CHAPTER 4

WATER WAYS, NATURAL FEATURES AND PLANTINGS

TABLE OF CONTENTS

4.0 WATERWAYS, NATURAL FEATURES AND PLANTINGS

The development over time of intensive land use such as dairy farms on much of the fertile lowland areas of New Zealand has occurred at the expense of native vegetation. There has also been a cumulative effect on waterways from pastoral land use.

Some of the effects have included:

- large-scale conversion of native vegetation to pasture
- wetland drainage and alteration of natural watercourses
- removal of stream-bank vegetation that provided shade and stabilised banks
- water quality decline due to sediment, faecal material and nutrient pollution.

Farmers are increasingly working to address these issues by excluding stock from waterways and replanting in appropriate areas on farms.

The dairy industry has developed policies to support this work through quality management systems, quality assurance and the Dairying and Clean Streams Accord. This work is supported by local and central government, and many local authorities have incentives in place to help plan or implement work to enhance waterways and natural features.

Managing waterways, trees and other natural or cultural features can bring many farm benefits including:

- better stock control and animal welfare
- more efficient use of nutrients by keeping them in productive areas
- better pasture utilisation with more fencing for farm subdivision
- reduced drain and culvert maintenance costs
- a more pleasant farm environment with enhanced recreational opportunities
- an increase in farm value
- the satisfaction of good stewardship.

Maximising these benefits can be achieved by a well-thought out approach across the farm system.

4.1 MANAGING WATERWAYS

Much of the focus of waterway management is on managing the riparian zone. A riparian zone is a strip of land next to a waterway, which is frequently moist and therefore has the characteristics of a wetland in terms of water purification (refer to Figure 4.1-1). Riparian zones and their associated wetlands are attractive to a wide variety of wildlife. In total, the waterway and its associated plant and animal life influence how the river or stream is valued scenically, recreationally, culturally and for conservation purposes.

Riparian zones may include flood plains, river flats, lake shores, wetlands, swamps, gullies or seeps and can occur beside freshwater, coastal or estuarine waters.

Riparian management may involve the following:

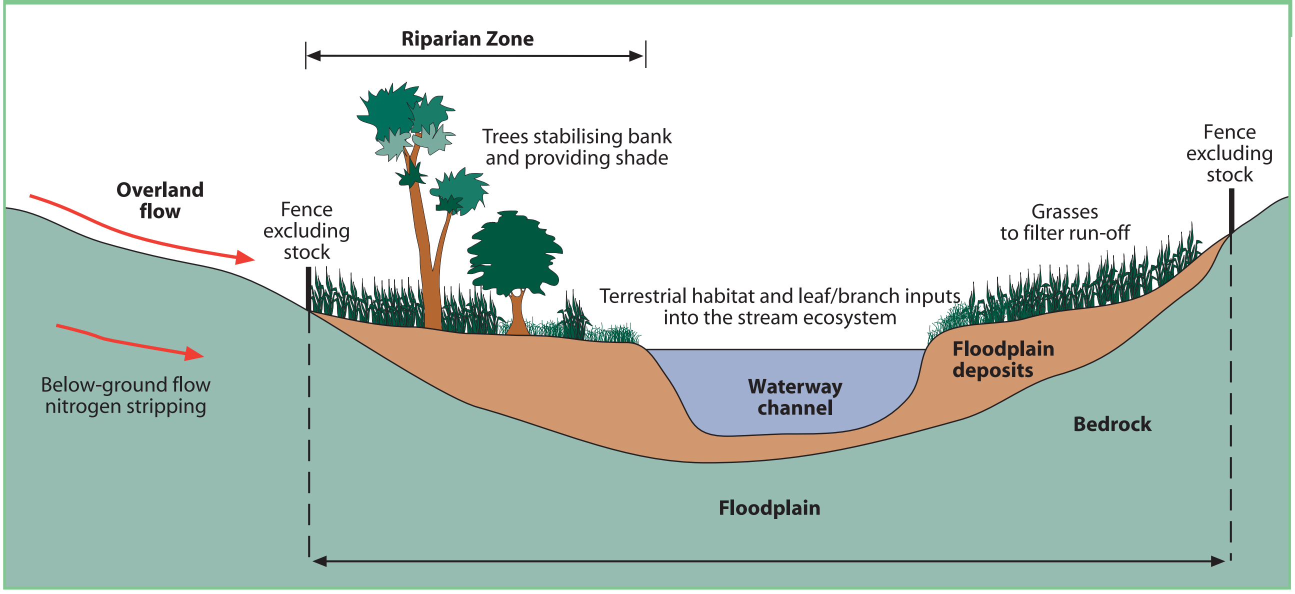
1. Fencing to exclude stock and constructing appropriate crossings where required.
2. Allowing the growth of rough grass or low-lying vegetation to slow and filter runoff.
3. Planting appropriate trees or shrubs to enhance habitat value.

Managing conditions upstream is the best way to influence rivers through riparian management. Small streams can be influenced more easily than large rivers.

Riparian areas are the last opportunity to manage farm runoff before it reaches a waterway. A focus on riparian management should not replace sound land management practice throughout the farm to reduce any adverse impacts of land use where they arise.

FIGURE 4.1-1

FEATURES OF A RIPARIAN ZONE



Well-managed riparian areas can enhance the environment by:

- Improving shading - most aquatic animals and plants in New Zealand streams originally developed under heavily shaded conditions. Returning shade to waterways helps native animals and plants and game fish by lowering stream temperature and reducing the growth of aquatic weeds and algae
- Improving bank and riverbed stability – excluding stock minimises bank damage and bed disturbance, while planted trees and shrubs prevent bank slumping (although too much shading can cause erosion). Riparian planting can also block flood channels
- Reducing pollution reaching waterways – plants, leaf litter and soil can filter out nutrients, sediment, bacteria, and other pollutants before they reach surface water. Also, moist wetland soils can release nitrogen in subsurface water back to the air. Refer to Table 4.1-1 for information on the effects of these pollutants on waterways
- Enhancing habitat - animals living on land around the waterway such as native birds, insects, snails and lizards benefit from revegetation planting. Riparian plants also enhance aquatic habitat by dropping leaves and branches that create food sources, hiding places and habitat surfaces for water-dwelling species. Trees help

maintain a cool, moist microclimate near waterways, making them attractive refuges for the adult stages of aquatic insects that in turn feed native fish and trout. Ungrazed riparian grasses and sedges also provide spawning sites for native fish. Pest control is required to maximise desirable wildlife and minimise unwanted pests

- Reducing flooding – undisturbed wetlands and small waterways with plenty of rough riparian vegetation absorb and slow peak flows, releasing water slowly to maintain summer low flows in streams and rivers.

TABLE 4.1-1

EFFECT OF FARM RUN-OFF ON WATERWAYS

Type of Farm Pollutant	Effect on Waterways
Faecal matter	Creates a health risk to people using the stream or downstream estuary for contact recreation or food source. Aquaculture may become unsuitable as a water source for people, stock or the farm dairy
Sediment	Makes water murky and streambed muddy - less appealing and more difficult to use as a water source. Muddy water is also less suitable for many native aquatic species and for game fish such as trout, which need clean gravels for spawning and clear water for feeding
Nutrients	Nitrogen and phosphorus can stimulate algae and weed growth, especially in shallow and slow-moving waters, while ammonium-N is toxic to fish. Different waterways are more sensitive to either phosphorus or nitrogen, depending on which element is most scarce in natural conditions. Elevated nitrate in drinking water is considered a human health risk and may be poisonous to stock. The most vulnerable aquifers have shallow groundwater and light soils. (Regional Councils can provide more detail on which nutrient issues are of greatest concern for a specific area)

4.1.1 How farm activity can pollute natural water

Each of the different types of pollutant in Table 4.1-1 may reach waterways or groundwater through different routes. These are described in Table 4.1-2.

