dimensions of each zone.
- Work out the area of each planting zone. For example, if zone A (waterway margin/lower planting area) is 200 metres in length and three metres wide the area will be 600m².
- Work out how many plants you need for each planting zone. Plants should generally be spaced one metre or one-and-a-half metres apart, although small rushes and sedges can be planted half a metre apart. Trees with a large mature size such as rimu and totara could be planted at five to 10 metre spacings with smaller species in between.
- Record your calculations in a table similar to the example below.

Waterway Name	Planting zone	Area (square metres)	Desired plant spacing (metres)	Number of plants required
Bob's drain	Zone A – margin and lower bank	600	1	600
Bob's drain	Zone B – Upper bank	600	1.5	266
	Other e.g wetland			

An example of a table noting planting number calculations

Where to get your plants

- Use native plants that have been grown from locally sourced seed.
- Buy from a reputable wholesale native plant nursery, close to your location. Local nurseries often source seed from the area. This is important – ask them!
- Place an order with the nursery ahead of time. You may need to adjust your plan for the year depending on plant availability.
- If you are involved in a large project, consider entering into a contract with a specialist nursery.
- Some agencies may provide you with free or cheap plants to get you started. Check with your regional council for any information about places to source good quality cheap plants.

Buying plants

- When buying plants, they are often in pb bags (pint size bags) or pots, with pots generally referred to in litres.
- Re-vegetation grade plants vary, but a good rule of thumb for cost effective sized plants will be pb2/pb3 which is the equivalent of 1.2 litres/1.8 litres.
- Larger sized plants will be more expensive, but are more resistant to weeds. Smaller sizes will be cheaper, but will require more weed control while they establish.
- Ecosourced plants have a higher survival rate as they are adapted to local conditions.
- Buy plants from a reputable wholesale nursery. Your regional council should be able to advise where to source them.
- Generally, bigger is better as plants have the ability to get up above rank grasses. However, leggy plants that are tall and slender often struggle when exposed to wind and dry conditions. Also ensure the plant is not root bound as they can also get shocked.



A common grade of plant is around the pb3 or 1.5L size.

Plant storage

- If you have to store your plants ensure that they are on a hard surface, not on soft ground or grass, as the roots will grow into the ground. This causes shock when moved at planting time and can damage or kill the plant.
- Keep plants exposed to the night air before planting to “harden them off”, but keep them under cover if they are frost sensitive and you are expecting frosty conditions.

Preparing the ground for planting

Weed control

- Make sure you do a thorough job of removing weeds before planting native trees.
- Four to six weeks before planting, spray one metre diameter circles at the location where you will plant each plant.
- Specialist products are available for protecting plants such as treeguards and biodegradable weed mat. Treeguards are designed to create a microclimate, reducing the effects of adverse weather. They also protect the plant during release spraying and give protection from rabbits and hares. They need to be installed at the time of planting.



Tree protectors like the ones shown here, can really help ensure a successful planting. They are particularly useful in cold areas, or where animal pests are an issue. They can be re-used and will help protect the plant when weeds are sprayed.

Animal pest control

- Animal pests such as rabbits, hares and possums can cause havoc for new plantings. Even native animals such as pukekos can sometimes be a problem. (Refer to the Waterway technote on pest animals, page 59).

Water plants

- Soak your plants before planting while they are still in their bags.
- Water them the night before or in the morning of planting day. This will be easier than trying to water them on site and will help reduce the shock to the plant when planted.

Space plants out before planting

- Positioning plants before planting makes for easier planting.
- Having an experienced planter lay out the plants ensures that plants will be positioned correctly.
- Remember your planting zones. Large growing trees (e.g. ribbonwood, kowhai, kahikatea) should be planted well back from the stream edge (at least five metres back).

Maintenance of grass or sedge filter strips

- In grass or sedge filter strips, or any planting that is completely dominated by monocot species, it will be possible to control broadleaf weeds without risk to the native plants.
- Use herbicides that contain Triclopyr. These are very effective against broadleaf weeds and will not harm grasses or sedges.

Timing for weed control/releasing

- Plantings will need to be cleared of or “released” from competing weed growth every spring and autumn, until your plants are big enough to shade out the weeds. Keep a close eye on your site as you may need to do it more often.

Secondary planting

As with any crop, you cannot expect 100 percent success with tree plantings, but if you plant good quality seedlings of the right species, at the right time of year and protect them well, you can expect a 70-80 percent survival rate. It is helpful to replant in the spaces where you have lost trees, to reduce gaps for weeds to grow in the future.

- Once your initial planting is established, go back in three to five years and plant some different species to help diversify the range of plants. This will help to ensure a long-lived riparian area.
- Native birds will also benefit from a more diverse range of plants. Many of the secondary plant species produce flowers and fruit that are part of the diet of native forest birds.

Links to more information

For scientific background on the effectiveness of riparian buffer zones in removing sediment and nutrients see Parkyn, 2004: Review of Riparian Buffer Zone Effectiveness. MAF Technical Paper No: 2004/05.

For information on appropriate species to plant for specific sites, visit www.natureservices.landcareresearch.co.nz.

Planting guides

Check with your regional council website for information on planting.

Regional planting guides are also available at dairynz.co.nz.

Appendix 1 – What are you aiming for?

When do you know you have it right, or if there is still more work to be done?

Good	Needs work	Action
Stable stream banks	Eroded, unstable banks	Investigate why erosion is occurring. For information on options for controlling erosion see <i>Waterways: erosion*</i> .
Plants do not obstruct the fence	Fences are shorting out when plants touch them	Move fence back further or prune plantings.
Native plants out competing weeds	Weed dominated riparian zone	Undertake weed control See <i>Waterways: pest plants*</i> for information about identifying and controlling various weeds.
No damage occurring to plants from animal pests	Animal pests damage planting	Undertake animal pest control. See <i>Waterways: pest animals*</i> for information about identifying and controlling various weeds.

