Drainage Maintenance Management Plan

and Implications for Waterways

Prepared by Waimakariri District Council
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1. Executive Summary

Purpose of the Drainage Maintenance Management Plan

This Drainage Maintenance Management Plan (the plan) confirms how the Waimakariri District Council (WDC) will work toward achieving sustainable drainage systems management. It also assesses how proposed drainage maintenance management approaches and actions will achieve positive effects for downstream waterways.

There are areas of natural waterway where drainage maintenance is carried out by WDC. For simplicity these areas have been included in the term 'drain' in this plan. The plan applies to all waterbodies managed by WDC. However, WDC acknowledges these areas are to be managed as rivers, as defined under the Resource Management Act (1991). This plan responds to recent objectives and policies for freshwater management indicated by Government. It recognises a widespread community aspiration for clean, healthier waterways. The plan also supports the Waimakariri Water Management Zone Committee recommendation that the Council works towards meeting the Land and Water Solutions Programme Zone Implementation Addendum (ZIPA) outcomes, which are actions and strategies required to improve water quality in the zone. The plan is based on the "Waimakariri Drainage Review" which investigates options for future sustainable drainage systems management for the District, completed on 3 April 2020 (TRIM 200403042466).

The plan is a component of the Council's application for a global drain management resource consent. It is intended to be a "live" document, to be updated and resubmitted from time to time through the term of the consent. The review provisions will enable implementation of new approaches and use of future technologies as these are trialled in coming years. Future plan updates will include results and effects of new methods as these are verified.

The plan includes a number of actions to redevelop Council drainage areas into more sustainable drainage systems. The proposed design options are intended to flush or reduce growth of aquatic weeds so that drainage areas can naturally self-clean and require less ongoing maintenance. Most of the recommended improvements incur a short term (one off) capital expenditure cost. These would be offset by medium and long term operating cost savings. The proposed changes could also improve hydraulic conveyance, cultural values, water quality, amenity, recreation and aquatic habitat diversity.

Many of the recommended actions within this plan have already been trialled by the Council in suitable locations. Enough success has been observed to date to now warrant expanded trials of these new approaches. These actions could continue to be implemented initially in selected drainage areas where the most frequent maintenance is currently undertaken and where sustainable design options could be implemented.

A summary table and suggested timeframe for the key proposed actions is included on the following page. Initially, the proposed actions could be trialled over the next few years to determine which approaches are practicable, best achieve a sustainable management approach and other desired outcomes, including maximising hydraulic capacity. Successful methods can then be implemented over the longer term (up to 35 years). An implementation approach is recommended in the proposed "*decision framework for drainage maintenance management*" flow chart.

The proposed decision framework encourages the Council to assess each current expenditure decision against its potential longer term benefits and costs. This involves comparing the following options: a) rehabilitation; b) reducing scheduled maintenance and accepting an option of less intervention (low impact management); or c) continuing the current maintenance management schedule. The "*decision framework for drainage maintenance management*" flow chart shows how each of these options could be applied in

practice. This assessment will determine which approach is most likely to reduce longer term costs and/or generate the best mix of additional future benefits. Actions proposed are intended to achieve natural flushing where possible. This approach intends, over time, for the drainage expenditure to be more likely to result in sustained conveyance improvements and environmental benefits.

The plan notes the role of the District Drainage Scheme Advisory Groups in advising Council about the most suitable actions for each of their schemes. It is intended the Advisory Groups will recommend the most appropriate action/s for each drain to the Council. This will take account of the different characteristics of each part of the network, including existing and desired future hydraulic capacity, level of fall, waterway characteristics and ground conditions.

Sustainable Drainage Systems via Intervention

The plan reviews new and recent industry guidance on drain design and management options. It confirms, in response to availability of this new guidance material, that some changes are warranted to current practice.

Taking account of this guidance, it recommends that the Council gradually implements a proactive redesign programme for its wet drains (drains with a baseflow) which currently receive frequent scheduled maintenance. The recommendation is to redevelop these drains into sustainable drainage systems.

Actions for each drain include any combination of: a) adding increased shading using native plants; b) forming an increased velocity low flow channel by planting reeds, rushes or native grasses on the water margins at the toe of the banks; or c) bank stabilisation, including re-battering or redesign of existing poor channel form where required. These actions are primarily to improve drain conveyance, by increasing velocity and reducing weed density to reduce the need for ongoing aquatic weed removal. There are also complementary actions proposed to increase the diversity of in-stream habitat such as creating pools and riffles, and less frequent ecological disturbance. These actions could combine in future to create a more self-managing and self-sustaining network of wet drains. Maximising drain hydraulic capacity is a key component of every proposed action and will be included in design of all projects selected for implementation.

Implementing these recommendations recognises drains are a component of larger freshwater ecosystems throughout the district. The management approaches adopted may have significant effects including on downstream waterways. The proposed actions can generate potential benefits to the Council as a network operator, as well as communities and wider ecosystems.

Sustainable Drainage Systems via Reducing Maintenance (Less Intervention)

The proposed decision framework also includes an opportunity to trial reducing regular scheduled drain maintenance on drains that are not prone to recurrent nuisance flooding, and then monitoring hydraulic capacity and environmental responses. This is recommended for selected frequently maintained drains, if nuisance historic flooding has not occurred and if climate change is not considered to pose a significant future risk. This is an alternative approach to achieving sustainable drainage systems management, as waterways tend to naturalise and become self-sustaining over time when intervention ceases.

The Council could allow natural seasonal temperature and light variation instead of scheduled maintenance to control weed growth. This trial would need to be supported by a communications programme with affected Drainage Advisory Groups and adjoining properties about their expectations for drainage maintenance management. It would need to examine with them if there is a perceived need for regular weed removal and the options available to create a more sustainable drainage system.

Best Practice

This plan also confirms best practice methods for undertaking drainage maintenance management and minor works in Canterbury waterways. This is prepared with reference to the Environment Canterbury *Defences Against Water Code of Practice 2019.* Also referenced are other local and regional industry guidance documents.

2. Summary of Proposed Actions

The following table summarises the key recommended actions:

Table 1: Summary of Recommendations

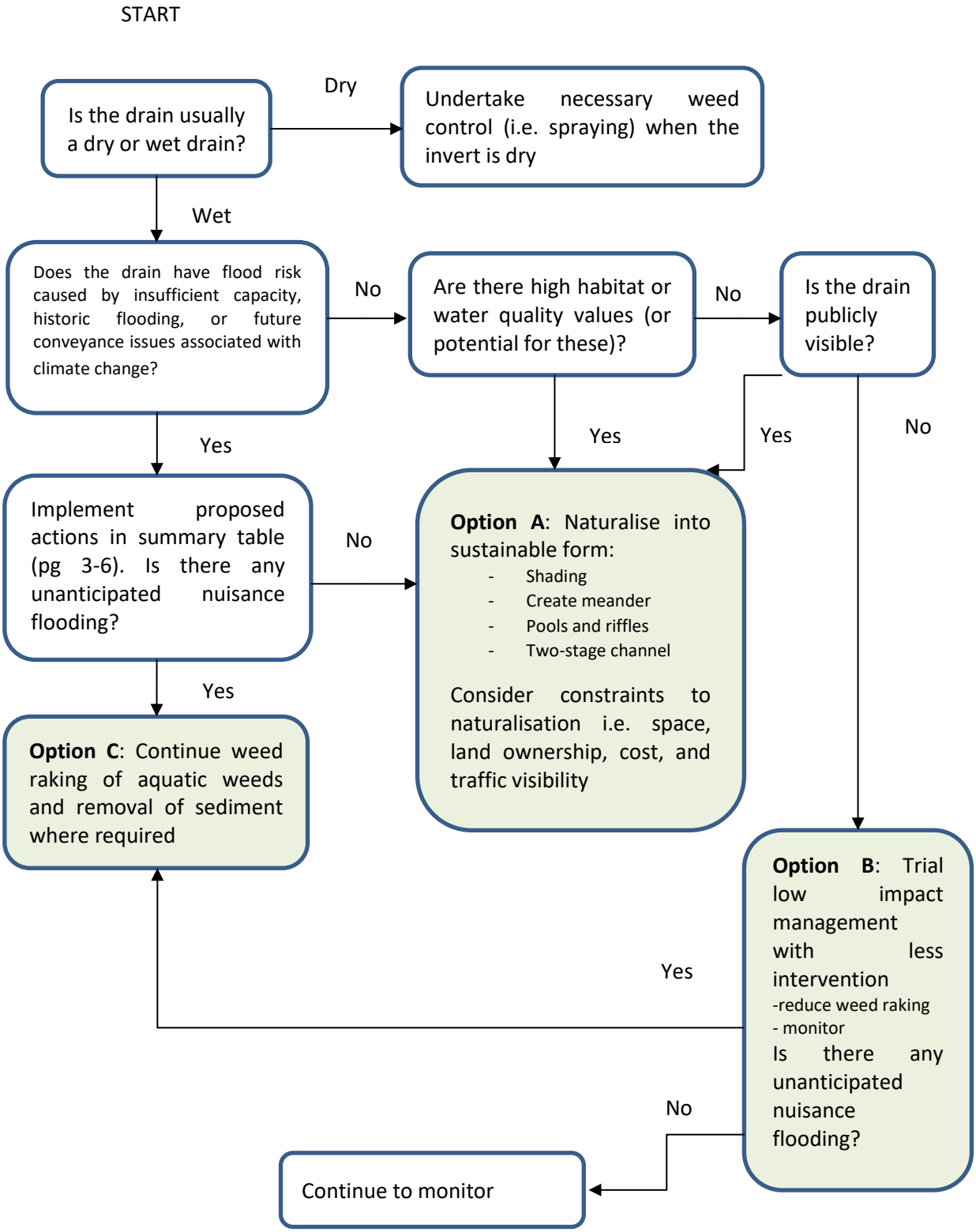
Recommendation	Rationale	Timeframe
Identify preferred management option: The decision framework on the following page includes a process for determining when a drain could be reformed or rehabilitated to become more sustainable. Alternatively it identifies situations when continuing or reducing the scheduled maintenance may be appropriate.	The redevelopment of a drain with rehabilitation or enhancement works, including potential bank re-battering (if needed) and/or riparian planting to improve shade or to create a high velocity low flow channel are key recommendations. The decision framework suggests a basis to redevelop selected drains where this is considered likely to improve hydraulic capacity, reduce medium and long term management costs and meet wider community objectives.	1-3 years
Reduce scheduled maintenance trial: Consider a trial of less intervention for selected drains, allowing the drain to naturally become more self-managing over time. The literature review (included in the Drainage Review (see TRIM 200403042466)) shows that aquatic weed cutting of dense macrophyte growths in summer/ autumn does not have a material effect on drain hydraulic capacity in winter, for drains with predominant macrophyte species that usually die back over winter. It is recommended that the Council trial non-management of selected drains (e.g. less intervention), allowing natural seasonal temperature and light variation to control aquatic plant growth. The Council should monitor and evaluate the effects of this approach as a part of the trial.	This trial may be justified in drains that predominantly contain species that are known to die back in winter (such as watercress and monkey musk). Aquatic weeds may be hydraulically rough at low flow, thus significantly reducing drain flow, but at high flow plants may bend over and are hydraulically smooth. Plants that bend over in the channel with increased flow velocities cause less reduction of hydraulic capacity than more rigid plants. This should be taken into account in making management decisions on frequency of mechanical weed removal in summer.	1-5 years
Biosecurity (weed) management Target and control problem weeds	Survey and respond to water weeds (sweet reed grass, lagarosiphon etc.) and riparian weeds (gorse and broom) and species that are listed in the Regional Pest Management Strategy	Ongoing
Create low flow channel to increase drain velocity: Naturally form a "V" shape in the base of flat drains by planting reeds, rushes or Carex grasses along the water margin/s at toe of the drain banks	Depending on drain water depth, plant options could include: 1) in the shallow or frequently wetted margins: *Schoenoplectus tabernaemontani (*sedge- grey clubrush – although may grow substantially and dominate small drains*);*	1-35 years

Recommendation	Rationale	Timeframe
where this will not adversely affect hydraulic capacity. Bank battering along the upper sides of drains can compensate for any loss of capacity in the base, if required. A faster moving channel will naturally limit nuisance weed growth and reduce future maintenance requirements.	*2)* on the periodically wetted margins: *Juncus edgariae (*rushes – wiwi*); Apodasmia similis (*Oioi - rushes*); or Eleocharis acuta (*spike sedge*);* or 3) on the occasionally flooded dry margins: *Carex virgata or Carex secta*. Addition of linear wetland plants within the drain bed itself will create a low flow and flood channel, creating the recommended "V" shape drain base. The plants will trap sediment along the margins, gradually lifting the riparian edges whilst filtering runoff from adjoining land. Cleanings from any future weed raking (if required) can be deposited behind the plants, further elevating the "V" shape and allowing rapid return of aquatic species to the waterway immediately following raking.	
Shading: Add additional shading to the north bank of west – east wet drains with usual baseflow, prioritising drains which currently require the most frequent maintenance. Also consider shading options for drains with more of a north – south alignment. Native grasses should be used for shading in potential inanga spawning areas, rather than non-suitable spawning species.	Will naturally reduce proliferation of undesirable aquatic weeds, reducing future frequency of maintenance. Shading with native plants also stabilises banks, filters sediment in runoff and provides habitat for birds.	1 - 35 years
Install sediment traps: Install purpose built sediment traps, or excavate natural sediment traps, in lower reaches of drains which require periodic fine sediment removal.	Reduce future adverse effects on aquatic habitat from sediment removal.	2-3 years
Delay seasonal timing of weed raking: Trial an option to delay weed raking of aquatic weeds where supported by ground conditions each year until March / April. This could both reduce the extent of regrowth that usually follows the mid-summer aquatic weed control, and could potentially reduce the overall scale of weed raking required. For instance, some aquatic weed may die back with the cooler temperatures, and be less likely to reestablish following late summer / autumn weed control.	Prolific weed growth usually peaks in the mid-summer period of December – January, however trout and salmon spawning does not commence annually until 1 May. This provides a window to undertake the weed raking in late summer or autumn. This option would not be appropriate in coastal inanga spawning drains due to the risk of disturbance of drain riparian vegetation with the weed rake. It would also not be appropriate in drains with silty ground or draining a high water table. These pug in wet weather and there is a risk of the weed rake machine causing bank collapse.	1-5 years
Protect critical source areas (CSA's): Fence off WDC drainage reserves from stock (working with adjacent farmers). Add wetland plants into rural tributary	Fencing for stock exclusion reduces sediment and faecal inputs. Wetland plants and bunding added to points where rural tributary drains, overland flow paths or low drainage points intercept	5 + years

Recommendation	Rationale	Timeframe
drains, overland flow paths or drainage low points which intercept Council drains. Create bunds that slow the passage of water and nutrients from CSAs.	Council drains can assist to trap and treat contaminants in rural runoff, including filtering nitrogen and sediment in rural runoff.	
Drain Reshaping: Reform shape of existing square, flat base drains by bank reshaping. Where sufficient riparian margin is available, reshape steep drain sides with wide flat bases into two stage channels or bank battering of at least a 1:2 grade. With limited riparian space, create a V shape with narrow base and steeper graded banks (1:1 grade). These options will improve bank stability and enhance riparian vegetation, improving aquatic habitat.	Higher velocity flows in narrowed drain beds provide natural flushing of weed and sediment. A two stage channel promotes high velocity weed reduction in the base, and trapping and treating of sediment during flood conditions. Gently sloping banks can be stabilised, reducing erosion risk as native vegetation or grass is established.	1-35 years
Add in - stream habitat into drain bed: Increase diversity of in-stream habitat by allowing natural development or adding new riffles and pools within drains if fish are present. Trial the natural development of meandering sections, by placing rocks or creating/allowing an uneven cross-section to develop.	This will improve availability and range of habitat for fish species. Pools will increase sediment trapping. Riffles or other gravelled sections provide opportunities for trout and salmon spawning. Meandering creates a more natural channel, with hydraulic variation that provides more habitat variation and may flush sediment from some areas.	3 + years
Willow cost / benefit assessment: Assess areas of drain with significant remnant willow populations. An average cost of management per drain could be compared; and above average management costs could be a trigger to consider removal of willows and replacement with native plants. A key consideration is whether the willow species (crack/grey willow) is present upstream and would re-establish in any cleared reach following willow control work. If not present upstream, removal of willows may assist to clear them from a catchment and prevent further spread.	Drains with significant willow populations could be proactively assessed. If the ongoing costs incurred for maintaining the drain are below those for an average drain, then retention of the willows may be appropriate. If above average drain management costs are incurred, particularly over a number of years, this may be a trigger to consider willow removal and replacement with native plants. Assessment could also be made of whether the existing habitat provided by willows offsets the ongoing management expenditure incurred, and whether an alternative native planting programme might introduce a wider range of ecosystem services. A further factor is whether the water uptake requirement of willows is reducing baseflow in the affected drain or stream.	5 + years
Gorse and broom risk assessment: Adopt a pro-active gorse/broom removal programme and remove or encourage private landowners to	Removal of gorse from drain margins reduces transfer (cycling) of nitrogen into waterways. Gorse is also a pest species noted in the Regional Pest Management Plan and restricts access for maintenance works. Gorse is a widespread	5 + years

Recommendation	Rationale	Timeframe
remove these species within 3m of drains.	nitrogen fixing plant which produces large quantities of litter debris which deposits in soils around the plants. Nitrogen may then leach from soils into ground and surface water during future rain events. Leaching potential of nitrogen into waterways from gorse debris is indicated to be significantly greater than the leaching potential from other common riparian plants likely to be present in or near the Waimakariri district drains. Broom is also a nitrogen fixing plant and could similarly be removed from close proximity to drains as a precaution to reduce transfer of nitrogen to waterways (refer report by Guna Magesan, Hailong Wang and Peter Clinton "*Nitrogen Cycling in gorse-dominated ecosystems in New Zealand",* November 2011, published online). In any decision to remove gorse/ broom, the benefits they provide should also be considered. These include provision of habitat for native lizards, or use as nursery plants enabling establishment of an understorey of juvenile native plants.	