TABLE 4.1-2

HOW FARM POLLUTION REACHES WATERWAYS AND GROUNDWATER		
Type of Farm Pollutant	**Where It Comes From on the Farm**	**How It Reaches Waterways or Groundwater**
Faecal Matter	• Cow dung deposited on land or in water • Dairy effluent ponds • Effluent applied to land • Areas of concentrated dung – feedpads, stand-off areas, races, etc	• Stock accessing streams • Pond discharges to waterways • Runoff from paddocks, races, pads • May enter shallow groundwater by draining through light soils, or reach subsurface drains by draining through cracks in the soil
Sediment	• Tracks and races • Bare ground • Stream banks	• Runoff from paddock surfaces, tracks and races, or slips • Bank collapse into a waterway
Nutrients	• Nitrogen is most concentrated in stock urine. N fertiliser and ammonia in ponds are less important sources • Phosphorus is mainly in stock dung or attached to soil particles. P fertiliser is a less important source	• N as nitrate is soluble in water and travels through the soil to reach subsurface drainage and groundwater. Urine patches are the main source. Dairy effluent discharges to land or water may also contain high levels of N, as may the leachate and run-off from stand-off pads, sacrifice areas and silage pits • P is not soluble and binds to solid material such as soil or dung. (See sediment and faecal matter above.)

4.1.2 Management options

Protecting and enhancing natural water on the farm involves both sound land management practices and effective riparian management.

These should aim to:
- prevent polluted runoff, subsurface drainage or direct discharge to waterways
- prevent nitrate leaching to groundwater and subsurface flow to streams
- enhance habitat in and beside waterways and wetlands
- slow flood flows.

Key practices for each of these are shown in Table 4.1-3

TABLE 4.1-3

KEY FARM PRACTICES FOR WATERWAY MANAGEMENT

Aim of Farm Water Management	Key Practices
Prevent farm pollutants from reaching surface waterways	• Prevent stock access to waterways • Maintain pasture cover and minimise bare ground or pugging • Fence and allow rough grass to grow in wet gully bottoms, seeps and beside drains and waterways to slow runoff and filter out sediment and faecal matter • Fence and plant eroding gullies or streambanks • Avoid raising soil nutrients above optimum levels • Ensure effluent ponds are big enough and working well • Apply farm effluent to land at low rates, when soil is not saturated. Have sufficient storage for flexibility • Lightly graze areas or steep slopes near waterways • Practice on-off grazing in wet conditions with a stand-off area where effluent is captured and managed • If planting a crop for strip-grazing, choose paddocks away from waterways when possible, or leave a good buffer strip (at least 2 m) between a cultivated paddock and water • Have sufficient cut-offs on tracks and races, directing runoff to grass or wetlands, not streams or drains • Provide appropriate crossings that direct effluent away from the water • Keep drains vegetated; only clean a portion at a time • Manage fertiliser carefully, especially near waterways • Provide shade, shelter and troughs away from natural water
Prevent nitrate leaching to groundwater and subsurface flow to streams	• Retain wet, swampy areas as nitrogen-stripping zones for subsurface water. Fence and allow rough grass or wetland vegetation to grow • Use on-off grazing in winter and capture effluent from pads or stand-off areas • Where appropriate use nitrification inhibitors in late autumn and early spring to retain N in the soil profile for plant uptake • Graze land with artificial drainage lightly when soil is wet • Manage land application of effluent carefully • Site silage pits away from waterways and seal them so that leachate and runoff can be collected and treated • Do a nutrient budget and ensure your N-use is efficient • Only apply N in periods of active crop or pasture growth
Enhance habitat in and beside waterways and wetlands	• Grow plants that will shade and overhang the waterway • Plant local native species for habitat value • Retain and fence wetland areas on the farm; avoid altering the natural shape and course of streams • In coastal areas, avoid grazing stream margins before and during whitebait spawning season (in autumn) • Find out what is living in the farm waterways; identify culturally or environmentally important species and their habitat needs
Slow flood flows	• Retain wetland and ponding areas as natural sponges. Fence and plant wetlands, streams and gullies and allow vegetation to grow to slow runoff. Retain natural stream channels

4.1.3 Riparian management

Because riparian areas can be effective buffer zones between farm activities and waterways, they should be subject to specific management. In addition to care with fertiliser placement (refer to 3.5.3 Fertiliser spreading) and careful grazing near waterways, riparian management actions may include fencing to prevent stock access and planting to enhance habitat and bank stability.

Crossings, culverts and managing runoff from races are also aspects of sound riparian management and waterway protection (refer to 6.4 Farm races and 6.5 Waterway crossings). Severe erosion may require bank protection works (refer to 4.3.1.4 Design for erosion control and 6.7.3 Streambank engineering and in-stream works).

The Dairy Industry Environmental and Animal Welfare Policies note the importance of waterway fencing and crossings. The Dairying and Clean Streams Accord aims to have crossings in place in 90% of cases by 2012 wherever stock cross a waterway more than twice a week, and dairy cattle excluded from 90% of streams, rivers and lakes by 2012. Another aim is to have 90% of existing regionally significant or important wetlands (as defined by regional councils) fenced by 2007 and their water regimes protected. These practices are also contained within the Farm Dairy Code of Practice NZCP1.

4.1.3.1 Riparian fencing

Stock exclusion from waterways is a minimum action required for water quality improvement and gives farm benefits in preventing stock losses and saving time in stock management.

Secure fences should be erected around drains and permanently wet areas, while seasonally wet patches in paddocks can be protected during winter with temporary electric fencing. Temporary fencing can also be used to create buffers between waterways and grazed crops or steep slopes during wetter months.

Two-wire electric fencing is usually sufficiently stock-proof on dairy farms. Simple two-wire fences are less likely to collect flood debris and be swept away in floods, and are easier to stand back up after a flood.

The decision on where to put the fence will depend on whether there are bank stability issues or flooding problems, and whether a grass filter or a planted margin are desired.

- A fence right beside the drain or stream will prevent stock from depositing dung and urine in the water, or breaking down the banks and stirring up the bed. It will not provide any filtering function or allow for any future bank erosion. Fences should be set further back where banks are unstable or prone to flooding
- Placing the fence further back to create an additional strip of rough grass will provide the best filter of farm runoff. It will not enhance shading or habitat value for the stream, or bank stability. For flat paddocks, a grass strip of 1-3 m per 100 m of slope length will give good filtering. For steeper land, a slope of 100 m requires up to 15 m of riparian margin for maximum filtering (refer to Figure 4.1-2). Note: These figures should be used as a guide. Actual riparian distances will depend on individual circumstances. On steep land it is also more important to fence out small seeps and gullies, to create buffers within the farmed area and along natural drainage channels (refer to Figure 4.1-3)
- A riparian strip of planted trees will provide water shading and cooling, habitat benefits for the stream and the riparian land, and extra bank stability. If planting is to be carried out, allow enough space within the fenced area to keep plants out of reach of stock
- A combined riparian area with a filter strip of grass on the paddock side of some planted trees will give maximum benefits.