Good	Needs work	Action
Plants are growing well	Plants seem to struggle in this location and grow slowly	Check that plants are suited to the conditions. See <i>Getting riparian planting right*</i> series. (e.g frost, soils, wind, soil moisture).
Plant survival is high	Plant survival is low	Check that plants are suited to the conditions (see above). Are weeds an issue? See <i>Waterways: pest plants/pest animals*</i> pg 48 and 59. Were correct planting techniques followed? See <i>Getting riparian planting right</i> series*.
Runoff is slowed and filtered before it enters the stream	Channels forming where runoff gets straight through to stream	Move the fence back and create a wider filter strip. See above

*For further information visit dairynz.co.nz.

Appendix 2– Examples of well planted waterways

Use the examples below to think about what might be possible on your farm.



Stream bank planted with a range of native species and sterile willows for erosion control.

Source: Waikato Regional Council, 2004: Clean Streams: A Guide to Managing Waterways on Waikato Farms. Waikato Regional Council. Hamilton.



Wetland planting is great for attracting wildlife as well as providing a valuable nutrient filter for any farm runoff.

Source: Bay of Plenty Regional Council Land Management Factsheet #33



Stream margin planting is excellent for stabilising stream banks, cooling water, filtering nutrients from farm runoff and providing wildlife habitat.

Source: Taranaki Regional Council. Sustainable Land Management Factsheet Series. Why manage stream banks? Factsheet #21. Taranaki Regional Council. Stratford.



Native planting around a Waikato peat lake. A wide riparian margin around peat lakes will help improve and protect water quality.

Source: Waikato Regional Council



Native planting around a pond. Even small farm ponds can benefit from planting.

Source: Waikato Regional Council



Poplar tree planting for erosion control (background) mixed with native planting (flax).

Source: Waikato Regional Council



Steep stream bank planted with low growing native plants. Using these on steep banks is important for stability and increases flow by supporting a V-profile.

Source: Waikato Regional Council



Carex sedges planted along a narrow waterway margin provide bank stability, habitat and nutrient filtering without restricting flood flows.

Source: Canterbury Regional Council: Living Streams Handbook – Part 1: Investigations and planning. Environment Canterbury. Christchurch



Before and after planting of a swampy area. As well as providing benefits for water quality and native biodiversity, this type of planting can dramatically improve the look of your farm.

Source: Whaingaroa Harbourcare



Planting farm drains can reduce weed growth and sedimentation and reduce the need for cleaning.

Source: Waikato Regional Council

Pest plants

Benefits of pest plant control

Pest plants can cause havoc on your farm, ruin your planting and cause major problems in and around waterways. When it comes to good waterway management, keeping on top of weeds is important.


Benefits of pest plant control around waterways

Well-executed plant pest control is beneficial as it will:

- Improve the chance of a successful riparian management project
- Reduce the likelihood of pests entering other farm areas from fenced off waterways
- Reduce maintenance time and costs in planted areas and reduce replacement planting costs
- Speed up the time it takes to achieve an established riparian planting project
- Improve native biodiversity and habitat.

Common pest plant species found in riparian areas and control methods

Vines & creeping weeds

Weed	Treatment methods (see control methods section page 55)
<p data-bbox="151 1220 375 1332">Wandering Willie/ Wandering Jew or <i>tradescantia</i></p> 	<ul style="list-style-type: none">• Rake and roll up (usually only in small spots, to minimise the initial spray) – this is best done in times of drought. A follow-up spray is usually required. Note – tradescantia presents major disposal problems, as dropped fragments can spread infestation.• Foliage spray with triclopyr (Grazon or equivalent) or Hydrocotyle Killer + penetrant. Follow up within two to three months. You need two to three treatments for total control and are likely to achieve limited results during colder months.• Weed wiper – triclopyr (Grazon or equivalent) or Hydrocotyle Killer + penetrant. Follow up after two to three months.

Japanese honeysuckle

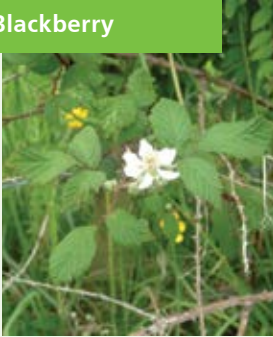


Source: <http://www.waikatoregion.govt.nz/PageFiles/3599/weeds%20and%20riparian%20margins.pdf>

A climbing shrub capable of climbing up the canopy to 15m. It can smother your riparian plantings, attract animal pests and reduces protection from erosion. From September to May, tube-like white to yellow flowers appear in pairs, followed by glossy black berries.

- Dig out small sites. Dispose of roots and stems.
- Foliage spray with Tordon Brushkiller or equivalent or metsulfuron-methyl (Escort or equivalent) at Old man's beard rates in summer to autumn. In sensitive areas use glyphosate + penetrant.
- Stump swab with metsulfuron-methyl (Escort or equivalent), or Tordon Brushkiller or equivalent+ penetrant.
- Check for new sprouts six-monthly until clear.

Blackberry



Picture & info source: Copyright C. Howell http://weedbusters.co.nz/weed_info/detail.asp?WeedID=88

Blackberry infestations will smother most low growing species, inhibiting the establishment of native plant seedlings and impeding access.

- Foliage spray with an appropriate herbicide e.g Tordon Brushkiller or equivalent + penetrant.
- Cut stump and treat with metsulfuron-methyl (Escort or equivalent) at label application rate or Tordon Brushkiller or equivalent. Gels may also be used on the cut stump (e.g Vigilant gel, Picloram gel, Cut n paste).