3. Decision Framework for Drainage Maintenance Management



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4. Glossary of Terms

Term	Meaning
Dry drain	Drain without a regular baseflow, invert is usually dry
EPA	Environmental Protection Authority
Inanga	(*Galaxias maculatus*) smallest of 5 common whitebait species
Kākahi	Freshwater mussel
Kanakana	Lamprey
Kekewai	Blue Damselfly
Kōura	Freshwater crayfish
Macrophyte	Aquatic plant large enough to be seen by the naked eye
Mahinga kai	Ngāi Tahu interests in traditional food and other natural resources and the places where those resources are obtained
MCI	Macroinvertebrate Community Index - an index used in New Zealand to describe the tolerance or sensitivity of species (taxa) to organic pollution and nutrient enrichment; benthic invertebrate taxa are assigned a tolerance value ranging from 1 (very tolerant) to 10 (very sensitive)
MfE	Ministry for the Environment
SQMCI	Semi-Quantitative Macroinvertebrate Community Index (see MCI)
Tuna	Eel
Wet drain	Drain with a regular baseflow
ZIPA	Zone Implementation Programme Addendum (Waimakariri Land and Water Solutions Programme) – outlines the actions and tactics required to improve water quality in the zone

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5. Introduction

This plan reviews drainage management practices in the Waimakariri District. Its purpose is to identify any improvements to current practices. The plan is intended to:

- Maximise benefit of drainage management and minor works expenditure to the ratepayer.
- Work towards achieving a sustainable drainage system.
- Demonstrate the Council's response to recent objectives and policies for Freshwater Management indicated by Government, recognising 'Te Mana o te Wai' and a widespread community aspiration for clean, healthy waterways.
- Support implementation of district wide drainage resource consents.
- Work towards achieving Waimakariri Water Zone Committee outcomes, particularly Recommendations 1.7 and 1.14 of the Zone Implementation Programme Addendum (ZIPA).

5.1. Scope

The plan focuses primarily on rural drain management, minor works and roadside drain management activities, and their implications for waterways. It includes scheduled or unscheduled maintenance works and minor works such as bank or structure repairs in rural drains and bank reshaping and naturalisation projects. The plan excludes privately maintained drains. The plan includes all open drains which are currently or in future could be managed by the Council. There are areas of natural waterway where drainage maintenance is carried out by WDC. For simplicity these areas have been included in the term 'drain' in this plan, so the plan applies to all waterbodies managed by WDC.

Urban drains are included when they have programmed maintenance actions within the rural drainage maintenance contract. This is the case with some drains in Rangiora.

The plan identifies opportunities for improved practices and long term cost reductions. This is in terms of implementing improved management options that enable more efficient future drain conveyance. This includes identifying opportunities to improve environmental performance, maximise drain hydraulic capacity and community satisfaction with drainage management.

The review includes consideration of how to reduce management costs in the longer term. This may be though options such as including increased wet drain shading or bank / bed redesign in ways that make the drain more self-managing. New opportunities for drain management are identified and trials of new methods and approaches are recommended.

The roading and rural drainage "Contract for Services" is estimated to go out for tender in early 2020. There is an opportunity to insert recommendations from this management plan into this new contract, due to be signed around October 2020.

The consultation on the associated drainage review identified an option to improve rural drainage retention through installing facilities such as swales, in-drain wetlands, ponds, weirs or similar into Council managed drains. These facilities would capture and attenuate or retain peak sub-surface and surface flows in order to protect downstream communities from flooding. This idea is considered outside of the scope of the Drainage Maintenance Management Plan. However it is detailed in the accompanying District Drainage Review as an option that can be separately scoped by the Waimakariri Water Management Zone Committee in future.

5.2. ZIPA and 'Maintenance and Minor Works in Waterways' Consent

5.2.1. ZIPA

This plan works towards achieving Waimakariri Water Zone Management Committee outcomes. These include improving quality and abundance of mahinga kai, fish habitat, fish passage and recreation opportunities, in context of achieving an improved rural economy.

Recommendation 1.7 states:

That Environment Canterbury, Waimakariri District Council, and Ngāi Tūāhuriri review the waterway management and maintenance methods used in the Zone. The review which should be publicly reported, would include:

a. Preparation of an inventory of the main methods, including chemicals and mechanical methods, used by public and private land and water managers in the Zone;

b. The findings of recent work by EPA, MfE or other relevant New Zealand organisations reviewing the potential effects of the listed chemicals on waterway ecosystem health and of other methods;

c. An assessment of the risk to soil biodiversity and waterway ecosystem health in the Zone from use of chemicals or other methods.

Recommendation 1.14 states:

That Environment Canterbury and Waimakariri District Council ensure waterway management and maintenance activities minimise contaminant losses to downstream waterbodies and loss of aquatic life, while maintaining flood carrying capacity.

5.2.2. Consent and Management Plan requirement

The Waimakariri District Council has applied for a drainage "maintenance and minor works in waterways" land use and discharge resource consents from Environment Canterbury. As a condition of these draft resource consents, a drainage maintenance management plan is to be lodged with Environment Canterbury as soon as practicable.

This plan supports implementation of the consents. It will be a "live" document, to be amended from time to time and resubmitted to Environment Canterbury (via consent conditions). Amendments will include improved management practices and learnings from results of initial trials intended to be initially implemented via the consents during the next 3 years.

5.3. Exclusions

The plan does not address private drain management in the district other than when identifying future public education opportunities. It does not include Environment Canterbury drain management, the management of the stockwater race network, or methods for improving urban stormwater quality.

5.4. Methods

The methods used to prepare this management plan were:

Literature Review:

- Review of latest industry publications and drainage management guidelines, including Environment Canterbury drainage and waterway management guidelines
- Review Ngāi Tūāhuriri policies and plans, including the Mahaanui Iwi Management Plan and Ngāi Tahu Freshwater Policy Statement.

Semi-structured interviews:

- Drainage Team staff
- Drainage contractors
- Drainage team at Selwyn District Council
- River Engineers at Environment Canterbury (Waimakariri Area)
- Mahaanui Kurataiao Ltd and Ngāi Tūāhuriri (will seek feedback on this draft version)
- WDC Roading team
- Drainage Advisory Groups

5.5. Context

The Waimakariri drainage system is comprised of a combination of natural or artificial channels, sub-surface drainage systems and associated water control structures, including culverts and flood gates. These are managed for the purpose of draining surplus runoff from farmland, to lower the water table on rural land or to prevent the inflow of tidal waters into low lying drainage channels.

Many of these drains provide an important habitat for aquatic fauna. For instance, wet district drains are usually modified waterways that are known or understood as likely to provide various migration routes, temporary habitat, or spawning habitat for fish. Fish known to be present within the rural drainage network include inanga (whitebait), eels, upland bullies, trout and salmon. Other aquatic species present in the drains are freshwater crayfish and freshwater shrimp.

It is also possible that the wet drains in the east of the district could provide habitat for a much wider variety of fish which are known in the nearby larger streams and rivers in the Waimakariri District. These include common smelt, common bully, giant bully, black flounder and others. The species listed here are all fish found in drains and drainage canals in New Zealand studies (Hudson and Harding *Drainage Management in New Zealand: A review of existing activities and alternative management practices"* 2004, p. 10) that are also referenced in various aquatic ecology studies in the Waimakariri District lowland streams.

5.6. Key Relationships

The management and minor works activities undertaken by the Council in the drainage network are of a great deal of interest to and have various impacts on the activities of key stakeholders such as Fish and Game. These activities are also of great importance to Ngāi Tūāhuriri.

This section is prepared taking account of key agency or stakeholder documents such as the Mahaanui Iwi Management Plan 2013 and Te Rūnanga O Ngāi Tahu Freshwater Policy. This plan also acknowledges the discussions currently underway between Te Rūnanga O Ngāi Tahu and the Crown over the Ngāi Tahu Rangatiratanga over Freshwater Strategy 2019. Taking account of these discussions, the Council undertakes to continue to involve Ngāi Tūāhuriri representatives in its various discussions over its future drain and associated freshwater management decisions and options, including those outlined within this management plan.

The document review is augmented with feedback from with Ngāi Tūāhuriri (to be carried out on this draft version) and various stakeholder representatives where available.

5.6.1. Te Ngāi Tūāhuriri Rūnanga

Te Rūnanga O Ngāi Tahu Freshwater Policy describes the primary management principle for Ngāi Tahu as being the management and enhancement of the mauri or life-giving essence of a resource.

With respect to waterways, it notes that "*mauri can be tangibly represented in terms of elements of the physical health of a river system. While there are also many intangible qualities associated with the spiritual presence of the river, elements of physical health which Ngāi Tahu use to reflect the status of mauri and to identify the enhancements needed include:*

- *Aesthetic qualities (e.g. clarity, natural character and indigenous flora and fauna);*
- *Life-supporting capacity and ecosystem robustness;*
- *Depth and velocity of flow;*
- *Continuity of flow from the mountain source of a river to the sea;*
- *Fitness for cultural usage; and*
- *Productive capacity*".

In terms of this plan, it is noted that drain management can adversely affect any of these values. However there are actions the Council takes to protect these values, which form the best practice approach outlined within the plan.

A guiding consideration affecting intent for drainage management is stated in the Mahaanui Iwi Management Plan Policy WM 14.1, which states:

"To require that drains are managed as natural waterways and are subject to the same policies, objectives, rules and methods that protect Ngāi Tahu *values associated with freshwater, including:*

(a) inclusion of drains within catchment management plans and farm management plans;
(b) riparian margins are protected and planted;
(c) stock access is prohibited;
(d) management methods are appropriate to maintaining riparian edges and fish passage; and
(e) drain cleaning requires a resource consent".

In terms of managing effects of the drainage management activities considered in this report, the IMP (WP14.2) also states:

"To require and uphold agreements with local authorities to ensure that the timing and techniques of drain management are designed to avoid adverse effects on mahinga kai and water quality, including:

(a) Identifying drains that are or can be used for mahinga kai;
(b) Returning any fish that are removed from drains during the cleaning process to the waterway;
(c) Riparian planting along drains to provide habitat and shade for mahinga kai and bank stability while reducing the frequency and costs of management by reducing aquatic plant growth;
(d) Ensuring drain management/cleaning does not breach the confining layers;
(e) Use of low impact cleaning methods such as mechanical 'finger buckets', as opposed to chemical methods such as spraying, to minimise effects on aquatic life;
(f) Notification to tāngata whenua of any chemical spraying of drains used for mahinga kai or connected to waterways used as mahinga kai; and

*(g) Involvement of tāngata whenua in drain management activities where there is a need to return native fish back to the drain (e.g. tuna (*eels*), kekewai (*blue damselfly*) and kanakana (l*amprey*)".*

Other guiding intent within the IMP, with implications for management of rural drains, is that the IMP recommends reconfiguring some of the river tributaries to re-establish historic wetlands. The IMP explains:

"Before European settlement began in the 1850s, the lower reaches of the Waimakariri and Rakahuri (Ashley) connected with a maze of waterways and wetlands fed by underground springs of the purest artesian water, which nourished a wealth of mahinga kai rich in birdlife, eels, fish and natural vegetation" (Mahaanui Iwi Management Plan 2013, p.215).

The IMP acknowledges that historically the Waimakariri and Rakahuri catchments were linked through extensive coastal wetlands, waipuna and waterways.

Te Rūnanga O Ngāi Tahu Freshwater Policy, page 22 also notes that "*Ngāi Tahu's fishing rights were explicitly protected by the Treaty of Waitangi. Not only was the right to engage in mahinga kai activity confirmed, also included was the right to expect that such activity will continue to be successful as measured by reference to past practice. Unfortunately, adverse impacts on freshwater resources have resulted in adverse effects on the diversity and abundance of mahinga kai resources and harvesting activity*".

The recommendations and best practice actions outlined in this plan are intended to improve habitat of mahinga kai species. Therefore the drain management activity and actions within the plan are viewed as consistent with the recommendations for drain management in the Mahaanui Iwi Management Plan 2013 and meet aspirations for improved mahinga kai abundance and diversity to match past practices as outlined in Te Rūnanga O Ngāi Tahu Freshwater Policy. Over time, the proposed actions should improve the abundance of future mahinga kai resources.

5.6.2. North Canterbury Fish and Game

The drainage management activity needs to protect indigenous fish and trout and salmon species which have habitat within, or which spawn in or migrate through the district's rural drains.

The main trout and salmon fishing season in the Waimakariri District is from October through April. The Waimakariri River, Kaiapoi River and Silverstream are a habitat for salmon, with a salmon hatchery on the Silverstream. Some of the drainage scheme's tributary drains flow into these rivers may provide habitat for young trout.

In December and January there are runs of fresh silver sea-run brown trout that also converge on the tidal areas of the salmon rivers near the coast. There is known trout spawning habitat in many of the lowland streams in the east of the district where gravel substrate is present. It is possible that trout migrate through or obtain food within some of the rural drains that are tributaries of the lowland streams, where baseflow is present.

Therefore the wet drains with usual baseflow are likely to provide habitat of value. These environments are protected through the best practice undertakings and recommendations made within this review.

5.6.3. Environment Canterbury

Environment Canterbury has prepared and published its most recent drainage guidance via its "*Defences Against Water Code of Practice*" (2019). That guidance has been referenced in many places within this plan and has assisted to form the recommended actions.

6. Background

In pre-European times the eastern part of the Waimakariri District from the coast to approximately 15km inland, together with an inland area west of Oxford, were all predominantly swamp land. Early settlers drained these swamps, creating the majority of the drainage network that exists today.

