Community Toolbox for Mitigating Erosion and Runoff

Waikawa Catchment Group

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Date: 25 November 2024

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Introduction

This document is designed to provide the Waikawa Catchment community with a practical tool to help focus and guide actions to reduce runoff and erosion. By introducing the **Source-Pathway-Receptor (SPR)** framework, we aim to enable and empower local farmers, foresters, and community members to identify and address key areas for erosion and runoff mitigation, whether at the scale of a paddock, farm, forest block, or the wider catchment.

1. The Waikawa Catchment is home to a skilled and knowledgeable community. This document has been created to work alongside your expertise, offering a simple but effective framework to support actions which manage runoff and erosion. We respect the critical role that farming, forestry, and other land-based livelihoods play in the region, as well as the wealth of knowledge and commitment local people bring to managing the land.

2. Consequently, the SPR framework is intended as a collaborative tool, which works best when used by those with an intimate understanding of t land and business operations. It is not a prescriptive solution but a resource to support informed decision-making which benefits both the environment and the economic sustainability of the land. The objective is to place this tool directly into the hands of the community.

3. Many sources of information were evaluated and used to generate this Community Toolbox for Erosion and Runoff Mitigation. All references are provided in the bibliography.

Part 1 Covers:

- **Catchment Characteristics and Runoff Risk**
- **Purpose of the Document**
- **A Tool for Land Users**
- **An Evidence Base for Mitigating Erosion and Runoff – why Slowing the Flow Works**
- **Slowing the Flow, Trapping, and Treating Sediment and Contaminants is Highly Effective**
- **Water as a Vehicle**
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Catchment Characteristics and Runoff Risk

Approximately 90% of the Waikawa Catchment is characterised by silt-dominated soils (Fig. 1). Large areas of these soils are either slowly permeable (S) or moderately permeable over a slow subsoil (M/S). This dominance of silt soils reflects the region's geology, topography, and ancient climatic history shaped by glacial and interglacial periods.

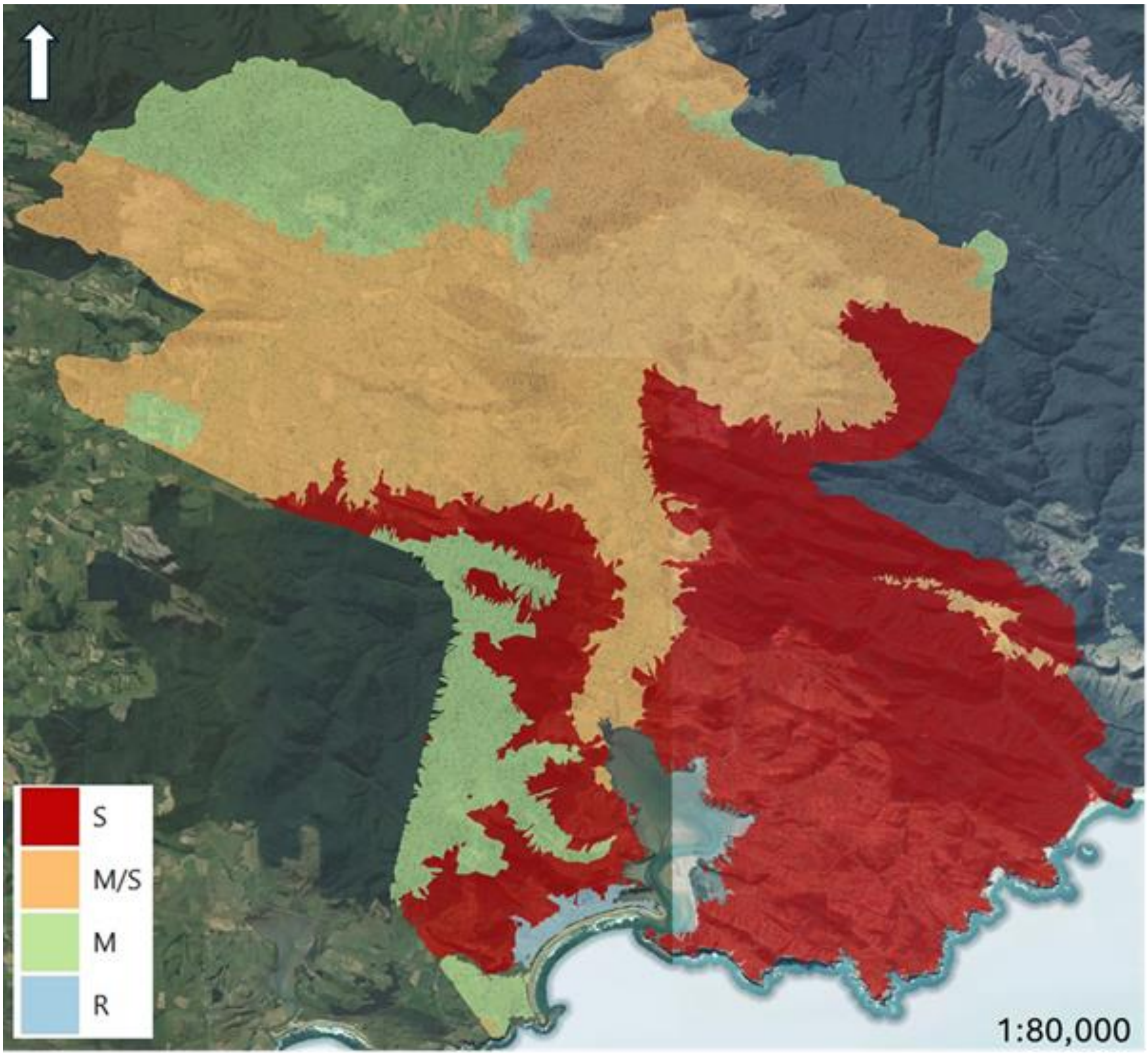

Figure 1. Soil permeability across the Waikawa Catchment (FSL). Ninety per cent of the soils are silt-dominated, with large areas of Slow (S), and Moderate over Slow (M/S) permeability which favours runoff. The difference in permeability is a factor of the geology and topography. Where soils are slowly permeable there is a naturally higher susceptibility to runoff and erosion.

Due to silt textures and slow infiltration rates, the catchment soils are susceptible to erosion and runoff (Fig. 2). Silt-textured soils characterised by elevated susceptibility to erosion and runoff are common across eastern and southeastern Southland.

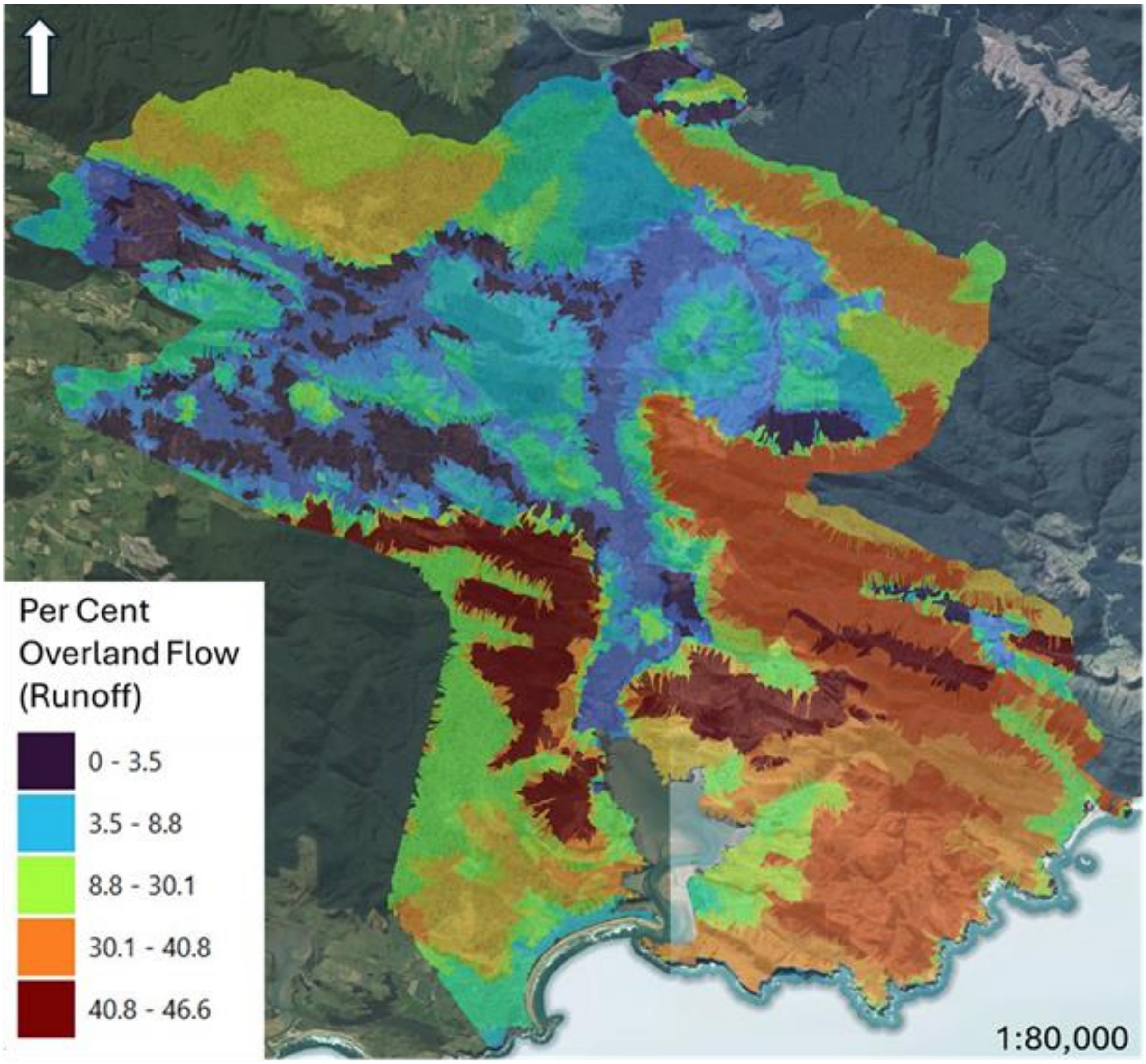

Figure 2. A model of the percentage of annual rainfall that occurs as runoff (overland flow) for the Waikawa Catchment. Note that runoff values >10% are elevated. Note: this model does not account for shallow groundwater in low-lying areas so may underestimate runoff risk around wetlands and areas with a shallow or perched water table.

Purpose of the Document

The purpose of this document is to introduce the **Source-Pathway-Receptor (SPR)** framework as a practical tool for identifying erosion and runoff-prone areas. By applying this framework, members of the Waikawa Catchment can prioritise their mitigation actions , ensuring these are efficient and impactful.

The SPR framework provides a simple yet adaptable structure that can be used across a range of landscapes and land uses to identify:

- **Source areas**: The main locations where erosion or runoff is most likely to originate.
- **Pathways**: The routes by which runoff travels from these source areas.
- **Receptors**: The open drains, streams, and water bodies that receive the runoff.

The examples in this document show how the **SPR** model can be applied to farmland within the Waikawa Catchment to support targeted mitigation efforts. It is designed to complement the erosion and runoff susceptibility classification produced by Land and Water Science but can also be used as a standalone resource or in conjunction with other tools.

While the application of the **SPR** framework at the catchment scale requires specialised prioritisation and community leadership, this document focuses on opportunities at the property scale, empowering individuals to make informed decisions about mitigation actions.

A Tool for Land Users

The goal of this document is to provide the Waikawa Catchment community with a tool that supports practical, locally led solutions to erosion and contaminant runoff challenges. By using the **SPR** framework, community members can:

- Identify areas where erosion and high-risk runoff are most likely to occur.
- Better understand how runoff moves through the landscape.
- Target mitigation actions to where they will have the greatest impact.

The SPR framework works best when it is informed by locale knowledge of the land and land use activities. Consequently, the expertise, skills, and insights that local farmers, foresters, and community members bring to managing the land are essential to the successful application of the SPR framework.

In addition to local knowledge, there are trained experts available to support community members in their decision-making. The team at Land and Water Science is committed to working with land users to apply the SPR framework, and Environment Southland's Land Sustainability Team offers a wide array of expert skills and experience to empower mitigation activities.

Alongside the Environment Southland's Land Sustainability team, various industry professionals, including those from Beef + Lamb New Zealand, the New Zealand Forestry Owners Association, and Deer Industry New Zealand, are also available to provide advice and support. These organisations bring valuable perspectives and resources to help the community make informed, strategic decisions about managing erosion and runoff.

This document can be used on its own or in partnership with these local experts to support strategic decision-making.

An Evidence Base for Mitigating Erosion and Runoff – Why Slowing the Flow Works

Over the past 100 to 150 years, land development in New Zealand has significantly increased the speed at which water leaves the land. Practices such as land clearance, subsurface artificial drainage, drainage ditches, and straightened streams all work to accelerate water movement, reducing the time water spends in contact with the landscape. This trend mirrors a global phenomenon tied to the intensification of land use for agriculture, forestry, and urban development.

The Impact of Water Speed on Water Quality

If there is one factor, aside from how the land is used, that determines water quality, it is the speed at which water moves across and through the landscape. Fast-moving water carries sediment, nutrients, and contaminants more easily to streams and rivers, leaving little time for natural processes to filter or break them down. Accelerated water movement also increases stream power, causing more erosion along streambanks and further reducing the land's ability to retain sediment and treat contaminants before they reach waterways.

For instance:

- Straightened channels in rivers can flow 2–3 times faster than natural meandering streams, increasing erosion and contaminant transport.
- Artificial drainage systems on farmland can double water movement speeds after heavy rainfall, further exacerbating nutrient and sediment loss.
- In catchments converted from native forest to pasture, the time water spends on the land (residence time) can decrease by 25–50%, bypassing natural infiltration and processing pathways.

These changes within a catchment are not minor. Faster water movement can elevate stream power by up to 50%, increasing streambank erosion and reducing the landscape's natural ability to filter out sediment and nutrients.

Soil Compaction and Its Role

Soil compaction, further contributes to rapid water runoff. This is a widespread phenomenon associated with land development. In New Zealand, bulk density, a key measure of soil compaction, has been shown to rise from about 1.1 g/cm^3 in undisturbed soils to 1.4–1.6 g/cm^3 across developed land.

This increase in soil density significantly reduces infiltration rates. Less compacted soils can absorb 20–30 mm of water per hour, while compacted soils may only manage 5–10 mm per hour. Reduced infiltration results in greater ponding, faster runoff, and increased transport of soil particles, organic matter, and nutrients. On steep or hilly terrain, this rapid runoff accelerates erosion along pathways like swales, gullies, and tributaries, further contributing to sediment and nutrient loss. In some cases, runoff rates from compacted dairy or sheep pastures can double or even triple compared to undisturbed soils.

Runoff Events: A Major Driver of Contaminant Loss

Critically, research in New Zealand and overseas consistently shows that a small number of high-intensity runoff events are responsible for the majority (up to 70–90%) of sediment and contaminant loss from developed land each year. Relevant here is that the quality of water leaving most properties is probably pretty good except for a handful of runoff events each year. These runoff events highlight the importance of slowing water down and managing its flow to reduce these losses.

Balancing Development and Sustainability

Land use is integral to economic and social well-being. However, we hope that understanding how practices like land clearance, drainage, and soil compaction affect water flow and quality supports an understanding of why investment in mitigation is so important. Slowing the flow of water not only reduces sediment and contaminant loss, but also helps protect the long-term value of the land.

By adopting strategies to control water movement, land managers have an opportunity to safeguard their livelihoods while supporting healthy waterways. Slowing the flow aligns the needs of the community with the broader goal of environmental sustainability, ensuring benefits for both the land and the people who depend on it.

The Opportunity to “Slow the Flow”

In summary, slowing down the movement of water across the land is not just an environmental focus; it is also a practical strategy to protect land use rights. Water that flows more slowly and spends more time in contact with the soil allows natural processes to act as filters, dropping sediment, binding nutrients, and breaking down contaminants. By managing water flow strategically, community members can significantly reduce sediment and nutrient loss while improving water quality in local waterways.

Slowing the Flow, Trapping, and Treating Sediment and Contaminants is Highly Effective

Here are summaries and findings of studies demonstrating how small-scale earthen or rock bunds and ponds reduce flow velocity, minimise contaminant export, and control erosion effectively in agricultural landscapes:

Detainment Bunds in New Zealand's Lake Rotorua Catchment

Detainment bunds (DBs), small earthen water retention structures, were installed in pasturelands across runoff pathways (swales). DBs, about 1.5-2.0 meters high, were found to significantly slow runoff, temporarily ponding water and allowing sediments and nutrients to settle. During a 12-month study in two catchments (20 ha and 55 ha), DBs reduced suspended sediment loads by 51-59% and total runoff volume by up to 43%. These results highlight DBs as effective, low-cost options for managing runoff and nutrient export from farmland.

Sediment Ponds in Idaho, USA

Small sediment ponds installed at the end of furrow-irrigated fields effectively trapped sediment and phosphorus. When combined with polyacrylamide (PAM) treatments in the fields, these ponds removed up to 86% of total phosphorus and 98% of suspended sediment from irrigation runoff, demonstrating their efficiency in retaining contaminants and improving water quality in drainage from farmlands.

Stone Bunds on Ethiopian Hill Slopes

Soil bunds on slopes in Ethiopia's Omo-Gibe River basin showed a remarkable reduction in runoff and soil loss. These small earthen structures lowered surface runoff by 80-92% and decreased soil loss by 96%. Bunds were especially effective on steep land, trapping sediment and preventing nutrients from washing away, which proved essential for protecting soil and water resources on sloping farmland.

Retention Ponds in UK's Belford Catchment

Small retention ponds, as part of a broader "Catchment Systems Engineering" approach, were used to slow and store runoff across the Belford catchment. These ponds successfully reduced peak flows and improved sediment trapping, mitigating the impact of high runoff events on downstream water quality and reducing the erosion potential along streambanks.

Southland Examples

Unfortunately, there have been few studies that document the reduction achieved by small-scale mitigations in Southland. One study undertaken by LWS employed peak-run-off control structures to reduce flow velocity and trap sediment in the Waituna Catchment. This trial identified an average reduction in sediment loss by 60% across the small control structures with a reduction of up to 180% at one site relative to control. However, there are many excellent examples of the application of the ***Source-Pathway-Receptor*** approach to farm and catchment scale mitigation of flow.