Old man's beard



Source: DOC website

Old man's beard is a deciduous woody vine producing small, creamy flowers from December to February, followed by masses of fluffy seeds. It can smother large areas of native forest remnants including the tallest trees.

Note: There are many species of native clematis, be sure you positively identify your plant as Old man's beard before controlling it.

- Foliage Spray with Tordon Brushkiller or equivalent + penetrant in spring to autumn.
- Stump swab – cut stems at ground level and treat with metsulfuron-methyl (Escort or equivalent), Tordon Brushkiller or equivalent, triclopyr (Grazon or equivalent), Banvine, Picloram gel or Vigilant gel. Leave stems in the air to dry. Dispose of cut-away segments.

Weed

Treatment methods (see control methods section page 55)

Greater bindweed, also known as *convolvulus*



Source: <http://www.envirolink.govt.nz/PageFiles/154/725-GSDC57%20Bindweed%20Control%20Methods.pdf>

This climbing plant will smother small plants and shrubs. It has very large, white, trumpet-shaped flowers and large triangular or arrow-shaped leaves. The extensive underground rhizome system makes the plant difficult to control.

- Foliage spray with Banvine at vine rates, metsulfuron-methyl (Escort or equivalent) + penetrant, or with Tordon Brushkiller or equivalent.
- Stump swab with metsulfuron-methyl (Escort or equivalent), glyphosate, or Banvine. Gels may also be used on the cut stump (e.g Vigilant gel, Picloram gel). Mulch the stems.

Trees

Weed

Treatment methods (see control methods section page 55)

Tree privet and Chinese privet



Source: Waikato Regional Council

Tree privet and Chinese privet are invasive and will take over if not controlled. It is a small to large evergreen tree with strongly scented creamy white flowers appearing between January and March.

- Hand pull or dig out seedlings and small plants.
- Stump swab with glyphosate or metsulfuron-methyl (Escort or equivalent) + penetrant.
- Frilling – metsulfuron-methyl (Escort or equivalent).
- Stem Injection – metsulfuron-methyl (Escort or equivalent) or undiluted Tordon brushkiller or equivalent.
- Foliage spray in spring to autumn with metsulfuron-methyl (Escort or equivalent) + penetrant.
- Follow-up work may be required.

Crack willow (*Salix fragilis*)¹




Source: Forest Flora



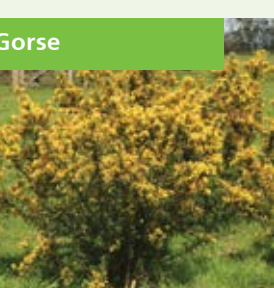
Crack willow (*Salix fragilis*)¹ will out-compete many native wetland or riparian plants. It is a deciduous tree up to 25m tall, occasionally only shrub size, with spreading rather than hanging branches, and rough, fissured bark.

- Begin willow control at top of catchment as crack and grey willow easily spreads from broken fragments. Treat every stem.
- Frilling (summer-autumn): Make one cut every 100mm around the trunk and squirt undiluted glyphosate (10ml) into each cut.
- Cut stump method: apply herbicide gel (e.g Vigilant gel, Picloram gel). Remove all plant material from site as all cut stems can root where they fall.
- Stem Injection (summer-autumn): Make one hole every 100mm around the trunk and pour undiluted glyphosate (10ml) or metsulfuron-methyl 600g/kg (2ml of 20g/L) or undiluted 2,4-D ester (20ml) into each hole.
- Foliage spray (full leaf stage only): glyphosate (12.5ml/L + penetrant, total coverage needed) or metsulfuron-methyl 600g/kg (35g/100L from January to April before leaf fall begins).

¹ Environment Southland, Weeds in Riparian Zones factsheet.

Weed	Treatment methods (see control methods section page 55)	
<p>Grey willow (<i>Salix cinerea</i>)</p>  <p>Source: Waikato Regional Council</p>	<p>Grey willow (<i>Salix cinerea</i>) is a deciduous shrub or small tree growing up to 7m tall, often 1-2m, spreading or thicket-forming. Will out-compete riparian plantings.</p>	<p>See treatment methods for Crack willow on the previous page.</p>

Shrubby weeds



Weed	Treatment methods (see control methods section page 55)	
<p>Barberry</p>  <p>Source: Department of Conservation website</p>	<p>Barberry is a spiny, woody, evergreen or semi-deciduous shrub growing to 3m tall. Small yellow flowers are followed by small purple berries covered in a yellow bloom.</p>	<ul style="list-style-type: none"> • Spray Tordon Brushkiller or equivalent + penetrant. • Cut stump and treat with metsulfuron-methyl (Escort or equivalent) at label application rate or Tordon Brushkiller or equivalent. Gels may also be used on the cut stump (e.g Vigilant gel, Picloram gel, Cut n paste).
<p>Broom</p>  <p>Source: Waikato Regional Council</p>	<p>Broom is an almost leafless, deciduous shrub growing up to 3m tall. It produces golden-yellow flowers in spring, followed by explosive pods.</p>	<ul style="list-style-type: none"> • Dig out small plants, while minimising any soil disturbance. • Foliage spray triclopyr (Grazon or equivalent) + penetrant from spring to summer. • Stump swab with triclopyr (Grazon or equivalent) or metsulfuron-methyl (Escort or equivalent) at label rates. Gels may also be used on the cut stump (e.g Vigilant gel, Picloram gel, Cut n paste). • Weed wiper – triclopyr (Grazon or equivalent) from spring to summer.
<p>Gorse</p>  <p>Source: Waikato Regional Council</p>	<p>Gorse is a very spiny, woody perennial shrub up to 2m tall. It produces yellow flowers, mostly in autumn and early spring, followed by explosive seed pods.</p>	<ul style="list-style-type: none"> • Pull or dig out small plants. • Cut stump and treat with triclopyr (Grazon or equivalent), Tordon Brushkiller or equivalent or metsulfuron-methyl (Escort or equivalent). • Foliage spray with triclopyr (Grazon or equivalent), Escort or Tordon Brushkiller or equivalent at label rates.