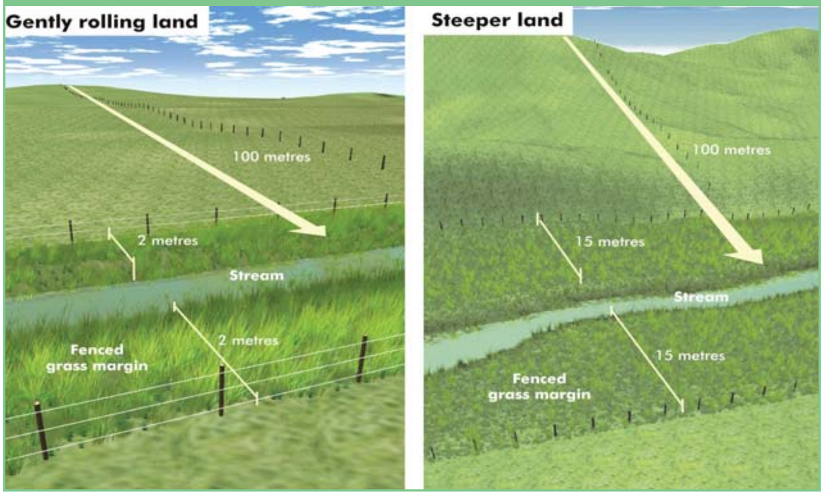
If machinery access is required to clean weeds, silt or debris out of drains, either use electric fencing that can be dropped to allow access, or leave enough space inside the fence for machinery to work. For internal farm drains, access on one side may be sufficient. On boundary drains, cleaning usually alternates between properties. Check with your local drainage authority for requirements. Note that in-stream works on waterways that are not drains will often require a consent - check with your Regional Council. For more information on drains refer to 4.1.4 Drain management.

Fencing out natural water requires adequate provision of stock water, which is important anyway for dairy herds to ensure good animal health.

Suitable crossings will also need to be in place, which do not restrict fish passage (refer to 6.5 Waterway crossings).

FIGURE 4.1-2

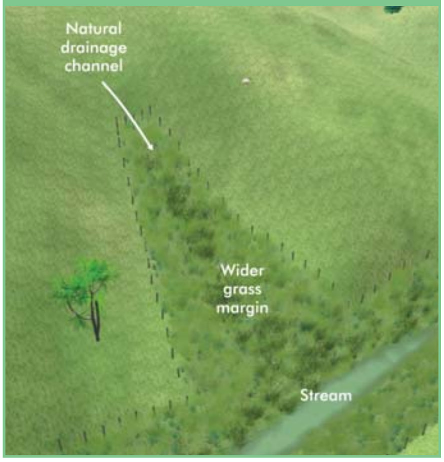
WORKING OUT THE AREA FOR A GRASS FILTER STRIP



Source: Environment Waikato

FIGURE 4.1-3

PROTECTING NATURAL DRAINAGE CHANNELS



Source: Environment Waikato

4.1.3.2 Grazing of filter strips

Occasional grazing of filter strips can be used to keep weeds down and possibly transfer nutrients stored by the growing grass away from the waterway. If grazing a riparian area:

- ensure stock do not access the waterway (e.g. use a temporary electric fence beside the stream)
- graze with young stock, as heavy cows may trample the banks
- graze lightly and leave a high pasture residual
- graze in dry conditions and allow for regrowth before the wetter months.

Grazing should be avoided where banks are unstable, where plantings have been carried out or where the area is a whitebait spawning ground. Spawning occurs in autumn with eggs being deposited on grass stalks, so grazing should cease in late summer to allow grass to regrow.

4.1.3.3 Riparian planting

Riparian planting is not necessary to obtain the filtering and stock exclusion benefits of a simple fence, but it will provide additional benefits to the stream and can visually enhance a farm landscape. Establishing trees in fenced areas can also help exclude weeds.

Exotic species may be planted for rapid bank stabilisation (e.g. poplars or willows) and if deciduous, will not shade pastures in winter. However, the dense growth of willows can block stream flow, while tall poplars can topple over, taking stream banks with them or creating obstacles to water flow. Avoid invasive species such as crack willow, weeping willow, grey willow and silver poplar.

Native trees tend to require less long term maintenance in riparian areas and may provide better conditions for stream life (e.g. by dropping leaves all year round, not in a single burst). A native strip can also provide food sources and habitat for native birds, lizards, insects and snails. Fast-growing natives for bank stabilisation include ribbonwood, cabbage trees and *Pittosporum* species.

Shade is the most important requirement for stream life as it cools the water and limits the growth of algae and choking waterweeds. Continuous strips of 200m or more are needed to provide effective stream cooling. However, too much shade on the stream banks can wipe out the grasses and sedges that hold the edges of the bank together. A forest stream is naturally wider and shallower than a pasture stream, so when a pasture stream is replanted, it will tend to revert to a wider channel, with some bank erosion. To avoid this, plant at a lower density near actively eroding areas, and use only sedges and grasses on smaller streams. On a wider stream or river, allow a wider margin, with sedges and grasses on the banks and trees set back from the stream. This will help stabilise the banks and avoid the loss of trees if there is some initial erosion.

If bank erosion is a problem:

- plant at 2-3 m spacings, on critical points where erosion is greatest
- avoid planting on the inside of bends where soil builds up – trees will trap sediment and deflect the current across to the eroding outside bend
- avoid planting narrow reaches where trees might impede floodwaters
- if using poplars, prune to maintain one strong leader.
- ensure poplar or willow stakes and poles are firmly planted.

For information on suitable species and tree planting, refer to 4.3 Plantings on dairy farms.

4.1.4 Drain management

Drains are effective at removing water from farm soils to avoid saturated conditions limiting pasture growth.

However drains can also:

- provide rapid transfer of farm pollutants into larger waterway
- be habitat in themselves, as they are home to native fish and eels. Drains are now sometimes the only remnant habitat left in intensively farmed areas for native fish and aquatic insect and plant communities
- be effective sites for nutrient capture and stripping. Any drain that mimics a natural wetland, with slow moving-water amongst vegetation and wet soils, can remove up to 90% of nitrogen from drain waters as well as some phosphorus.

The drainage network (both constructed and natural) becomes a source, a sink and a conduit of farm pollutants. However, with careful management, farm drains can maintain effective drainage, while minimising pollution and maximising habitat value.

Good management practices include the following:

- retain vegetation where possible (refer to 4.1.4.1 Benefits of vegetation in open drains)
- carry out drain clearing only where necessary (refer to 4.1.4.2 Minimising the need for drain maintenance) and using best practice techniques (4.1.4.3 Low-impact drain clearing)
- avoid straightening natural drainage channels, as a meandering drain creates better habitat and allows longer contact time between drainage water and drain surfaces, thus enhancing nutrient processing and retention
- manage grazing, fertiliser and effluent application carefully near open drains.

Subsurface mole and tile drains are an often-overlooked conduit of nutrients. Unlike open drains, subsurface drains do not collect surface runoff (sediment and solid particles containing nutrients and faecal material). However, subsurface drains receive dissolved nutrients that leach down through the soil - mainly N (as nitrate) but also some P in its soluble form. They may also receive solids that drain through cracks in the soil, carrying sediment and faecal material with P attached. Both N and P are often present in dairy farm drainage waters at levels sufficient to promote algal growth in downstream waters.

Best practice for managing these subsurface drains includes the following:

- manage grazing carefully above subsurface drains, especially in wet conditions
- avoid applying effluent in these areas, or if effluent is to be applied, defer effluent irrigation until soils are drier and apply at low depths, low rates and uniformly. Apply effluent across the tile drains. There should be no drainage from mole and tile drain outlets following effluent irrigation
- irrigate clean water only when there is a soil moisture deficit and at low depths and rates and with high uniformity
- consider feeding crops to stock on a feed-pad rather than wintering stock on a crop in mole and tiled drained paddocks
- do not apply N fertiliser in cold, wet conditions when pasture uptake is reduced and soils are saturated
- wetlands can also be created in some circumstances at the end of subsurface drains to treat the discharge from mole or tile drains before it enters a waterway (refer to 4.1.4.4 Constructed wetlands to treat drain discharges).