The above examples demonstrate how strategically placed '**detention**' (slowing the flow) and **'retention'** (trapping and treating sediment and contaminants) can effectively slow runoff, trap sediments, and reduce nutrient loss. Members of the Waikawa Catchment can use similar methods to protect soil, improve water quality, and enhance the sustainability of their lands by preventing valuable resources from washing away during heavy rain events.

Detention v Retention Structures

Note that '***detention structures'*** (e.g., bunds, rank grass, dense flax or tussock, staked hay bales rock or earthen bunds) are focussed on slowing runoff. In contrast, '***retention structures'*** (e.g., ponds, and wetlands – including long narrow corridors of dense flax stands) provide a longer-term and more effective solution for trapping and filtering runoff. Importantly, runoff from an area of accumulated animal waste is better treated by a retention structure that traps sediment and contaminants for as long as possible to maximise attenuation.

Water as a Vehicle

Water is a powerful vehicle—it mobilises soil and carries sediment, nutrients, and pathogens with it. The faster water flows across the land, the more it picks up, and the greater the losses we experience. These losses are not limited to soil; they also include essential nutrients and organic matter that would otherwise contribute to soil fertility and land productivity. Accelerated flow not only removes valuable resources from the land but also intensifies erosion in vulnerable areas, like gullies and streambanks, making the landscape even more susceptible to future damage.

Conversely, slowing down the speed water moves not only reduces erosion and contaminant loss but also increases the opportunity for contaminants to be attenuated via a range of natural processes (e.g., filtering, straining, denitrifying).

Therefore, the overarching concept to reduce sediment and contaminant loss is to **'slow the flow'** of water at strategic points within the landscape. By slowing down runoff, we give water a chance to interact with soil and vegetation rather than sweeping over it, which reduces erosion, increases the opportunity for contaminants to be naturally processed by the land, and protects downstream water quality. *Slowing water leaving the land also means less that rivers and streams* *have less erosive force, which is especially important given that 40 - 60% of the sediment exported by rivers to lakes, estuaries or harbours may be derived from streambank erosion.*

Recommended Plant Species
Jesse Bythell

When choosing plants to stabilise areas prone to erosion and runoff, international best practices recommend a focus on functional characteristics rather than specific species. The primary goal is to anchor the soil, slow water flow, and enhance infiltration, which helps prevent further erosion and promotes long-term stability. Understanding the functional qualities helps to choose locally adapted species. Locally relevant species provide additional benefits like biodiversity linkages and avoids the use of any potentially invasive introduced species. This multiple-benefit approach can make a project even more efficient and may also make it eligible for funding support from a wider range of sources (i.e. one project can achieve erosion, biodiversity and amenity goals).

Plants with robust root structures are particularly effective. Deep-rooted plants penetrate the soil profile, securing it against movement and reducing erosion on slopes or loose soils. Their roots improve soil structure, allowing water to infiltrate more easily rather than running off the surface. Additionally, plants with fibrous root systems create a dense network near the soil surface, binding soil particles together and preventing them from being detached by flowing water. This dual-layer stabilisation is crucial for protecting both the upper and deeper layers of soil in erosion-prone areas.

Dense, low-lying foliage is another critical characteristic, as it provides excellent ground cover, shielding the soil from the direct impact of raindrops. This protection reduces splash erosion and limits the formation of runoff, which often leads to further erosion. Fast-growing plants are particularly valuable because they quickly establish ground cover, minimising the window of vulnerability before permanent vegetation takes hold.

In areas where water collects or flows intermittently, plants that can tolerate variable moisture conditions are ideal. Species that thrive in both waterlogged and dry conditions ensure stabilisation in swales or along rill pathways. Furthermore, plants with high water-use efficiency can reduce excess soil moisture, helping to minimise runoff caused by soil saturation.

For many erosion-prone areas, soil quality is often degraded or compacted. Plants capable of thriving in low fertility, compacted, or acidic soils are essential for initial stabilisation efforts. These hardy species not only stabilise the soil but also improve its structure and fertility over time, paving the way for additional vegetation. Perennial plants are highly effective as they provide continuous stabilisation year-round, eliminating the need for repeated replanting. Low-maintenance plants are also a practical choice, especially for remote or challenging areas where post-planting care is difficult or more costly.

By selecting plants with these characteristics—strong root systems, dense foliage, adaptability to variable conditions, and resilience in poor soils—land managers can effectively stabilise areas that are susceptible to erosion and runoff, reduce sediment loss, and protect their valuable land.

Native plants evolved to be browsed by birds and most species do not tolerate browsing by ungulates (sheep, cattle, deer). In some contexts, you may be able to establish natives within a grazing regime, but this can be hard to get right. Exotic species like poplars or non-weedy willows may be suitable in grazing contexts (see advice below in Part 3).

Native Plants that Fit the Bill

There are hundreds of native plant species which naturally occur in the Waikawa Catchment, ranging from tiny coastal turf plants only a few centimetres tall to mighty rimu which live for centuries and grow to over 35 metres. This planting advice focuses on a subset of local plants with various adaptations for riparian environments including gully floors, backswamps, swales, riverbanks and other floodplain habitats. Some of these species were historically more widespread in the catchment but have become sparse due to past land management practices, For example flax / harakeke which is palatable to cattle and tends to dominate in fertile swamps which typically get drained for pasture.

=Species with the following characteristics are recommended because they also have the following characteristics which will help intercept sediment/nutrients and stabilise the land,thus slow the movement of water and help reduce erosion across the Waikawa Catchment:

- Perennial and evergreen
- Hardy and fast-growing
- Tolerant of wet, sour or compacted soil conditions (or occasionally silt deposition/burying)
- High water-use efficiency
- Root strength (lateral stabilisation and sheer resistance)
- A mix of taller species and lower groundcover species
- Taller plants are deciduous or semi-deciduous to reduce winter shading

Additional benefits of the recommended species include:

- Easy to source and propagate
- Low palatability to feral deer and goats
- Assist in gene flow with local plant populations for long-term resilience (native to the catchment)

- Relevant to habitats which are historically much reduced in the catchment
- Create biodiversity corridors for wildlife (invertebrates/fish/birds/bats)
- Provide a strong sense of place – local plants for local landscapes

The plants discussed here are 'first responder' species and over time planting sites will naturally become more diverse as other native species become established. Enrichment planting can be undertaken if desired, but there is generally a good seed source for many local species in the catchment and letting nature do the work can produce effective and efficient results.

For the full list of recommended species see Part 4.

At-Risk and Threatened Plant Species of the Waikawa Catchment

The Waikawa Catchment contains several plant species which have the conservation status of threatened or at-risk. The need for specialist advice relates to the existence of several at-risk and threatened plant species which could be enhanced with careful management. If you are unsure, please contact a local expert before removing or introducing new species. Given these plants may not occur anywhere else specialised advice is essential before any work is undertaken.

The following at-risk and threatened plant species occur in the Waikawa Catchment:

- **Twiggy mahoe (*Melicytus flexuosus*) Threatened – Nationally vulnerable**

  Prefers stressed sites such as fertile alluvial terraces prone to heavy winter frost and summer drought (can tolerate flooding).

- **Bloodwood (*Coprosma wallii*) At Risk – Declining**

  Prefers stressed sites such as fertile alluvial terraces prone to heavy winter frost and summer drought (can tolerate flooding).

- **Narrow-leaved tree daisy (*Olearia lineata*) At Risk – Declining**

  River terraces in or near seepages and ephemeral wetlands, sometimes even growing in shallow water.

- **Fragrant tree daisy (*Olearia fragrantissima*) At Risk – Declining**

  Gravelly soils such as steep gullies on the margins of forests.

- ***Coprosma virescens* (At Risk – Declining)**

  On well-drained to poorly draining fertile soils in riparian forest and shrubland.

Notes on Riparian Planting

Fencing and protecting existing remnants of native riparian vegetation is much more efficient than planting from scratch. In addition, connecting fragments of habitat leads to more resilient plant communities less impacted by weeds. Riparian planting in the Waikawa Catchment offers a chance to enhance and extend existing ecosystems as well as improve the health of freshwater and coastal ecosystems. Fencing and protecting existing remnants of native riparian vegetation is much more efficient than planting from scratch. In addition, connecting fragments of habitat leads to more resilient plant communities less impacted by weeds that are also more vigorous.

In pre-human times, the dominant ecosystems along the Waikawa River would have been kōwhai-ribbonwood-matai forest and around the estuary margins variously lowland podocarp hardwood forest (with localised kahikatea, rimu or matai depending on drainage and fertility), saltmarsh ribbonwood-jointed rushland or totara forest on stabilised dunes depending on the context. Riparian kōwhai-ribbonwood forest was historically rare in Southland and is now much reduced. Mobile and infertile sand dunes would have supported pingao sedgeland, and cold-stressed frost flats support communities of twiggy tree daisy adapted to the harsh conditions.

A range of inland freshwater wetland types would also have been more widespread in the catchment, including peat bogs, swamps, fens, marshes and oxbow lakes (cutoff meander channels). Some wetland types are very fragile and sensitive to soil chemistry and quite slow to develop, such a bogs. For fragile wetland, the best gains are made by restoring the few that remain. Other wetland types like marshes are fertile and historically have been developed, but can be relatively straightforward to recreate.

Remnant plant populations in parts of the Waikawa Catchment represent a reservoir of locally adapted genetics which are important for the overall restoration potential of the catchment and its rare ecosystems. Existing native vegetation provides clues about soil chemistry, hydrology and past river behaviour, as well as containing a complex community of soil fungi and bacteria which confer benefits to native plant species. Furthermore, these local populations contain genetics adapted specifically for the local conditions.

One of the key species most popular in riparian planting around New Zealand is lowland ribbonwood. This species naturally occurs in the Waikawa Catchment in riparian forest, is easy to propagate and fast growing. **The last Table in Part 4 'Planting for Success' contains a list of recommended species along with characteristics such as ease of propagation, growth rate and site requirements.** Groups of species are specified in the various Source-Pathway-Receptor scenarios elsewhere in the report.

Other species could be used for riparian forest restoration, however, expert advice is recommended site by site, as many of these other species are not tolerant of exposed conditions, are vulnerable to browsing mammals or are more technically challenging to propagate.

Fish Passage and Habitat Disturbance

Kelsi Hayes

This guidance on fish passage and habitat disturbance is specifically relevant to intermittent and perennial watercourses, particularly perennial streams that flow year-round. It is important to note, however, that the broader recommendations within this guidance document focus on avoiding work in perennial watercourses wherever possible. These areas are highly complex and present significant challenges, including regulatory requirements, the presence of threatened plant and aquatic species, and other ecological considerations.

The recommendations provided here are included for awareness purposes only, to help landowners and managers understand what can be achieved in perennial waterways if work is necessary and permitted. The primary focus of this resource remains on managing smaller, ephemeral runoff pathways and first-order streams, where the regulatory burden is lower, and the potential to mitigate sediment and contaminant loss is substantial without directly impacting sensitive or heavily regulated areas.

By being aware of the challenges and opportunities presented in perennial watercourses, land managers can make informed decisions while prioritising efforts in areas that offer the most straightforward and effective opportunities for environmental improvement.

Re-meandering and Channel Widening

Reintroducing meanders has the effect of increasing the total length of the riverbank and can introduce more varied habitats into the streambed through pools, riffles, and runs. Increasing the bends in a stream generally increases the pool area of streams which is an important habitat for species like the longfin eel, inanga, and kokopu. Kākahi/freshwater mussel populations in the Waikawa River are also found in greater abundance in pools. Increased bank length is an important consideration for species such as kōaro (climbing *galaxias*) and inanga (common *galaxias* or whitebait (as juveniles)), which use the bank for reproduction.

Channel widening can also introduce more varied habitats and may be beneficial for those species that use the banks and streambeds for reproduction. One impact of channel widening that should be considered is that it reduces the effect of the riparian margin in providing shade and habitat for the entire channel. Most native fish prefer to live in shaded areas and stream banks with debris. Ensuring there is sufficient riparian vegetation in these areas will provide a more stable and long-term habitat for native fish species to thrive.

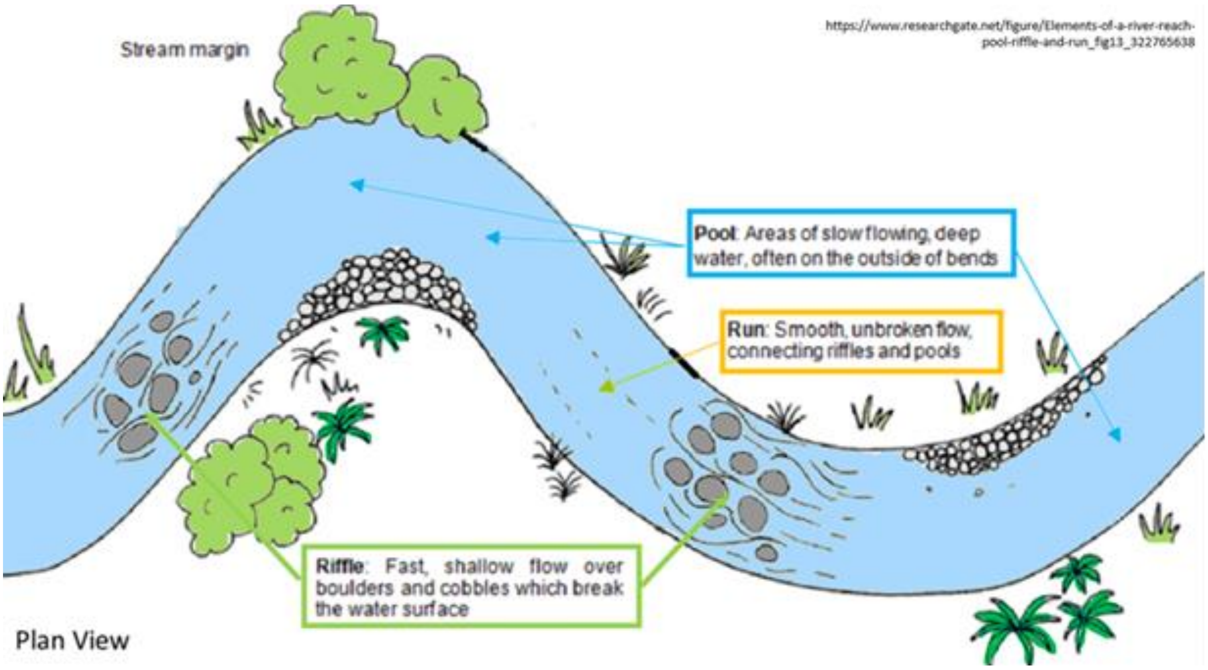

Figure 3. Diagram explaining pools, riffles, and runs in a stream (WaiGoodPolicy NZ).

Two-Stage Channel Design

In autumn, mature Inanga migrate downstream to spawn in flooded riparian vegetation. Introducing a vegetated flood plain in the parts of the catchment that are affected by the tide will introduce a breeding habitat. Ideally, livestock would be kept out of this flooded area during the autumn after spring tides. Spraying should also be avoided during this time. Even though the tide comes a long way up the Waikawa, this is probably only a concern for areas of the catchment below Mangaipiri/Niagara Falls and around the estuary as inanga are notoriously poor climbers.

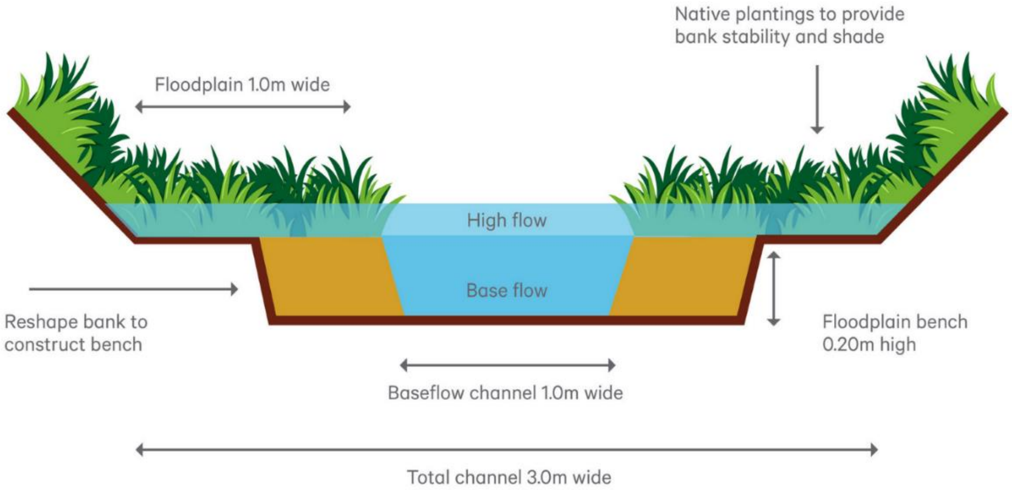

Figure 37. Two-stage channels are useful options for open drains and small tributaries but are less suited to larger streams (Living Water, n.d.).

In-Stream Structures to Distribute Flow Energy

Many indigenous fish species in New Zealand are diadromous which means they migrate between freshwater and the sea, 18 species of the total 35 indigenous freshwater fish migrate as a part of their natural life cycle. Kanakana/lamprey, both species of eel, torrent fish, some bullies, and all five of the native whitebait species are diadromous so they need access upstream and downstream.

While kanakana, torrent fish, and bullies all prefer swift currents, some of the whitebait species will actively avoid swift currents. Again, the poor climbing inanga will struggle to get over high barriers so height will be a consideration of structures within 10km of the estuary. The other species that avoid the main channel are very good climbers and penetrate further inland so structures in inland areas can be built higher, provided there is an artificial or natural ladder, i.e., creviced rocks, ropes, tree branches, or pipe. In areas with limited trout incursion, limiting fish passage to good climbers may be more beneficial to indigenous species in general but this should not be the status quo option and requires more specific investigation.

Other whitebait/galaxiid species, including some of the non-diadromous species which spend their whole lives in freshwater, use the banks for reproduction. For example, kōaro lay their eggs amongst rocks and stones on the bank during high flow events. This means that with riparian planting projects, spraying is inadvisable after heavy rain, even if the river levels have dropped. It is assumed that larval fish hatch at the next high-flow event but reproduction is staggered so some females will still be laying while larval fish are hatching.[33] It is unclear at which stage of the year spawning takes place in the Waikawa but it will be sometime during the summer months.