Aquatic weeds

Controlling weedy aquatic plants is difficult. There are also strict rules in place regarding the use of herbicides around waterways. If you wish to tackle weeds in streams/lakes/ponds/wetlands, ask for advice from your regional council first.²

Controlling aquatic weeds is tough but doable. Here's what to do if you're a³:


- **Farmer/ Landowner** – don't allow diggers or drainage equipment, eel nets or boats into your waterways without checking they're free of weeds.
- **Drainage and machinery contractor** – stop the spread of weeds by cleaning down machinery before and after use.
- **Fisherman or eeler** – remove any weed fragments from all nets, lines, and equipment, including waders, before you go. A salt bath and/or mild bleach will sterilise fishing nets overnight.
- **Boat operator** – check hulls, props, trailers and anchor lockers for tag-along weeds before entering waterways.
- **Aquarium owner** – don't dispose of aquarium contents into or near a waterway, and avoid flushing plants or fish (they can end up in waterways).
- **Duck shooter** – check dogs, boots and boats for weed before you leave the area.

Weed	Treatment methods (see control methods section page 55)	
<p>Alligator weed</p>  <p>Picture Source: http://www.waikatoregion.govt.nz/Services/Regional-services/Plant-and-animal-pests/Plant-pests/Farm-weeds/</p>	<p>Alligator weed does not set seed in New Zealand but spreads aggressively from even the smallest stem fragments. It can double in area in less than two months. It can out-compete pastures and crops, affecting farm production and profit.⁴</p>	<ul style="list-style-type: none"> • If you think you have this plant pest, contact your regional council for information on control. • In some regions your council will undertake the control.
<p>Manchurian wild rice</p>  <p>Source: Copyright NIWA http://www.nrc.govt.nz/Environment/Weed-and-pest-control/Pest-plants/Freshwater-weeds/Manchurian-wild-rice/</p>	<p>Manchurian wild rice forms dense stands that can block drains, destabilise stop banks, and cause flooding. It also invades flood-prone pastures and wetlands. Broken fragments are easily spread to new sites, through water movement or contaminated machinery.</p>	<ul style="list-style-type: none"> • If you think you have this plant pest contact your regional council for information on control. • In some regions your council will undertake the control.

² Weedbusters (2014). Weedbusting A guide to recognising and controlling invasive weeds. Weedbusters. New Zealand

³ Department of Conservation. (2014). Stop the spread of freshwater pests. Retrieved from <http://www.doc.govt.nz/stopthespread>

⁴ Waikato Regional Council. (2011). Biosecurity series – pest plant factsheet BIOSECURITY FACTSHEET Alligator weed. Retrieved from <http://www.waikatoregion.govt.nz/PageFiles/3606/Biosecurityfactsheet10-Alligatorweed.pdf>

<p>Reed sweet grass (<i>Glyceria maxima</i>)</p>  <p>Source: Northland regional council</p>	<p>Aggressive, perennial, mat-forming grass up to 1.9m tall. Forms dense mats on water and in damp areas, replacing most other species. Causes silt accumulation and flooding.</p>	<ul style="list-style-type: none"> • Weed wipe (spring-autumn): glyphosate (200ml/L + penetrant). • Foliage spray (spring to autumn) with glyphosate (10ml/L + penetrant) or use Gallant NF (5ml/L + 5ml crop oil).
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Maintaining a pest plant (weed) free riparian area

Active control of pest plants

The best pest control methods target different weeds on land (terrestrial) or water (aquatic).

Follow the steps below to keeping your waterways weed-free⁵.

- 1. Identify the pest:** If in doubt ask your regional council (biodiversity officer) for help to identify the type of weed and the treatment is needed. Or check these websites:
 - weedbusters.org.nz
- 2. Start small:** Avoid creating large cleared areas – this encourages more weeds to take hold and it ensures you don't bite off more than you can chew.
- 3. Plan work in stages:** It's best to ensure each area is clear before moving onto the next. Start at the edges before dealing with the worst affected areas.
- 4. Plant up:** Replace weeds with natives or non-weedy plants as you go. It'll help prevent weeds returning.
- 5. Take care:** Avoid over-spraying and avoid spraying your sensitive plantings. Only spray on wind-free days. Consider using a spray guard on the nozzle to avoid drift.
- 6. Removal:** Seeds and stalks can grow again. Use fabric or rubbish bags, or solid containers to carry away weeds.
- 7. Disposal:** Many weeds will die back and can be left in place after spraying but some will need removal or composting.

Tips for protecting planted sites from pest plants

Riparian maintenance involves ongoing weed control – it's often overlooked, but can come back to bite you. Although it's often labour intensive, good control early on pays dividends when plantings become well established.

Check your riparian plan has pest plant maintenance included.

To help maintain a pest-plant free environment you may wish to consider the following when planning your riparian planting:⁶

⁵ Weedbusters. (2014). 7 top tips for control. Retrieved from http://www.weedbusters.org.nz/resource_centre/control.asp

⁶ Waikato Regional Council. (2012). Controlling weeds in riparian margins A guide to restoration projects and other plantings. Retrieved from <http://www.waikatoregion.govt.nz/PageFiles/3599/weeds%20and%20riparian%20margins.pdf>

Weed mats



You can stop weed germination by putting weed mats around plants, either as a blanket over the entire area or around individual plants.