4.1.4.1 Benefits of vegetation in open drains

Weedy plants can be a problem in drains where water flow is impeded. However, vegetation in and around drains can also provide benefits. Drain vegetation:

- stabilises banks and bed sediment
- provides habitat for fish, koura, other aquatic life and birds
- cools the water, which benefits aquatic life including native fish and trout
- takes up dissolved nutrients from the water before they reach rivers or lakes where they can feed algae and water weeds that turn water green and choke up channels
- provides a supply of organic carbon through its leaf litter that can feed the bacteria that remove nitrogen from the water and release it to the air.

Before removing weeds from drains, consider whether they are really a drainage problem, and if not, keep drains vegetated.

4.1.4.2 Minimising the need for drain maintenance

Drain maintenance is necessary when silt or weeds are impeding drainage. As sediment collects in a drain, weeds often grow in it, in turn trapping more sediment.

The need for drain maintenance can be minimised by careful grazing and land management (refer to 4.1.5 Managing grazing to protect water quality). Drain management practices should also be adopted that prevent sediment and weed build-up:

- fence drains to exclude stock and prevent damage to banks. This may reduce the frequency of drain cleaning needed from every 1-2 years to every 5-10 years
- spray weeds in slow flowing drains to avoid the need for diggers. However, only spray the bed of the drain, leaving vegetation on the banks to avoid slumping
- leave an ungrazed grass strip beside drains to filter nutrients and sediment
- if cultivating, stop at least 2 m from any drains (further away on sloping ground)
- if access is not required, plant a row of trees on the northern side of the drain to shade out weeds
- create flat batters on drain banks, rather than steep banks (i.e. a 'V' shaped channel with a gradient of 1:2).
  This will concentrate flow and provide a low-maintenance, weed-free central channel (refer to Figure 4.1-4)
- consider putting sediment traps in the slower-flowing sections of your drainage network. A sediment trap is a short drain section about 1.5 metres wider than the main channel and 1.5 metres below the average bed level, where the current will slow and sediment will drop out. You can remove sediment from the traps regularly (e.g. after flood events) without cleaning the whole drain. Talk to your drainage authority about siting and design of these.

FIGURE 4.1-4

SLOPING BATTERS ARE BETTER THAN STEEP BANKS

In deciding how to manage your drains, remember that drains are not isolated to a single farm and often form part of an interconnected drainage scheme. If you are part of a drainage scheme, check local regulations before planting trees. Always allow access for cleaning and maintenance when fencing or planting (e.g. gates in drain fences, culverts over side drains, a tree-free zone on one side of the drain).

4.1.4.3 Low-impact drain clearing

The options for drain clearing include:

- chemical spraying
- mechanical cleaning
- hand clearing.

Spraying is cheaper than mechanical clearing, but involves the use of toxic chemicals in or near water. It may also result in large amounts of dead vegetation that, if left to decompose in the drain, can lower dissolved oxygen levels and affect aquatic life.

Best management practices for chemical drain weed control include the following:

- do not use persistant and residual chemicals such as tordon, atrazine, simazine, diuron and bromacil which have long term activity and can cause down stream effects to other users. Use only glyphosate over water. Check with your Regional Council to see if you need a consent to spray over water
- Notify downstream users as there is the potential for offsite effects where treated water is abstracted for irrigation of crops or water supply
- spray only the centre channel and leave a strip of weed along the toe of the batter
- use hand-gun equipment at low pressure to ensure bank vegetation is not damaged
- spray when drains are seasonally dry
- spray weeds when they are small to avoid choking the waterway with dead material
- consider spot spraying target weeds or strip spraying rather than blanket spraying. Contact herbicides such as paraquart and diquat can be useful on banks as roots systems will remain to stabilise the banks
- follow the label and use minimum effective rates more often, rather than high concentrations less often
- avoid spraying during peak fish spawning and migration periods. In tidal areas, spray only in summer. In non-tidal areas, spray in summer or autumn.

For more information on farm agrichemical use, refer to 7.1 Agrichemical use.

Mechanical drain clearing can disturb sediment, remove fish or other water life, and cause the spread of aquatic weeds downstream. It should only be done when necessary.

Best management practices for mechanical drain cleaning include the following:

- only clear part of any drain at one time so that vegetated areas remain as filters. Clean the lower end of the drain last so that a weed filter is present during cleaning
- use a digger with a weed-rake or stream-cleaning bucket so that fish and other water life can escape back into the drain, or have someone walk alongside to return them
- avoid excavating during peak fish spawning and migration (seek advice from local Department of Conservation staff for these times for your area). If you are near the coast, avoid disrupting the whitebait spawning in autumn
- spread out drain cleanings away from waterways and wetlands, so that the nutrients are returned to paddocks rather than waterways
- ensure machinery is clean when it enters the property to avoid the spread of weeds
- avoid deepening drains as you maintain them, especially on peat soils or near wetlands.

Note that some farm drains may in fact be modified streams – if they originate in a natural headwater rather than a paddock, then they may be classified as a stream and you may need a consent to carry out in-stream work. Check with your Regional Council.

Hand clearing may be feasible for short drains. This can include cutting vegetation on the drain edges with a brush cutter or weedeater, removing weeds from the channel with a drain rake, scythe or sickle, or even just walking up a weed-choked drain in waders to create a fast-flowing zone in the central channel. Where possible, cut weeds should be removed from the water and not left to rot in the drain and reduce oxygen levels.

If there is an infestation of a particular weed, it is advisable to seek advice from a plant pest contractor or Regional Council staff. Some weed treatments may be ineffective or counterproductive (e.g. mechanical removal of Eurasian water milfoil typically releases many viable fragments that can reinfest or spread).

4.1.4.4 Constructed wetlands to treat drain discharges

The successful use of wetlands to polish effluent discharges from treatment pond systems has created interest in the use of wetlands for treating drainage waters from the farm (refer to Figure 4.1-5). Constructed wetlands for this purpose can be located within surface drains (i.e. in-stream wetlands) or at the outlets of the drainage network of either surface or, more commonly, of subsurface drains.

FIGURE 4.1-5

A CONSTRUCTED WETLAND TO TREAT FARM DRAINAGE WATER

Source: Sukias, Tanner, and McKergow, 2005

Processes such as denitrification (nitrate being converted to gaseous forms and released to the air), nutrient incorporation into soil organic matter or plant material, settling of P in the sediment layer, and aerobic-anaerobic reactions at the soil-water interface can all contribute to nutrient removal. There is also some die-off of faecal microbes when water is held in the wetland for sufficient time.

Annual removal rates of around 20-35% of nitrate and total nitrogen can be expected for wetlands comprising 1% of the drained catchment. Larger wetlands 2-5% of the catchment area can increase removal rates to 40 - 70%.

The use of low nutrient carbon-rich supplement such as sawdust, wood chips or cereal straw in the wetland can increase the effectiveness of nitrate removal. Alternatively, porus woodchip filters can provide good nitrate removal. Maintaining the porosity of the wood chip filters (preventing clogging) may be a challenge for continued effectiveness.

Wetlands at the end of farm drains receive water at variable rates and nutrient concentrations, because of natural rainfall patterns. It is likely that constructed wetlands will not adequately retain and treat all water in a storm event. However, runoff from very high rainfall events will generally contain more diluted nutrients after the initial flush, and therefore may pose less threat to the environment than normal drainage water. Where agricultural soils in the wetland are flooded and converted to wetland soils, there may also be an initial increase in P released from the wetland. This should be considered in catchments with receiving waters that are sensitive to increased phosphorus levels.