The presence and composition of sediment are important requirements for species such as kanakana/lamprey, koura/freshwater crayfish, and kākahi/freshwater mussels. Mechanical construction of instream barriers should be limited in all areas and avoided in areas with known populations of these species. Areas with these species are unlikely to require active management so this should not present a significant restriction for management efforts. Other fish are unlikely to be majorly impacted by short-term in-stream disturbance during construction and maintenance of in-stream structures.

Part Two

Source Pathway Receptor Tool

Community Toolbox for Mitigating Erosion and Runoff
Waikawa Catchment Group

Source-Pathway-Receptor Tool

The **Source-Pathway-Receptor (SPR)** tool provides a practical framework for identifying where runoff and erosion originate. It helps to highlight areas with elevated risk, which may arise from both natural landscape features (e.g., gullies, stream banks) and land use-related activities (e.g., gateways, wintering paddocks, skid sites, harvested forest). Importantly, areas with high risk that also have short and direct pathways to an open drain or stream represent the greatest overall risk. This is a factor of connectivity. Where the distance between a source and a receptor is short and there are few barriers to connection the risk is naturally elevated in contrast with scenarios when the path is long or there are numerous barriers along the path that work to slow down, trap, and treat sediment and contaminants.

1. As applied here, the SPR tool is used within the context of a watershed (Fig. 3). Watersheds can vary greatly in size, ranging from less than 1 hectare to hundreds of thousands of hectares.

2. For property-scale applications, we recommend focusing individual mitigation efforts on smaller watersheds, typically in the range of 2 to 5 hectares or less. Watersheds larger than 5 hectares often generate discharge volumes and energy levels that may exceed the practical capacity for effective mitigation.

3. For larger watersheds, we recommend the daisy chaining of multiple detention (slowing the flow) and retention (trapping and/or treating sediment and animal wastes).

Part 2 Covers:

- **Source Pathway Receptor Tool**
- **Why Focus on Ephemeral Swales?**
- **Daisy-chaining along a Flow Path**
- **Native Plants for Swales**

Source Pathway Receptor Concept

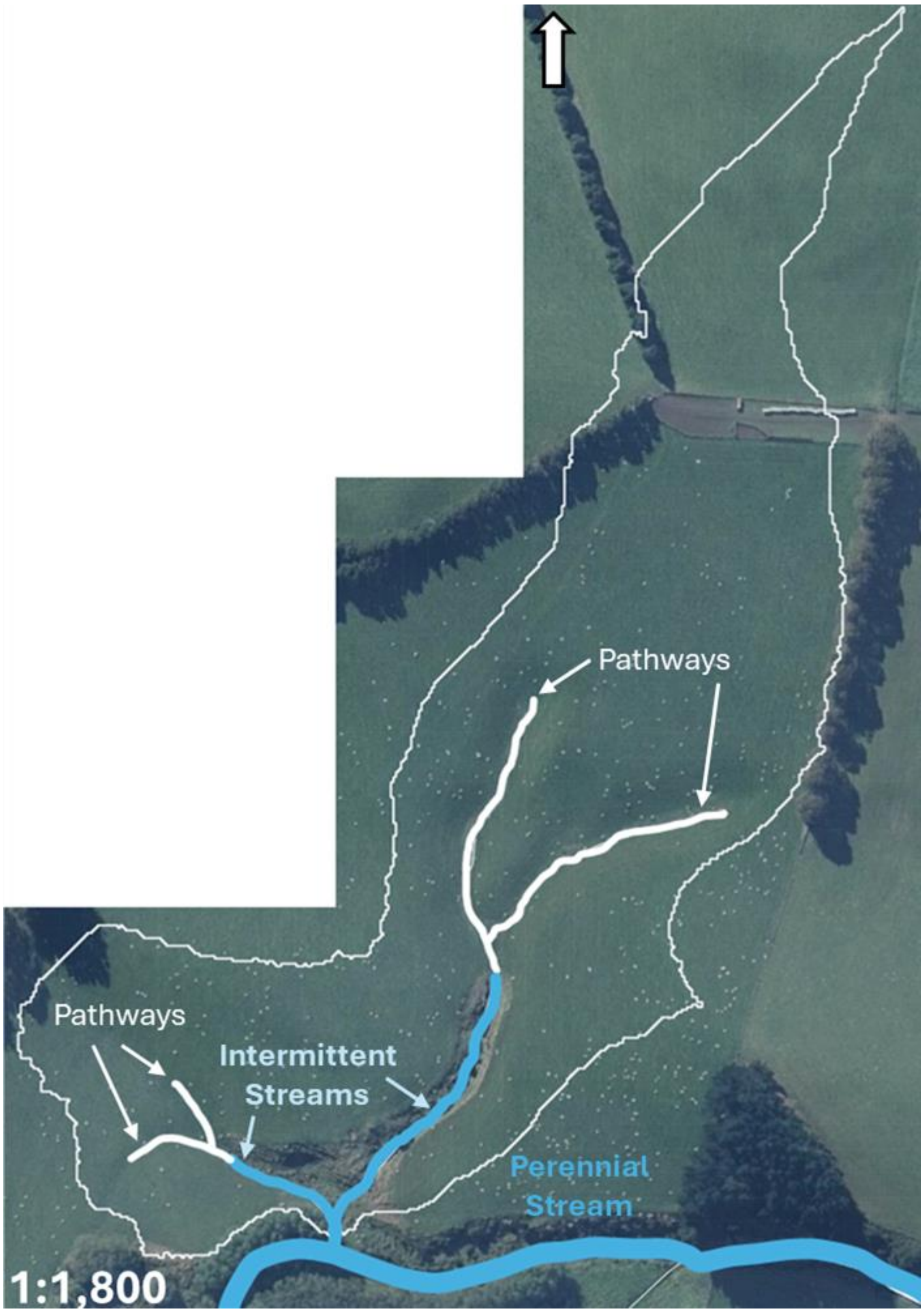

Figure 4. A fictionalised interpretation of a watershed within the Waikawa Catchment (~5 ha). In this case, soil creep and other erosional source areas are restricted to the slopes of the gullies that host the intermittent streams - these appear well-vegetated. Note that other than the intermittent streams, all land within the watershed boundary is a source area. Even under pasture, runoff will carry dissolved nutrients, animal manure, silt, and other debris (sticks, dead plant material) towards the pathways (swales), before discharging it into the area of intermittent streams. If the area of intermittent streams is channelised there will be little mitigation of runoff that reaches the perennial stream. If wintering or cultivation were to occur in this watershed the risk of sediment and contaminant loss increases dramatically.

Source Areas: Source areas within a watershed are locations where runoff or erosion begins, or where land use activities generate higher concentrations of contaminants on the land surface. While all developed land can act as a source area due to elevated levels of nutrients (e.g., nitrogen and phosphorus), pathogens, or sediments, certain areas pose a higher risk and contribute disproportionately to sediment and contaminants (e.g., bugs, nutrients, excess organic matter).

High-risk source areas can include a steep or erodible hill slope, compacted or heavily used soils prone to pugging and runoff, wintering paddocks, stock camps, frequently used gateways, or poorly managed drainage points. Beyond agricultural land, source areas may also include forestry blocks with exposed soils after harvesting, on-site disposal fields, construction sites, or industrial operations within a catchment.

If left unmanaged, these high-risk areas can release soil, nutrients, and other contaminants directly into runoff pathways (swales), streams, or rivers, contributing to sediment and contaminant loss. By identifying and managing source areas effectively, we can significantly reduce the volume of material entering runoff and minimise downstream impacts on water quality and ecosystem health.

Pathways: This is the route that water—and any mobilised soil, nutrients, or contaminants—takes as it moves downhill toward a stream, drain, or low-lying area. If a source area discharges to an adjacent paddock or low-risk environment it may already be partially mitigated.

Receptor: This is where soil, nutrients, or other contaminants eventually end up, often in a waterway or low-lying area. If the main receptor is an open drain or stream, then it is important to consider what options are best suited for mitigating runoff, trapping, and treating sediment and animal-derived contaminant losses.

Without effective management of the source and/or the pathway, runoff can transport significant amounts of sediment and contaminants to the receptor, negatively affecting water quality and downstream ecosystems. By the time runoff reaches an open drain or stream, it is often too late to prevent sediment and nutrient loss effectively.

However, collective efforts to slow the movement of water from source areas and along key drainage pathways can help reduce stream velocities and minimise stream bank erosion. These actions can significantly improve water quality and reduce the cumulative impacts of erosion and runoff on downstream environments.

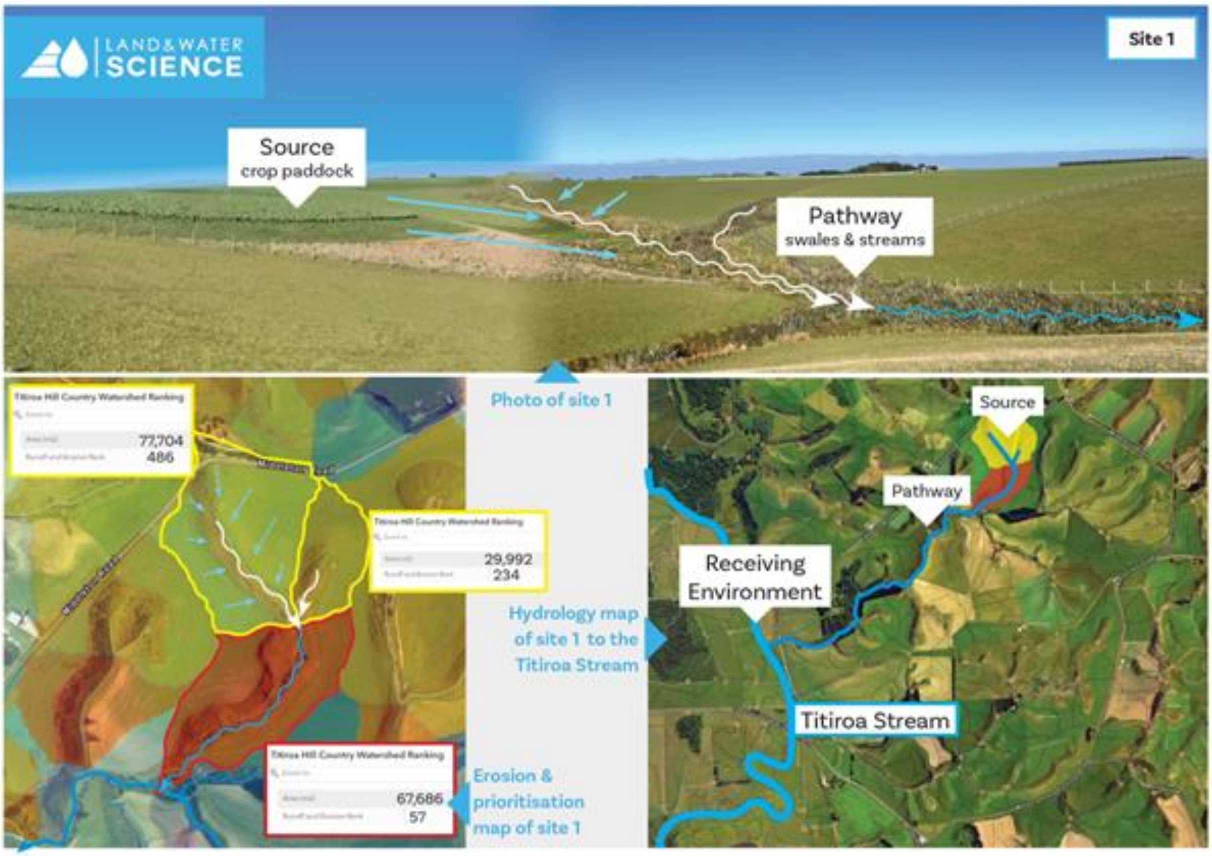

*Figure 5. A **Source-Pathway-Receptor** assessment for a property in the Titiroa Catchment, Southland (photos courtesy of Philip Golden). Note the wintering paddock as the **source** area and the dense stands of harakeke along the **flowpath** that act as detention structures. In this example, there is a sediment trap (pond) at the end of the Harakeke wetland. This is an example of an intervention that provides both detention and retention of sediment and animal wastes, conferring a high level of protection to the Titiroa Stream (**ultimate receptor**).*

After identifying the source area, trace the likely overland flow path (runoff) towards its ultimate destination. A direct pathway from a source area to an open stream or river is typically associated with a channelised structure or swale that does not contain adequate ground cover, **detention**, or **retention** structures to slow down the flow of water sufficiently for sediment and contaminants to either settle out or be trapped by vegetation. Where runoff has a clear shot from a source area to an open drain or stream the opportunity for attenuation is limited. Rank grass may be effective if the length of the pathway is long, otherwise it may be laid flat by the passage of water.

The **receptor** in this case is any **open drain, stream, or low-lying waterway where runoff could eventually end up**. If contaminants reach these areas, they can degrade water quality and affect downstream ecosystems. By intercepting and treating runoff along the pathway, we can significantly reduce the risk of contaminants entering waterways. Once the sediment or other contaminants have reached the stream it is too late, or at the very least too costly and challenging to remove. However, **riparian buffers, sediment traps (duck ponds), or wetland systems** can act as final filtration zones, catching residual sediment and nutrients before they reach open water. Dense planting in these areas provides a natural, last line of defence against contaminant loss.

"Before doing anything, identify the source area, identify the pathway that links the source area to an open drain or stream."

"The key idea is to identify and link source areas to receptor environments (open drains, streams) via a pathway."

"Prepare for the worst-case scenario."

Focus on Swales and Low-lying Drainage Pathways

A swale is often a natural feature that aligns with first-order drainage lines—small, shallow channels or depressions that typically follow the land's contours (Figs. 4 -8). These drainage lines play a vital role in managing surface water runoff, especially in rolling or hilly terrain. **Swales capture and concentrate runoff.** Even in relatively low-relief settings, lower-lying parts of the landscape function as a key pathway for water movement and the transfer of runoff from one area to another, or direct to an open drain or stream.

Swales typically collect and concentrate runoff from a much larger, uphill area, directing water downgradient. Normally, swales are **"ephemeral"** pathways, meaning they only carry water during heavy rainfall or very wet conditions and do not flow consistently. **Critically, due to their ephemeral nature, swales do not meet the requirements for fish passage regulations, making them suitable locations for strategic intervention to manage runoff and control contaminants.**

Therefore, **for effective runoff control, we recommend focusing interventions on the pathway —in this case, ephemeral swales—rather than directly in open drains or stream channels**. By working within swales, you can slow down the flow of water and give it time to spread out, allowing soil and vegetation along the pathway to absorb contaminants and nutrients. When done well, intercepting flow along a swale reduces the volume and velocity of water reaching open drains or streams, minimising erosion and protecting downstream water quality (see "**Slowing the flow, trapping, and treating is highly effective**").

Figure 6. Example of a swale (pathway) in a paddock that collects drainage and runs off in heavy weather (DairyNZ).

Figure 7. Pathways: Left: Overland flow (runoff) pathways, where blue dots are open drains. Right: A photo of the runoff associated with the blue dot on the bottom right of the lefthand picture (Tirlan).

Figure 8. Pathways. Runoff and water channelisation along ephemeral pathways, 3 - 7 days after a peak runoff event, Southland (LWS)

Why Focus on Ephemeral Swales?

Swales (ephemeral flowpaths) are ideal for interventions because they gather water from the entire watershed (Fig. 4). By considering the size of this source area and the type of flow along the pathway, you can tailor management practices—such as establishing buffer vegetation, constructing small bunds (water bars), or adding filter strips—to suit the needs of each swale. This slows down water movement and helps trap sediment and nutrients before they reach more sensitive water bodies. For property-scale applications, we recommend focusing mitigation efforts on smaller watersheds, typically in the range of 2 to 5 hectares or less. Watersheds larger than 5 hectares often generate discharge volumes and energy levels that may exceed the practical capacity for effective mitigation. For larger watersheds, the daisy chaining of multiple small detention (slowing) and retention (trapping and treating) structures along a flowpath is recommended (see Section 2.2).

Tips and options for interception along a flowpath (swale)

Avoid Channelising Flowpaths: Avoid channelising (ditch drainage) flowpaths, especially when they are connected directly from a source area to an open drain or stream[1].

Staked Hay Bales: Placing hay bales staked along the flow path can act as temporary sediment traps, slowing down the runoff and capturing sediment and organic material. These bales are especially useful in slowing down water during heavy rainfall events.

Figure 9. Staked haybales within an ephemeral flowpath that is connected to a perennial stream (Thriving Southland).

Vegetated Swales: Leaving any pathways or swales vegetated helps slow down water flow and allows the grass or other plants to filter out contaminants. Vegetation also stabilises the soil in these areas, reducing the risk of further erosion.

Figure 10. A vegetated swale between areas of grazed winter forage (Environment Southland).

Figure 11. A vegetated swale between areas of winter forage, early autumn, Southland (DairyNZ).

Dense Flax or Tussock Stands: In suitable areas, establishing dense stands of flax or tussock along the pathway is highly effective. Tussock and Harakeke (flax) naturally thrive in wet conditions, and their dense growth can force water to meander through a longer route, slowing it down and trapping sediment along the way.

Figure 12. Winter paddock (source area) with dense stands of flax (Harakeke) along the pathway to a perennial stream, Titiroa Catchment, Southland (courtesy of Philip Golden, Titiroa Catchment Group).

Sediment Traps and Small Wetlands: Where practical, constructing small sediment traps or *'retention'* basins along the pathway can help capture larger particles before the runoff reaches a sensitive receptor like a stream. These traps are especially effective when positioned just before water exits the farmed area or enters a wetland.