How to implement

For individual plants each mat should be at least 1m². Use biodegradable products including woollen carpet, woollen weed matting, coconut fibre, cardboard and wet newspaper. If using carpet, make sure plants don't rub against the hard edge.

Do not use plastic weed mat or polythene because it is not biodegradable.

Make sure matting is pegged down to stop it moving during flooding or high winds.

Advantages:

Matting helps to retain moisture and offers some weed control, depending on the material you use.

Disadvantages:

In windy conditions, matting can blow around and damage the plants.

Mulch



You can spread organic material (at least 100mm thick) around the base of your plants. This helps prevent weeds and stops the soil drying out.

How to implement

Ideal mulch materials are bark and untreated sawdust.

It's a good idea to add fertiliser as the mulch decomposition process takes nitrogen from the soil, depriving the plants.

Avoid putting mulch near streams – if it floods, the material might be washed away and cause downstream blockages.

Advantages:

Mulch helps to retain moisture and provides long-term weed control depending on the material you use.

Disadvantages:

Weeds will penetrate mulch if you lay it too thinly. It can also be blown away by wind, disturbed by birds, dogs and other animals, and washed away by rain or in high stream flows.

Plant protectors



Protect the plants from weeds as well as exposure to cold and windy conditions. Many come with a biodegradable weed mat.

How to implement

Install at time of planting. They are re-usable so look after them, as you may get several plants underway during the life of a plant protector.

Ensure you remember to remove the protector once the plant is above the height of the protective sheath as they can hinder later growth.

Advantages:

Gives plants protection against weeds, rabbits, possums and hares.

Regional pest plant information

Visit your regional council website for information on identifying and controlling common pest plants or go to weedbusters.org.nz.

Pest plant control methods

Pest plants growing on land


The table below outlines several different methods for controlling pest plants

Non-chemical control⁷ methods:


Hand weeding or mechanical control			
Suitable for:	How to implement:	Advantages/ Disadvantages	Disposal method:
Small infestations of weedy herbs, grasses and ground covers.	Hand weeding can be done with tools such as weed-eaters and grubbers, or by digging up the weeds by hand. Some weeds can sprout from fragments, so all plant material – including roots – should be removed from the site.	<p>Advantages: No persistent chemicals used.</p> <p>Disadvantages: Labour intensive and can still lead to regrowth of the target weed.</p>	If you wish to compost the weeds, put them in plastic shopping bags and leave them tied up to rot for 12-18 months before adding them to your compost. You can also dry or burn weeds, but make sure there is no objectionable smoke beyond your property boundary and that smoke doesn't cause a hazard.

⁷ Waikato Regional Council. (2012). Controlling weeds in riparian margins A guide to restoration projects and other plantings. Retrieved from <http://www.waikatoregion.govt.nz/PageFiles/3599/weeds%20and%20riparian%20margins.pdf>


Chemical control⁸ methods:

Foliage spraying			
Suitable for:	How to implement:	Advantages/ Disadvantages	Disposal method:
<p>Best suited to low weed growth or for re-sprouting stumps, and can be used to control weeds before planting and/or around established plants.</p>	<p>You can either spray the entire area or spot spray – but to be successful, you must spray the entire plant.</p> <p>Before spraying consider:</p> <ul style="list-style-type: none"> • how long the chemical will stay in the soil (residual herbicides) • how close to the stream you can spray • the weather conditions • whether you’re using a ‘broad spectrum’ (which affects all plants) or ‘selective’ (which doesn’t affect desirable plants) herbicide. You can get this information from the manufacturer’s product label. <p>Add a wetting agent (‘surfactant’) to the mixed herbicide. This will help it stick to the weed and increase the amount of herbicide it absorbs.</p> <p>When applying the herbicide, place a shield around the plants to protect them from spray drift. Shields are simply two pieces of material at right angles to each other, with a handle protruding from the top.</p>	<p>Advantages: Foliage spraying provides long-term weed control if you use a residual herbicide. You can also use selective herbicides. It is usually less labour intensive than other weed control methods.</p> <p>Disadvantages: You can damage the non-target plants if you don’t apply herbicides carefully and correctly. Chemicals can leach into the waterways.</p>	<p>See weedbusters.org.nz for disposal methods</p> <p>Spray during fine weather with little wind.</p> <p>Usually spring and summer is the best time for herbicide control.</p>
			

⁸ Waikato Regional Council. (2012). Controlling weeds in riparian margins A guide to restoration projects and other plantings. Retrieved from <http://www.waikatoregion.govt.nz/PageFiles/3599/weeds%20and%20riparian%20margins.pdf>

Cut stump method or stump swab (often called cut and paste)			
Suitable for:	How to implement:	Advantages/ Disadvantages	Disposal method:
Trees or shrubs	<p>The cut stump method involves cutting the tree or shrub as low as possible and applying the herbicide immediately to the stump.</p> <p>If you don't do it immediately, a protective skin will form over the wound (usually within five minutes) and the stump will need re-cutting.</p> 	<p>Advantage: Stump cutting destroys standing trees and allows a natural breakdown. It requires only small amounts of herbicide and poses minimal risk to desirable plants or water. It is also simple to use.</p> <p>Disadvantages: Stump cutting opens areas to light, which can trigger weed germination. Felling large trees can also damage desirable understory plants. Felled trees make future access into weed control areas difficult.</p>	See weedbusters.org.nz for disposal methods