A presentation on *Low Impact Drain Management in the Waimakariri District*, by the Council's Drainage Engineer Greg Bennett in 2012, noted that until approximately 2008 historic drain cleaning used high impact methods such as a weed/silt bucket, with little emphasis on sediment management, biodiversity, in-stream fauna protection or enhancement. It noted that over the last 10 years the drainage management activity has been refocusing on a wider range of low impact drain cleaning methods. These include drain raking in place of silt bucket and areas of drain naturalisation being introduced in places.

These changes, approaches, benefits, costs and options for further improvements are discussed in detail in this plan.

6.1. Past Drainage Management

6.1.1. History of Catchment Management Governance

The 2012 presentation by Greg Bennett described the historic management of the extensive drainage network in the Waimakariri District as ad-hoc. It was managed under various river and roads boards and County Councils but mostly maintained by the landowners until the North Canterbury Catchment Board was formed in 1944.

Community evidence supplied to the Council states that, in the 1950's, torrential rain in the Alps caused minor flooding in the Clarkville area near where the motorway bridges are today. The Kaiapoi township was protected from this flooding by a major modification which had been made to the lower Waimakariri River in the 1930s. During the 30's the "north branch" was cut off to become the Kaiapoi/Silverstream system and the Eyre Diversion was created.

The diversion of the (lower) Eyre River into the Waimakariri River, and (lower) Cust River to the Kaiapoi River in the 1930's drained two swamps at Flaxton and Mandeville. Before the 1930's these rivers did not reach the coastal plains as they do today. Over time, as settlement of the area increased the demand for drainage also increased, through to the recent work around Mandeville and Mandelea.

Following this 1950's flooding, the Catchment Board created the Ohoka Drainage District and levied rates for drainage.

The North Canterbury Catchment Board was dissolved in 1989 during local government reforms and the responsibility for the drainage in the district was ceded to the Canterbury Regional Council and Waimakariri District Council. Environment Canterbury assumed responsibility for the major rivers. Approximately 420km of smaller creeks and network of land drains became the responsibility of the Waimakariri District Council.

6.1.2. Historic Drainage Management Practices

During the County Council period, drain cleaning was usually carried out annually whether the drain needed cleaning or not. Digger operators would take great pride in making the sides and invert as straight as possible; they would scrape the bucket down the far bank, across the bottom and up the near bank. Many of the waterways were over deepened and the spoil was left piled high on the banks. No consideration was given to sediment control or biodiversity values. It was common to allow stock access to the waterways.

6.2. Current Drainage Management

The Council currently maintains a number of both wet and dry drains throughout the district. These are spread across a number of drainage management schemes, with their management funded by ratepayers within each scheme. These drains are shown at district overview level in the Appendices to this plan. Detailed maps are available in a separate file.

The dry drain management is undertaken "on demand", meaning only when a specific issue arises.

Wet drains are more likely to have a regular management schedule. This may range from every 3-4 years to being maintained several times per annum.

The Council administers regulations regarding rural drains under the Stormwater, Drainage and Watercourse Protection Bylaw 2018.

6.2.1. Regular Scheduled Works – Overview

Many drains are currently regularly or periodically cleaned of weeds and sediment build up with the intention to retain their conveyance. The growth of weeds drives the key current perceived requirement for drain management. Open drains and small waterways are encouraged to freely flow at all times without obstruction.

Drain cleaning is generally carried out as needed depending on weed growth. Some watercourses are cleaned three times per season, some are cleaned annually, some are cleaned once every few years and some not at all.

This scheduled drain clearance is outlined in the waterways management schedule attached to this plan, with locations shown in maps in the Appendices. Note these are indicative frequencies, put together for the purposes of contract pricing.

6.2.2. Reactive management – Dry Drains

All of the dry drains in the district are maintained "on-demand" and have no regular management schedule in place. This translates to periodic (usually no more than annual) spraying of dry drains with glyphosate to control rank grass. Spraying of dry drains is undertaken in accordance with best practice requirements as outlined in the "*Chemical Weed Clearing"* section of the review.

These drains fall within the following drainage rating schemes: Ohoka, Waikuku, Oxford Rural West, Oxford Rural East, Cust, Loburn Lea, Central Rural, Clarkville and Coastal, Rangiora and Kaiapoi.

6.2.3. Scheduled management - Wet drains

Wet drains are drains with usual baseflow, that are currently maintained at various frequencies. This ranges from longer return management periods of 3-4 years, to more frequent annual scheduled management. Several wet drains are maintained several times per year.

Some of these drains are however only maintained "on demand" when an issue arises.

These drains fall within the following drainage rating schemes: Ohoka, Clarkville, Oxford Rural East, Oxford Rural West, Central Rural, Coastal, Oxford, Cust, Rangiora and Kaiapoi.

The more regular management requirements on wet drains, as opposed to dry drains, indicates a tendency for more conveyance issues to occur in the wet drains. These issues include regular aquatic weed proliferation, sediment build up (which may in part be caused by trapping from weed proliferation) and regular blockages requiring maintenance.

Surface factors such as sunlight, excess sediment in runoff and nutrients entering the waterway during rainfall contribute to periodic prolific aquatic weed growth.

Drains with baseflow are also likely to be augmented at times with spring flows or resurgent groundwater. This indicates that high groundwater may be a factor in limiting surface drain conveyance and surface storage of runoff. With ground saturation more runoff is retained in surface channels rather than infiltrating into groundwater.

6.2.4. Unscheduled Maintenance

Issues such as windfall, bank erosion or scour, or excessive debris entering a drain during storm events can lead to a requirement for unscheduled maintenance, described as “on-demand” in the drainage schedule. There are various methods involved in managing effects of unscheduled maintenance activities which are outlined in detail in this plan.

7. Drain Management Activities

The main reason why the waterways are currently regularly maintained is because of the rampant growth of exotic aquatic weeds that infest them. The weeds directly block or reduce drain conveyance during summer and autumn, or trap sediment or storm debris which also reduces conveyance.

The aquatic weeds which proliferate in the District drains are notably *Nasturtium officinale* (Watercress), *Erythranthe guttata* (monkey musk), Veronica or water speedwell (*Veronica anagallis-aquatica*), *Elodea canadensis* (Oxygen weed), *Potamageton crispus* (curly pondweed) and *Glyceria fluitans* (floating sweet grass) (Greg Bennett "*Low Impact Drain Management in the Waimakariri District*" Water New Zealand Stormwater Conference paper 2012).

The Council chooses the most appropriate methods to control aquatic and riparian weeds. It may apply mechanical, chemical, hand, or increasingly, stream shading or other low impact management options to reduce prolific weed growth or weed density, as outlined in the sections below.

This plan notes a recent growing community concern about the effects of chemical weed control on the environment. There is also increasing recent contractor concern about the safety of the hand weed control method. The current drainage contractor has confirmed that any hand weeding projects will now be subject to a site specific health and safety risk assessment because of safety concerns, including muscle strain and trip/slip hazards. Therefore the default main weed control method is now mechanical weed removal via weed rake.

A report to Council on 30 January 2018 titled "*Herbicide, Glyphosate Use for Waimakariri District Council weed control operations"* by Greg Bennett, Land Drainage Engineer and Gerard Cleary, Manager Utilities and Roading (TRIM 180111001840v2), compared the costs of mechanical versus chemical weed control for the drainage activity. The report showed costs of mechanical weed control to be in the order of 6-10 times greater than costs of chemical weed control for undertaking district drain maintenance. Actual costs depend on which alternative mechanical weed removal method is selected for any drain.

These reported costs are rough order estimates and not based on site specific assessments. The exact cost of the most suitable alternative weed control method for each site was not able to be identified for every site, due to the potential cost of gathering that level of information for the entire network. The cost estimates were instead based on extrapolations, from actual costs reported during mechanical weed control trials from recent years.

It can be seen that the cost of moving to a predominantly mechanical weed removal method is significantly greater than when using chemicals. In the 2018/2019 year the Council responded to public concerns by avoiding spraying with glyphosate where practicable around wet drains. Recent drainage budgets are now correspondingly greater than when spraying was more commonly undertaken. It is unclear that the Council could return to using chemical weed control in the current political environment; however there is now growing concern within Council about the increasing costs of the undertaking the drain maintenance activity using predominantly mechanical weed removal methods.

It is also unclear that scheduled summer weed removal is effective at reducing flooding which usually occurs later in the year, during winter rainfall. The literature review in Section 11 shows that for most plants prevalent within the District drains, there is no material effect from summer aquatic weed cutting on winter flooding or hydrology of drains during the winter season. This plan therefore examines the wider rationale for the weed control activity. It recommends some alternative design or low impact management options and approaches that could both mitigate flood risk whilst reducing the current intrusive and costly mechanical removal of weeds from drains.

Some waterways periodically require the removal of silt to maintain drain capacity. However with modern sediment control measures and the exclusion of stock from waterways, the removal of silt is no longer the main focus of drain cleaning. It is currently only undertaken on an ad-hoc basis to maintain drain capacity. Silt removal is usually commissioned as a result of a specific catchment drainage investigation where flooding of roads or property has recently occurred.

Current drainage management is driven by an emphasis on flood prevention. The corresponding enhancement of environmental and cultural values is now being increasingly integrated into the programme where practicable.

The various drainage management activities commonly undertaken by Council are described in the following sections.

7.1. Managing Drain Conveyance

The management of conveyance capacity in the drains remains the key current driver for provision of the drainage management activity.

7.1.1. Maintaining conveyance - Effects

Both scheduled and reactive drain maintenance are currently undertaken to maintain drain capacity. This includes periodic removal of built up sediment in drains where sediment commonly accumulates, and periodic removal of margin vegetation that may grow into the drain.

Aquatic weeds are also periodically removed in accordance with the maintenance schedule. Environmental effects associated with each of these maintenance methods are conveyed in detail in the following sections. This section therefore focuses on effects of unanticipated nuisance flooding on private property, including farm and lifestyle block management and safety for the transport network.

Inundation of private property can reduce safe access of homeowners to their dwellings and throughout their properties. Unplanned ponding increases risk of injury for those needing to provide essential maintenance to various parts of their properties.

Prolonged periods of ponding cause a reduction in productive capacity of farms and reduce grazing area and food availability for stock. Nuisance flooding therefore places pressure on farm and lifestyle block management and can adversely impact the health or safety of both stock and people.

Unplanned inundation of the transport network creates danger for motorists. It increases the risk of traffic accidents, particularly from flash flooding overnight which is not visible to approaching motorists. Unplanned road inundation can also cut off access to rural properties, which can impact supply of essential food or other supplies for people or stock.

7.1.2. Maintaining Conveyance – Best Practice

The drainage contractor has contracted availability to respond to drain blockage issues immediately once reported via a service request. The response time for contractors to unblock drains where flooding of private or public property or roads may result is currently 2 hours for emergency works, and 24 hours for urgent works. These actions are specific requirements within the Drainage Maintenance Contract.

Maximising hydraulic capacity through the network is a key consideration of every drain management option and method considered in this plan. Implications of each action for hydraulic conveyance is considered further in the following sections.

7.2. Mechanical Weed Clearing

Mechanical drain cleaning best practice currently involves weed clearance with a rake.

7.2.1. Mechanical Weed Clearing - Effects

Mechanical weed clearance with weed rake temporarily destroys aquatic habitat and removes potential food sources for aquatic life from the reaches where the activity is undertaken.

All mechanical clearing is non-selective and desirable plant species including inanga spawning vegetation in coastal drains may be removed along with non-desirable aquatic weeds. Disturbance of inanga spawning vegetation may occur if coastal drain riparian vegetation is disturbed during weed raking of aquatic weeds. However in the Waimakariri District this is avoided as the banks in these locations are not usually maintained and weed raking is only of aquatic plants on the drain bed.

There is a risk of disturbance of Canterbury mudfish spawning habitat during weed raking of aquatic weed. However no drains included within the drain maintenance schedule have any recent record of providing Canterbury mudfish habitat. Additional Canterbury mudfish surveys were undertaken in rural drains near Oxford in early 2020 by WDC staff, at locations where mudfish had been historically identified in the 1950's. No mudfish were located during these recent surveys.

There is one rural drain where there could be mudfish (Drain C2) which has not been recently surveyed. This drain is very rarely cleaned- and should only be cleaned in future if absolutely essential. An ecological survey of the drain would be carried out before any maintenance, to establish if there are any Canterbury mudfish present, and mitigation measures or reassessment of the need for maintenance undertaken.

The activity also risks removal of fish and invertebrates from the watercourse. The activity risks mobilisation of fine sediment which further impacts aquatic habitat by interfering with fish gills and their behaviour, reducing food available for invertebrates or fish, and potentially mobilising contaminants (if present in substrate). Weed raking also reduces dissolved oxygen levels in the water from decomposition of plant material if weed is disposed of in the water column.

Conversely, some effects of not undertaking weed clearance are:

- During heavy rain events clumps of weed, especially watercress, can become unrooted, float downstream and build up to cause blockages at culverts, for example.
- Excessive weed is likely to reduce dissolved oxygen which adversely impacts fish habitat. This is due to overnight plant respiration removing oxygen from waterways – particularly those with dense plant cover.
- Macrophytes trap sediment or debris that reduces drain capacity, clogs stream beds, reduces habitat for open-water biota, and like a self-perpetuating system, enables more prolific weed growth.
- Excess weed will hinder the passage of some introduced and native fish populations.
- Detracts from the aesthetic appeal of a body of water.

7.2.2. Mechanical Weed Control - Options

The use of a rake for mechanical drain cleaning is considered the best practice method currently available to remove excess weed and sediment entrained within weed from waterways. The rake is less intrusive than the silt bucket method as metal spikes (tines) rather than a cutting bucket surface removes only the weed.

This reduces the disturbance of soil from the bed or sides of the drain and the drain substrate is usually not excavated. This method also avoids scraping up the drain banks. It lifts weeds up and over the sides of the

drains, allowing water and fauna to escape back into the waterway whilst minimising the disturbance of sediment.

The spacing between the tines on weed rakes the Council currently uses in drains is 165mm-270mm (see photo below):

Figure 1: Weed Rake: Photo credit Greg Bennett

This is in contrast to the width of the tines in a standard silt bucket with cutting edge which has spacing of only 40 - 50mm between tines (see photo on following page):

Figure 2: Weed Bucket: Photo Credit Greg Bennett

The cutting surface of this standard silt bucket, in combination with its narrowly spaced tines makes it challenging for aquatic fauna to escape the weed removal process.

The weed rakes now currently used by Council are considered a significant improvement in avoiding adverse effects of weed clearance, enabling escape of aquatic species through their widely spaced tines.

The weed rake method also avoids unnecessary removal of riparian vegetation including inanga spawning vegetation. It produces less disturbance of riparian bird habitat than other methods.

The operator is able to flick the cleanings on to the near or far bank without having to pivot, reducing disturbance of the drain bank. The raking operation overall is faster, with a lower cost and has less environmental impact than the bucket silt removal method.

Following raking, the channel is usually almost immediately available for aquatic fauna to re-establish, provided there has been minimal silt disturbance. Fauna that is collected with the cleanings is usually able to self-migrate or be relocated back into the waterway if cleanings are placed nearby on the bank.

However in recent years the development of the lifestyle property has introduced land owners wanting a tidy groomed road frontage and garden. Many property owners do not want stream cleanings spoiling their lawns and expect the Council's contractor to immediately remove the cleanings. The impact is that any fauna is totally removed from the stream and is unable to return.

The Council prefers to transport cleanings from a drain once these are dry. If wet cleanings are transported then sediment and water can drain onto roads during transport. This creates a further amenity issue of dust in future dry weather, or with sediment draining to waterways from road runoff in future rainfall events.

Feedback from consultation with the Selwyn District Council indicated that weed regrowth is reduced when aquatic weed removal is undertaken in late summer or autumn. Noting that trout and salmon spawning season is from 1 May to 31 October and prolific weed growth usually peaks in the period December – January, it is therefore recommended that an option to delay aquatic weed removal until March / April is considered.