The use of substrates to aid P removal is still being researched. For example, zeolites (natural alumino-silicate minerals) may aid nutrient removal by providing a greater surface area. However, they may also become nutrient-saturated and require replacement for ongoing effectiveness. Options may include laying zeolites or other similar absorbant materials on the wetland floor, or as a filter bed at the end of wetlands (for ease of replacement). However, field-scale research is in its early days and so no firm recommendation can be made on the use of zeolites or other similar materials for wetlands yet.

Carbon-rich anaerobic environments are also most efficient at converting a greater proportion of nitrogen to inert N_2 gas rather than the greenhouse gas N_2O. Constructed wetlands are most efficient where flow variations are not extreme and nitrate loadings are not excessive, so wetlands should be seen as a final buffer and not replace sound management of grazing, nutrient and effluent application on drained land. While not always applicable, constructed wetlands at drain outlets may be useful where there are sensitive downstream waterbodies.

For recommended guidelines developed by NIWA for the design and construction of these wetlands, see 4.1.4.5 Wetlands and wood-chip filters to treat drainage water.

4.1.4.5 Wetlands and wood-chip filters to treat drainage water

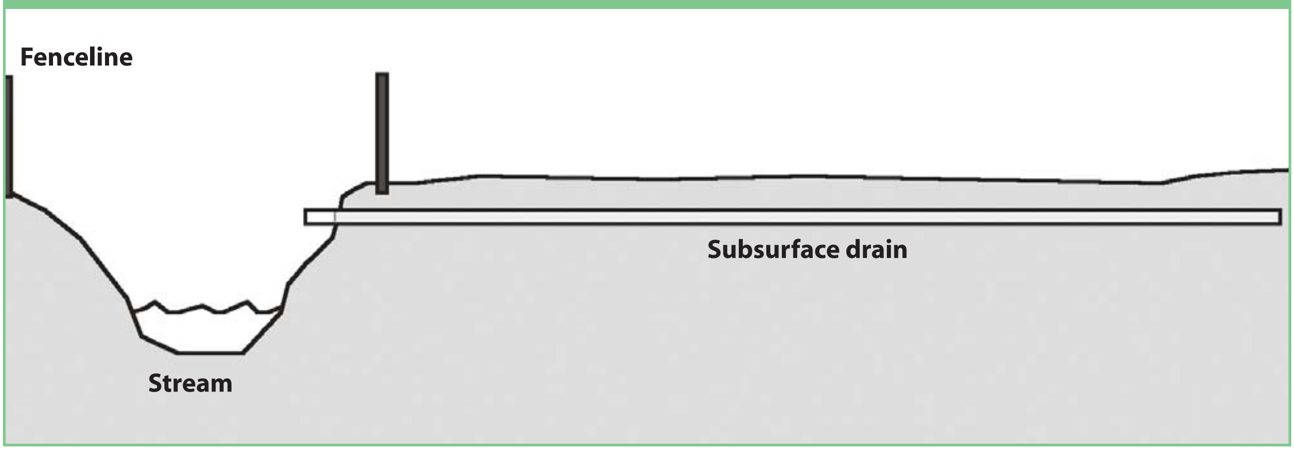
Wetlands or filters can be established at the discharge of subsurface drains to promote nutrient removal before the drainage water reaches a stream or other water body (refer to 4.1.4.4 Constructed wetlands to treat drain discharges). The following guidelines have been provided by NIWA based on field research into these systems on dairy farms.

Treatment systems need to maintain the efficiency of the existing drainage system, and yet allow sufficient time for the effective removal of nutrients by the filter.

Figure 4.1-6 shows an existing subsurface drain discharging directly into surface drain or stream. In this situation, the drainage water bypasses the riparian zone so no filtering takes place.

FIGURE 4.1-6

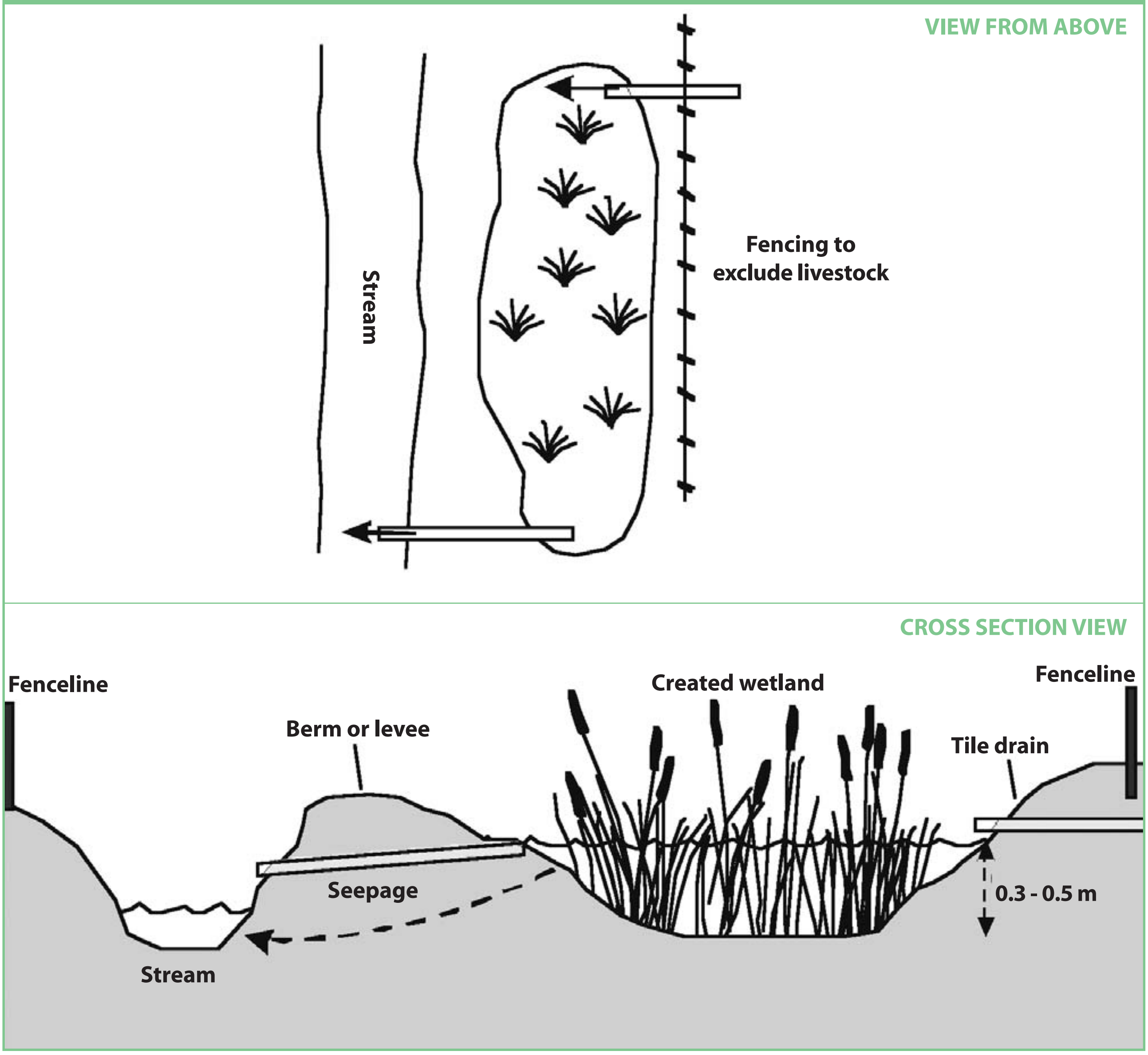
TYPICAL SUBSURFACE DRAIN OUTLET TO SURFACE DRAIN OR STREAM



The water level in a wetland or wood-chip filter treating drainage water needs be higher than in the adjacent waterway to enable outflow. Similarly, the outlet from the filter should be lower than the main in-flowing tile drain, to minimise back-up of water in the drain. In some instances this will be hard to achieve in existing drainage systems. New drainage systems can be specifically designed with the additional fall required for filters.