Stem injection			
Suitable for:	How to implement:	Advantages/ Disadvantages	Disposal method:
Larger trees or shrubs	<p>Drill holes sloping down into the trunk at regular intervals around the base of the tree or shrub. You can use a disused animal drench pack and gun, or a plastic squeeze bottle with a long nozzle, to place the herbicide into each hole as soon as possible.</p> 	<p>Advantages: Useful for trees or shrubs where their removal is difficult or would cause damage to surrounding vegetation. Avoids overall spraying of large plants.</p> <p>Disadvantages: Stem injection opens up areas to light, which can trigger weed germination. There are also dangers from dead trees falling, including into streams where they can obstruct the flow.</p>	See weedbusters.org.nz for disposal methods

Frilling			
Suitable for:	How to implement:	Advantages/ Disadvantages	Disposal method:
Trees	<p>Frilling involves making deep cuts into tree trunks at regular intervals around the base. Herbicide is applied to the fresh cut using a paintbrush or low pressure sprayer (such as a knapsack). It is important not to ring bark (that is, to remove a ring of bark from the tree), as this reduces the herbicide absorption.</p> 	<p>Advantages: Frilling stops the plant from seeding almost immediately. Avoids overall spraying of large plants.</p> <p>Disadvantages: Frilling opens areas to light, which can trigger weed germination. There are also dangers from dead trees falling, including into streams where they can obstruct the flow.</p>	See weedbusters.org.nz for disposal methods

Weed wiping			
Suitable for:	How to implement:	Advantages/ Disadvantages	Disposal method:
Releasing around native plants (best on low lying vegetation)	Weed wipers are herbicide applicators that disperse herbicide by wiping it onto the plant.	<p>Advantages: Removes the risk of spray drift.</p> <p>Disadvantages: You can damage the non-target plants if you don't apply herbicides carefully and correctly. Chemicals can leach into the waterways.</p>	See weedbusters.org.nz for disposal methods

Pest animals

Benefits of pest animal control

Animal pests can cause havoc on your farm, ruin your planting and cause major problems in and around waterways. When it comes to good waterway management, keeping on top of pest animals is important.


Benefits of pest animal control around waterways

Well-executed pest animal control is beneficial as it will:

- Reduce the likelihood of disease transmission (e.g TB)
- Improve the chance of a successful riparian management project
- Reduce the likelihood of pests entering other farm areas from fenced off waterways
- Reduce maintenance time and costs in planted areas and reduce replacement planting costs
- Speed up the time it takes to achieve an established riparian planting project
- Improve native biodiversity and habitat.

Common pest animal species found in riparian areas and control methods

When it comes to native planting, here are some common animals that will give your plants a hard time:

Animal	Control / Management Options
<p>Hare</p>  <p>Picture and info source: http://www.es.govt.nz/media/431113/pest_animals_web.pdf</p> <p>Hares are particularly destructive as they bite off new plants to mark their territory (rather than to feed). They can kill large numbers of plants in a few nights.</p>	<p>Shooting</p> <p>Shooting is regarded as the only form of control available. Night shooting is recommended as the most successful method when dealing with hares. It is important to carry out this control thoroughly as the animal can become light-shy making them difficult to eradicate in the future¹. If shooting, .22 rifles and shotguns are the preferred firearms. Hares can be identified by the pinky/red colour of their eyes at night.</p> <p>Tree guards</p> <p>There are a range of different types of protective devices/tree guards on the market to keep hares away from young trees. See <i>Waterway Technote: Planting</i> pg 35.</p> <p>Repellents</p> <p>The most effective of these are egg-based products which are high in protein and lipids and when mixed with an adhesive (acrylic resin) will provide some protection from hares. Other ready-mixed repellents include Thiroprotect and Treepel.</p>

¹ Taranaki Regional Council, Brown Hare factsheet.

Rabbit



Picture and info source: http://www.es.govt.nz/media/43113/pest_animals_-web.pdf

Rabbits will eat tree seedlings as well as neighbouring pasture.

There are a range of ways to control rabbits including shooting, poisoning, fumigation and biological control.

Tree guards

There are a range of different types of protective devices/tree guards on the market to keep rabbits away from young trees. See *Waterway Technote: Planting* pg 35.

Repellents

The most effective of these are egg-based products which are high in protein and lipids and when mixed with an adhesive (acrylic resin) will provide some protection from rabbits. Other ready-mixed repellents include Thiroprotect and Treepel.

For further information we recommend searching rabbit control on your regional council's website or give them a call.

Possum



Source: http://www.es.govt.nz/media/43113/pest_animals_-web.pdf

Possums will not only eat palatable tree species, but also cause breakages and damage to plants they don't like to eat. They are a predator of native wildlife and a carrier of TB.

The main methods for controlling possums are shooting, trapping and poisoning. Use of repellents or barriers can also be used to protect small areas or individual trees.

Contact your local regional council animal pest control officer or farm supply store for advice and information on effective methods of control in your area.

Pukeko



Picture and Info Source: Copyright Sabine Bernert. Source: <http://www.doc.govt.nz/conservation/native-animals/birds/birds-a-z/pukeko/>

Pukekos, although not classified as a pest, can pull out new plants and leave them lying on the ground.

To deter pukekos from pulling out plants, use larger and heavier potted plants, place tree guards around young plants or try placing squares of carpet around each plant (they are heavier than regular weedmat).

Protecting plants from animal pests

Protect your farm and waterways from animal pests by:²

- Reducing pest levels before and keeping levels low after planting
- Taking the time to work out what you're dealing with:
 - Rabbits and hares nip at the growing tips of seedlings. Rabbits will stop when plants exceed their height, but hares only stop browsing when plant stems are fairly large.
 - Tree guards will protect plants from both. Tree guards cost about \$1.20 each and can be re-used for later plantings.
 - Long grass will also deter rabbits and hares. Keeping long grass barriers within your planting area can help reduce the damage to entire planting areas.
 - As your plants mature, they will attract birds and insects – a good thing! Controlling rats, mice, stoats, ferrets, and feral cats will make your planted area a healthy habitat. Most of these pests can be targeted together with certain poisons, but each requires a different trapping method if poisons aren't used. Traps are available from regional councils. Contact the biosecurity or pest animal division of your regional council for further detailed information on pest animal control.