7.2.3. Mechanical Weed Clearing - Best Practice

The Environment Canterbury Defences Against Water Code of Practice includes various recommendations pertaining to vegetation removal from water. A summary of aspects most relevant to the drainage management activity, adapted to meet specific contractor, Ngāi Tūāhuriri, stakeholder and ratepayer requests are outlined below.

If mechanical weed clearance is deemed necessary to be undertaken to reduce flood risk then the Council will require the following:

- Use of a weed rake with spacing between its tines of at least 165mm, to maximise aquatic fauna escape back to the waterway
- Avoid excavating into the drain bed and drain banks to minimise disturbance of fine sediment and protect aquatic species habitat and refuge
- Inspect site where works intended and identify any features which should not be disturbed, including pools, riffles, woody debris, salmon/trout spawning gravels, watercress mahinga kai sites or threatened species habitats, and avoid these where possible

- Avoid works that damage native plants or riparian vegetation used for inanga spawning, or that disturb sediment in inanga spawning areas during the period 1 February to 1 June
- Avoid pulling roots where the bed is dominated by a fine sediment base (e.g. avoid dragging roots through fine sediment)
- Inspect debris vegetation for any captured fish that appear still alive, or koura or kākahi and return any found to the waterway where practicable. The Council will not remove any cleanings from the waterway until at least 24 hours after the mechanical raking is complete. The relocation of aquatic fauna is then undertaken in accordance with a specific agreement with Ngāi Tūāhuriri whom will usually visit the site on the afternoon or evening following the cleaning. Council staff or contractors will be trained to undertake the aquatic fauna relocation in the event that Ngāi Tūāhuriri are unavailable at any time to perform this function.
- Where there is a confining layer between the drain and groundwater, ensure drain cleaning does not breach this layer. This is not usually an issue in the Waimakariri drains which at the invert often already intercept resurgent groundwater – noting the high groundwater table present in the east of the district.
- It is recommended that an option to delay weed raking of aquatic weeds annually until March / April is considered. This would reduce the extent of weed regrowth that usually follows mid-summer weed control, and could potentially reduce the overall scale of weed raking
- The Council will only remove cleanings from drains once they are dry. This avoids dispersal of mud during transport of cleanings.
- Ensure any cleanings are deposited evenly along on the inside of the banks (near the top) and not below the water line. This will:
  a) avoid any concentrated flows causing scour from drying weed stockpiles;
  b) avoid blocking downstream structures from cut weeds deposited into waterways; and
  c) avoid decomposition of weeds in waterways which cause adverse effects on aquatic habitat.

The Council's current practice, agreed with and implemented by its contractor, is to remove the weeds and deposit them inside the drain banks to an elevated area above the water line. It leaves the weeds within the drain for a period of at least 24 hours after cleaning so that aquatic fauna can escape or be relocated. It then returns at a later date to remove the cleanings for composting elsewhere. This addresses the amenity concerns of adjoining property owners and meets road drain cleaning requirements to remove cleanings, where necessary. Otherwise, wherever possible cleanings will be left within the upper drain channel to break down.

7.3. Chemical Weed Clearing

The Council historically sprayed its drains periodically with glyphosate or other chemicals targeted to particular species to control weeds. However there has been recent community concern about use of herbicide in or near waterways. The advice from the Environment Protection Agency as of October 2019 is that glyphosate is considered safe, provided that all of the rules around its use are followed.

7.3.1. Herbicide Spraying – Effects

Spraying with glyphosate may have adverse effects on non-target species of flora and fauna. There is a risk of accidental spill of chemicals during operations, which can harm aquatic life. If sprayed plant debris enters a waterway, it can cause de-oxygenation of the water through plant decomposition. Spraying also removes aquatic and inanga spawning habitat.

7.3.2. Council Approach to Herbicide Use – Options

The Council drainage staff currently have discretion about circumstances and locations around the drains where herbicide may be used. Staff are able to continue to use glyphosate to control weeds within and adjacent to drains if this is the most appropriate option. However, no spraying with glyphosate was undertaken in the 2018/19 year due to public environmental concerns and only approximately 1km of drain along Tram Road was sprayed in 2019/20. The Tram Road spraying in 2019/20 is necessary as mechanical weed removal cannot be safely undertaken due to high traffic speed, high traffic count and the difficulty in working safely on the narrow road berm adjacent to this drain.

Council staff have discretion to determine whether to spot spray to remove pest plants from the riparian margin area or from the drain bed. Problem weeds may be sprayed if located on fairly flat ground adjoining the drain, where there is a low risk of creating bank erosion and, for spraying of the banks, where the spray drift will not accidentally enter surface water. Care is also taken to reduce the risk of decomposing material from falling into the waterway following spraying.

Council contractors spray dry drains to control rank grass. They are instructed to spray only the invert of the drain and to leave the banks untouched. Usually one spray per year is enough to keep the drains manageable.

Contractors spray wet drains with glyphosate 360 using a vehicle mounted spray unit. A resource consent is held by Waimakariri District Council for this activity (CRC 120402). When spraying aquatic emergent weeds, the practice is to spray the middle of the drain only and not the banks. It may not always be possible to prevent spray drift residue from entering the flowing water, however this is minimised by spraying only thick areas of emergent plants which are above the water. Glyphosate is only effective on emergent weeds as sprays are diluted beyond effectiveness when mixed with stream water. Historically approximately 8-10% of spring fed drains were sprayed every year.

Glyphosate gel is used to control willow and other woody debris along open drains and streams. The plant is either drilled and injected with the gel or the plant is cut and the stump pasted. These methods ensure no product enters the water.

Glyphosate is also used for managing riparian areas which have been planted with natives. The practice is to target problem weeds that could compete with the natives. A backpack sprayer is used. This practice is temporary because as natives become established they may prevent exotic weeds establishing on the margins.

There are no other herbicides in New Zealand that are approved to be sprayed over water for emergent weeds. Most of the organic products on the market contain fatty acids, pine and other oils that are toxic to stream fauna and flora and as such are not appropriate or approved to control in-stream emergent macrophytes. Other non-herbicide options require heavy, cumbersome equipment such as hot foam and electro-weeding equipment, that are not suitable for access to rural drains.

The report to Council "*Herbicide Glyphosate Use for Weed Control, 30 January 2018 (TRIM 180111001840[v2])"* prepared by Greg Bennett provides further details of Council's current approach to determining situations where it is appropriate to use glyphosate. The Council is working to reduce use of glyphosate in recent years, taking a precautionary approach.

Details of the most recent review of Council use of glyphosate are in report "*Glyphosate –Review of Council Practices*" 6 August 2019 *(TRIM 190702093110[v2]),* prepared by Grant MacLeod and Sophie Allen. This includes a provision that a 'No Spray' register is kept across all Council Departments. Landowners may register their property to not have glyphosate sprayed by Council contractors within the close vicinity (e.g.

5m) of their property. Staff are required to carefully consider options for reduction of the use of glyphosate, as a precautionary principle.

The Council holds a resource consent from Environment Canterbury to spray aquatic macrophytes, using diquat (CRC 120402). As at the date of publication of this review, it is current practice to not use diquat to control aquatic macrophytes, unless for control of an Unwanted Organism under the Biosecurity Act, such as *Lagarosiphon major*. The use of diquat is not a prioritised management option within waterways.

7.3.3. Environmental Protection Authority – Glyphosate and Public Health

The Council previously sought advice from the Ministry of Health (MOH), Ministry for the Environment (MfE), Parliamentary Commissioner for the Environment (PCE) and the Environmental Protection Authority (EPA), on the impact of use of glyphosate and other sprays on public health and on the environment. Their responses are summarised here.

The EPA response referred Council to a recent report it had commissioned, titled "*Review of the Evidence Relating to Glyphosate and Carcinogenicity*", published in August 2016. This report was prepared by toxicologists Dr Wayne Temple with contributions from Michael Beasley of the New Zealand National Poisons Centre. The report found that, "*based on a weight of evidence approach, taking into account the quality and reliability of the available data – glyphosate is unlikely to be genotoxic or carcinogenic to humans and does not require classification under HSNO as a carcinogen or mutagen"*.

The letter from the MOH referred the Council to the EPA as the most appropriate authority in New Zealand on assessing and regulating glyphosate use. Therefore the report prepared by Dr Wayne Temple is considered the most comprehensive and recent resource provided by the Government for New Zealand organisations to assess public health impacts of the use of glyphosate.

The MfE also concurred with the findings of the EPA report. It noted that the EPA has approved the use of glyphosate in New Zealand following consideration of the likely effects of glyphosate on both human health and on the environment. It concluded that "*both could be safeguarded by placing appropriate controls on the use of products containing glyphosate"*. It went on to state that "*the level of glyphosate in Kaiapoi, according to your own testing on 4 April 2016, is not at a level that would cause significant adverse effects for either humans or the environment.*"

Apart from a letter received to acknowledge the request for information no further correspondence has been received from the PCE.

Representatives from the Environmental Protection Authority visited Council in September 2016. They had no issues with the use of glyphosate by Council but cautioned against using more toxic alternatives available in New Zealand.

7.3.4. CAREX Study– Glyphosate and In-stream Aquatic Fauna Biodiversity

In the summer of 2016 – 2017 the Waimakariri District Council partnered with the Canterbury Rehabilitation Experiment (CAREX) in a trial to understand the persistence of glyphosate in stream water and sediment and its short-term effects on freshwater invertebrates and fish following spraying of waterways. The results of the trial are summarised as follows:

- Glyphosate was present in the sediment before spraying had even started.
- Glyphosate was present in the water column for 1-2 days following spraying, but quickly bound to sediment and broke down.
- The study did not detect any effect of glyphosate used to control emergent macrophytes on stream invertebrate species or fish

- However it noted that species present in these drains may be already tolerant of existing water quality
- It found that re-growth of weeds following spraying with glyphosate fell from 90% cover prior to spraying, to 20% after spraying, to 50% after 14 weeks.

The study was titled "*Persistence and ecological consequences of glyphosate to control aquatic weeds in Waimakariri lowland waterways".* It concluded "*We could not detect any effect of glyphosate on stream invertebrate species richness, metrics such as the MCI and SQMCI or fish".* Results showed that both the unsprayed and sprayed reaches in the trial had a reduction in the invertebrate species richness, MCI and SQMCI, 6 weeks after spraying when compared with the pre-spray indices. This reduction can be attributed to natural seasonal changes affecting the drain habitat, rather than to the use of glyphosate.

It was concluded that as these drains are highly modified environments, invertebrates and fish that continue to occupy them may be already tolerant of existing water quality in these systems.

7.3.5. International Evidence – Glyphosate and Soil Biodiversity

This review has also considered a number of international studies of effects of glyphosate use on soil biodiversity. This includes effects of glyphosate on soil function and effects on non-target soil organisms or microbes.

These studies mainly cover effects of glyphosate on soils used for cropping. Therefore they are not directly relevant to this review which covers effects of glyphosate in or adjacent to drains or waterways. However as they demonstrate the current knowledge base about general effects of glyphosate use on soil biodiversity the findings are discussed in this review.

A common theme within the international literature is that although extensive research has been done on short-term soil fauna and micro-flora response to glyphosate, relatively less information is available on its long term effects. There are many studies of soil organism or microbe response to one-off single treatments, but less information is available about potential gradual changes in soil function over time from effects of long term glyphosate use. Also, increasingly, there are more frequent glyphosate treatments applied across a reducing time span observed in recent international cropping trends, for which cumulative and long term effects are not well understood.

Many studies indicate that effects of a single use of glyphosate treatment on soil fauna and soil function are minor and transient. It is noted this is dependent on the actual rate and composition of the product used and on background characteristics of the soil, climate and other local environmental factors.

However, comparing results of recent studies reveals there is still uncertainty about the long-term impact of glyphosate on soil composition and functioning of soil micro-organism species and ecosystems. For instance, it appears that application of glyphosate to soils causes abundance of some microbial populations to increase and others to reduce. In the long term these changes could "*affect rhizosphere nutrient status"* (see Molli M.N. et.al. "*Glyphosate effects on soil rhizosphere-associated bacterial communities"*, in Science of the Total Environment, Volume 543, Part A, 1 February 2016, Pages 155 – 160).

This study by Molli et.al noted that *"Examining the effects of pesticides, such as glyphosate, on soil and rhizosphere microbial communities is important due to the critical role of microorganisms in driving biogeochemical processes and controlling pathogens….".*

Further, there are potential effects on soils of other chemical substances that are added such as solvents and surfactants in commercial glyphosate products.

There are also studies which show adverse effects on certain soil fauna, including some earthworm species. These contrast with other studies of the same species which do not identify any adverse effects.

It is difficult to assess and weigh the available evidence about effects of glyphosate on soil biodiversity as published international sources provide varying and sometimes conflicting findings.

This desktop review therefore supports the need for a "precautionary" approach in applying glyphosate near rural drains and waterways. This approach acknowledges the limited information available internationally on the long term impact of glyphosate use on soil fauna and microflora.

7.3.6. Herbicide Application by Private Property Owners

The use of herbicide by private property owners is outside the scope of this review. It may however be included in any future review of private drain maintenance practices.

Council advises private property owners who wish to spray their private drains to only spray dry drain beds and not the banks. Blanket spraying drain banks can cause bank destabilisation and soil erosion. Spot spraying rather than blanket spraying is encouraged.

7.3.7. Herbicide Application - Best Practice

The Environment Canterbury Defences Against Water code of Practice April 2019 includes some requirements for use of chemical sprays to control aquatic and riparian weeds. A summary of these, where relevant to the drainage management activity is outlined below.

If chemical weed control using glyphosate is deemed to be necessary by staff, then the Council will require the following:

- Spot spraying only where necessary to control problem or nuisance plants, adopting a precautionary approach
- Spray only the invert of a dry drain or emergent plants in a wet drain, and avoid accidental spraying any drain banks if emergent weeds are the target
- Consider any practicable economic alternative management methods to spraying aquatic weeds (for example, hand or weed rake is preferred)
- Notify the Mahaanui Kurataiao Ltd main office administrator 10 days prior to use – the administrator will contact the relevant parties, including the Cultural Monitor or Runanga Executive members, as required.
- No cleaning or rinsing of equipment or containers:
  -Within 5 metres of a surface water body or bore
  -In the bed of the stream or drain, unless mixing or dilution takes place within a sealed, bunded system that contains a volume of at least 110% of the largest spray tank to be filled, or the mixing or dilution is for a hand-held application technique or method
- Native vegetation must be avoided whilst spraying
- Undertake works in calm conditions as far as practicable to avoid spray drift
- Avoid spraying vegetation that could provide inanga spawning habitat between 1 January to 1 June.
- To avoid potential negative impacts on foraging bees, do not spray during the peak of the flowering season wherever possible

7.4. Hand Weed Clearing

Hand clearance of weeds is a low impact method of drain weed control. However the method is labour intensive, with a high associated cost. It has relatively high safety risks for the contractor including of muscle strain and trip / fall hazard. The current contractor has indicated that any hand removal of weeds will only be approved subject to a site specific health and safety risk assessment.

7.4.1. Hand Weed Clearing – Effects

As weeds may be intended to be pulled by the roots, it is possible that the rate of weed regrowth in cleared reaches is reduced relative to mechanical clearance with a weed rake. However as complete root removal is unlikely, weed species are usually not completely able to be removed from a stretch of drain. Root removal is also not desirable in areas with fine sediment on the drain bed.

Hand Weed Clearing can also have a direct effect on aquatic species in drains. This is particularly from boots on the drain bed crushing invertebrates underfoot, or from weeds removed from the root destabilising banks and suspending fine sediment into the channel.

7.4.2. Hand Weed Clearing – Options

Small drains with sensitive mahinga kai populations or high habitat values are the most appropriate environments for hand clearance of weeds. These are likely to have good existing water clarity and available existing cobble. The hand clearance of weeds may be the lowest impact method of weed clearance. Due to its high cost this method is most justifiable in areas of high quality existing habitat.