FIGURE 4.1-7

SUBSURFACE DRAIN WITH WETLAND FILTER BEFORE DISCHARGE INTO STREAM



To achieve 40-50% nitrate and total nitrogen removal, constructed wetlands need to cover 2-3% of the catchment from which they are receiving drainage water. Smaller wetlands (~1% of catchment area) will generally remove 20 - 30% of nitrogen, while larger wetlands (4 - 5% of catchment) can achieve 70% nitrogen removal.

An adequate source of organic matter is required as an energy source for the microbes that convert nitrate into nitrogen gas. A fast growing plant that drops a lot of leaf litter such as raupo (Typha orientalis) is the most effective.

Until sufficient leaf litter accumulates in the wetland, adding carbon-rich organic materials can enhance performance. This can be woodchip, sawdust or cereal straw added to wetland soil at up to 40% by volume. The addition of straw bales may also be considered in this period to act as an alternative source of carbon, to filter out sediment in the water, and to create a "plug flow" within the wetland so that water spreads evenly throughout the wetland areas and is retained for a sufficient period. The bales should be anchored to stop them floating.

Wetland construction

For low permeability, clay soils, some natural seepage out of the wetland system will occur, but lining will not generally be necessary provided that enough moisture is maintained over summer for survival of the wetland plants. An impermeable liner is necessary for sites with relatively free-draining soils or where severe cracking of the soil occurs. This can either be a thick synthetic liner or compacted clay.

For planted wetland systems (e.g. raupo or bulrush), the wetland base should be backfilled with 15-20 cm of topsoil for plant rooting.

It is important that water entering the wetland is dispersed across the channel and is not allowed to create a channel through the wetland. A simple pipe may be used for small wetlands but multiple openings should be used in larger wetlands.

The outlet pipe should be set in the base of the wetland with an upwards facing elbow, into which riser pipes can be fitted to keep the water level around 300 - 400 mm deep during normal drain flows (Fig 4.1-9). A riser pipe with a suitable orifice set at the normal desired water level can be used to temporarily retain higher outflows so there is more opportunity for them to be treated during passage through the wetland. A high level overflow (normally the open top of the riser) will allow pasage of sustained high flows. The outlet pipe needs to be protected from blockage by plant material. This is best achieved using a slatted wooden barrier or slotted plastic pipe (anchored to a fence post or waratah as shown in Fig 4.1-9.) These should be checked and cleared of blockages every year at the end of Autumn before seasonal drainage flows resume.

Wood-chip filters are an alternative option being researched, which have shown good potential to remove nitrate from tile drainage flows. The woodchips can remove and immobilise a proportion of the nitrogen passing through them, and provide a slow-release of organic matter that promotes bacterial conversion of nitrate to nitrogen gas. Wood-chips are favoured over sawdust because they provide a porous matrix that water can pass reasonably easily through. The woodchips will need to be replenished every couple of years and eventually replaced to maintain porosity and nitrogen removal performance. The operational lifetime of these systems is the subject of current research. A suggested basic design for a wood-chip filter is shown in Figure 4.1-8. Properly designed wood chip filters of ~ 30-60 m^3 per ha (= 30 m^2 for 1 m deep filters) are expected to be able to provide around 40-50% N removal from tile drainage.

FIGURE 4.1-8

SUBSURFACE DRAIN WITH WOODCHIP FILTER SYSTEM BEFORE DISCHARGING INTO STREAM

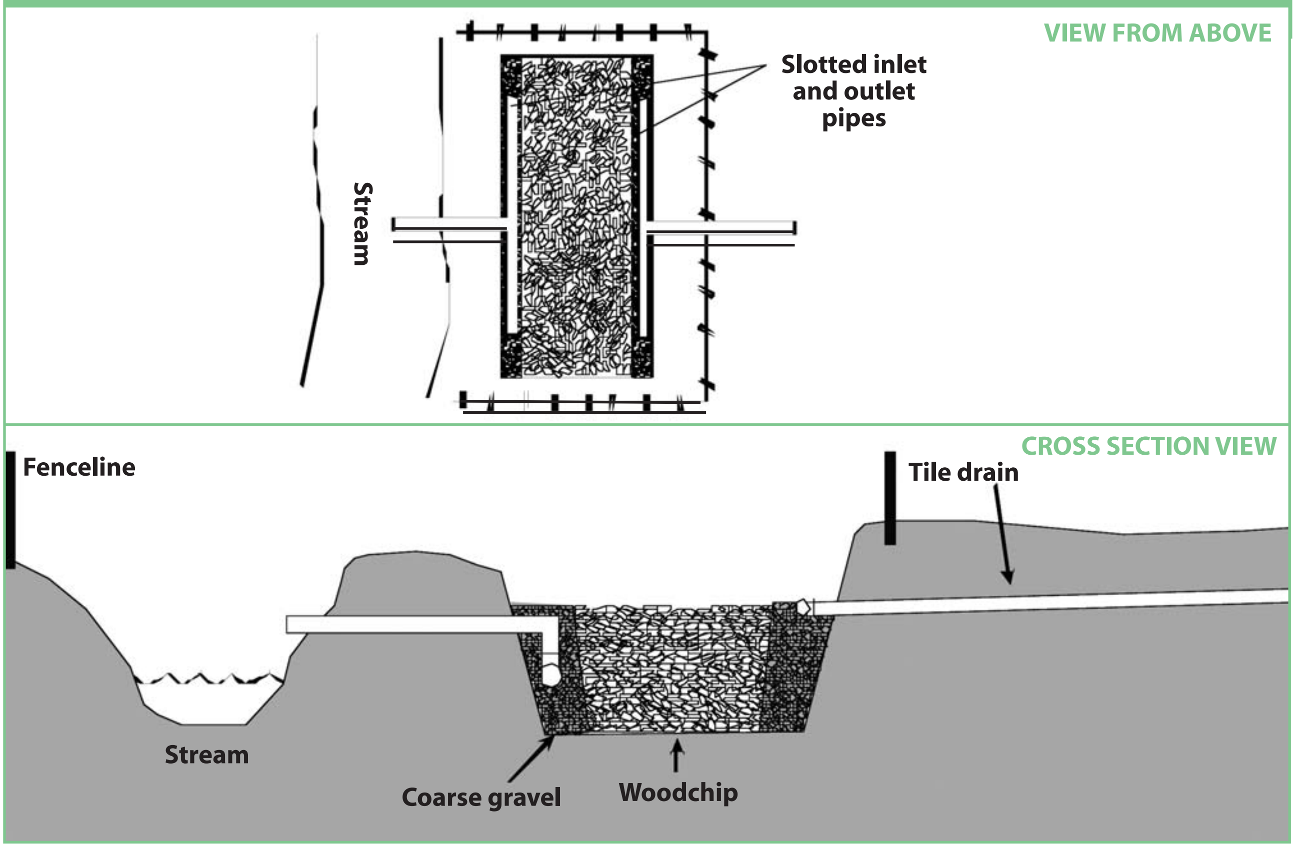
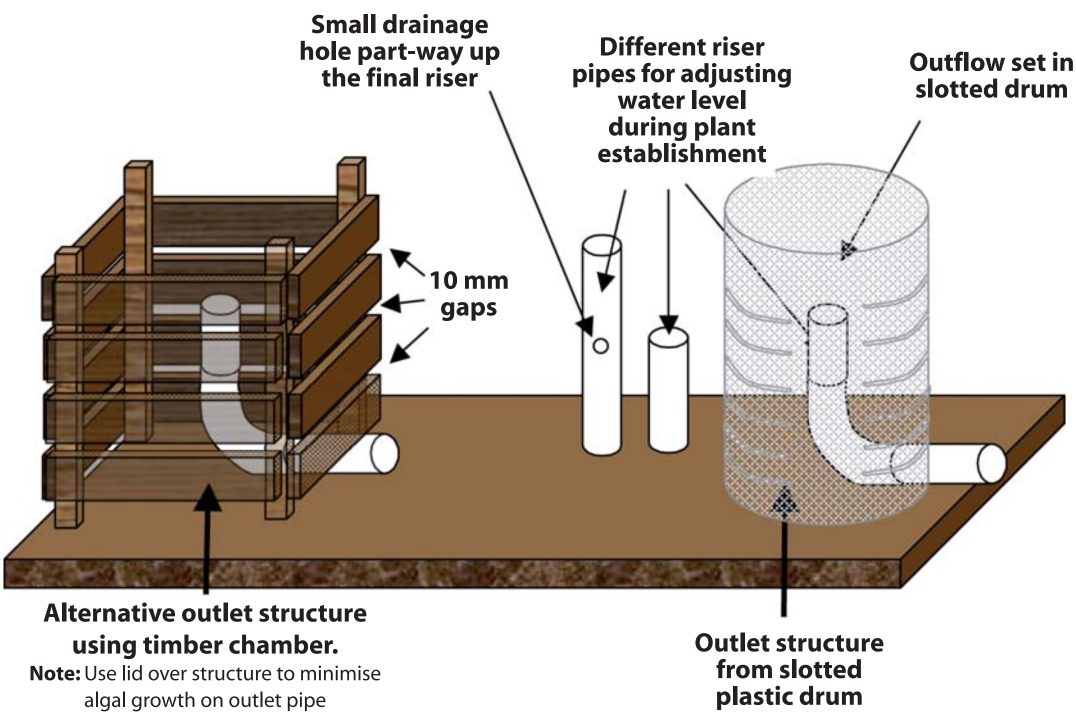