Regional pest specific information – pest animals

To find out more about identifying animal pests and methods for their control visit your regional council websire or visit landcareresearch.co.nz³

Northland:

nrc.govt.nz

Auckland:

arc.govt.nz

Waikato:

waikatoregion.govt.nz

Bay of Plenty:

boprc.govt.nz

Hawkes Bay

hbrc.govt.nz

Gisborne:

gdc.govt.nz

Horizons:

horizons.govt.nz

Greater Wellington:

gw.govt.nz

² Otago Regional Council. (2005). *Environmental Considerations for Clean Streams – A Guide to Managing Waterways in Otago*. Retrieved from http://www.orc.govt.nz/Documents/Publications/Farming%20and%20Land%20Management/env_considerations_cleanstreams.pdf

³ Landcare Research, *Vertebrate Pest Control Decision Support System*. Retrieved from <http://pestdss.landcareresearch.co.nz/>

Nelson:

nelson.govt.nz

Marlborough:

marlborough.govt.nz

marlborough.govt.nz

Tasman

tasman.govt.nz

Canterbury:

ecan.govt.nz

Southland:

es.govt.nz

Otago:

orc.govt.nz

Pest animal control methods

The most up-to-date information on controlling vertebrate pests in New Zealand belongs to the National Pest Control Agency (NPCA). This website has all you need to know about vertebrate pest control, including the best types of control for each pest, licencing, where to purchase materials, monitored pest numbers and where to go for advice. See: <http://www.npca.org.nz/index.php/publications/a-best-practice/157-a-series>

Managing erosion

Benefits of managing erosion

Stream bank erosion can be a major source of sediment within a dairy system. Managing erosion will reduce the loss of productive land, reduce flooding effects downstream and reduce the effect of sediment on water quality.

Stream erosion is a natural process but will be accelerated by:

- The removal of stabilising vegetation from stream banks and catchments
- A channel blockage upstream that is redirecting water flow.



Two examples of bank erosion.

Photos courtesy of Waikato Regional Council

Mitigations for erosion control at a glance

Mitigation type	Benefits	Limitations
Exclude stock	Reduces pressure on banks, allows vegetation to establish.	Will not prevent erosion that has begun when done in isolation.
Fence back far enough to allow some movement of the stream	Reduces stock or equipment pressure on the bank, stabilises bank while vegetation establishes, prevents the need to move the fence.	Will not prevent bank collapse.
Low natives (sedges and rushes)	Reduces scouring, survives sediment and flooding over the top. Good for lower bank.	Will not prevent bank collapse.
Full range of natives	Excellent control of the bank with diverse root systems. Long term solution.	Will not prevent erosion on vertical banks greater than 1.5m high.
Poplars and willows (non-weedy varieties)	Fast growth, strong root system to lock the bank together.	Requires ongoing maintenance and have a relatively short life span. Do not self-propagate.
Natives with poplars and willows	Long-term solution with fast stabilising effects from the poplars and willows.	Greater costs, increased planting rate and maintenance.
Erosion control structure	Long-term solution which provides armouring to the stream in areas of severe erosions or to protect infrastructure.	High cost involved, requires consent from regional council, may require assistance from an engineer, and makes it difficult to establish vegetation.

What can we do about erosion?

Severe to moderate erosion

Fence back far enough to allow for some movement of the stream, this will depend on the stream. Consider how far the stream moves during large storm or erosion events and how many events occur yearly. Vegetation will not protect the stream straight away, so fence back far enough to allow for three years of erosion.

Plant appropriate species on the outside of bends to help anchor them against erosion. Tree species with deep and extensive root systems are the most appropriate in these situations. In most cases a diverse range of native plants will stabilise the bank, however in more severe cases poplar and willow species will be beneficial.

For erosion that is occurring quickly, Matsudana willow, shrub willow and/or poplars are the best option because they grow quickly. Plant native species such as ribbonwood, cabbage tree and lemonwood among the exotics, as they also have extensive root systems¹. A wider mix of other native plants can then be planted further back. For further information on how to plant native species see: *Waterway Technote: Planting*.

Where eroding banks are greater than 1.5m in height, it is unlikely that planting native species alone will be enough to control the erosion. Other methods such as erosion control structures or planting erosion control exotic species will need to be considered.

In cases of moderate erosion, plant appropriate species in the lower bank zone such as grasses, sedges, rushes and other dense groundcovers. These plants stabilise banks and will withstand flood flows.

For added erosion protection you can also plant deep rooting native species (e.g. ribbonwood, cabbage tree, lemonwood and lacebark) or poplar and willows several metres back from the grasses, sedges or rushes.

If erosion is occurring slowly, native species such as ribbonwood, cabbage tree and lemonwood may be sufficient. For further information on how to plant native species, see the planting section of the waterways technical series, page 35 and for planting erosion control trees and native species, see page 39.

See: *Waterway Technote: Planting* for guidance on planting erosion control trees and native species, page 35.

Note: Tall trees with small root systems, such as pines, are not appropriate as they can be easily undercut which leads to erosion.



An example of severe erosion.

Source: Basher, LR & Watson AJ, 2006: *Stream bank erosion: a review of process of bank failure, measurement and assessment techniques, and modelling approaches*. Landcare Research. Nelson. New Zealand.



An example of moderate erosion.

Source: Environment Southland

¹ Phillips C, Marden M and Rowan D, 2001: Soil stabilising characteristics of native riparian vegetation in New Zealand. Paper presented to NZARM Conference 2001, Hamilton/ Landcare Research.