In addition, areas of weeds around culverts or other physical structures in drains sometimes need to be removed by hand as the weed cannot practicably be removed by machinery. Hand removal of weeds from around culverts also avoids spraying. Culverts may provide aquatic habitat such as shelter for eels, therefore it is worth avoiding spraying them where practicable.

All hand weed removal projects in high quality habitat areas or around culverts or other physical drainage infrastructure are subject to a site specific risk assessment for contractor safety.

7.4.3. Hand Weed Clearing - Best Practice

The Council will not prioritise the hand clearing of weeds during its usual drainage maintenance due to the high cost and safety risks of this method.

However specific weed clearing projects such as around culverts, other physical assets in drains, or in high value habitat areas are sometimes preferably undertaken by hand. This will be subject to a site specific health and safety risk assessment by the contractor.

Each proposed hand weeding task will be assessed for hazards. Resulting actions may be required to be undertaken to minimise the risks. Approval of site specific health and safety risk assessments, and requirements to undertake any associated risk reduction actions will be applied at the discretion of the contractor.

7.5. Sediment Removal

The removal of sediment from drains is occasionally required to maintain drain conveyance.

Sediment removal can be undertaken either with an excavator with a self-draining weed/silt bucket (preferred), or with an excavator and solid bucket (alternative – not preferred). The self-draining bucket is the preferred option as it enables some aquatic species escape and return to the waterway and releases dewatering water directly to the stream.

7.5.1. Sediment Removal - Effects

As with mechanical weed removal, the removal of sediment with weed bucket or solid bucket temporarily destroys aquatic habitat and removes potential food sources for aquatic life from the reaches where the activity is undertaken. All mechanical clearing is non-selective and desirable plant species including spawning vegetation may be removed along with the sediment.

This activity also removes fish and invertebrates from the watercourse.

It also mobilises fine sediment within the watercourse, which further impacts aquatic habitat by, for instance, interfering with fish migrations and reducing food available for invertebrates or fish. It also potentially mobilises contaminants (if present in substrate) and reduces dissolved oxygen levels in the water.

7.5.2. Sediment Removal - Weed/Silt Bucket Option

The self-draining weed/silt bucket method is the best practice method available for drains where both sediment and weed removal is required.

The weed/silt bucket has a cutting edge that rapidly removes drain substrate and sides along with any weeds. This is the preferred method to use for drain widening (or deepening) particularly for large reaches of drain. The bucket enables cost effective removal of large reaches of legacy silt that accumulate in drains from time to time. The purpose of legacy sediment removal is usually to maintain drain flood conveyance, and also has ecological benefits for some macroinvertebrates and trout spawning for example.

The photo below is of a self-draining weed/silt bucket.

Figure 3: Weed/Silt Bucket: Photo Credit Greg Bennett

It is important not to over widen or excessively deepen channels. This can slow water movement which leads to more sediment deposition and weed growth. This is unless a sediment trap is being excavated into the drain downstream of a legacy sediment removal operation, or if a riffle/pool system is being purposely developed.

The weed/silt bucket cleaning option is not recommended for regular drain maintenance works if only weeds are required to be removed. This is because the relatively narrowly spaced teeth are more damaging to aquatic fauna, permitting less fauna escape and causing more damage to aquatic habitat than the alternative weed rake. The narrow slots and dish shape of the bucket cause any water scooped into the bucket to excessively slosh about hindering the cleaning operation and making a mess.

The operator can only deposit the soil/weed onto the nearest bank, meaning there are fewer locations to place cleanings than when using a weed rake. This leads to potential piling up of weeds and future soil mounds. This potentially adds a concentrated flow with scour risk for stockpiles of drying weeds and soil, and a future additional management requirement for ground levelling where the stockpiles mound over time. The machine also requires pivoting to deposit soil and cleanings outside of the drain and therefore causes more bank damage than the weed rake.

It is anticipated that legacy silt removal requirements will reduce in future as rural land management practices improve over time. This should occur as / when rural privately managed drains are increasingly fenced and/or planted. This is now increasingly required by regional plan rules and encouraged by rural advocacy organisations.

7.5.3. Sediment Removal Method - Solid Bucket Option

This alternative option of sediment removal using excavator and solid bucket can be used to remove either: a) large areas of legacy sediment; or b) small areas of sediment that are blocking areas of drains. This method is not preferred as it does not allow for any escape of aquatic species which enter the bucket with the sediment. Further, it contains water which is likely to be deposited on banks for dewatering, which can cause scour and erosion during dewatering drainage.

7.5.4. Sediment Removal - Best Practice

The Environment Canterbury Defences Against Water Code of Practice includes various requirements pertaining to silt removal from water. A summary including aspects most relevant to the drainage management activity is provided below.

If sediment removal is required to be undertaken then the Council will:

- Avoid disturbing inanga spawning habitat (banks and bank vegetation inundated by high tide) between 1 January to 1 June
- Inspect site where works intended and identify any features which should not be disturbed, including pools, riffles, woody debris, salmon/trout spawning gravels, or threatened species habitats, and avoid these where possible
- Retain small variations in streambed profile (do not level the stream bed) – these variations provide habitat diversity

- Avoid excavation works that damage native plants
- Reform areas of existing steep banks into areas with a gentle grade, or create a two stage channel or form the channel into a V shape, wherever practicable. This is subject to a site specific assessment of the likely soil response to bank grading and the resulting erosion risk. Note that there is contractor concern that a V shape is difficult to create with a digger bucket, and is harder to weed rake than a drain with vertical sides. Therefore site specific design of V shape drains will be required if formed from sediment excavation projects
- Do not unnecessarily scrape the bed or banks with the digger bucket. Bare banks are more prone to erosion and slumping, removing all bank vegetation removes habitat and refuges for fish and insects
- Inspect spoil material for any captured fish that appear still alive, or koura or kākahi and return any found to the waterway as far as practicable. This is undertaken through a specific partnering agreement with Ngāi Tūāhuriri who usually undertake fish relocation during the afternoon or evening following the sediment removal excavation. Fish relocation will be undertaken by trained Council staff or contractors if members of Ngāi Tūāhuriri are unavailable at any time to perform this function
- Where there is a confining layer between the drain and groundwater, ensure silt removal does not breach this layer. This is not usually an issue in the Waimakariri drains which at the invert often already intercept resurgent groundwater – noting the high groundwater table present in the east of the district
- If silt removed from the watercourse is to be dried near the worksite, the drying area shall be located and shaped, so it does not allow any sediment-laden water to enter the waterway directly. This may require contouring of the site and dewatering drainage treatment areas where sediment can settle out or drain to grass, to prevent runoff channels causing bank scour if flowing back to the waterway.
- Where practicable, only remove fine sediment from the channel. Where course substrate is present it provides valuable habitat for fish and invertebrates and has the added benefit of being a poor root environment for recolonising macrophytes
- Where possible, regrade banks and plant appropriate native riparian species to provide nutrient filtration and shading to work towards longer-term solution for excessive weed growth
- When removing large areas of legacy sediment from wet drains the Council will install a downstream sediment trap, or excavate a natural sediment trap, wherever practicable. Sediment trap design will be in accordance with the template sediment trap guidance and design in Henry Hudson's report "*Scoping Strategy for the Three Brooks and Channel Enhancements in the Middle Cam River and Tuahiwi Drain*" 2017. Alternatively the Council may excavate a natural trap downstream of an area where legacy sediment is being removed from a drain. In this context large areas of legacy sediment are defined as drain lengths of at least 100m.
- Isolated areas of sediment removal from wet drains will have the works area protected or isolated in channel by a silt fence/turbidity curtain, or similar sediment control method used within the flowing drain/stream where practicable. This is often constrained by the presence of the sediment already within the drain. The Waimakariri District Council will refer to the Erosion and Sediment Toolbox for Canterbury to select a suitable sediment control method for each activity.

7.6. Management of Cleanings

Cleanings are weeds that are removed from the drain to be discarded following the drain cleaning.

7.6.1. Removal of Cleanings – Effects

Following drain cleaning, the cleanings need to be removed from the water channel, as if left in the drain they will rot, reducing oxygen levels in the water. Adverse effects on water quality and aquatic fauna arise from decomposition of cut weeds that remain in the waterway.

Further risks are of blockages of downstream structures such as culverts and floodgates.

7.6.2. Removal of cleanings – Options

Landowners may not support the discarding of cleanings on the banks of drains on their properties due to visual effects or build-up of sediment mounds at the top of each drain over time. The Council can mitigate these objections by asking the contractor to disburse the cleanings evenly across rank grass so they do not pile up into mounds. Alternatively some cleanings may need to be removed into external composting facilities. This should be avoided whenever possible due to cost. Cleanings could also be transported to be deposited on other Council property or on nearby areas of Council drain margins in locations where the cleanings are less obvious to the private landowner.

No cleanings are allowed to remain on roadsides, so any cleanings deposited on road verges require removal from the drain. This is the current Council roading contract requirement, necessary to protect the road shoulder from deterioration from water or from decomposing vegetation.

7.6.3. Disposal of Cleanings – Best Practice

The Council will ensure cleanings are deposited evenly along on the banks adjacent to the works, above the water line. This will:

- Provide an easy path for aquatic fauna such as eels to escape back to the stream
- Avoid any concentrated flows causing scour from drying weed stockpiles;
- Avoid blocking downstream structures from cut weeds deposited into waterways; and
- Avoid decomposition of weeds in waterways which cause adverse effects on aquatic habitat.
- The Council will also arrange for the debris vegetation to be inspected for any captured fish that appear still alive, or koura or kākahi and return any found to the waterway where practicable. This is done by the Ngāi Tūāhuriri cultural monitor under a specific partnering arrangement or by trained Council staff/contractor, if the cultural monitor is not available. This partnering agreement should be regularly reviewed.
- The Council's current practice is to rake, capture and deposit weeds inside the drain banks to an elevated area on the bank sides above the water line. It leaves the weeds within the drain for a period of at least 24 hours after cleaning, enabling aquatic fauna to escape or be relocated. The contractor will then return at a later date to remove the cleanings for composting elsewhere if needed. This addresses any amenity concerns of property owners and meets the roading contract requirement of no cleanings left on the road reserve.
- Ideally cleanings are deposited on banks adjacent to the top of the drain, in a location where the weed cannot be easily conveyed back into the drain by rainfall or wind. The cleanings will then rapidly biodegrade into the riparian vegetation adjoining the drain (usually into rank grass).
- If cleanings are removed from the drain this will occur at least 24 hours after the maintenance operation is complete. The cleanings will be left on the bank for at least 24 hours to allow fish escape or relocation. The contractor will then return at a later date to remove the cleanings for composting.

The diagram below shows the preferred placement options for drain cleanings in relation to channel alignment:

Drain Cleanings Diagram

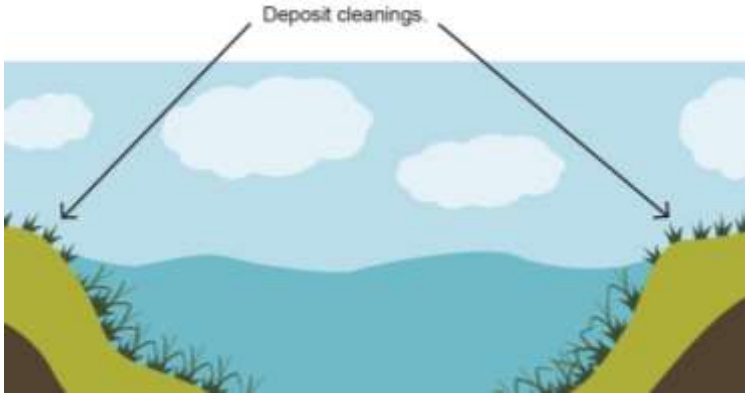


Figure 4: Location to deposit cleanings

7.7. Management of Willows

Willows were historically planted along drain banks for many years to provide bank stability. Juvenile willows may currently still be permitted to grow where they provide bank stabilisation.

7.7.1. Willow Management– Effects

Intruding willow roots or dropped large branches can encroach into shallow drains or stream beds, causing loss of waterway conveyance or temporary unintended damning. Willow encroachment into drains sometimes causes flooding, bank instability and soil erosion. There is a risk of willows falling into drains in high winds.

Willows grow prolifically and in dry periods can uptake lots of water, reducing minimum baseflow in waterways.

The species grey willow *(Salix cinerea*) and crack willow *(Salix fragilis)* are common in the Waimakariri District drain sites and create a number of issues for drain management.

Grey willows in particular are a problem as these spread rapidly from windborne seeds, covering large areas of ungrazed land very quickly. It is recommended that the Council control female grey willows immediately to avoid seeding.

As crack willow is male it will only spread from broken off fragments which drift downstream and take root.

Willow roots seek out the nearest watercourse sometimes from several meters away and form a dense root mat that raise the invert and cause erosion of the nearby banks. The only recourse in these situations is to cut the root mat away. However the problem will repeat unless the trees are removed altogether and the stumps poisoned to prevent regrowth.

7.7.2. Shading with Willows or Native Plants– Options

Willows are less desirable than native plants in providing riparian shading of waterways to reduce aquatic weed growth. This is because willows, although shading and possibly stabilising drain banks, are prone to eventually shedding branches (often directly into the waterway) and have root intrusion into the waterway, raising the invert, as well as deciduous shedding leaves before winter that can reduce oxygen levels in water. Native riparian planting, in contrast, once established, usually requires no ongoing management or further intervention. This avoids the ongoing need to operate heavy machinery near the waterways in future.

The drainage activity currently includes targeted removal of willows where these are encroaching on the waterway's conveyance, destabilising the banks or where windfall has occurred.

Areas where willows are removed are recommended to be replaced with native plantings to provide the same channel shading function. These native plants provide shade of the waterway (similarly to the willows) but also provide food for native birds, indigenous biodiversity values, better filtration of runoff and other ecosystem services. For instance, planting a combination of native grasses and taller shading plants in place of willows can help to intercept sediment and nutrients in overland flows from entering drains as well as providing shade to reduce nuisance weeds.

Native plantings can be configured to provide a dense, optimal riparian vegetation margin cover including at both the canopy, understorey and ground level. In contrast willows do not provide understorey or ground cover and so do not intercept runoff and may not be as effective at controlling proliferation of nuisance weeds, including on the drain banks. Native plantings introduce a wider range of environmental services at each of the canopy, understorey and ground levels, without ongoing costly management interventions needed to control unwanted root growth or windfall.

7.7.3. Willow removal – Options

Willow control involves removing whole willows or branches, cutting away willow root mats, poisoning stumps and spraying regrowth. These activities can carry a significant cost. In the last decade willow control activities have consumed up to approximately 25% of the drainage management budget.

A key consideration is whether the willow species (crack/grey willow) is present upstream and would re-establish in any cleared reach following willow control works. If not present upstream, removal of willows may assist to clear them from a catchment and prevent further spread in the downstream drains.

Willow control should be undertaken in stages to enable biodiversity recovery in a cleared reach and creation of indigenous species refuges, prior to undertaking control in the next reach. This will minimise any adverse effects on species habitat of the works.

7.7.4. Management of stumps – Options

Once a stump has been drilled and poisoned, it is usually left within the stream bank to stabilise it whilst newly planted replacement vegetation establishes. Over time many of the stumps left within drain banks will break down and be overwhelmed by the new native vegetation.

7.7.5. Bank stabilisation with felled trees – Options

Felled trees employed in bank stabilisation are placed into a carefully prepared site and covered over. Sometimes the stream is corrected, such as when gravel shoals are moved to direct flow away from the repaired site.

Once a felled tree is placed within a drain bank, further bank stabilisation options will be assessed. This could be from any combination of the following: rocks, wire rope tie backs, geotextile cloth, mulch, re-grassing or riparian planting. This will be undertaken in accordance with the bank stabilisation and erosion and sediment control sections of this plan.

The Council considers it is able to mitigate and avoid any risk of felled trees used for bank stabilisation becoming subsequently dislodged.

7.7.6. Willow Control – Best Practice

The Council may commission a future proactive network survey of willows on Council managed drains.