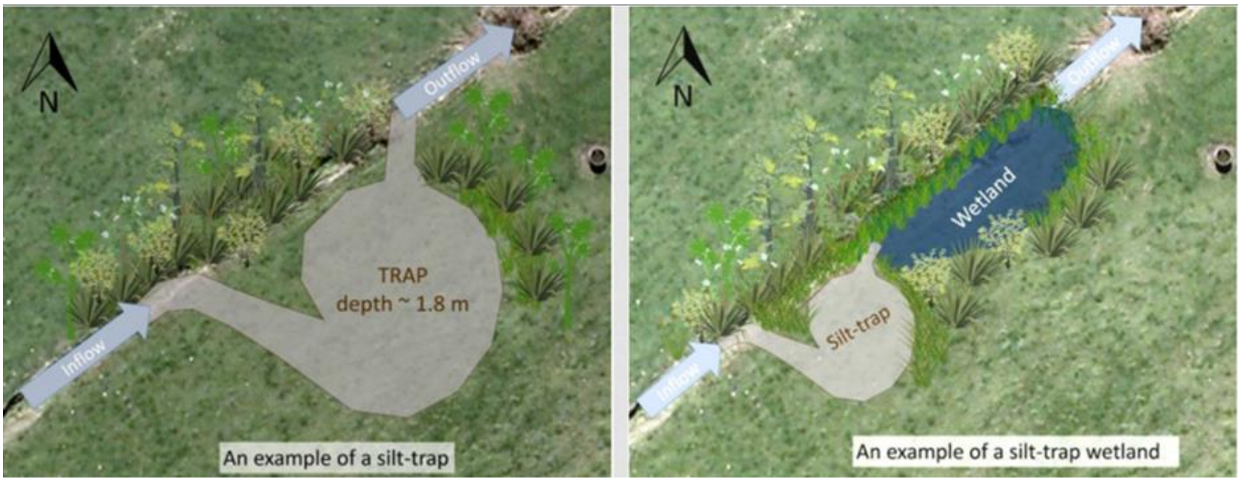

Figure 13. Retention structures along an overland flowpath. Left: Silt trap only along a flowpath. Right: silt trap and wetland along a flowpath. The combination of a silt trap and wetland is best suited for runoff from areas of concentrated animal wastes. A silt trap-only mitigation is suited for eroding soil (www.landscapeDNA.org).

Bunding/Check Dams/Water Bars: Earthen, rock, or timber (log) bunds can help slow down (detain) runoff and cause sediment to drop out.

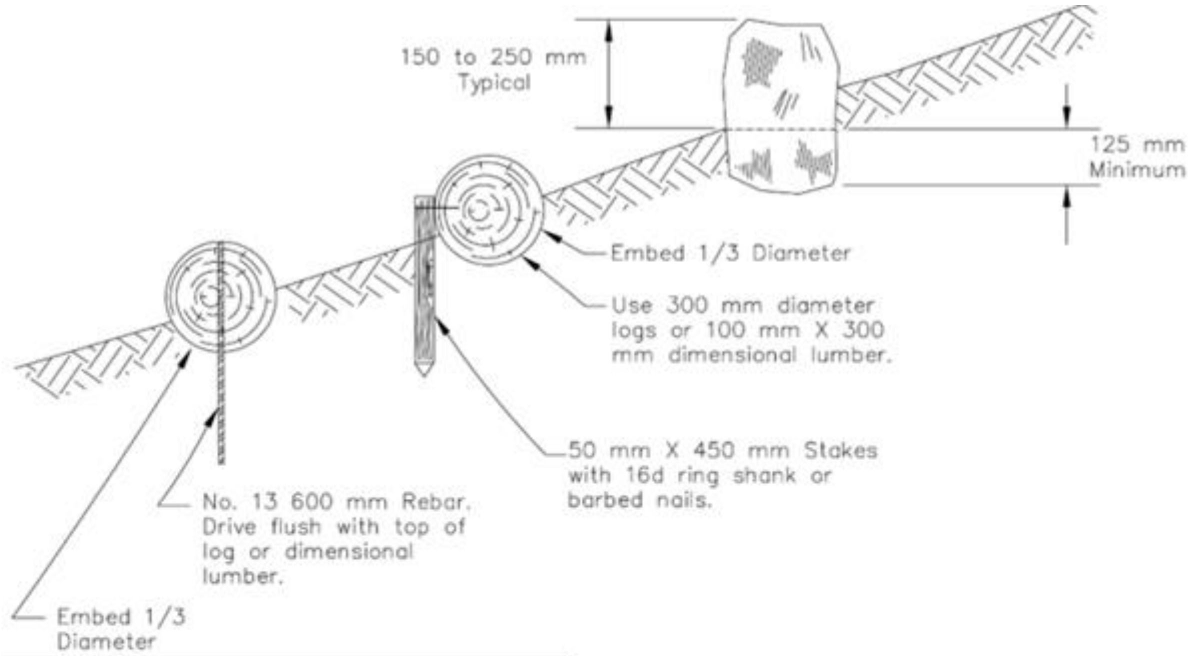

Figure 14. Log or boulder check dams (water bars) on a slope or within a flow pathway. Examples of a rock (upper), staked log, and rebar staked log, check dam designed to slow runoff and reduce erosion (United States Forestry Service).

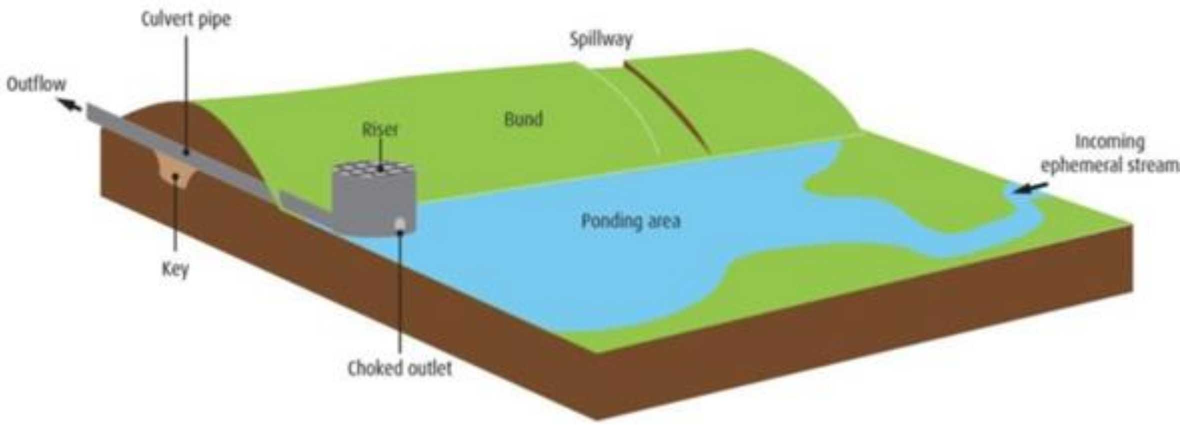

Figure 15. An example of a decanting earth bund. Runoff is trapped in a ponding area, and the reduction in velocity causes the sediment to settle out. Studies using this design in New Zealand and overseas have document large-scale reductions in sediment and contaminant loss to waterways (LandscapeDNA)

Note that ***'detention structures'*** (e.g., bunds, rank grass, dense flax or tussock, staked hay bales, rock or earthen bunds) are designed primarily to slow down the flow of water. Whereas ***'retention structures'*** (e.g., ponds, and wetlands (including long narrow corridors of dense flax stands) provide a more effective solution for trapping and filtering runoff. Runoff from an area of accumulated animal wastes is better treated by a retention structure that traps, filters and retains sediment and contaminants.

Figure 16. A sediment retention structure (sump) at the end of a runoff pathway, before an open drain (Aqualinc). The open drain is behind the end of the retention sump. The water gradually infiltrates through the soil to the stream, leaving the sediment behind.

Figure 17. Example of a wetland retention area adjacent to a ditch drain (Aqualinc). The wetland receives runoff from the surrounding farmland (up gradient from the photographed area).

Figure 18. A recently installed interception (detention) swale at the base of a steep hillslope (Tonkin & Taylor). Note the rock and earth wall in the top left and the use of geotextile and rock battering along the ephemeral flow path This is an example of daisy chaining. Over time the area will be colonised by plants.

Variable Width Buffers: Variable width buffers are scaled to the size of the area water is sourced from. The United States Department of Agriculture noted that variable-width buffers used 50% less land area and were orders of magnitude more effective at mitigating runoff than fixed-width buffers. This makes good sense given that runoff tends to enter an open drain or stream in a fixed location, along a flowpath, not uniformly.

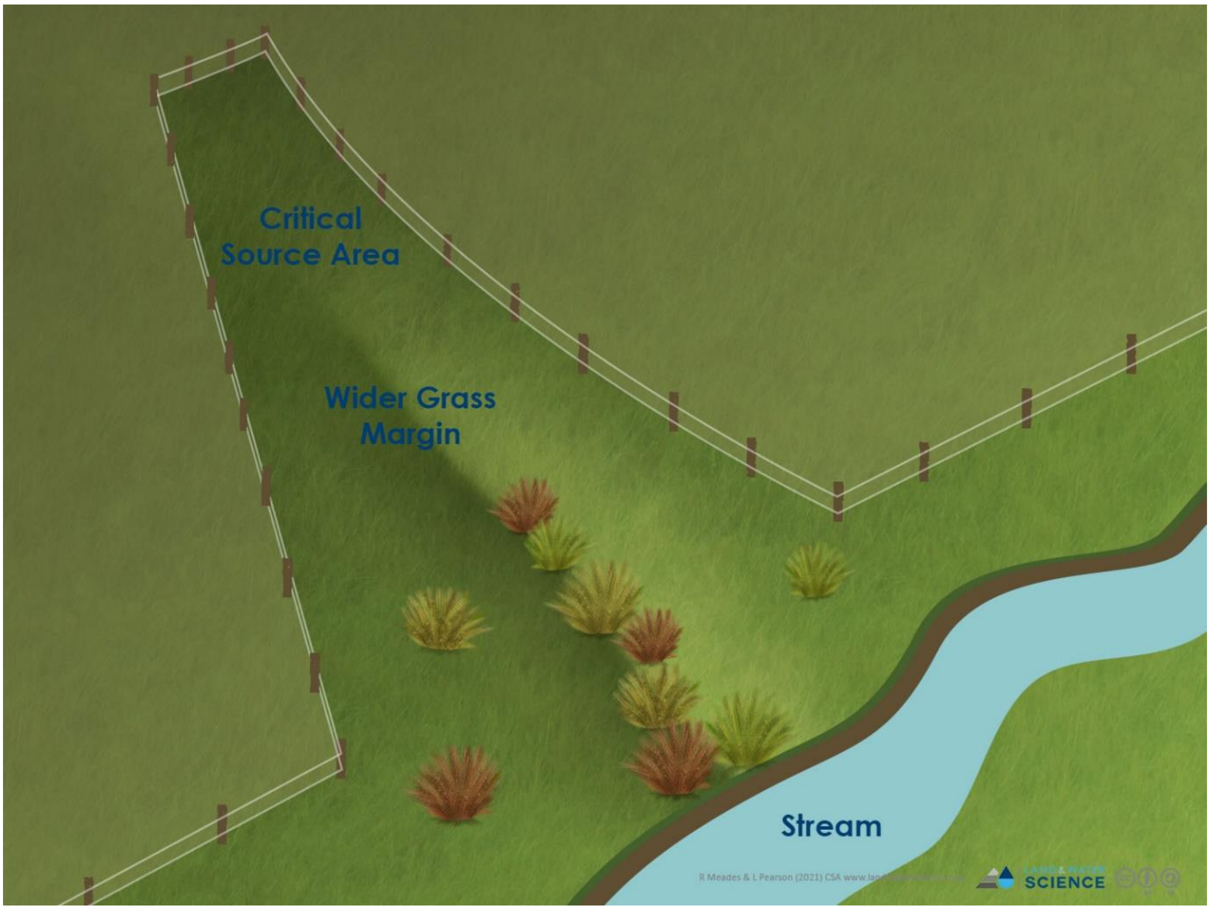

Figure 19. An example of a variable width buffer associated with a swale. Narrow fixed-width buffers are often ineffective when runoff is concentrated (www.landscapeDNA.org).

Planting Notes for Retention Structures

Note, there is a lot good of advice available for planting around constructed wetlands and retention ponds, but this advice is often generalised for all of New Zealand and recommends species which do not occur in Southland and may not thrive in the local conditions. Non-local natives such as raupō (Typha orientalis) or Cyperus ustulatus are not recommended here.

Around retention structures effective plants include toetoe, purei and flax. If sediment is to be periodically extracted, access should be considered within the design and shorter plants like purei planted at certain points. Extracted sediment should be distributed so it does not easily become mobilised again. In the flow-path purei and flax can be used on the wettest areas, South Island toetoe or flax on the drier margins. Including some taller plants on the outer edges such as ribbonwood or mānuka can provide some stock shelter.

Upper embankment:

- Copper tussock
- South Island toetoe
- Cabbage trees / tī kōuka

- Lowland ribbonwood / mānatu

Water's edge:

- Purei
- Flax / harakeke

Daisy-chaining along a flowpath

For effective water and contaminant management, especially where the contributing watershed is larger than 2-5 ha, the distance to a receptor is short, or the runoff volume is likely significant, we recommend using a **"daisy-chaining"** approach to mitigation. Instead of relying on a single, large structure at the bottom of a drainage pathway, daisy-chaining involves installing a series of smaller, strategically placed interventions along the length of the pathway. This approach can be more cost-effective, reduce the risk of structural failure, and enhance overall effectiveness in managing runoff.

Figure 20. Daisy chain (there are three of these structures in a row, one is hidden from view) of boulder check dams within an ephemeral (overland flow) pathway on a Southland farm – Jack Russel for scale (courtesy of Chris and Andrea Bullied, Waimea Catchment Group).

If you are seeking to mitigate runoff from an area with a high concentration of animal waste, you may need to consider the use of both **detention** (slowing) and **retention** (trapping and treatment) structures. **Runoff from source areas characterised by elevated animal wastes requires far greater treatment than runoff from an area of eroding soil or pasture.** As most forage crop areas, cultivated soils, or forestry blocks, are larger than 5 ha we recommend the use of daisy chaining of **detention** and **retention** structures along flowpaths (Figs. 9 - 21).

1. **Multiple Small Interventions**: Placing several small mitigation features along a swale or low-lying drainage pathway allows each intervention to capture and slow down water incrementally, reducing flow speed and contaminant load gradually. Examples include small berms, vegetated buffer zones, or shallow basins that help retain water and allow sediment and nutrients to settle out.

2. **Cost-Effectiveness**: Smaller interventions are typically less expensive to install and maintain compared to one large structure. They require less excavation, material, and engineering support, making them accessible for regular farm management budgets.

3. **Lower Risk of Failure**: Large structures can sometimes fail under heavy flow conditions, particularly if they are overwhelmed by runoff from a large catchment area. Smaller, distributed features, however, divide the flow management task, reducing stress on any single point and minimising the chance of erosion or overflow failures.

4. **Enhanced Effectiveness**: Small features along the pathway build on each other's effects. By slowing water flow at multiple points, the interventions work together to give contaminants more time to settle, nutrients a greater chance to be absorbed, and soil and plants along the pathway a longer opportunity to process the runoff naturally. This cumulative benefit of daisy-chaining results in a more thorough treatment of runoff before it reaches open drains or streams.

In essence, daisy-chaining small features provide a more resilient and adaptable strategy for handling runoff across diverse landscapes and paddocks, helping to retain valuable soil and nutrients on the land while protecting downstream water quality (Figs. 20 & 21).

Figure 21. Example of a daisy chain of interventions along flowpaths. Note the use of a densely vegetated gully floor, wetlands, and multiple ponds to slow, trap, and treat runoff from areas of winter grazing at the head of the gully (courtesy Murray Ward, Gore Catchment Group).

Finally, it is important to note that interventions **<u>are not recommended</u> in open drains (channels with seasonal flow for 3-6 months) or in perennial streams (channels that flow year-round except during extreme drought)**. These are complex environments requiring consent and fish passage considerations. By focusing on ephemeral runoff pathways, we maximise contaminant control while protecting the integrity of open drains and streams.

Native Plants for Swales

Where swales occur within a grazed area, the most practical steps may be to leave these vegetated with rank grass or any pre-existing vegetation such as rushes, copper tussock (*Chionochloa rubra* subsp. *cuprea*), flax / harakeke (*Phormium tenax*) or some tuft-forming evergreen sedges such as purei (*Carex secta*) or pukio (*Carex virgata*). Sward-forming sedges such as *Carex coriacea* or *Carex geminata* (often referred to as cutty grass) can often persist in swales, however, they are summer-green and thus provide less biomass to intercept water and sediments over the winter months when they have died down.

Typically, the rushes which persist in a grazed environment are the introduced species *Juncus effusus* and the native soft rush *Juncus gregiflorus*. Swales which only experience intermittent flows may be able to support South Island toetoe which prefers less saturated soils. Of these species, the most versatile and easiest to establish within a grazing environment is flax /

harakeke – it tolerates a wider range of soil moisture conditions and large fans, or entire plants, can be sourced and planted with relative ease.

All these species mentioned above are vulnerable to cattle browsing,therefore in some instances, it may be desirable to fence off key areas. All young plants are vulnerable to being trampled or plucked out by curious livestock of all classes so need to become established before grazing can occur. Depending on the site and wider context, permanent or cattle-only (single hot-wire) fencing may be suitable.

Swale species

- Retain existing vegetation where possible (e.g. rushes, sward-forming sedges and pasture grass)
- Plant additional species such as purei or pukio (*Carex spp*.), copper tussock, South Island toetoe or flax depending on moisture levels (permanent fencing may be necessary depending on stock type, temporary fencing is recommended until plants become established)

Part Three

Application of Source Pathway Receptor Tool

Community Toolbox for Mitigating Erosion and Runoff

Waikawa Catchment Group

Application of the Source-Pathway-Receptor Tool

1. **Identifying the Source Area**

2. **Identifying Pathways**

3. **Identify the Receptor(s)**

Part 3 Covers:

- **Creeping Soils (Terracettes) and Shallow Slips**
- **Actively Eroding Gully**
- **Rill Erosion**
- **Wintering Paddock Example**
- **Stock Camps and Gateways**
- **Farm Woodlots During and Post-Harvest**
- **Stream Bank Erosion**

Creeping Soils (Terracettes) and Shallow Slips

Before doing anything: Identify the source area, identify possible runoff pathways, and identify if runoff will make it to an open drain or stream.

Step 1. Identify the Source Area:

Creeping soils (small step-like formations or 'Terracettes') and shallow landslides indicate active soil movement and potential slope instability, resulting in sediment loss. The sidewalls of steep gullies or hillslopes are common locations for creeping soils and shallow slips to develop. Focus on the areas you consider the most severe and most critical to your farm performance. Where practical, stabilisation of the source area is the best bang for buck.

Figure 22. Photo of Creeping Soils (Terracettes) and small slops and slumps.

Creeping soils often evolve into small slips and slumps that release significant chunks of soil and expose bare earth. These areas are actively moving down the slope, albeit slowly enough to seem imperceptible (mm to cm per year). Movement is driven by the combination of gravity and wetting and drying cycles.

Figure 23. Creeping soils and shallow slips with exposed soil adjacent to an open drain or small stream.