In-stream blockages

Islands

Islands often form in streams in places where the water slows down and deposits its sediment load, such as inside bends. They can form a habitat for pest plants such as willow, and trap debris or divert water causing bank erosion. (See below for pest willow removal.)

When deciding what to do with the island you must contact your regional council. The island is a natural feature of the stream bed and removal may require resource consent.



Debris pile

Leave large wooden debris in the stream as it makes a good habitat for invertebrates. Check your regional council rules before removing any large items from the river. Major blockages that disturb the stream bed may require resource consent to remove.

Pest willows causing erosion

Pest species of willow (grey and crack willow) often grow in the beds of waterways causing blockages and erosion. Where this occurs only remove the trees causing a problem and selectively prune the rest so they can be left to support the bank.

First check with your regional council to see if you need resource consent which may be required for any disturbance of the bed of a waterway.

If you have more than a few trees that require removal, contact your regional council for advice as you may require resource consent and they also may assist with funding.



An excavator removing pest willow trees from a stream.

Source: Gibbs, 2007: Best Practice Guidelines for Vegetation Management and In Stream Works. Waikato Regional Council Technical Report 2007/41.

Cutting down trees

- Trees can be removed by cutting them off at the base and lifting them away from the waterway with an excavator.
- Cut trees as close to the ground as practical, but do not pull out stumps or remove stumps from the bed of waterways unless absolutely necessary, as this will accelerate bank erosion.

Poisoning trees

- Without poisoning, willows will grow back after cutting. Ensure that stumps are treated with herbicide or the willow is poisoned before cutting.
- Poison stumps immediately after cutting – use Glyphosate (10 percent) with a penetrant and marker dye.
- If you are only removing a few trees, you could also use vigilant gel herbicide.
- You must minimise the possibility of sediment entering the watercourse.
- Fell trees away from watercourses, use machine assistance where practical.

- Begin removal works at the upstream end and work downstream to reduce the impacts of sediment disturbance and catch floating debris in the downstream trees.
- Machinery should grab and lift slash, not pull or drag. A digger with a “thumb” or grapple is advised.

Take care with the timing of works

- Undertake works during periods of dry weather and low flows.
- Works are best undertaken from December to April when the willow sap is flowing into the roots (senescence) because this will result in the best kill. However, also note that March and April are peak spawning times for Inanga in tidal streams and disruption breaches the Resource Management Act.
- Time works so that follow-up herbicide spraying can be undertaken before autumn leaf fall.

Make a plan to deal with debris

- Pile debris high as far away from the floodway as possible. If there is a risk that piles will be moved by a flood, then they should be disposed of immediately or anchored in place.
- Burn willow logs as soon as possible following removal using diesel as an accelerant. Green trees will produce a lot of smoke and is likely to be a problem, so you may need to wait three to four months for the trees to dry out before burning. Check with your local authority regarding fire restrictions before burning.

Follow up with riparian fencing and planting with appropriate plant species.

Erosion control structures

If the erosion is severe and/or threatening core infrastructure, a more immediate erosion control solution may be required. Immediate solutions include hard structures such as rock and gabion baskets, flumes and detention dams.

This work will most likely require resource consent. Contact your regional council for information about what solution would be most appropriate and any consent requirements. In some cases regional councils may be able to assist in planning or funding some of the work.



An example of an erosion control structure (rock rip rap).

Source: Gibbs, 2007: Best Practice Guidelines for Vegetation Management and In Stream Works. Waikato Regional Council Technical Report 2007/41.

Where to go for advice, information and help

Your regional council is the best place to start when seeking advice on waterway erosion, consenting advice and stream management.

Regional councils can offer advice on riparian fencing and planting as well as pest plants and animals. Councils also produce helpful publications and may be able to provide funding assistance, particularly for the protection on significant waterways. Other sources of advice include:

Agency/organisation/company	Type of advice
DairyNZ	Helpful publications: dairynz.co.nz Riparian planning Fencing advice
Your local rural supply store	Fencing advice Costs for materials
Local native plant nurseries	Planting advice
Farm Consultants	Preparing a plan

Glossary

Waterways: The term waterways includes rivers, streams, creeks, drains, ponds, wetlands and estuaries. It is also important to think about gullies, which often don't hold water but can be responsible for channelling runoff into main waterways during wet periods.

Broadleaf weeds – Broadleaf means having relatively broad rather than needle-like or scale-like leaves. Note: Broadleaf is also the common name for the native plant *Griselinia littoralis* – this is not a weed.

Carex – A genus of sedge species (grass-like plants). There are many different species of *Carex* but those most commonly planted along waterways include *Carex secta*, *Carex geminata* and *Carex virgata*.

Ecosourced plants – Ecosourcing refers to the propagation of native plants from local areas and the planting of them back within the same region.

Monocot – One of the two major types of flowering plants – monocots and dicots. Monocots have a single cotyledon or seed leaf. A cotyledon is the first leaf developed by the embryo of a seed plant. These are the first little leaves that you see when a plant germinates from seed. All grasses are monocots. (Example pictured right).

Releasing – The task of removing weeds from around plants (releasing them from weeds).

Riparian – The area of land next to water courses.

Riparian margin: A strip of land along the edges of waterways including streams, lakes and wetlands.

Sedimentation: The amount of suspended material (solids) in a waterbody. Sediment in a stream is natural, but if sediment levels get too high, it can disrupt ecosystems and kill aquatic life. Excess sediments can cause damage by blocking light that allows algae – an important food source – to grow, harming fish gills, filling up important habitats, and stopping fish from seeing well enough to move around or feed.⁴

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*For photos taken directly from websites the website address has been provided next to the photo.

dairynz.co.nz