It may remove willows from drains where an above average drain management cost of repeat willow control has been required in recent years, and replace these with native plants.

Each assessment would consider whether the existing habitat provided by willows offsets the ongoing management expenditure incurred. It would consider whether an alternative native planting option might introduce a wider range of ecosystem services.

An average cost of management per drain could be compared; and above average management cost for willows would be a trigger to consider removal and replacement with native plants.

Other specific actions/assessments are:

- Control female grey willows immediately to avoid seeding.
- Determine whether the willow species (crack/grey willow) is present upstream and would re-establish in any cleared reach following willow control works. If not present upstream, removal of willows may assist to clear them from a catchment and prevent further spread in the downstream drains.

Large areas of willow removal should be staged to allow for recovery of biodiversity in the stream reach, and creation of refuges before the next stage of control commences.

7.8. Management of Other Problem Weeds

The Council periodically removes nuisance exotic trees or weeds (willows are specifically addressed in the previous section) including gorse, broom and exotic woody weed species, where these interfere or could potentially proliferate to interfere with drainage conveyance in a waterway.

It also deals with a variety of noxious or problem weeds which require a specific management approach.

It also maintains grass and other vegetation by mowing and weed trimming (e.g. weed eating).

7.8.1. Gorse and Broom - Effects

There is an ecological benefit of removing gorse before it grows into waterways. Gorse can potentially introduce nitrogen into a drainage system as it is a very widespread and invasive nitrogen fixing plant. It has a high rate of litter production which means it deposits nitrogen in soils around the gorse plant, which then leaches to ground or surface water during future rainfall.

Gorse produces large quantities of litter. N concentrations are generally higher in gorse litter than in the litters collected under other shrubs and trees. During and after litter decomposition, N is released into the surrounding soil, resulting in higher N concentration in the soils under gorse sites compared with under other species. This is due to the ability of gorse to fix N and produce large quantities of litter. The presence of gorse near drains creates a risk of nitrate pollution of groundwater and eutrophication of surface water (from report by Guna Magesan, Hailong Wang and Peter Clinton "*Nitrogen Cycling in gorse-dominated ecosystems in New Zealand",* November 2011, published online.

However any proposal to remove gorse from in or near a waterway requires firstly an assessment as to whether the gorse provides habitat for native lizards.

Lizards are known to inhabit gorse, broom, rank grass, native grasses and shrubs. Lizards inhabit rocky/stony outcrops and areas of berm not usually disturbed by either drain management or flood flows.

Selected spot removal of gorse, broom or other woody weeds is carried out. This occurs for vegetation which poses a risk to bank stability or drain conveyance. Risks with this vegetation occur when it grows inwards towards the drain channel, impeding the flow or causing slippage of the banks.

This work will not be carried out within the inanga spawning season within or near any inanga spawning site. Environment Canterbury provided inanga spawning maps to identify these sites. There are proposed conditions to prevent weed and tree removal in the inanga spawning riparian vegetation areas within CRC195065 - 67.

7.8.2. Problem Weeds – Effects

There are a few plant pests that infest the drains within the district and many of them are listed in the National Pest Plant Accord: https://www.mpi.govt.nz/protection-and-response/long-term-pest-management/national-pest-plant-accord/ and the Canterbury Pest Management Plan: https://ecan.govt.nz/get-involved/news-and-events/2018/new-pest-plan-takes-effect/. These plant pests can be split into two categories; aquatic and terrestrial.

Aquatic plant pests are weeds that grow within the flowing water and can be emergent, i.e. extend above the water surface or submergent, i.e. grow under the surface of the water. Once these pests are present in the waterway they are virtually impossible to eradicate. Therefore it is prudent to be familiar with these pests and take measures to prevent their spread to other waterways.

For example the oxygen weed *Lagarosiphon major* is present within the Silverstream and so far has not spread to the other streams within the district. This is probably due to the Silverstream being maintained by Environment Canterbury and the surrounding streams maintained by WDC. With separate management and machinery involved, fragments are not transferred via the machinery from the Silverstream to the nearby Council drains. Different contractors are responsible for maintaining these streams. Control of aquatic plant pests is currently undertaken mechanically and whilst the existing herbicide consent does permit the use of diquat for aquatic weeds, it is not currently used.

Terrestrial plant pests are weeds that grow along the riparian margins of the waterways. The establishment of native riparian planting also creates opportunities for these plant pests to establish and spread. Therefore

it is prudent to remove and ideally eradicate them before they become a bigger and more expensive problem. These pests can be targeted with spot spraying or mechanically removed.

In some situations immediate eradication may be required. If on the drain margins, this work would only be carried out within the inanga spawning season within or near any inanga spawning site as a last resort, by using targeted spot spraying or mechanical removal. Any eradication would be contained to the specific plant/s requiring immediate removal and care would be taken to avoid disturbance of the surrounding riparian vegetation. If this immediate eradication is required it would be undertaken in consultation with a qualified ecologist to identify the best approach to protect the spawning vegetation.

If immediate eradication of any problem riparian weed was required adjacent to a salmon spawning area or in any critical habitat of threatened indigenous freshwater species, this work would only be undertaken as a last resort using targeted spot spraying or mechanical removal. Any eradication would be contained to the specific plant/s requiring immediate removal and care would be taken to avoid disturbance of the surrounding habitat area. If this immediate eradication is required it would be undertaken in consultation with a qualified ecologist to identify the best approach to protect the spawning sites or habitats.

7.8.3. Rank Grass and Weed Mowing or Trimming - Effects

The Council periodically mows and arranges trimming of weeds on Council drains. This is usually to improve amenity, improve visibility of drains or improve safety of access for drain cleaning.

This work will not be carried out within the inanga spawning season within or near any inanga spawning site, as inanga spawn in riparian vegetation. Environment Canterbury provides inanga spawning maps to identify these sites. There are conditions to avoid weed and tree removal occurring in the inanga spawning riparian vegetation areas within CRC195065 - 67.

7.8.4. Problem Weed Removal – Best Practice

Removal of gorse reduces transfer (cycling) of nitrogen into waterways. This is because gorse is a widespread nitrogen fixing plant which produces large quantities of litter debris which deposit in soils from where these can leach nitrogen into ground and surface water. It can also restrict access to a drain. The Council has a pro-active gorse removal programme and where practicable will remove, or encourage private property owners to remove all gorse within 3m of Council drains.

The Council needs to continue to proactively remove other problem nuisance weed species that appear in any drain by either mechanical removal, spot spraying or with an aquatic spray for submergent weeds e.g. diquat, only if necessary to prevent a proliferation of a problem weed. These actions are required to prevent more invasive future weed proliferation.

If urgent noxious or nuisance weed removal is required in any inanga spawning season at an inanga spawning site, this would be undertaken by using targeted spot spraying, manual or mechanical removal. Any eradication would be contained to the specific plant/s requiring immediate removal and care would be taken to avoid disturbance of the surrounding riparian vegetation. If immediate eradication is required during a spawning season at a spawning site, it would be undertaken in consultation with a qualified ecologist to identify the best approach to protect the spawning vegetation.

7.9. Jetting of Culverts

Typically culvert cleaning by WDC is reactive work, cleaning out of short roadside drain culverts that provide access to rural properties. Since the culverts are short, large amounts of silt are not mobilised. The cleaning moves already existing material a little downstream where it is able to be removed if required. This work is performed as required.

7.9.1. Reactive Culvert Jetting - Effects

For wetted drains with usual baseflow where fish are likely to be present, the jetting of culverts may have an adverse environmental effect on any aquatic species present. Jetting of culverts that releases silt into water can reduce oxygen levels in the water, and impair fish feeding and flight response.

Any material that is suspended during jetting of pipes in wet drains with usual baseflow will be captured via a turbidity curtain, sediment tube or similar sediment capture device at the downstream end. This may allow some of the jetted sediment to settle out and be collected (if any settlement has occurred). The sediment control device will be removed at a time when the waterway is in low flow during dry weather, following the removal of any sediment that has been collected by the device during the jetting.

For jetting of soil from culverts in dry / ephemeral drains, material flushed onto rank grass or soil will be removed where practicable without affecting the underlying bed/banks. Otherwise it will be left to revegetate.

7.9.2. Culvert Jetting – Best Practice

For jetting of soil from culverts in wet drains with usual baseflow, any material suspended during jetting will be captured where practicable via a turbidity curtain, silt tube or similar device at the downstream end. This may allow some of the jetted sediment to settle out and be collected (if any settlement has occurred). The sediment control device will be removed at a time when the waterway is in low flow during dry weather, following the removal of any sediment that has been collected by the device during the jetting.

For jetting of soil from culverts in dry / ephemeral drains, material flushed onto rank grass or soil will be removed where practicable without affecting the underlying bed/banks. Otherwise it will be left to revegetate.

8. Minor Works Activities

8.1. Naturalisation of Drains – Planting to Increase Shade and Velocity

The naturalisation of drains to provide waterway shade or to increase channel velocity is now a periodic component of the drainage management activity. The establishment of native plants to introduce shade along stream banks is a proven method to reduce macrophyte growth or density. Planting design should consider how to control weeds and rural fire risk.

Two large trials of note in the District involved naturalisation of the lower Ohoka and lower Waikuku Streams. These have been successful at reducing macrophyte density. The former was a Council-managed project whilst the latter was undertaken and managed by a private property owner. Both drains required regular maintenance prior to naturalisation. Following establishment of the native vegetation on the margins, no further drain cleaning has since been required. Other smaller areas of drain in parks and public places have also been naturalised in recent years, and effects are being monitored to inform selection of further locations.

With shading, in many cases, especially with an east – west aligned stream, the use of glyphosate and or weed raking can be completely eliminated.

Another option is to plant native reeds or grasses within the drain bed margins at the toe of the bank/s. This will increase drain velocity and naturally limit nuisance weed growth.

The type and height of vegetation required for shade is dependent on the width and cross-section of the drain. This means tailor-made planting programmes need to be developed for each drain.

New naturalisation areas identified for inclusion in the drainage maintenance contract are added from time to time. Naturalisation provides for filtering of nutrients and sediment, improves amenity and bank stabilisation. Naturalisation creates shelter and wind breaks, which increase local drain system humidity and can improve the microclimate in vicinity of drains. The shelter belts created also provide shelter for nearby stock.

A report by Hudson and Harding notes that "*several overseas reviews have indicated that more cost-effective and sustainable management can be achieved by naturalising the waterway… If left alone, channelized reaches will frequently return to their natural shape… In Denmark, three years following re-meandering of 580m of the Idom A Stream significant increases in the trout population were observed. In the re-meandered reach, trout populations had recovered to the levels observed in a natural reach downstream*" (Hudson and Harding *"Drainage Management in New Zealand: A review of existing activities and alternative management practices", 2004, p.28).*

In particular, naturalisation adds shade to the drain, reducing proliferations of aquatic weed growth. Riparian planting is ideally undertaken on northern banks, to maximise shade that will reduce growth of aquatic weeds. Access for the weed raking excavator can be provided on the southern bank where native grasses can be planted to stabilise the bank edge. The excavator can reach over the grasses to provide future drain cleaning. Over time as the riparian species establish, less drain cleaning will be required. Public visibility of the drain can be retained by planting low growing carex plants, which will still stabilise the margins.

Planting of grasses or rushes/reeds inside the drain bed itself will naturally create a low flow channel. This speeds up flow velocity which will reduce nuisance weed growth.

Some general guidance for root protection is provided by Henry Hudson in the following diagram;

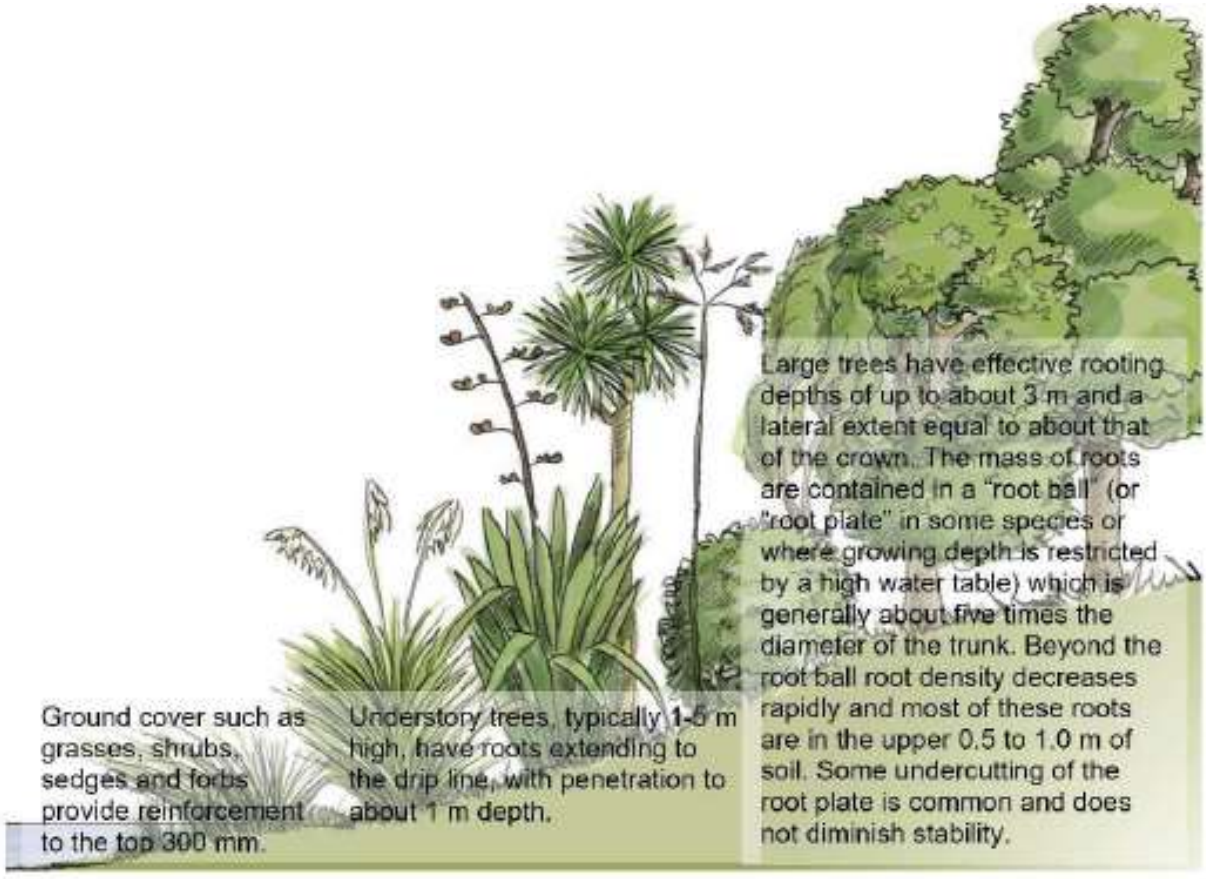


Figure 5: Riparan Plantings Guidelines

Source: Henry Hudson "*Scoping Strategy for the Three Brooks and Channel Enhancements in the Middle Cam River and Tuahiwi Stream",* August 2017.

The Environment Canterbury Defences Against Water Code of Practice adds further requirements for riparian waterway planting. These are:

- Introduction of planting of vegetation shall not be of a species listed in the Biosecurity New Zealand Unwanted Organisms Register or the Canterbury Pest Management Plan.
- Introduction of planting in, on or under the bed of any river or lake listed as a "high naturalness waterbody" in Sections 6 to 15 of the proposed Land and Water Regional Plan shall only be of indigenous plant species that occur naturally in the catchment.
- Where site conditions and funding allows, incorporate planting of appropriate native species.

8.1.1. Riparian Planting - Drain Margins

Riparian planting has many benefits such as providing habitat and food for native birds, introducing shade to the waterway and filtering runoff of nutrients and sediment from surrounding land.

Native grasses can provide dense ground cover which intercepts nutrients and sediment in runoff.