Creeping soils and shallow slips are a form of mass wasting i.e., the movement of soil or earth materials downslope under the influence of gravity. In addition to movement downslope under gravity, the rough, exposed surface of creeping soils and shallow slips makes them prone to rapid erosion by running water, especially during heavy rainfall.

Management Options within the Source Area:

Exclude heavy stock classes, limit or stop clearing vegetation, and cease any cultivation: As these areas are already unstable trampling by heavy animals, further vegetation clearance or cultivation greatly exacerbates sediment loss and runoff volume. If practical, consider fencing these areas off. Restricting access by heavier livestock will help avoid mechanical disturbance of soil and vegetation damage, both of which can exacerbate erosion.

Revegetate: Plant deep-rooted vegetation, to stabilise soil, reduce erosion risk, and anchor the soil more effectively. This will help prevent the further development of terracettes and slips. Plants with a deep rooting network that are suited to exposed faces and can withstand pronounced seasonal variation in wetting and drying are required. Species that grow low to the ground, have a vigorous rooting network, are resistant to browsing by sheep or other smaller stock classes, and naturally spread out to cover the area are optimal.

Divert Water: If practical, construct shallow contour drains or minor berms (lips) above the area of creeping soils to intercept and redirect surface runoff, preventing it from saturating the area and carrying sediment downslope. Isolating the area from runoff that is generated upgradient is optimal but not always practical, which is why planting is so critical.

Figure 24. Creeping soils on a steep hill with areas of shallow slips and slides.

Native Plants for Creeping Soils

Plants with a deep rooting network that are suited to exposed faces and can withstand pronounced seasonal variation in wetting and drying are required for terracettes. Species that grow low to the ground, have a vigorous rooting network, are resistant to browsing by sheep or other smaller stock classes, and naturally spread out to cover the area such as South Island toetoe or flax are optimal for farming contexts. Copper tussock may also perform this role well, however, it is slower to become established than flax and South Island toetoe and therefore needs more post-planting care to survive amongst rank grass before sheep grazing could occur (cattle grazing is not advised within red tussock in this context).

Note, our native grasses evolved to be browsed by birds, which pluck out the tillers and feed differently to mammals which chew off the tips. Over-grazing copper tussock with cattle can cause it to collapse, but with care, it can be managed as a 'green infrastructure', offering good lamb shelter and soil conservation services.

Taller species which can rapidly grow and help stabilise shallow slips include mānuka (*Leptospermum scoparium*) and cabbage trees (*Cordyline australis*). Mānuka can laterally stabilise soils more quickly when planted densely and at higher stocking rates as found in naturally regenerating stands (Marden et al., 2018). Denser planting will also reduce maintenance costs by more quickly outcompeting weeds and pasture species. Cabbage trees have deep tap roots and can tolerate some burying so are ideal for planting at the bottom of an eroding hill face.

Planting mānuka or thin-barked tōtara (*Podocarpus laetus*) can combine soil conservation efforts with stock shelter and other benefits (e.g. honey or timber). However, using mānuka varieties bred for high methylgloxal content (or Ultra Mānuka Factor (UMF)) is not recommended as these are typically sourced from the North Island and will likely underperform in Southland conditions (Greer et al 1991). Indeed, a popular UMF mānuka is now regarded as a separate species (*Leptospermum tarawhitiensis*) native to the East Cape (de Lange et al. 2023).

Thin-barked tōtara has a slower growth rate than mānuka but it is long-lived and alsohas strong lateral roots which effectively stabilise soils (Bergin 2003). Note, thin-barked tōtara is the most widespread species in Southland (*Podocarpus laetus* not *P. totara*) and tolerates wider range of growing conditions.

Creeping soils/terracette species

- Copper tussock
- South Island toetoe
- Flax / harakeke
- Cabbage tree / tī kōuka
- Mānuka

Mikimiki (*Coprosma propinqua*)

- Thin-barked tōtara

Step 2. Identify the Pathway(s):

As revegetation and stabilisation of the source areas is often a slow process, the interception of runoff is a key management option. Runoff from an area of creeping soils can be diffuse but will tend to accumulate in one or more areas downslope. Try to identify the area at which pathways converge and act in this location.

Optimal solutions for runoff from an area of creeping soils are 'retention' structures, ones that trap and remove sediment and contaminants from flowing water (e.g. a sediment trap and treatment wetland). However, the type of intervention will depend on the size and severity of the source area. In some instances, a string of small 'detention' structures, e.g., small earthen bunds or rank vegetation, may suffice, especially if the source area has been stabilised with planting.

Step 3. Identify the Receptor:

The receptor, often an open drain, stream, or other low-lying waterway, is where water, along with any remaining sediment or contaminants, ultimately ends up. If the area of creeping soils and small slips does not discharge directly to an open drain or stream it is of lower priority. Once again, to maximise value, focus on the most severe areas which are most critical to farm performance.

As the revegetation and stabilisation of the source areas is often a slow process, riparian buffer zones or wetland vegetation near the receptor act as a last line of defence against contaminant loss. However, they are typically easily overwhelmed by concentrated runoff.

See recommendations regarding riparian plant species for the Waikawa Catchment.

Actively Eroding Gully

Before doing anything: Identify the source area, identify possible runoff pathways, and identify if runoff will make it to an open drain or stream.

Step 1. Identify Source Area:

A gully that receives runoff from upslope paddocks, with eroding sides (featuring creeping soils and small slips). The gully may/or may not have a channelised floor that accelerates water flow (i.e. a drainage ditch has been dug or a channel has naturally been incised by rapidly flowing runoff). The slopes of the gully, or in some instances the gully floor, contain little ground cover other than pasture or rank grass, with terracettes and occasional patches of bare soil increasing susceptibility to ongoing erosion and sediment loss. Some gullies may contain remnant scrub and native plants.

Figure 25. Eroding gully with creeping soils on steep side slopes and semi-vegetated floor.The main sources of sediment and contaminants are the unstable gully sides and any upslope paddocks. Bare soil, terracettes, and slips on the gully sides contribute significant sediment, especially during rain events.

Managing the Source

- Planting on Gully Sides: Re-establish vegetation on the gully sides to stabilise soil and reduce slips. Choose plant species that are excellent stabilisers of soil. Selecting plants with strong root systems and resilience to local conditions, including browsing by stock, is critical.
- Creating Buffer Zones Upslope: Where feasible, establish vegetated buffer zones upslope from the gully. These zones can intercept some of the runoff before it enters the gully, reducing both the volume of water and its speed, entering the gully.
- Redirecting Runoff: If practical, consider redirecting some water away from the gully using shallow contour drains or low bunds, especially during intense rainfall events, to reduce the water volume entering the gully.

Step 2. Identify the Pathway(s):

The gully floor acts as the main pathway, where water becomes concentrated, flowing rapidly due to the narrow shape. Flow from outside the gully or that generated from within the gully gets focussed or concentrated in the valley floor. In addition to transporting sediment and contaminants from upgradient areas, high-speed flows further erode the gully floor which often increases the instability of gully wall slopes.

Managing the Pathway (Gully Floor)

De-channelising and Slowing Flow: Avoid further channelising the gully base, as this practice only increases flow speed and erosive force. Instead, allowing water to spread out or force it to travel further (e.g., through a dense stand of flax, tussock, or other ground cover species), reduces velocity and potential erosion. If there are existing ephemeral (only runoff a few times a year) channels, consider planting them out with dense vegetation.

Flow-Reduction Structures: To slow water flow along the gully floor, consider placing temporary structures, such as staked straw bales, or rock check dams. These structures help trap sediment and reduce water speed, particularly during peak flow, while providing time for sediment to settle.

Vegetation on the Gully Floor: Where possible, encourage low-growing, durable plants to establish on the gully floor. Grasses or ground covers suited to stabilising soil and handling variable moisture conditions can help absorb some of the flow’s energy, further slowing water and trapping sediment before it is carried downslope.

Native Plant Species for Gully Walls and Floors

Gully floor species need to withstand constant moisture, gully side species need to tolerate seasonal wetting and drying cycles. Existing native vegetation may be providing some stock shelter which encourages animals to use this space, potentially exacerbating shallow slips. Existing native woody vegetation may provide clues as to what can grow in the area, but sometimes the plants that persist are remnants of forest ecosystems and established under more sheltered conditions. If the same species are planted out in the open without shelter they can be slow to establish or vulnerable to browsing while less than 2 meters tall (e.g. patē / sevenfinger (*Schleffera digitata*), kōtukutuku / tree fuchsia (*Fuchsia excorticata*) or *Coprosma rotundifolia*). Gully floors may already support a range of wetland plants such as sward-forming or tuft-forming sedges, rushes or flax. Minimising stock access to these areas will maximise plant performance.

Gully floor:

- Tuft-forming sedges such as purei and pukio
- Flax / harakeke

Gully sides:

- Cabbage tree / tī kōuka
- South Island toetoe (sunny edges)
- Mānuka
- Mikimiki
- Thin-barked tōtara
- Copper tussock (plant in sunny edges)

Step 3. Identify the Receptor(s):

Identify if the runoff from a gully ends up discharging directly to an open drain or stream (the receptor). If it does the receptor is likely a stream or drainage system downstream from the gully. Unmanaged runoff from the gully could deliver sediment and contaminants to these waterways, impacting water quality and stream health.

See recommendations regarding riparian plant species for the Waikawa Catchment.

Protecting the Receptor

Sediment Retention at the Gully Outlet: Where practical, consider installing a sediment trap or retention basin at the base of the gully. This structure can capture sediment before it reaches downstream waterways, helping maintain water quality in the catchment.

Riparian Buffers: Establish riparian buffers at the gully outlet or along any downstream waterways. Planting dense vegetation in these buffer zones can filter out sediment and nutrients before they reach water bodies, providing a final line of defence. However, without intervention along a pathway, riparian buffers are unlikely to be effective at mitigating significant runoff.

See recommendations re riparian planting.

Figure 26 Planted source areas (eroding gullies) and flowpaths on a Southland farm, provide maximum protection and negligible environmental risk to the operation (www.landscapeDNA.org).

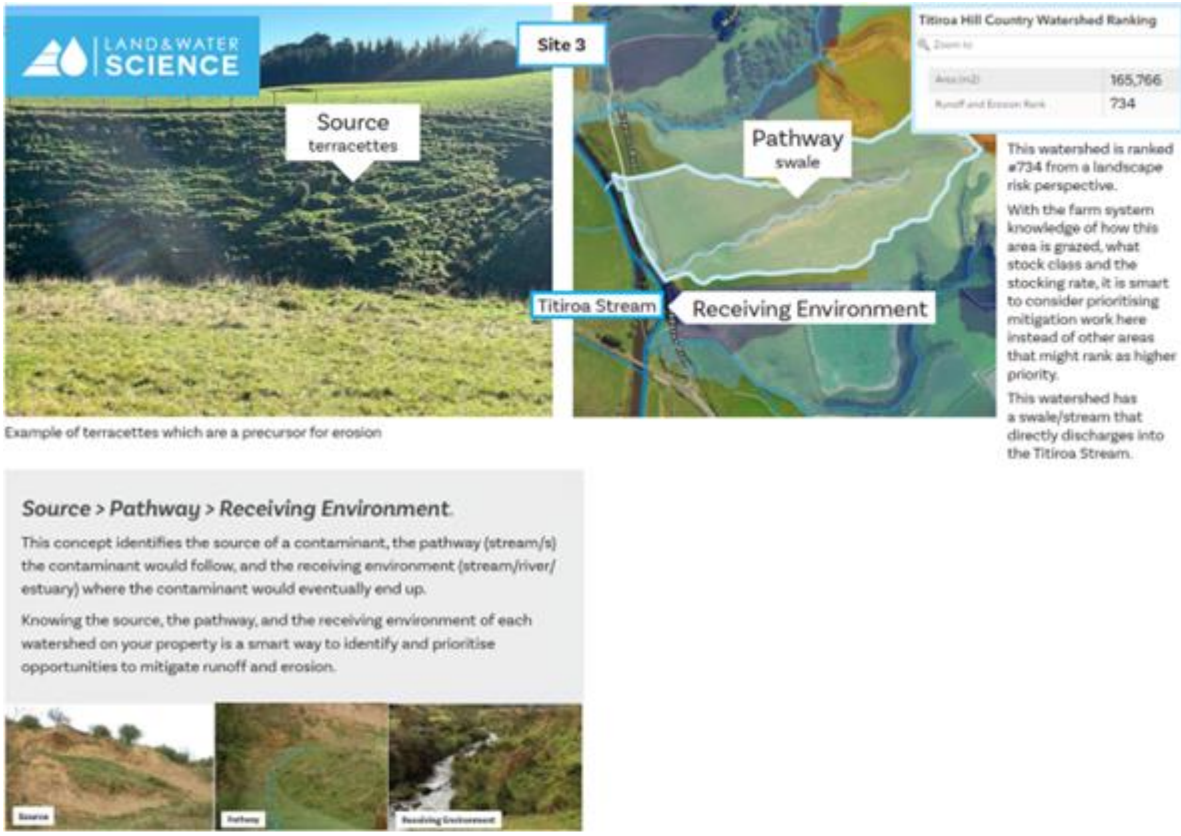

Figure 27. Example of application of the source pathway receptor approach to a narrow gully within the Titiroa Catchment. The side slopes are characterised by creeping soils and small slips (Courtesy Philip Golden, Titiroa Catchment Group).

Rill Erosion

Before doing anything: Identify the source area, identify possible runoff pathways, and identify if runoff will make it to an open drain or stream.

Step 1. Identify the Source Area

Rill erosion, characterised by the formation of long linear channels on sloping farmland, often arises due to concentrated surface runoff during heavy rainfall. Rill erosion is most common where silty soils, such as those in the Waikawa Catchment, have been cultivated. Left unchecked, rills can evolve into larger gullies, significantly reducing soil productivity and contributing to sedimentation in waterways.

Silt-dominated soils with low permeability and sparse vegetation (grass or scrub) cover are especially susceptible to rill erosion. A significant area of the Waikawa Catchment is prone to rill erosion due to silt-dominated soils that have slow infiltration rates that favour runoff generation (Fig. 1). ***The most effective mitigation is the stabilisation of the source area.***

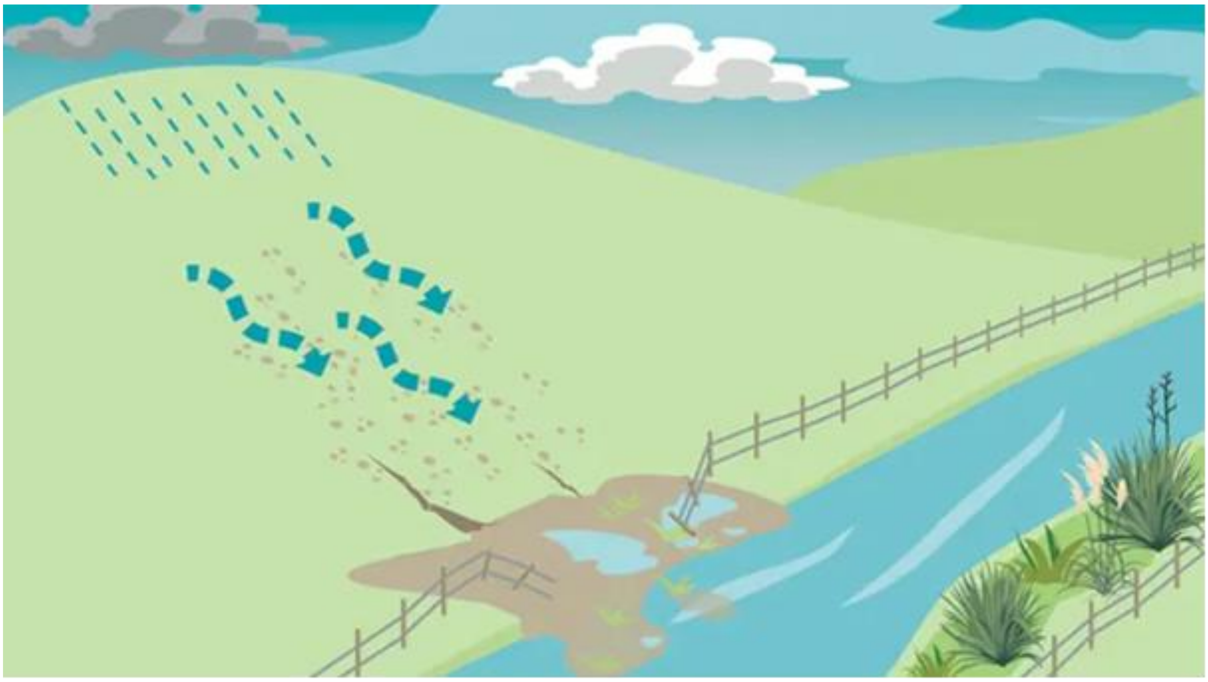

Figure 28. Runoff, rill erosion, and discharge to stream (DairyNZ).

Figure 29. Rill formation in a cultivated paddock (Tirlan)

Figure 30. A small area of rill erosion in silt (loess) soils (Environment Canterbury). The area of rill erosion can be small or large.

Managing the Source Area:

The primary goal is to stabilise the area of rilling. Effective stabilisation measures include:

Avoid Cultivation on Vulnerable Slopes: Avoid conventional cultivation of paddocks that have silt-dominated, slow-draining soils and are on slopes steeper than 10 degrees. Cultivation on these slopes can increase rill erosion risk, especially after heavy rains.

Use No-till Practices: Silty soils characterised by low permeability are especially susceptible to structural breakdown. Minimising soil disturbance preserves the soil's organic matter and enhances its structure, making it more resistant to erosion. No-till practices improve water infiltration, reducing the likelihood of runoff concentrating into rills.

Contour Farming: If cultivation is necessary, align planting rows along the contour of the slope. This alignment slows water flow, reduces the risk of rill formation, and promotes infiltration rather than runoff.

Maintaining Soil Cover: If rill formation occurs in a paddock planting or maintaining a cover crop, such as grasses or legumes, helps protect bare soil from the impact of raindrops and reduces the velocity of surface runoff. The vegetative cover provides a physical barrier that limits the initiation of rills and supports soil structure. If rill erosion occurs in an area of low productivity or particularly vegetated land consider planting species that anchor the soil, slow water flow, and enhance infiltration, which helps prevent further erosion and promotes long-term stability.

Diversion of Water: If practical, diverting water away from entering the rill can help slow down erosion and sediment export. However, any diversion would need to ensure that diverted runoff would not result in new rilling.