FIGURE 4.1-9

OUTLET STRUCTURES FOR A CONSTRUCTED WETLAND



When plants are first added, the water level should be kept at 10–20 cm. After 2–3 months, the water level can be raised by putting progressively longer risers on the outlet. The water level should be kept to no more than half the height of the plants with a normal operating water level of 30 - 40 cm (refer to Figure 4.1-10).

Wetland arrangement

There is no set formula for the arrangement of wetlands and filters on a farm, as long as they are positioned at the end of the drainage system. Wetlands should ideally be positioned alongside the streams and main drains where they look natural and add valuable habitat diversity. Each sub-surface drain could have an individual treatment system or these might be combined if the outflow points are not far apart. Similarly, they will function just as well whether they are rectangular or have a more curved natural shape as long as the channel flow path width does not vary by more than 20%. Ideal length-to-width ratios are between 5:1 and 10:1. Figures 4.1-11, 4.1-12 and 4.1-13 show alternative layout options.

FIGURE 4.1-10

RAUPO AND GRASSES SHORTLY AFTER PLANTING A CONSTRUCTED WETLAND - WATER LEVELS MUST BE KEPT LOW UNTIL PLANTS ARE WELL ESTABLISHED

Source: Sukias, Tanner and Mc Kergow, 2005

FIGURE 4.1-11

RANGE OF POSSIBLE WETLAND CONFIGURATIONS TO MAINTAIN LENGTH-TO-WIDTH RATIO OF 4:1 TO 6:1

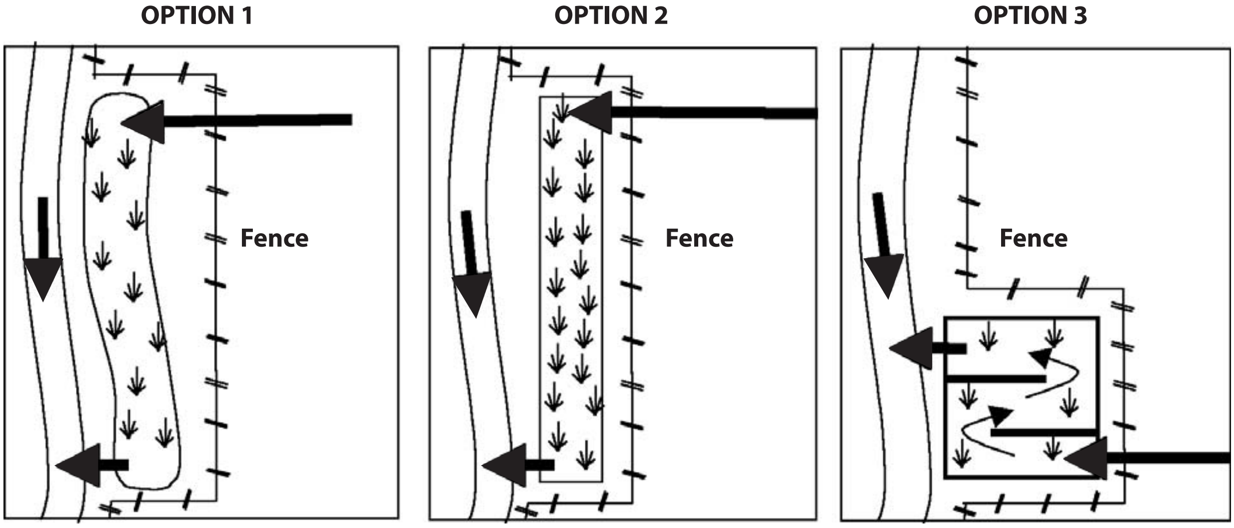


FIGURE 4.1-12

TYPICAL ARRANGEMENT OF SUBSURFACE DRAINAGE LINES WITH INDIVIDUAL WETLANDS OR FILTERS (Viewed from above)

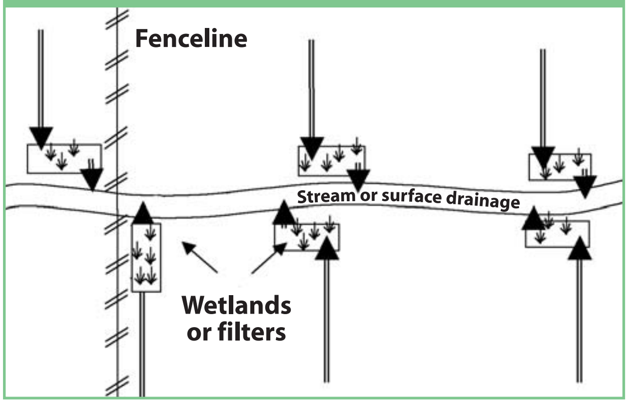
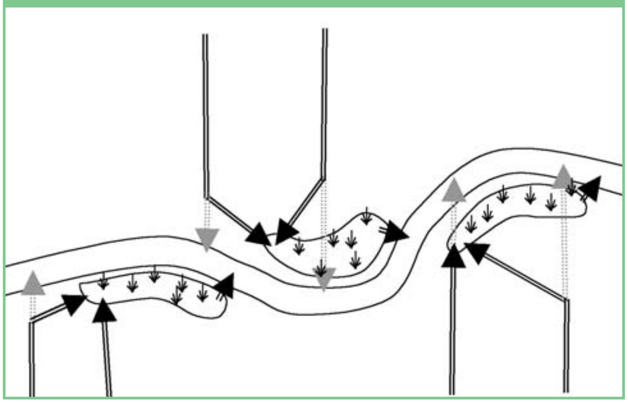


FIGURE 4.1-13

ALTERNATIVE ARRANGEMENT OF SUBSURFACE DRAINAGE LINES - Diverted so that several are treated within one wetland or filter, fitting the natural shape of the stream and landscape



4.1.4.6 Managing water levels in peat soils

Peat soils are a fragile resource that will shrink under cultivation or dry conditions. To continue to farm peat profitably in the long term, farmers must find a balance between maintaining the water table at a low enough level to optimise production, yet high enough to minimise the inevitable loss of peat soils and damage to neighbouring wetlands or peat lakes.