Carex secta or *Carex virgata,* when encouraged to overhang the waterway, reduce water weed proliferation along the stream margins and can provide inanga spawning habitat.

Flax plants *(Phormium* species) grow very large and have a shallow root base. They should only be planted on stable fairly flat ground. They should not be planted on steep bank sides or too near the water due to the risk of collapsing into the water and causing drain blockages.

Having areas of riparian planting with some low grasses enables an excavator with rake or bucket to reach over the plants into the drain in case future management is required.

For maximum benefits a width of 10m+ on either side of a waterway may be considered ideal for riparian planting. However this may not always be practical in a working landscape.

Technical advice on establishing riparian planting is provided by Henry Hudson in 2017, in his "*Scoping Strategy for the Three Brooks and Channel Enhancements in the Middle Cam River and Tuahiwi Drain*" report. He advised plants to be selected based on the purpose of the planting. This may be for biodiversity, erosion control; contaminant trapping; or for shading, and include assessment of the desired bank shape (profiles) and how frequently the zones are flooded.

A design option for planting narrow steep drains, if bank battering is not an option due to limited space, is shown in the following diagram:

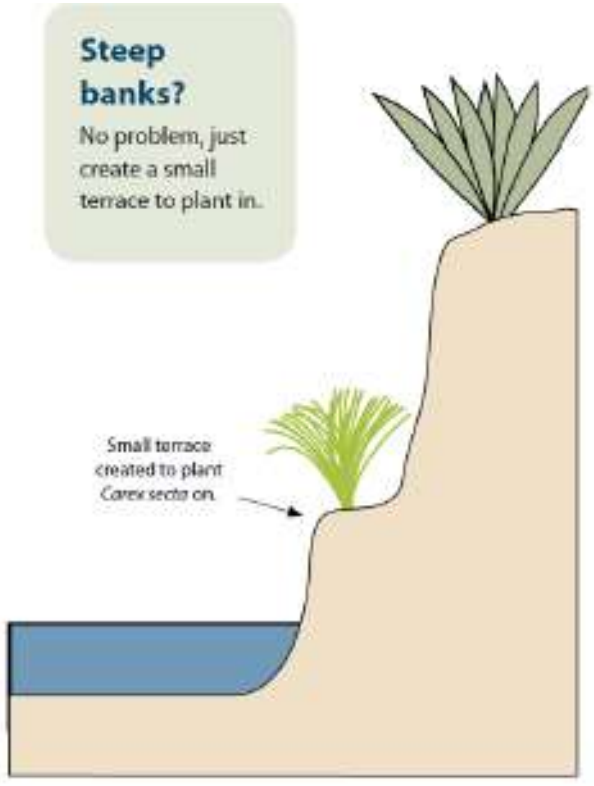


Figure 6: Riparian Planting on Steep Banks

Source: Environment Canterbury Living Streams Handbook Part 3: Planting and Maintenance

The planted areas will range from the "margins" that are continuously wet (they intercept the groundwater table and are flooded by streamflow), to frequently wetted lower bank zones; and upland fringe zones that are flooded infrequently.

Further as also suggested in the Hudson Report 2017, the first priority will be to establish ground cover on the disturbed areas (e.g. regrassing). This grass will provide a high degree of protection against streamflow

and surface wash (rainsplash and runoff) in a short period of time. Following re-grassing, lower bank plants such as rushes, flax and toitoi; and shrubs and trees will be planted progressively further up the bank. Upper bank planting is also proposed, to provide a stream corridor that is biologically diverse.

Deep rooted plants may be required on benches and side slopes to control mass slope failure and provide additional erosion resistance where channel migration may occur. The advice from Henry Hudson (2017) was adopted within the Assessment of Environmental Effects (AEE) for the Environment Canterbury consent for stream planting and bank reshaping granted in 2019 for works in the eastern Waimakariri District.

8.1.2. Riparian Planting Small Tributary Drains, Gullies and Critical Source Areas

Riparian planting can also be targeted to small farm inflow drains or channels and wet ground depressions to intercept the runoff at the point just before it enters the Council drain. This planting can be in or around the riparian area of the depression junction with the drain.

This will intercept surface runoff, slowing water movement and allowing sediment to drop out. Wetland plants intercepting the runoff will also directly uptake nitrogen from within the rural runoff and reduce enrichment and associated weed growth in downstream Council drains.

8.1.3. Increase Velocity - Create a Low Flow Channel with Toe Planting

The Council may also trial naturally increasing the velocity of the drain base flow by planting reeds, rushes or Carex grasses in the water margin/s along the inside toe of the drain banks, in appropriate locations where hydraulic capacity will not be compromised. This naturally creates a “V” shape, considered suitable for the base of wide flat drain beds.

Bank battering along the upper sides of these drains can compensate for any loss of capacity in the base, if required.

A faster moving low flow channel will naturally limit nuisance weed growth and reduce future drain maintenance requirements.

Depending on water depth, plant options could include:

1) Shallow or frequently wetted channel: *Schoenoplectus tabernaemontani (*sedge- grey club-rush*)* - although may grow substantially and dominate small drains*;*
2) Periodically wetted margins: *Juncus edgariae (rushes – wiwi);* or *Apodasmia similis (Oioi - rushes); or Eleocharis acuta (spike sedge);* or
3) Occasionally wetted dry margins (Carex virgata).

Addition of linear wetland plants within the drain bed will create a low flow and flood channel (two stage channel) with “V” shape drain base. The plants will trap sediment along the margins, gradually lifting the riparian edges whilst filtering runoff from adjoining land.

Cleanings from any future weed raking (if required) can be deposited behind the plants, further elevating the “V” shape and allowing rapid return of aquatic species to the waterway immediately following any drain cleaning.

This is shown in the following diagram:

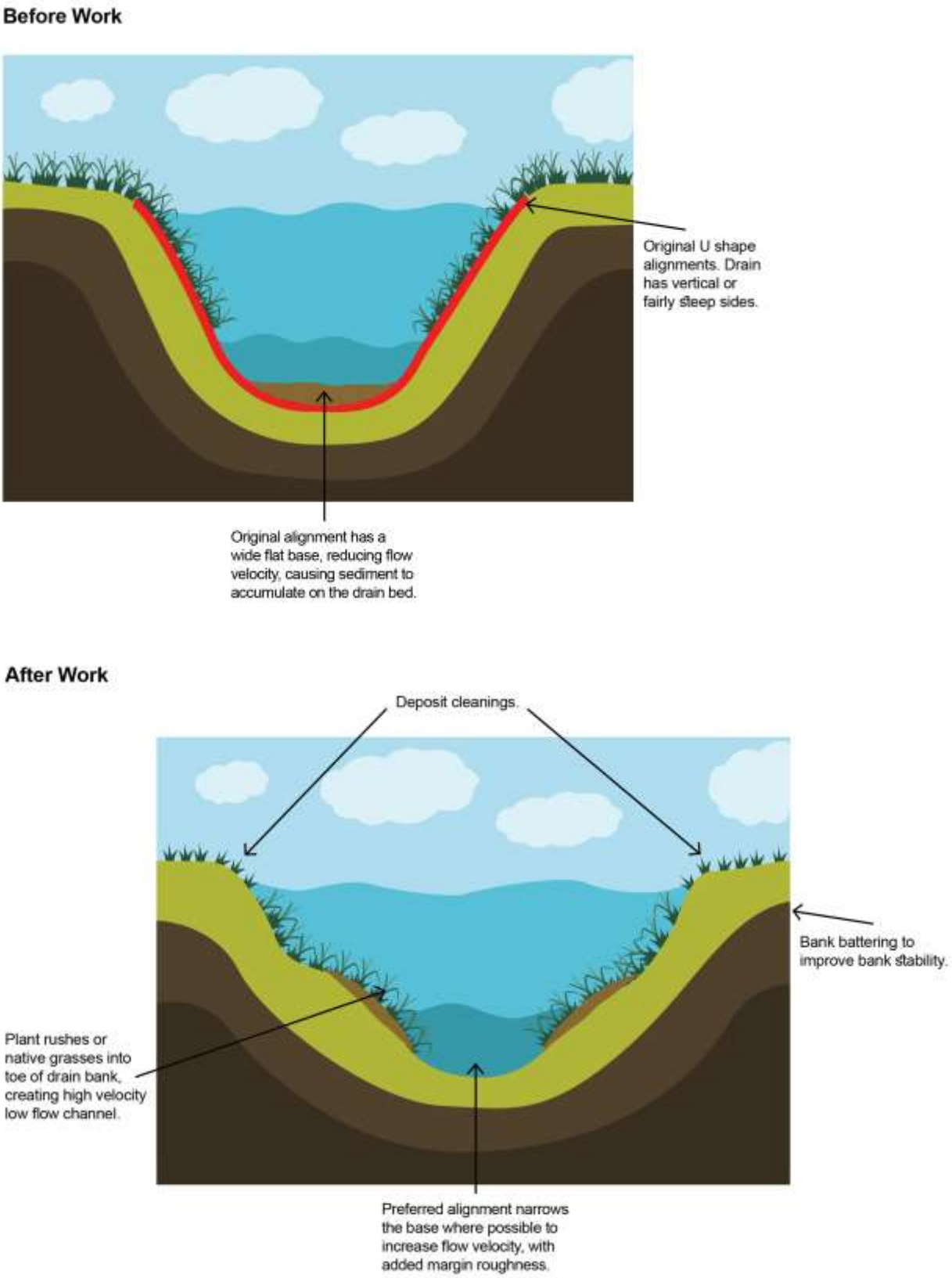


Figure 7: Low Flow Channel Creation

8.1.4. Provision of Shade

Shading of the waterway reduces aquatic weed growth, reducing the future frequency required for drain cleaning. It also reduces water temperature which can increase levels of dissolved oxygen in the water, improving conditions for fish and other fauna.

Tall plants such as cabbage trees and flax can provide shade across much of the drain, particularly if planted on the northern bank.

The following photos indicate effects of shade provided by overhanging Carex and tall riparian plants on the banks of a channel. Aquatic macrophytes can remain more prolific in the less shaded areas. The effect of the overhanging vegetation and partial shading reduces density of aquatic macrophytes in the deeper main channel, establishing a more natural meandered low flow channel. The low flow channel achieved by this method improves velocity in the shaded reaches. Grass on the riparian margin of the top photo naturally forms a flood channel, where sediment will be trapped during high flows.

Figure 8: Riparian Shade and Meander

Source: Dr Henry Hudson "*Scoping Strategy for the three Brooks and Channel Enhancements in the Middle Cam River and Tuahiwi Stream*", August 2017.

Figure 9: Riparian Shade

Shade at the point where the water meets the stream bank can reduce germination of weeds and the amount of weed growth spreading across the channel. This is also demonstrated in the above photos.

The aim is not to shade out all water weeds, as they provide habitat for many species. Planting for shade intends instead to reduce the areas of excessive and dense growth. A well designed buffer of vegetation will also reduce the amount of sediment reaching the drain, further reducing the need to clean.

If the main aim of riparian planting is to provide shade to the water, then for smaller deep channels, relatively narrow plantings of grasses and sedges will be sufficient. For larger drains, taller shrubs and trees (and time for them to mature) will be required.

Shading of drains may reduce plant biomass and density, and change the prevalence of the plant species present. Shading is shown to increase the prevalence of native aquatic plants.

A study by Hudson and Harding in 2004 found that "*In an 8 month trial in a small drain in the Waikato, Scarsbrook et al. (2000) reduced light levels by 90% with artificial shading. In this study there was no effect on the overall amount of plant cover that occurred across the stream. However there was a significant change in both the type and density of plants growing under the shade. During the summer months shading dramatically reduced the growth of the dominant aquatic plant Polygonum, and plant biomass was only 20% of that in an unshaded "control" reach. The shaded reach also supported a more diverse plant community with several native species being co-dominant (particularly Potamogeton and Nitella) in contrast the unshaded portion was almost entirely dominated by Polygonum" (*Hudson and Harding *"Drainage Management in New Zealand: A review of existing activities and alternative management practices"* 2004, p.27).

8.1.5. Retention of Rank Grass/ Pasture Grass

Rank grass retention is an alternative approach to riparian planting. Similarly to native plantings, rank grass stabilises stream banks and provides some filtration of rural runoff. It can provide inanga spawning habitat. However rank grass does not enable shading of the waterway, meaning that weeds can proliferate. It also does not provide additional biodiversity.

8.1.6. Meandering a Drain Channel

Meandering a drain into a more natural, sinuous flow pattern may add both flushing and sediment deposition areas into the stream bed. Flushing may clean sediment to reveal gravel substrate, or gravel can be added to flushing areas which creates spawning habitat for trout and salmon. A meandered flow also creates a more diverse habitat for aquatic species. Meandering of a drain may not be feasible within space constraints such as land ownership and road boundaries.

A meandering channel can be established by adding rocks or overhanging grasses on one bank. This can be followed up by slightly widening alternate areas on opposing banks if required. Alternatively with restoration planting, drains are likely to naturally meander to some extent over time.

8.1.7. Drain Naturalisation – Best Practice and Recommendation

It is recommended that the Council adds a proactive riparian planting programme each year into the drainage management programme. This would make each planted section of drain more self-maintaining in future. This adds shade that directly reduces nuisance weed growth and the associated need for ongoing weed control. Shading of drains reduces plant biomass and density, and increases the prevalence of native aquatic plants.

Trials are also recommended to increase velocity of the channel base flow. This is achieved by planting rushes, reeds or Carex grasses into the drain bed at the toe of the bank. Increasing velocity naturally reduces nuisance plant growth.

In addition, a meandering channel can be established by adding rocks or overhanging grasses, to increase habitat diversity for fish and invertebrates.

Naturalisation with planting provides for filtering of nutrients and sediment, improving amenity and bank stabilisation. It creates shelter and wind breaks, which increase local drain system humidity and can improve the microclimate in vicinity of drains. The shelter belts also provide shelter for nearby stock.

Shade at the point where the water meets the stream bank can reduce germination of weeds and the amount of weed growth spreading across the channel.

The aim is not to shade out all water weeds, as they provide habitat for many species, but to reduce the areas of excessive and dense growth.

The areas to be planted could be drains where most frequent repeat annual maintenance to control weeds is currently required. Also drains with good habitat values, or potential to provide good habitat for fish could be prioritised.

Critical source areas such as small rural tributary drains or overflow channels could also be intercepted with plants and/or bunds to assist to treat contaminated runoff before it enters the drain. These could be installed by the Council or landowner of adjoining privately-owned land.

8.2. Bank Stabilisation

Bank stabilisation seeks to create a more gentle profile from the drain bed to the surrounding land. This replaces the historic approach to drain management of digging “square” bottom drains with flat beds and steep or vertical sides. Bank stabilisation creates drains with more gently graded sides with a narrow base,

which can also possibly incorporate a meandering / natural cross-section rather than strictly straight form into the design.

Banks of silt tend to be less stable than gravel and bedrock, thereby more likely to require bank stabilisation.