Step 2. Identify the Pathway(s):

Rills form channels that guide water downslope, increasing its erosive power and enhancing sediment transport. Consequently, the source area and the pathway overlap. Therefore, it is important to identify where channelised runoff leaves the rill and enters an open drain or stream. Identifying these channels allows for the strategic placement of erosion control measures. Intercepting and slowing water flow along the pathways that concentrate runoff. These measures are critical for reducing the erosive power of water and preventing further rill evolution.

Detention structures such as dense stands of flax or tussock and rock bunds along the flow path are effective at intercepting and slowing down the speed of runoff, thereby reducing erosion and sediment loss. The longer the rill the greater the number of small detention structures required. The goal is to slow the flow.

Native Plants for Rill Erosion

If land is to be retired from grazing, then fast-growing natives can be used. Species like flax and cabbage trees are tolerant of some silt burying and variably wet/dry conditions typical at the lower end of a rill erosion area. The area could be fenced with a single hotwire to exclude cattle and permit sheep access once plants are established.

In some contexts where erosion management and summer shade for stock are desirable but retirement from grazing is not practical, planting poplars or willows could also be considered. Advice can be sourced from the NZ Poplar and Willow Trust or the local branch of the Farm Forestry Association as to which poplar hybrids and varieties have the requisite qualities for Southland conditions and how to establish these in a grazing context. Willows and poplar hybrids can offer some forage for native species such as kereru / wood pigeons. Planting weedy species such as crack willow (*Salix fragilis*) or pussywillow (*Salix cinerea*) is not permitted under the Southland Regional Pest Management Plan (SRPMP 2019). If in doubt, check with an expert about which species you are using before planting potentially invasive plants.

Step 3. Identify Receptor:

If unchecked, rill erosion channels can transport large quantities of sediment and other contaminants directly to open drains or streams. Riparian buffers may be inadequate when associated with concentrated runoff. So, if rill erosion leads to sediment transport into waterways, additional receptor-focused measures may be necessary such as constructed wetlands or large vegetated buffers. *See recommendations regarding riparian plant species for the Waikawa Catchment.*

Wintering Paddock Example

Before doing anything: Identify the source area, identify possible runoff pathways, and identify if runoff will make it to an open drain or stream.

Step 1. Identify the Source Area:

In this case, the source is a winter grazing paddock. During winter, these paddocks become heavily loaded with contaminants due to the density of stock and the high concentration of effluent, mud, and bare ground. As a result, any runoff from these paddocks is likely to carry a high load of nutrients, sediment, and pathogens.

While it is not practical to stabilise the paddock directly, farmers with the catchment are already employing good management practices such as grazing downhill to minimise trampling near waterways, leaving grass buffers around the paddock, and carefully managing stock movement to reduce soil damage. However, under high-intensity rainfall or wetter-than-average conditions, these mitigations may be inadequate to stop runoff and contaminants from leaving the source area and reaching an open drain or stream. Unfortunately, runoff from winter grazing constitutes the highest possible risk to the environment of all farm practices.

Step 2. Identifying the Pathway(s):

The pathway is where we focus our interventions for winter grazing paddocks. Runoff from the paddock is likely to flow along natural drainage lines, swales, or low-lying areas. There may be more than one pathway or swale leaving a wintering paddock. These pathways become the critical points for intervention to slow down the water, trap sediment, and filter out contaminants before they reach an open drain or stream.

Optimal solutions for runoff from an area of accumulated animal wastes are ***'retention'*** structures, ones that trap and remove sediment and contaminants from flowing water (e.g. a sediment trap and treatment wetland). In some instances, a string of ***'detention'*** structures, e.g., small earthen bunds or rank vegetation, may be useful upgradient of a final ***'retention'*** structure. Two notable examples that combine ***'detention'*** with ***'retention'*** structures to slow, trap, and treat runoff from winter grazing from Southland farmers are provided below (Fig. 31).

Figure 30. Two examples of combining detection (slowing the flow) and retention (trapping and treating) runoff from areas of winter grazing, Southland. Note that the dense stand of flax (Harakeke) in the bottom example (Philip Golden, Titiroa) acts as both a detention and retention structure and that there is a retention pond at the end of the flax wetland corridor.

The examples provided above of mitigating runoff from winter grazing provided by Southland Catchment group members are excellent examples of combining **detention** (slowing the flow) and **retention** (trapping and treating) along a flowpath. As winter-grazed paddocks constitute the greatest sediment and contaminant loss risk of all farm activities it is important to consider **retention** not just **detention**. However, any vegetation that intercepts, traps, and extends the path that runoff must take before reaching an open drain or water course will be of benefit.

Native Plants for Animal Wastes

Refer to comments about swales in Part 2. The most versatile species are flax and to an extent purei and sometimes copper tussock which tolerate nutrients and water running in, but these need stock excluded from them. Grass/strawbales/better wintering practices are probably easier to apply in a grazing regime.

Note, there is a lot good of advice available for planting around constructed wetlands and retention ponds, but this advice is often generalised for all of New Zealand and recommends species which do not occur in Southland and may not thrive in the local conditions. Non-local natives such as raupō (*Typha orientalis*) or *Cyperus ustulatus* are not recommended here.

Around retention structures effective plants include toetoe, purei and flax. If sediment is to be periodically extracted, access should be considered within the design and shorter plants like purei planted at key points. Extracted sediment should be distributed so it does not easily become mobilised again. Plants for the flow-path include purei and flax on the wettest areas, South Island toetoe or flax on the drier margins. Including some taller plants on the outside edge, such as thin-barked tōtara, ribbonwood or mānuka, can provide some stock shade and shelter.

Upper embankment:

- Copper tussock
- South Island toetoe
- Cabbage trees / tī kōuka
- Lowland ribbonwood / mānatu

Thin-barked tōtara

Water's edge:

- Purei
- Flax / harakeke

Step 3. Receptor:

The receptor, often an open drain, stream, or other low-lying waterway, is where water, along with any remaining sediment or contaminants, ultimately ends up. Protecting the receptor is essential, as contaminant loads here can impact downstream water quality and ecosystem health.

See recommendations regarding riparian plant species for the Waikawa Catchment.

Stock Camps and Gateways

Stock Camps and Gateways

Before doing anything: Identify the source area, identify possible runoff pathways, and identify if runoff will make it to an open drain or stream.

Step 1 Identify Source Areas:

Stock camps and gateways, where livestock frequently gather, often experience pugging, soil compaction, vegetation loss, and high concentrations of animal waste. These areas are particularly vulnerable to erosion and contaminant runoff.

Figure 31. Gateways are often close to waterways.

Step 2 Identify Pathways:

As there is often little that can be done to stop soil damage or animal waste accumulation in these areas it is best to identify the pathway any runoff might take to an open drain or stream.

Management Options:

Redirect Runoff: Install diversion channels or low berms to guide runoff away from watercourses to an area where the runoff can be intercepted and treated.

Retention Structures: Due to the high concentration of animal wastes the use of retention structures is recommended. A retention structure should retain, trap, and isolate the sediment and contaminant load from these areas, but allow the water to drain:

A pond (sediment trap) with a wetland outlet is a good example of a retention structure. It need not be large if the source area is relatively small.

Dense stands of flax or tussock along a flow path may also act as a retention structure, retaining contaminants and slowing down water movement.

Detention Structures: If the source area is small and there is ample distance between it and a receptor (open drain or stream), simple detention structures may be sufficient. In this case, place structures along the pathway to slow runoff and trap sediment:

Staked Hay Bales: Temporary sediment traps during peak flow periods.

Bunds: Small earth bunds to pool water and allow sediment to settle out.

Sediment Traps: Excavated traps near gateways or stock camps to capture and retain sediment.

Vegetated Swales: Low-lying, grassy swales that act as natural filters by slowing water and capturing contaminants.

Native Plant Species for Gateways and Stock Camps

Interception of overland flow/nutrients/water in these high-traffic areas can be challenging because they are not always set up to allow space for planting. Poplar varieties with their upright form, fast growth and deciduous quality coupled with a row of purei to intercept overland flow or South Island toetoe may be a suitable combination depending on the context and space available.

When designing new crossings/lanes/gates provide sufficient room for plantings to intercept contaminants. Check how big plants can get to avoid the ongoing cost of continually pruning lanes/gateways/crossings. A row or two of sedges purei or pukio can be helpful where space is limited, if there is more space then flax may also be suitable. Copper tussock may be used, but due to its slower growth rate it needs more diligent post-planting care to establish amongst tall rank grass species such as cocksfoot compared with purei or toetoe – young copper tussock plants can easily be overshaded and succumb to rot when smothered by tall grass.

Stock camps are often a result of limited areas of shade or shelter in the paddock. Consider planting additional shelter to disperse stock more evenly – this has animal welfare benefits too. South Island toetoe makes good low shelter for lambing but will not tolerant saturated soils so it is not suitable for spots where excess water is running in. Flax makes excellent low shelter and is very tolerant of sediment and nutrients, but sufficient space must be allowed for it that so fences and other infrastructure are not affected (2x2m area per plant is recommended).

Step 3. Identify the Receptor:

Pathways from stock camps or gateways often lead directly to open drains or streams, where the accumulated contaminants can degrade water quality. Riparian buffers unless very wide (10s or meters), are unlikely to be adequate. However, they offer a last line of defence.

See recommendations regarding riparian plant species for the Waikawa Catchment.

Farm Woodlots During and Post-Harvest

Before doing anything: Identify the source area, identify possible runoff pathways, and identify if runoff will make it to an open drain or stream.

Forestry on marginal lands, particularly in New Zealand, presents significant challenges due to the poor and erodible soils common in these areas. The removal of forest canopy during harvesting operations exposes soil to the elements, leading to substantial sediment loss. Research highlights that sediment yield can increase dramatically after harvesting, with studies documenting total sediment yield (TSY) increases of up to 700%, equivalent to 477 tonnes per square kilometre per year in extreme cases. This phenomenon is particularly pronounced during clearcutting and heavy precipitation events, where roads and skid trails become significant sediment sources [28-32].

The dynamics of sediment loss follow a predictable cycle. Sediment yield peaks during the harvest phase due to soil disturbance and typically decreases as vegetation recovers. **However, this recovery process can take decades, depending on soil type, management practices, and environmental conditions.** Research globally and in New Zealand has shown that sediment yields tend to stabilise once forests mature, but harvesting activities trigger another significant spike in sediment loss. This pattern underscores the importance of long-term planning and sustainable management practices to mitigate sedimentation risks [28-32].

Compared to other land uses, sediment loss from harvested forests is often higher, particularly due to the increased hydrological connectivity and the extent of exposed soil during the harvesting period. This highlights the importance of adopting stringent management practices to reduce sedimentation and ensure landscape stability, especially when forestry is conducted on fragile, marginal lands prone to erosion [28-32].

In summary, woodlot forestry on marginal and easily erodible land poses significant sedimentation risks, particularly post-harvest. While mitigation strategies can reduce sediment loss, these require rigorous application tailored to specific site conditions. Currently, erosion management from harvested forests is poorly managed in New Zealand.

"Before starting: Identify the source area (e.g., harvested woodlot), runoff pathways (e.g., skid tracks, haul roads, gullies, swales), and the receptor (e.g., nearby waterways or drains) to prioritise interventions."

Step 1: Identify the Source Area:

Harvesting operations in woodlots can expose large areas of bare soil, especially on steep slopes or poorly drained sites. Soil disturbance from machinery, removal of tree cover, and concentrated water flow along tracks can result in significant runoff and sediment generation.

Figure 32. Commercially harvested woodlot, Waikawa Catchment.

Figure 33. A farm woodlot, c. 1-year post-harvest.

Key source areas include:

- Skid Sites and Haul Roads: These areas often have compacted soil, leading to poor infiltration and high surface runoff.
- Steep Slopes: The removal of trees can destabilise soil, increasing the risk of erosion.
- Exposed Bare Earth: Harvesting exposes soil to rainfall, making it vulnerable to sediment loss.

Management Options for Source Areas:

- Limit Soil Disturbance: Plan harvesting to minimise ground disturbance, particularly on steep slopes or erodible soils. Use low-impact machinery or cable logging systems where possible.
- Revegetate Quickly Post-Harvest: Replant harvested areas as soon as practical with either production species or stabilising cover crops (e.g., grasses or legumes). For erosion-prone areas, consider deep-rooted, fast-growing species.
- Stabilise Skid Sites: Regrade skid sites after harvest to promote even water distribution and reduce concentrated flow. Seed with fast-growing ground cover to stabilise the surface.
- Divert Runoff: Construct shallow contour drains or berms upslope to intercept and redirect water away from bare soil and steep slopes.

Step 2: Identify the Pathway(s)

Runoff from harvested woodlots often follows tracks, gullies, or other low-lying areas, concentrating water flow and increasing its erosive power. Sediment-laden water from these pathways can quickly reach nearby waterways if left unmanaged.

Management Options for Pathways:

Check Dams (Water Bars) and Cross Drains: Install check dams (also called 'water bars') on steep slopes, natural swales or gullies, and skid sites to break up runoff pathways and redirect water into stable, vegetated areas. Check dams and cross drains are erosion control structures designed to manage surface water runoff on harvest or bare-sloping land. They redirect water flow off the surface to reduce erosion and prevent concentrated runoff from causing damage further downslope. Here is an explanation of each:

A check dam is constructed diagonally across a steep slope or along a flow pathway to slow down and or divert water towards a stable vegetated area.

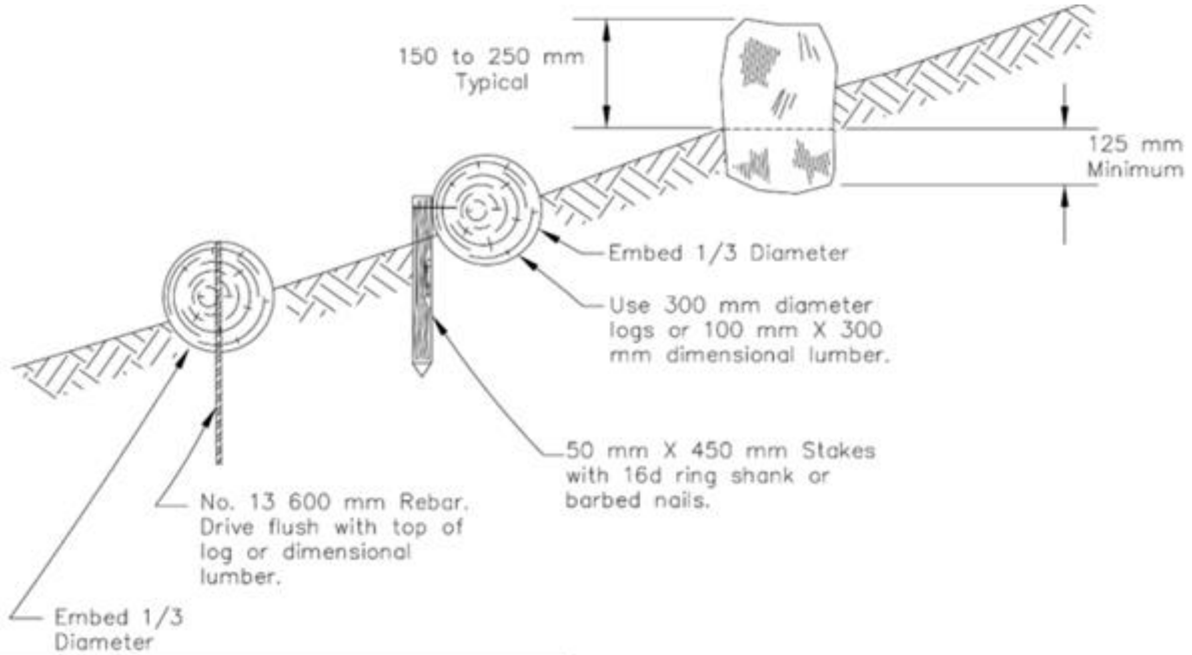

Figure 34. Example of a rock (upper), staked log, and rebar staked log water bar (check dam) on a harvested slope designed to slow runoff and reduce erosion (United States Forestry Service).

Purpose of a check-dam or water bar:

- Reduce the speed and volume of water flowing along a track or road.
- Minimise erosion caused by concentrated runoff.
- Direct water into areas where it can safely infiltrate into the ground.

Construction:

- Typically made from soil, rocks, or timber. Installed at a slight angle (30–45 degrees to the road or track) to direct water off the surface. Spaced at regular intervals depending on the slope and soil type (steeper slopes require closer spacing).

Applications:

- Used on forestry roads, farm tracks, and trails in steep or erosion-prone areas. Ideal for controlling water during and after woodlot harvesting operations.

Cross Drain

A cross drain is a culvert, pipe, or channel installed underneath a road or track to carry water from one side to the other, preventing it from pooling or flowing along the surface.

Purpose:

- Safely channel water under roads or tracks to reduce surface runoff and erosion. Maintain the structural integrity of roads by preventing water damage.

Construction:

- Made from durable materials such as plastic or concrete pipes or excavated earthen channels.
- Installed perpendicular to the slope and at intervals to capture runoff.
- The outlet must direct water to a stable, vegetated area to prevent erosion.

Applications:

- Commonly used on haul roads, skid trails, and other high-traffic areas during forestry and agricultural operations.
- Effective where water bars are insufficient, such as in areas with high water volumes or where water must cross a road.

Both structures are essential tools in managing runoff and preventing erosion, particularly in areas like farm woodlots, forestry operations, and steep farm tracks. Using them in combination can provide effective water control across a range of conditions.