Peat farms that have significant wetlands on their boundaries may be subject to drainage restrictions to protect those wetlands. These can apply to both new drains and deepening of existing drains – check with your Regional Council.

As soon as peat is drained and the water table lowered, the natural process of accumulating organic matter stops and the organic matter begins to shrink and decompose as a result of exposure to air. This may impact on the need for stop-banking and pumping of water for flood control.

The deeper and more closely spaced the drains, the quicker the peat will subside. When drains are cut through peat into permeable layers of sandy subsoil, shrinkage can be severe as cracks form. Over-drained peat often fails to re-wet in winter as the dry peat becomes waxy and rainwater flows through the surface cracks into the subsoil. Therefore deep drains should be avoided on peat soil.

Ideally, drainage systems on peat should be designed not only to remove excess water during winter, but also to maintain the water table during summer. The optimum depth for the water table is around half a metre below the surface. Maintaining water levels in summer will not only avoid peat shrinkage, but will improve grass growth.

The capacity of the farmer to manage water levels in drains will depend on the layout of the drain system and proximity to neighbouring properties. Discussing issues with neighbours is a good idea to coordinate water table management.

One of the best ways to prevent the water table dropping too much in summer is to block secondary drains off in late spring before they run dry, for example using sandbags to dam the drain. Alternatively, water control structures can be built such as a weir that extends out to either side of the drain (to avoid bypass flows), where boards can be inserted and removed as required to maintain water levels.

More information can be found in the Environment Waikato publication "For Peat's Sake. Good Management Practices for Waikato Peat Farmers." This is also available at www.ew.govt.nz .

4.1.5 Managing grazing to protect water quality

In addition to direct management of waterways and riparian areas, overall grazing management can impact on the quality of runoff or subsurface drainage to water.

Avoiding pugging will benefit waterways by reducing bare soil and compaction, which create the potential for runoff of sediment, faecal material and P (refer to 2.1.1 Limiting pugging damage).

It is more difficult to prevent the leaching of N as this occurs primarily from urine patches, which can only be fully managed when stock are contained on a sealed surface and the effluent collected and treated. Nitrification inhibitors applied to pasture have been shown to slow the conversion of N to soluble nitrate form and thus retain N in the soil for longer (refer to 3.3.3 Nitrification and urease inhibitors). Altering the feed type of the herd can also reduce the amount of N that is excreted in urine. Seeps and swamps offer the only other means to strip nitrogen from water once it has leached below the surface. Water resurfacing in these areas can be processed by wetland bacteria that release nitrogen back to the air. It is therefore good practice to retain wet areas and prevent stock grazing them so that wetland vegetation can establish to slow water flows and maximise retention time in the wet soil. The area can be grazed in summer if sufficiently dry.

Particular care is needed to prevent waterway pollution when grazing crops, grazing near waterways, or grazing land with subsurface drains.

4.1.5.1 Grazing winter crops

Break-feeding stock on a winter crop results in bare, often pugged soil, with concentrated effluent deposits. Rainfall and the resultant overland flow can transport sediment and faecal matter into drains and waterways. Topsoil is lost that can silt up drains, make streams murky, and block culverts and tile outfalls. Nitrate can be washed through the soil and contaminate subsurface drainage or shallow groundwater.

One simple and cost-effective action is the use of electric fencing and retention of a grass strip to filter overland flow before it reaches a waterway (refer to Figure 4.1-14).

Consider where water will flow from the paddock during heavy rain to identify hotspots or exit points for runoff. These can then be protected by a wide buffer zone using electric fencing.

When cultivating for a winter crop, preferably choose paddocks away from a natural watercourse. If this is not possible, keep the plough line 2-4 m back from the edge of drains and watercourses. This ungrazed riparian margin will help keep sediment and nutrients within the paddock, improving water quality and conserving farm resources.

Nitrate may still be lost under a grazed crop through leaching of urine deposited onto bare soil. The only sure means to prevent this occurrence is to feed the crop off the paddock, on a feed pad where effluent is collected and managed (refer to 6.6 Stand-off pads and feed pads). Resowing the area immediately after grazing the crop may help increase the uptake of N in the soil.

FIGURE 4.1-14

A GOOD GRASS BUFFER BETWEEN CROP AND WATERWAY, vs NO GRASS BUFFER

Source: Environment Southland

4.1.5.2 Grazing paddocks near waterways

Paddocks near waterways should be grazed carefully, especially during wetter months and where there is a steeper gradient towards the waterway. Consider:

- fencing off areas of different contour so that grazing can be managed more easily
- keeping stocking rates low or only grazing lighter stock in paddocks by waterways
- monitoring grazing and moving stock before pasture residuals get too low.

4.1.5.3 Grazing mole and tile drained land

Research has shown that while installing artificial drainage will greatly reduce surface runoff and pugging, there is an increased risk of nutrients and faecal matter reaching the subsurface drains and then discharging into waterways at the drain outfall.

Therefore, even though these areas will be resistant to pugging in wet conditions, grazing should still be avoided when soils are saturated. Overgrazing and pasture damage should be prevented to ensure rapid nutrient uptake after grazing.

4.1.5.4 Grazing seeps and wet areas

Grazing of seeps and wet areas should be avoided when soils are saturated. Although these areas can be small and scattered, they are extensions of the waterway network and so there is an increased risk of nutrients, sediment and faecal matter reaching streams if they are grazed. Seeps occur when water is forced towards the soil surface and may flow continuously or seasonally. When rain falls on seeps and wet areas it immediately becomes runoff and can rapidly transport pollutants to streams. In addition seeps and wet areas with organic soils may provide suitable conditions for nitrate removal.

Filter strips can remove farm pollutants from runoff by slowing down water velocities and allowing pollutants to settle out of runoff, drain into the soil and sieve pollutants from runoff. To maximise filtering they should be:

- dense grass, as channels within a filter strip will render it ineffective
- as much on the contour as possible, so that runoff enters the filter strip as shallow sheet flow.

4.1.6 Top tips for waterway protection

- **Exclude stock to prevent waterway pollution, save time mustering and prevent erosion of land along stream and drain banks.**
- **Leave a grass strip to slow and filter runoff from high-risk land uses such as cropping or steep slope grazing.**
- **Create shade along a waterway with overhanging grasses and sedges and trees set back to avoid bank slumping.**
- **Practice careful grazing of mole and tile drained areas, steep slopes and areas beside waterways.**
- **Maintain drain vegetation where possible and carry out low-impact drain cleaning of the drain bed only.**
- **Create gentle batters on drains to concentrate flow in the centre of the drain for minimal maintenance.**
- **Retain wet and ponding areas in paddocks as filters and sponges for farm runoff – instead of draining, fence these areas and allow rough grass or wetland vegetation to grow.**
- **In coastal areas, allow rough grass to grow beside streams in late summer to prepare for autumn whitebait spawning.**