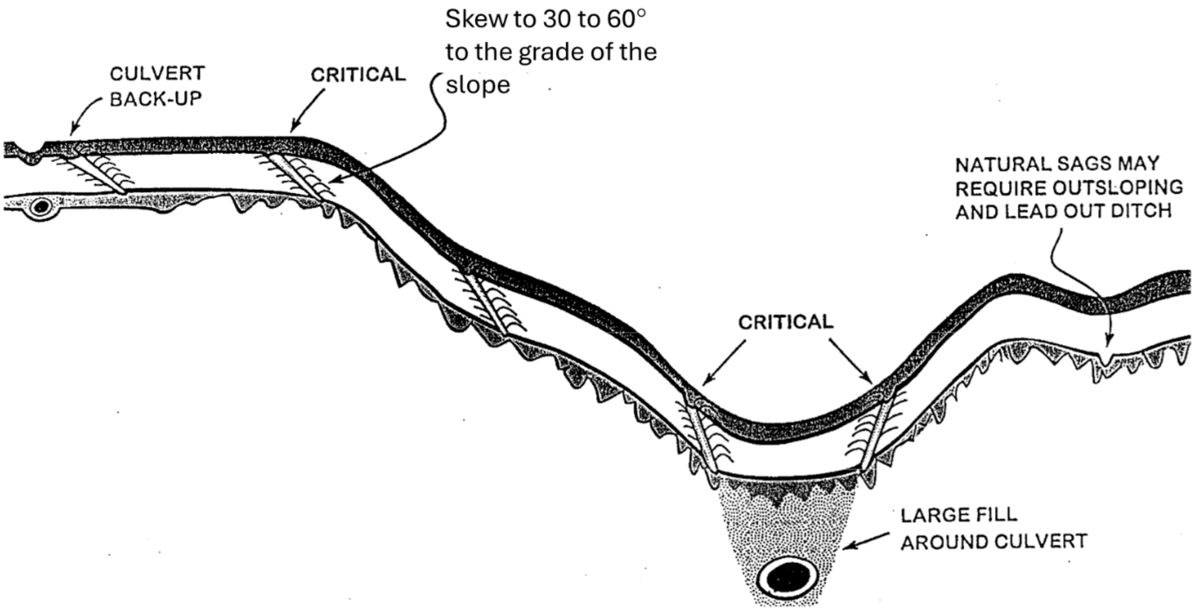

Figure 35. Placement of check dams (water bars) and a cross drain, post-harvest of a wood lot (United States Forestry Service).

Vegetated Filter Strips

Establish dense vegetation along skid tracks or haul roads to intercept runoff and trap sediment before it reaches waterways.

Flow Reduction Structures: Place small check dams or sediment traps along gullies and flowpaths to slow water and allow sediment to settle out.

Grassed Waterways: Use grassed or planted swales in pathways to absorb and slow water flow while trapping sediment.

Sediment Retention Ponds: Construct retention ponds at key discharge points to trap sediment before it enters waterways.

Variable Width Riparian Buffers: If possible, establish a wide area of riparian planting along a runoff pathway near harvested areas to filter runoff.

Constructed Wetlands: If feasible, create small wetlands downstream of harvested areas to filter runoff and improve water quality.

Step 3: Identify the Receptor

Nearby waterways, drains, or wetlands are the final receptors where runoff and sediment from harvested woodlots can accumulate, impacting water quality and aquatic ecosystems.

See recommendations regarding riparian plant species for the Waikawa Catchment.

Native Plant Species for Farm Woodlots

Successfully establishing native vegetation within any less-visited parts of property such as forestry lots can be impeded by feral deer or goats. The impact of feral animals can be reduced by selecting species which are less palatable such as mānuka or flax. Both these species will naturally establish if there is a nearby seed source, but they need full sun, so larger buffers are recommended to reduce shading by maturing adjacent forestry species. Wineberry / makomako (*Aristotelia serrata*) will grow in dappled light conditions, can stabilise soil and is somewhat tolerant of deer browse, but prefers relatively fertile soils and moderate shelter from wind (Marden et al., 2018). Retaining existing vegetation in vulnerable areas when establishing farm woodlots is an efficient approach.

Flax may be the best species to establish around skid sites and haul lines because it will tolerate a wide range of moisture and soil fertility conditions. South Island toetoe could be used around haul and skid sites where soil fertility is low due to topsoil removal, however, it will not tolerate waterlogged soils so compacted sites could prove challenging. The key difficulty with using any species around haul lines and skid sites in clear-felling forestry operations is these areas are typically shaded when harvest commences and then exposed to full sun. Species such as flax or toetoe will be hard to establish in shady conditions and then once harvest starts there is only a short period to establish good vegetation buffers before sediment is mobilised. Ideally, large buffers of permanent native vegetation are incorporated into all key source areas within forestry plantations – the relevant species will be determined by localised conditions such as soil moisture, fertility, availability of light and browsing pressure from feral ungulates.

A sediment trap and wetland sited at the bottom of the gully can be effective for sediment management where steep-sided gullies have been used for farm-forestry woodlots. Wetlands and sediment traps along with access needs such as farm crossings can be incorporated into the planting design when establishing woodlots.

Consider planting higher value, longer-rotation species in farm-forestry woodlots and avoid clear-felling harvest practices. Depending on scale and existing access provisions, there can be a significant difference in the relative costs-benefits of small-scale, lower value, fast-growing species compared to higher value, slower-growing species such as tōtara. Woodlots managed for continuous canopy forestry could be established in terracettes or steep gullies or other tricky areas where sediment and nutrient loss occurs. Check with local forestry experts about harvest access, for example access track incline requirements for logging trucks have changed since the early 2000s and machinery has generally increased in size.

See Tane's Tree Trust for information about establishing native species such as tōtara for timber. Thin-barked tōtara naturally occurs in the Waikawa Catchment and can be used in range of applications from timber to cosmetics and pharmaceutical uses (see for example Shi et al., (2018) for anti-bacterial properties of totarol, a chemical compound extracted from tōtara).

Stream Bank Erosion

Step 1. Identify Source Areas:

As noted above, stream bank erosion may contribute between 40 to 50% of fine sediment to estuaries, lakes, and harbours. However, stabilising streambanks requires more than just local fixes; it is about addressing the bigger picture. In New Zealand, one of the main challenges is the speed at which water leaves the land. Furthermore, many perennial streams and rivers have been straightened over time, leading to higher flow velocities. This increased stream power causes riverbeds to deepen and banks to erode more rapidly. While local efforts, such as planting deep-rooted vegetation or fencing off streams to exclude livestock, are helpful, they will not fully resolve the problem. Unless we tackle the wider issues—like reducing the speed at which water leaves the land, restoring natural meanders, and improving water retention within the landscape — streambank erosion will continue to be a challenge.

Figure 36. Stream bank erosion of the Waikawa Stream downstream of an area of river shortening (straightening).

Therefore, reducing srteambank erosion can only be effectively achieved by addressing the root cause: the speed and volume of water flowing through the system. This means focusing efforts further upstream, particularly in areas with ephemeral waterways (swales), to slow down the flow before it reaches the main channels. By improving water retention in the landscape and reducing the power of peak runoff events, we can take pressure off downstream streambanks.

Whilst some actions can be taken, many of the works aimed at stabilising banks—such as rock armouring, planting, or installing engineered structures—are often expensive, require significant consenting processes, and may not provide long-term solutions if the underlying issue of fast water flow is not dealt with. Without tackling the excessive stream power caused by land drainage, rapid runoff, and stream straightening, these interventions risk being temporary fixes that fail to endure.

Eroding Streambanks

An unstable streambank is typically steep, vertical, or even overhanging, with bare soil showing where vegetation has been lost. You may notice sections of the bank collapsing or slumping into the stream, leaving it looking uneven or jagged. Often, tree and plant roots will be exposed because the soil around them has been washed away. At the base of the bank, undercutting is common, where fast-flowing water erodes the soil, leaving the top unsupported and prone to collapse. Vegetation on unstable banks is usually sparse or stressed, and bare patches are often visible. Downstream, you might see signs of the problem, like sediment building up in the streambed. Unstable stream banks can erode, contributing sediment to waterways and altering stream morphology.

Other than retaining more water and reducing the speed with which is leaves the landscape, some of the localise options to reduce peak velocities and reduce stream bank erosion include:

Re-meandering and Channel Widening:

Reintroducing Meanders: Where possible, re-meandering the stream channel allows water to flow through a longer path, reducing velocity and dissipating energy. Meanders slow down the flow by increasing the channel length and decreasing the steepness of the streambed.

Widening the Channel: By widening overly narrow channels, more room is provided for water to spread out, which reduces flow velocity. This approach can be effective in sections where re-meandering is not practical. A wider channel with a more gradual slope can help maintain stream capacity during high-flow events without increasing stream power.

Two-Stage Channel Design:

In agricultural landscapes, a two-stage channel effectively incorporates a low-flow channel within a wider, vegetated floodplain bench. This design is best suited for open drains and flood channels. During normal flow, water stays within the smaller low-flow channel, but during high flow, water spreads onto the vegetated bench. This design slows down high flows, reduces stream power, and allows sediment to settle out before reaching downstream areas.

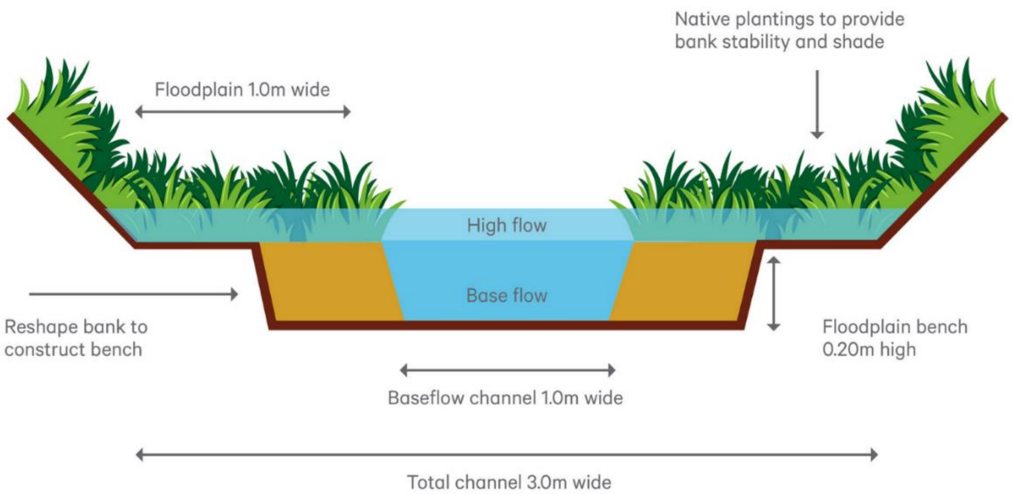

Figure 37. Two-stage channels are useful options for open drains and small tributaries but are less suited to larger streams (Living Water, n.d.).

In-Stream Structures to Distribute Flow Energy:

Rock Vane or Boulder Clusters: Installing angled rock vanes or strategically placed boulder clusters directs the strongest currents away from banks, reduces flow velocity near the bank, and dissipates stream energy. Rock vanes are particularly useful in straightened channels to guide flow toward the centre, stabilising eroding banks.

Deflectors and Weirs: Constructing low-profile weirs or flow deflectors in the channel can help reduce flow speed and create areas of slower flow where sediment can settle out. These structures slow down the water without obstructing flow completely.

Vegetated Bank Stabilisation:

Riparian Buffer Zones: Establishing deep-rooted vegetation along banks helps stabilise soil and protect against erosion. Native grasses, shrubs, and trees create a network of roots that bind soil particles, increase bank resistance to erosion, and can help absorb excess water. However, without reducing stream velocity, vegetation alone may not stop erosion in high-energy channels.

Figure 38: Example of mature kōwhai (estimated 30 years old) successfully stabilising bank of strongly meandering stream in central Southland. Note however the thin vegetation margin – in time if this tree gives way there is no other established vegetation Photo: Jesse Bythell

Closely related native large-leaved kōwhai (*Sophora tetraptera*) roots have a mean tensile strength of 43 MPa, comparable to Veronese poplar (*Populus* x *euromericana*) (Watson, 2004). It seems likely the species naturally occurring across Southland, small-leaved kōwhai (*Sophora microphylla*), has a similar capability given its preferred habitat – plants with an estimated age of >200 years have been recorded growing along streambanks in Southland.

Live Fascines and Willow Wattles: In areas with significant bank instability, woven willow or fascines (bundles of cuttings) can be staked along the bank to reinforce soil structure. This approach is particularly helpful on outside bends or in sections prone to high erosion. Over time, these structures take root, providing a natural and robust barrier against erosion. However, planting weedy species such as crack willow (*Salix fragilis*) or pussywillow (*Salix cinerea*) is not permitted under the Southland Regional Pest Management Plan. If in doubt, please check with the Environment Southland biodiversity staff.

Floodplain Reconnection

Allowing Overbank Flow: Reconnecting the stream to its floodplain reduces the stream's energy during high flows by allowing water to spill over into adjacent areas. This can be achieved by removing or lowering levees, reducing bank heights, or creating additional outlets. Floodplain reconnection not only reduces flow velocity but also promotes sediment deposition on the floodplain rather than downstream in estuaries or sensitive areas.

Sediment Trapping Wetlands:

Constructed or restored wetlands along the stream's edge or downstream can capture sediment, trap nutrients, and slow water flow before it enters sensitive areas. These wetlands can be especially effective in capturing sediment mobilised from upstream erosion, helping protect estuaries and downstream ecosystems.

Practical Considerations

Implementing these methods depends on the land use and available space, as well as the stream's hydrology and gradient. In some cases, a combination of techniques may be necessary to reduce velocity effectively and stabilise banks. While re-meandering and floodplain reconnection offer the most sustainable long-term results, interim measures like in-stream structures and vegetated buffers can provide stabilisation while larger restoration work is underway.

Addressing the primary cause—flow velocity—through these methods will help stabilise banks and reduce sediment loss, ultimately protecting downstream water quality and land productivity.

Management Practices:

Riparian Planting: Establish native vegetation along stream banks to stabilise soil and provide habitat.

Livestock Exclusion: Fence off riparian zones to prevent trampling and allow vegetation recovery.

Bank Regrading: Where necessary, reshape banks to a more stable slope and reinforce with bioengineering techniques.

Planting Advice for Riparian Buffer Zones

A key challenge with establishing plants to stabilise banks is the banks may be eroding faster than the plants can provide stabilisation. Excluding livestock and reducing erosional force is vital, along with planting both densely rooted plants to reduce erosional friction on the lower banks where possible and fast-growing, deep-rooting tree species on the terrace and lower banks. Denser plantings can stabilise areas faster and buffers should be sufficiently wide to account for potential future channel movement. Fencing too close to the bank risks infrastructure as well as minimises planting opportunities to improve bank stabilisation.

The ability of a tree to stabilise banks is a combination of the type of roots (lateral versus tap), the depth the roots can penetrate (often affected by soil type) and the diameter of the root. Generally, New Zealand native trees have strong root systems which can stabilise soils, however, their slower growth rate compared with exotic trees means they are often overlooked as an erosion mitigation tool. For example, cabbage trees have a similar tensile strength to willows at all root diameters.

Figure 39: The fibrous roots of South Island toetoe (Austroderia richardii) enable it to bind up and grow into a steep bank. Note, the area to the right has no toetoe planted and is suffering from active bank erosion. Photo: Jesse Bythell

Species to reduce erosion friction on lower banks:

- Purei
- Flax
- Toetoe (good for slumps where soils are low fertility)
- Fast-growing species for bank stabilisation:
- Cabbage tree / tī kōuka
- Lowland ribbonwood / mānatu
- Mānuka
- Slower-growing species for bank stabilisation (upper terrace):
- Small-leaved kōwhai
- Thin-barked tōtara

WAIKAWA
CATCHMENT GROUP

Part Four

Planting for Success

Community Toolbox for Mitigating Erosion and Runoff
Waikawa Catchment Group

Planting for Success

1. **Planting**
2. **Sourcing**
3. **Plant Care**

Part 4 Covers:

- **Planning tips**
- **Sourcing tips**
- **Plant health**
- **Plant size**
- **Planting Tips**
- **Post-planting care tips**

Planning Tips

Site preparation: Depending on the time of year and the site conditions, you may need to spray 4-6 weeks before planting to allow the grass to rot down (grasses such as cocksfoot or tall fescue may need two spraying treatments if they are the dominant species). Spot spraying is recommended as it uses less herbicide, and the unsprayed grass provides some shelter from the elements for young plants and reduces their discovery by hares or rabbits. Take care when using herbicide around waterways and follow the regulations. Become familiar with the equipment, apply techniques that increase droplet size to reduce drift, avoid spraying on windy days.

Take extra care: When spraying near existing vegetation, especially using aerial applications or spraying tall gorse and broom from the ground, it is easy to overshoot or have drift onto sensitive species and only one wrong move can severely impact an ancient tree like kahikatea or kōwhai. Consider cutting and stump pasting taller broom or gorse plants to reduce non-target effects of spray, avoid any aerial spray near mature kōwhai and if doing aerial spraying near native vegetation use smoke flares for real-time feedback on the localised conditions. Become familiar with the Southland Regional Air Plan, especially if spraying near waterways, native vegetation or property boundaries

Planting density: Plant density is based on a range of factors such as species used, scale of the planting site, weed management needs and resourcing to do post-planting care. Denser plantings cost more initially but can shade out grass faster or suppress competitive weeds such as blackberry or gorse thus reducing overall maintenance effort. Along with canopy closure being achieved faster to suppress competitive weeds, below-ground biomass mirrors above-ground biomass and denser plantings achieve faster lateral stabilisation as roots connect more quickly. See the Tīmata Method for a discussion on low-density planting techniques for retired erosion prone hill country at scale. Work out your area and check how big the plant species get when mature and ensure there is plenty of space around fences and other important infrastructure.

Domestic livestock: Some plants can tolerate light browse by sheep once they are established. However, all young plants are vulnerable to trampling/being plucked out by curious animals before they root in and achieve some growth. For example, an area could have flax planted at low density with a single hot wire fence erected to exclude cattle and once the flax is established sheep can be permitted allowed in. Supplementary temporary fencing may be needed initially to keep sheep out until the flax is firmly rooted.

Feral browsers: goats and deer can have a devastating impact on planting projects which means resources are not effectively used and people lose motivation. Pigs will also root up and disturb sites, damaging young plants and encouraging weed growth. Fast growing and browse tolerant species are best used at ites which have few people coming and going should employ the, while a wider range of species can be used at sites where feral animals are less common (e.g. areas regularly visited by people).

Brush weeds: Gorse and broom becoming established in planting sites can be a key challenge for land managers. In cases where the seedbank is relatively small intermittent management of individual plants as they occur is effective and not too resource intensive. In damp areas where there is a large gorse or broom soil seed bank, consider planting only monocotyledonous plants (e.g. flax, toetoe, sedges, cabbage trees). This approach enables the use of broadleaf herbicides which will not affect your monocotyledonous plants. However, proceed with caution as herbicides containing Picloram and Triclopyr can be mobilised in the soil and negatively affect nearby mature woody species nearby. In other contexts where there is a gorse/broom soil seedbank, fast growing species such as mānuka can easily overtop and shade young gorse plants if they are the same age or older than the gorse (note, mānuka is light-demanding and will not establish under gorse). In some cases, gorse is easier to manage in steep gullies by simply spraying it off the fences and leaving the rest to be overtaken by taller native forest species over time. Indeed, gorse will facilitate natural native regeneration where an adequate seed source is available - gorse overshades grass and provides early-stage protection from browsing ungulates.

Wider weedy considerations: Look at the weeds in the wider area to determine which are competitive and which are disruptive. Species like sycamore can grow so fast they will overtop plantings, Darwin's barberry, Cotoneaster and holly are shade tolerant and can invade established planting areas, gorse or willow can overshade shorter vegetation like tussock and sedges, Chilean flame creeper can smother saplings of all kinds. Some weeds can be tolerated or locally managed to get your plants tall enough to cope on their own, some plants are so aggressive the most efficient approach is to nip them in the bud before they spread into your planting area. For example, killing Darwin's barberry growing on the roadside will protect your distant planting sites because the fleshy fruit is spread by birds.

Managing grass: Release spraying is best done in November and March, sometimes more regularly depending on the local conditions and grass growth. Spraying grass when it is about 20-30 cm tall is beneficial because dead grass acts as a mulch to suppress the next batch of grass. In contrast, spraying when grass is very tall risks non-target impact on your plants, or when too short dead grass will rot away rapidly enabling more grass or other pasture species to germinate. The bare areas created when spraying short grass can invite the establishment of gorse, dock, thistles etc. Trampling tall grass and then spraying it can be effective, though it is more time consuming and some plants can be overlooked.

Plant grades: Larger grade plants (e.g. PB2 and above) may establish faster in some contexts (e.g. low fertility sites) which can be beneficial when operating at small scale and you are seeking fast results. However, sometimes larger grade plants are more prone to planting shock than smaller-grade species, especially if they are rootbound. Larger grade plants cost more, take up space when transporting to the site are heavier to carry to planting sites and slower to plant. Smaller grade plants (e.g. forestry grade or V150) are cheaper, can withstand planting shock, are easier to transport to the site and quicker to plant. However, depending on the species and site conditions, smaller plants may need a longer period of post-planting care before they are established. Sometimes planting denser smaller grade plants (especially fast growing species like Carex) will give better results than lower density larger grade plants. Each site is different and you may need to experiment to work out the best combination for your project area in terms of scale, cost, labour and timing.

Salty conditions: Sites which experience salt spray may need special consideration. All the key species mentioned are tolerant of some salt spray except kōwhai and lowland ribbonwood. On the estuary margin or in lower reaches of streams which can be brackish, consider using flax, oioi/jointed rush (Apodasmia similis) or Carex appressa and saltmarsh ribbonwood (Plagianthus divaricatus).

Plant guards: There are many plant guard products on the market ranging from plastic (film sleeves or coreflute tubes), carboard or jute. Mulch mats may be single or double layered felted wool or coir, and bamboo stakes may be 2-4 per plant and of varying lengths/diameter and mesh netting can be added for extra hare protection. Taller stakes are good for wet areas where you may need to stab them in deeper to securely anchor them in place. Some plant guards are designed to be removed, some are designed to rot in place. Plastic combo guards can be re-used several times (though not the mulch mat which rots away) so long as the plastic sleeve is removed before the plant gets too big. Carboard guards are good where clumpy, fast-growing plants are able to stop the sides flopping over and shading the plant (e.g. Carex, toetoe, flax). Windy sites can be challenging for carboard which may soften when wet and work itself loose in the wind, however if incorrectly installed plastic guards are also prone to blowing away in strong winds. Coreflute can create a 'greenhouse effect' cooking young plants and it tends to break down in UV creating plastic fragments. Instructions on how to install the Combo Plant Guard can be found here. Consider the scale of the planting, how windy/prone to flooding the site is and the labour involved in removing guards before choosing which product will be suitable for your project. If you have lots of labour available and are not willing to use chemicals you can hand-weed the site, however this does not protect plants from hares, rabbits or possums.

Fences: Excluding domestic livestock can be expensive, but sometimes the key stock to exclude are cattle as their impact is more intense (heavier on the soil, able to browse plants which sheep struggle with). Sometimes a simple waratah and single hotwire fence is enough to let sheep have intermittent access but keep cattle off sensitive areas. Note, all plants need a chance to become well established before any sheep can access the area. Feral and goats will not be deterred by regular fencing and impact planting sites.

Tools: The following online resources developed by Tane's Tree Trust are useful:

- Planting calculator tool for planning and costing out planting projects.
- Other online resources about using native species for timber (includes growth and yield calculator and carbon calculator).

Sourcing Tips

Genetics count: The plants are not just a static objects in the landscape, they will interact with the local plants and their offspring will contribute to future local plant populations. For a resilient outcome, it is important to source plants grown according to eco-sourcing principles – this means plants are grown from seed sourced from large, naturally occurring populations local to the planting area. In the Waikawa Catchment there are many good seed sources, though permission is needed to collect on private land and permits are needed to collect on public land (council reserves and public conservation land administered by the Department of Conservation). Local plants are adapted to local conditions and seed sourced from larger populations (>50) is more genetically diverse than that collected from small populations thus allowing your plantings to better able to cope with future disease or adverse climactic events.

Natural is best: Avoid cultivated varieties, e.g. purple flax or cabbage trees - they are not genetically diverse and tend grow more slowly due to less chlorophyll.

Clones are not good: Plants grown by cutting or division are generally very closely related and therefore more vulnerable to diseases or adverse weather events. Many of our plants are dioecious (male and female on separate plants) and cuttings may all be one sex if material is not carefully sourced.

Names are important: Always ask for plants by their scientific name to ensure you get the right species. There are multiple species of toetoe (Austroderia spp.) and kōwhai (Sophora spp.) in New Zealand and some growers may be informally referring to plants using only common names or may not actually know exactly which species they are growing. The local species will give the best performance, and sometimes non-local species can have negative impacts on local populations of closely related species.

One of the biggest threats to kowhai is hybridisation with non-local species, including a Chilean species (Sophora cassioides) sometimes sold by nurseries as a native kōwhai. The best way to protect our locally important population of kowhai is to collect from a range of naturally occurring plants along the Waikawa River and avoid sourcing material from outside the region or from garden specimens (which are typically not the local species).

For example, lacebark (Hoheria spp.) and ribbonwood (Plagianthus spp.) are separate genera in the Mallow Family but sometimes the common names are used as if the plants are interchangeable.

Some nurseries have previously sold invasive pampas grass (Cortaderia selloana and C. jubana) perhaps mistaking it for toetoe. Make sure you are buying the native toetoe – the key difference to look for on young plants is the leaf strength (if you can tear it in half, it is likely native toetoe, weedy pampas has a very prominent midrib which is hard to tear with your hands).

Plant Health

Rootbound plants: root congestion will reduce the effectiveness of stabilisation (i.e. roots grow in tight circles instead of outwards, over time the roots may become choked up and sometimes a few years after establishing rootbound planted trees may die). Some species, such as manuka, are not tolerant of root disturbance so planting younger plants is more effective. Gently squeezing the root mass will help determine if a plant is rootbound – healthy plants will have a some give, rootbound ones will be very hard.

Disease: Plants which are obviously diseased should be avoided, but note small-leaved kowhai, lowland ribbonwood and saltmarsh ribbonwood are deciduous so may look dead when they are not.

Hardening off: Check plants have been hardened off before you plant them. Some nurseries grow plants at speed in very benign conditions and then when these are planted they 'soft' and struggle with the transfer shock. Plants with lots of tender new growth are more prone to shock, so avoid putting these out in windy, frosty or hot conditions. Sometimes plants can be cut back before planting to reduce water loss from leaves and overall shock (e.g. wineberry), but check if the species can tolerate this as some plants cannot.

Plant Size

'Root to shoot' ratio: Plants with small root masses and tall 'leggy' growth are more prone to transfer shock, lower growth rate and poor survival outcomes. Digging up plants and relocating them is not usually successful as it is hard not to tear the roots or to extract a plant with sufficient root mass to support the plant. 50:50 root to shoot ratio is good.

Enrichment and diversity: Some plants are easier to grow than others and some are very slow to germinate (e.g. mataī, pōkākā). Many forest species will not tolerate being planted out in the open but will thrive once some initial shelter is available. Enrichment planting is sometimes carried out to enhance basic planting projects where fast growing, tough 'first responder' species have already been established. Nature of course can do the enrichment planting - be patient.

Planting Tips

Big holes: Wrench the soil around the planting hole to enable faster penetration of roots and firm the plant in properly without tearing roots (do not pull the plant upwards while stamping down the soil). Soil wrenching is particularly important when planting into compacted areas, otherwise water may pool in the planting hole causing the plants to rot.

Little holes: When planting sedges at sites which may be prone to flooding before plants are firmly rooted in, use forestry grade plants and use a waratah to make a deep stabbing hole rather than a more conventional planting approach. This planting technique reduces soil loss/scouring out of young plants if they become inundated before they are established.

Plant stress: Do no allow plants to dry out before planting, the stress will reduce survival.

Timing is everything: The best planting time is spring; however, this is a busy time of year for many farmers. If planting into coastal sites, late July/early August is workable as there are few frosts to stress new plants. In wet sites, sometimes planting can occur year round, however in areas prone to winter ponding planting when water has receded is recommended. Plantings undertaken in autumn are generally slower to establish than spring plantings, but this may be the most practical time to plant for some people. It may be necessary to water in plants if soil moisture is low when planting occurs.

Handle with care: Do not carry plants to site by their stems unless they are very robust – tearing of roots before planting will negatively affect survival and growth.

Planting depth is important: Putting plants in too deep can cause them to rot, too shallow and they may dry out and die. Mimic the soil depth in the potting medium. If planting divided flax fans, plant at a depth that allows the fan to be stable, ensure each fan has sufficient roots and trim back outer leaves to reduce moisture loss while new roots develop.

Fast versus effective: Fast planting is not always good planting, take care and your plants will reward you with better survival and performance.

Post-planting Care Tips

Plant guards: Use plant guards to increase survivability (protects from hares, planting shock, grass competition and spray drift). Wool can be used as a mulch too but be careful of spreading weed seeds into new areas. Use cardboard guards in low lying areas which could be subject to flooding to prevent plastics entering the waterways. Planter guards also discourage pūkeko from plucking at newly planted sedges and grasses.

Grass management: Trample grass and/or release spray at least twice a year to give young plants the best chance of establishing. Tall grass flopping over young plants reduces growth rates significantly and can sometimes cause plants to fail due to lack of light or fungal issues caused by excess humidity. Grass will also compete with young plants for water and nutrients.

Avoid spraying in gusty conditions: Spray drift can easily kill a young plant. Spray guards can help but may encourage spraying when conditions are still too windy and still result in non-target impacts.

Less is more: When plants are taller than the surrounding grass they can usually be left to grow in peace once their plant guards have been taken off. Note, the temptation to tidy up and spray or stomp grass away from established trees can be counter-productive, as this leaves the trunks bare and easily accessed by possums. One possum can ring-bark and kill a young tree with only a small amount of feeding in one night.

Weed watch: Manage any emerging weeds as needed (see planning comments about anticipating what might turn up).

Scientific name	Common name	Moisture tolerance	Nutrient tolerance	Light preference	Growth rate	Propagation difficulty	Deer/goat browse sensitivity	Root type	Soil stabilisation	Estimated mature basal size (m^2)	Estimated mature height (m)	Biodiversity values	Other qualities
Carex secta	purei, a sedge	High	Low - high	Full sun	Fast	Easy	Low	Fibrous	Medium	1	1.5	Supports invertebrates and whitebait spawning	Can grow in shallow water
Carex virgata	pukio, a sedge	High	Low - high	Sun/partial shade	Fast	Easy	Low	Fibrous	Medium	1	1.5	Supports invertebrates and whitebait spawning	Green colouration
Phormium tenax	harakeke, flax	High	Low - high	Full sun	Fast	Easy	Medium	Fibrous	Medium	3	2	Habitat for birds and invertebrates	Potential permanent cover crop (used in nutriceuticals, costmetics, medicine).
Chionochlora rubra sub. *cuprea*	copper tussock	Medium	Low - high	Full sun	Slow	Medium	Low	Fibrous	Medium	1.5	1.5	Habitat for invertebrates	Attractive and iconic Southland plant, good lambing shelter
Austroderia richardii	South Island toetoe	Medium	Medium - high	Full sun	Fast	Easy	Low	Fibrous	Medium	1.5	1.5	Supports invertebrates	Attractive seedheads; easy care low stock shelter
Coproma propinqua	mikimiki (mingimingi)	Medium	Medium - high	Sun/partial shade	Medium	Easy	Medium	Fibrous	Medium	1.5	5	Habitat for birds and invertebrates	Autumn berries
Cordyline australis	tī kōuka, cabbage tree	High	Low - high	Full sun	Fast	Easy	Medium	Fibrous and penetrating	High	1	12	Habitat for birds and invertebrates	Scented flowers, visually distinctive
Plagianthus regius	lowland ribbonwood, mānatu	Medium	Medium - high	Sun/partial shade	Medium	Easy	Low	Fibrous	High	1	10	Habitat for birds and invertebrates	Upright growth form, deciduous
Sophora microphylla	small-leaved kōwhai	Low - medium	Medium - high	Sun/partial shade	Slow	Medium	Low	Fibrous	High	1	25	Habitat for birds and invertebrates	Beautiful when flowering; brevi-deciduous; less tolerant of strong winds when young
Aristotelia serrata	wineberry, makomako	Medium	Medium - high	Sun/partial shade	Medium	Easy	Medium	Fibrous	Medium	2	10	Habitat for birds and invertebrates	Attractive flowers, autumn fruit
Podocarpus laetus	thin-barked tōtara	Medium	Medium - high	Sun/partial shade	Slow	Medium	Low	Fibrous	Medium	2	20	Habitat for birds and invertebrates	Not deciduous; high timber value and also has medicine and cosmetics uses; vulnerable to possum browse
Plagianthus divaricatus	saltmarsh ribbonwood	High	Medium - high	Full sun	Medium	Easy	High	Fibrous	Medium	2	1.5	Habitat for birds and invertebrates	Tolerates salt, scented flowers, visually distinctive
Carex appressa	southern cutty grass	High	Low - medium	Full sun	Fast	Easy	Medium	Fibrous	Medium	1	1	Host for a range of moth species	Tolerates salt, summer green sedge
Apodasmia similis	oioi, jointed rush	High	Low - medium	Full sun	Slow	Medium	Low	Fibrous	Medium	1	1.5	Habitat for invertenbrates	Tolerates salt

	Plants														
	Carex secta	*Carex virgata*	*Phormium tenax*	*Chionochlor a rubra sub. cuprea*	*Austroderia richardii*	*Coproma propinqua*	*Cordyline australis*	*Leptospermu m scoparium*	*Plagianthus regius*	*Sophora microphylla*	*Aristotelia serrata*	*Podocarpus laetus*	*Plagianthus divaricatus*	*Carex appressa*	*Apodasmia similis*
	purei, a sedge	**pukio, a sedge**	**flax, harakeke**	**Copper tussock**	**South Island toetoe**	**mikimiki (mingimingi)**	**ti kōuka, cabbage tree**	**mānuka**	**lowland ribbonwood, mānatu**	**small-leaved kōwhai**	**wineberry, makomako**	**thin-barked tōtara**	**saltmarsh ribbonwood**	**southern cutty grass**	**oioi, jointd rush**
Moisture tolerance	High	High	High	Medium	Medium	Medium	High	Medium	Medium	Low - medium	Medium	Medium	High	High	High
Nutrient tolerance	Low - high	Low - high	Low - high	Low - high	Medium-high	Medium-high	Low - high	Medium	Medium - high	Medium-high	Medium - high	Medium - high	Medium - high	Low - medium	Low - medium
Light preference	Full sun	Sun/partial shade	Full sun	Full sun	Full sun	Sun/partial shade	Full sun	Full sun	Sun/partial shade	Sun/partial shade	Sun/partial shade	Sun/partial shade	Full sun	Full sun	Full sun
Growth rate	Fast	Fast	Fast	Slow	Fast	Medium	Fast	Fast	Fast	Slow	Medium	Slow	Medium	Fast	Slow
Propagation difficulty	Easy	Easy	Easy	Medium	Easy	Easy	Easy	Easy	Easy	Medium	Easy	Medium	Easy	Easy	Medium
Browse sensitivity	Low	Low	Medium	Low	Low	Medium	Medium	Low	Low	Low	Medium	Low	High	Medium	Low
Root type	Fibrous	Fibrous	Fibrous	Fibrous	Fibrous	Fibrous	Tap and fibrous	Fibrous	Fibrous	Fibrous	Fibrous	Fibrous	Fibrous	Fibrous	Fibrous
Soil stabilisation	Medium	Medium	Medium	Medium	Medium	Medium	High	High	High	High	Medium	Medium	Medium	Medium	Medium
Estimated mature basal size (m)	1.0	1.0	3.0	1.5	1.5	1.0	1.0	1.0	1.5	1.0	2.0	2.0	2.0	1.0	1.0
Estimated mature height (m)	1.5	1.0	2.0	1.5	1.5	5.0	12.0	8.0	1.5	25.0	10.0	20.0	1.5	1.0	1.5
Biodiversity values	Supports invertebrates and whitebait spawning	Supports invertebrates and whitebait spawning	Habitat for birds and invertebrates	Habitat for birds and invertebrates	Habitat for invertebrates	Habitat for birds and invertebrates	Habitat for birds and invertebrates	iat for birds and invertebrates	Habitat for birds and invertebrates	Habitat for birds and invertebrates	ır birds and inve	Habitat for birds and invertebrates	Habitat for birds and invertebrates	Host for a range of moth species	Habitat for invertenbrates
Other qualities	Can grow in shallow water	Green	Potential permanent cover crop (used in nutriceuticals, costmetics, medicine).	Attractive and iconic Southland plant, good lambing shelter	Attractive seedheads; easy care low stock shelter	Autumn berries for wildlife	Scented flowers, visually distinctive	Upright growth form; attractive flowers; evergreen	Upright growth form, deciduous	Beautiful when flowering; brevi-deciduous; less tolerant of strong winds when young	Autumn berries for wildlife	Not deciduous; high timber value and also has medicine and cosmetics uses; vulnerable to possum browse	Tolerates salt, scented flowers, visually distinctive	Tolerates salt, summer green sedge	Tolerates salt

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