The relative stability of a range of drain slopes is presented in the following diagram:

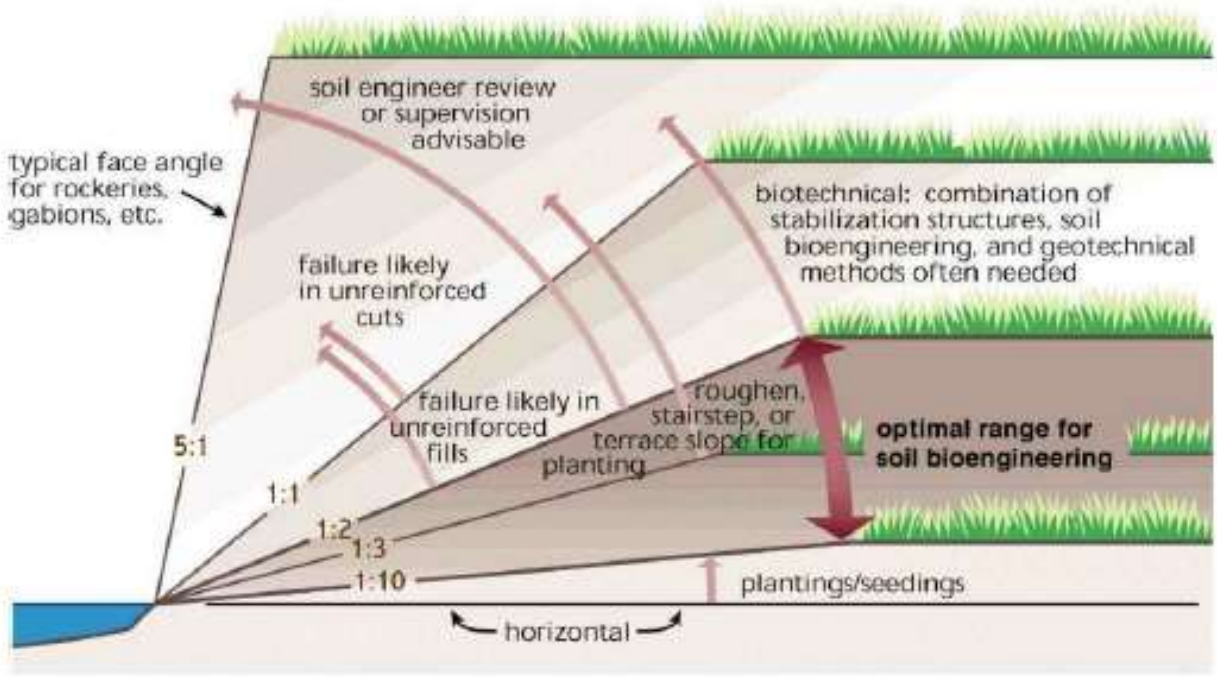


Figure 10: Bank Stability

Source: Dr Henry Hudson "*Scoping Strategy for the Three Brooks and Channel Enhancements in the Middle Cam River and Tuahiwi Stream*", August 2017.

Bank stabilisation is recommended in future to be combined with legacy sediment removal projects, or within drains where riparian land is available to enable bank battering.

Bank stabilisation will also be undertaken where required to stabilise any unstable, eroding or collapsing drain bank.

Bank stabilisation can create short term effects in wet drains, releasing sediment which may interfere with fish passage and create temporary disturbance of aquatic habitat and spawning vegetation. However, the outcome of bank stabilisation will reduce future incidences of bank erosion and improve spawning habitat (for coastal drains). This is by creating a gentle bank grade where suitable inanga spawning vegetation can more easily establish than on steep or vertical drain banks. The narrowing of a drain base channel will improve flushing of sediment and may expose areas of gravel suitable for trout or salmon spawning.

On completion, revegetation is required to be promptly undertaken to provide a protective surface to mitigate erosion and scour. This may be initially achieved with re-grassing followed by planting of larger native riparian plants.

The Council currently uses rocks in many locations to stabilise drain banks. It is recommended that stabilisation with rocks be accompanied with bank reshaping where suitable land is available. However for narrow drains with minimal land on the margin, and for drains immediately adjacent to roadsides, rocks may remain the most suitable stabilisation option.

8.2.1. Bank Stabilisation Techniques – Bank Grading

The creation of a bank batter with grade of at least 1:2 will reduce steep bank slopes thereby reducing the risk of future bank erosion. If insufficient land is available to achieve a 1:2 batter then a grade of 1:1 can be excavated, but these steeper sides may be more prone to slips. Bank battering is a component of drain naturalisation and is recommended whenever suitable riparian land is available to create the batter. This may require a widened margin between the drain bed and bank top. The resulting shallow grade reduces soil erosion into the drain and assists to retain and enhance flood carrying capacity.

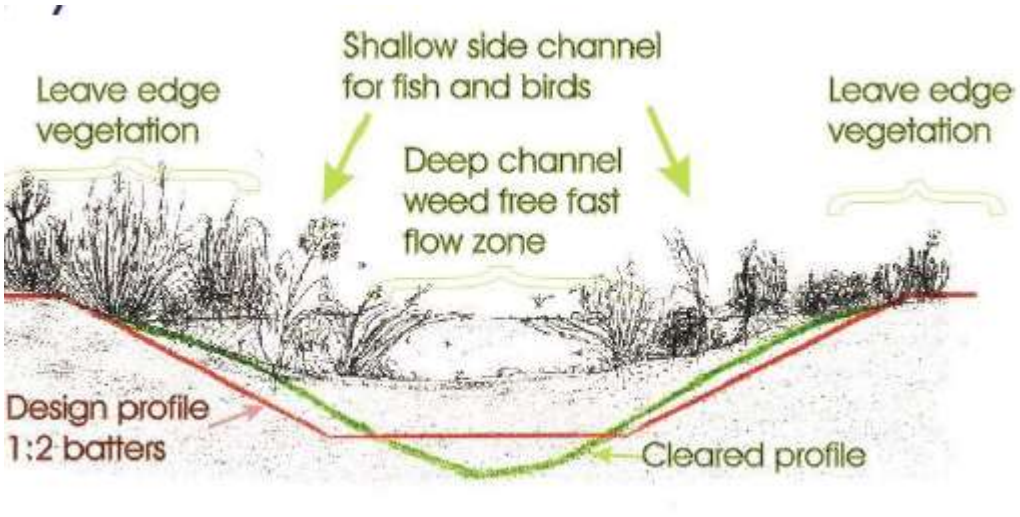


Figure 11: Drain Bed Profile

Source: Henry Hudson "*Scoping Strategy for Three Brooks and Channel Enhancements in the Middle Cam River and Tuahiwi Stream*", August 2017.

8.2.2. Bank Stabilisation Techniques - V Shape Channel Creation

The creation of a V shape channel is recommended in situations where there is insufficient land available to achieve bank battering of at least a 1:2 grade or to create a two stage channel. A V shape can also be established just in the channel base, even if there is no room to batter the banks.

It is acknowledged that it may be difficult to excavate a V shape into existing drains and once excavated the V shape may be difficult to maintain with the weed rake. A modification to existing drain cleaning machinery may be required to assist to implement this method.

A V shape channel (e.g. aim for grade of a minimum of 1:1, or ideally, 1:2) will help bank stability and the establishment of vegetation. This will also create faster water flow in the narrowed centre of the channel which will reduce weed growth. Rebattering or reshaping of the banks can increase the flood capacity at times of peak flow and gently sloping banks can provide a platform to establish buffer vegetation.

8.2.3. Bank Stabilisation Techniques – Two Stage Channel Formation

The introduction of battering can include areas of two stage channel in locations where suitable riparian land is available adjoining the drain. The low flow channel is formed by excavating a narrow channel within the

existing drain base. The flood channel is formed as a component of bank battering. It is extended as a low shelf with gradual batter outwards from the toe of the bank.

The narrow "low flow channel" assists to flush sediment and weed from the faster flowing increased velocity base. The flood channel creates a shallow overflow swale adjacent to the narrow base. In the flood channel, planted riparian vegetation or rank grass can assist to trap and treat suspended sediment during flood conditions. It will also filter runoff from adjoining land. The banks above the swale can also be planted.

This option requires sufficient space to be available on the drain margins. A two stage channel design option is shown in the following diagram. The narrow low flow channel is excavated into the substrate (or formed by narrowing the original bed width profile), and a periodically inundated vegetated high flow channel is excavated or allowed to naturally form surrounding the narrowed base:

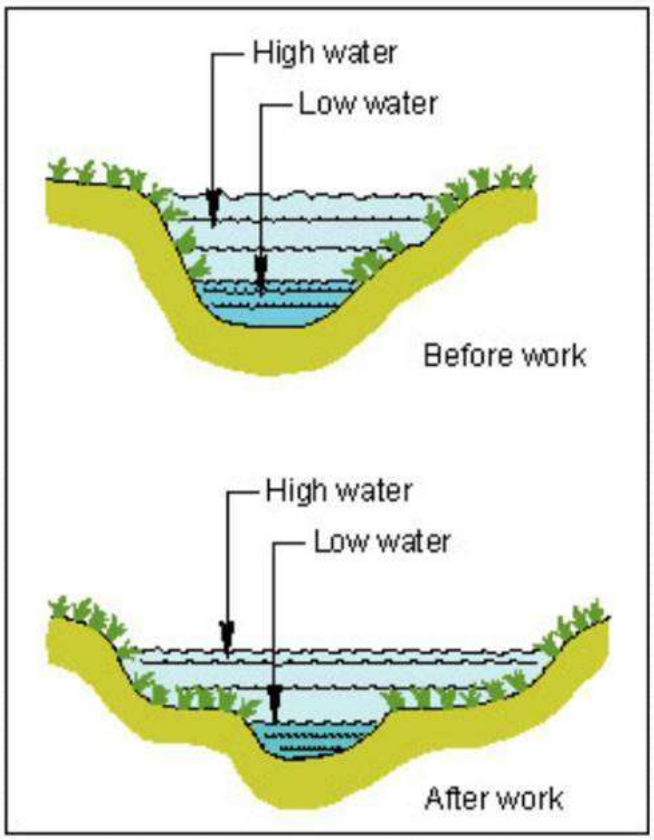


Figure: Construction of multi-stage channels.
(Adapted from Cowx & Welcomme, 1998.)

Figure 12: Multi- stage Channel

Source: Dr Henry Hudson "*Scoping Strategy for the Three Brooks and Channel enhancements in the Middle Cam River and Tuahiwi Stream"* August 2017.

8.2.4. Bank Stabilisation Best Practice and Recommendation

It is recommended that the drainage management programme include the following future activities:
Reshape drains with high vertical banks and flat beds, either;

- Into a two stage channel (narrow low flow channel and wider, elevated flood channel possibly forming a shelf or swale);
- Bank battering (aim for grade of 1:2) into a wide V shape, in areas where wide channel margins are available; or

- Creation of a narrow V shape channel (typical grade 1:1) to reform straight deep channels with square flat bases, at locations where limited riparian land is available for creation of gentle bank battering.
- Excavation and future maintenance (if required) of a V shape channel may require modifications to existing drain cleaning machinery.
- Continue to use rocks where relevant to stabilise narrow steep drain banks.

8.3. Creation of In-stream Habitat

Creation of riffles and pools, or two stage channels are great opportunities to improve in-stream habitat whilst undertaking general drain management activities. When an excavator with bucket/rake is present at a site for weed excavation it can also excavate areas of riffles and pools, or form a two stage channel within a stream bed.

Riffles create trout spawning areas and are a preferred habitat for insects and for elvers (baby eels).

The pool areas, when slightly deepened and widened will trap sediment in the drain. These also provide areas of deeper water which provide preferred habitat for some fish species.

8.3.1. Riffle and Pool Method Creation

Excavation of riffles and pools is achieved by excavating raised ridges and pool areas into a drain bed.

Each riffle, once excavated, could have gravel deposited which creates new fish spawning habitat. Riffles often naturally occur at about 6 or 7 channel widths apart.

Pools can be deepened and widened using an excavator between the riffles, so as to slow the velocity of the channel and trap sediment in these locations.

8.3.2. Riffle and Pool Creation – Best Practice and Recommendation

It is recommended that the drainage management programme include the following future activities:

- riffle and pool creation in drains that currently have fair or good water clarity, which provide or with potential to provide trout, salmon or native fish habitat

8.4. Repair of In Channel Physical Structures

8.4.1. Repair of Timber Drains or Retaining Walls

The Council repairs timber walls, headwalls, retaining walls, slipped banks or damaged bank cladding as required. It is obtaining consent to undertake these activities through the consents CRC 195065 – 67.

Repair options include coffer dams, which involve building an enclosed dry area within a wet drain. This requires pumping to create a dry work environment.

Alternatively, silt fences or turbidity curtains can isolate a work area within the drain or along the banks, and reduce the dispersal of sediment into a flowing waterway.

The Council will follow the erosion and sediment control measures required by these consents during works, or refer to the Environment Canterbury Erosion and Sediment Control Toolbox for Canterbury.

8.4.2. Repair of Utilities

The Council repairs drainage or other utilities infrastructure intercepting drains as required. As with repair of retaining walls, it is obtaining consent to undertake these activities through the consents CRC 195065 – 67. It will follow the erosion and sediment control measures required by these consents during works, or refer to the Environment Canterbury Erosion and Sediment Control Toolbox for Canterbury.

8.4.3. Repair or installation of rock riprap or gabions

Occasionally the Council installs or repairs rock riprap or gabions in its drainage network. This is to provide bank stability and protection from scour, particularly for protection of lateral structures such as fences, roads, or management access strips.

As with repair of retaining walls, the Council is currently obtaining consent to undertake these activities through the consents CRC 195065 – 67. It will follow the erosion and sediment control measures required by these consents during works, or refer to the Environment Canterbury Erosion and Sediment Control Toolbox for Canterbury.

9. Addressing Drain Management Effects

9.1. Erosion and Sediment Control

Erosion and sediment control measures are required to manage many of the effects of drainage management. This is to minimise the disturbance of sediment and its discharge into waterways, and to avoid the potential for erosion to occur or be exacerbated as a result of the works.

There is a risk that sediment removal or other works in drains will cause stranding of fish, or disruption to fish passage. Drain management work areas will be designed so that a separate passage for fish can be provided around the activity wherever possible. In-channel protection of an area of clear water will be provided if feasible.

There is a risk that disturbance of drain beds, banks or riparian margins during drain cleaning or legacy sediment removal can cause a release of suspended sediment. This can clog up fish spawning gravels or affect fish passage, reduce food availability for fish, or lower oxygen levels in waterways reducing suitable habitat.

The Environment Canterbury Defences Against Water Code of Practice 2019 contains several specific requirements pertaining to erosion control associated with drainage management works. The Council will implement these approaches when undertaking any works which disturb sediment in drains. These are:

- For earthworks located near open water, erosion and sediment control measures implemented in accordance with the Erosion and Sediment Control Toolbox for Canterbury
- Avoiding nuisance effects of dust, including requirements when using dust suppressants
- Minimising area of disturbance
- Avoid clearance of native vegetation wherever possible
- Consider impacts of earthworks on lizard habitat (possibly on rocky areas of drain margins)
- Excavated material not removed from site stockpiled outside of flowing water while awaiting backfilling
- Stabilise disturbed areas as soon as possible after works. This may involve sowing grass, planting with appropriate native species, re grassing/hydro mulching or placement of appropriate erosion protection fabrics/mats
- Ensure vegetation cover is achieved as soon as practicable

Any machinery used for drain management activities needs to be kept out of the water as far as is practicable. If machinery is required to be used within a drain then a single crossing point will be used as far as practicable, with erosion and sediment control measures in place downstream of that point.

WDC undertakes to ensure that, for any works in wet drains, discharges of sediment, other contaminant or organic material from the site into a waterbody (as defined by the Resource Management Act) will not occur for more than 10 hours in any 24 hour period, or for more than 40 hours in any calendar month. Works in wet drains should only occur during dry weather, and machinery should be sited on the banks, not within the watercourse, wherever possible.

9.1.1. Sediment Controls During Weed Raking

The best erosion and sediment control options for use in conjunction with a weed rake are:

- Configure the rake to remove bed weeds whilst avoiding excavating into the drain banks and margins
- Disburse the cleanings as evenly as possible along the tops or elevated insides of the drain banks. This will avoid concentrated flows from drying weed stockpiles from creating scour as flows enter the watercourse

9.1.2. Sediment Controls During Silt Removal in Wet Drains

For large reaches of legacy sediment removal in wetted drains, the Council will add a sediment trap into the lower reach of the drain, or alternatively, excavate a natural trap, where practicable. This will trap suspended sediment released during the works and reduce its dispersal into the downstream waterway.

The Council will refer to relevant technical design guidelines available to design and construct sediment traps, from the Dr Henry Hudson report "*Scoping Strategy for the Three Brooks and Channel Enhancements in the Middle Cam River and Tuahiwi Stream*" 2017. The diagram below is of a conventional sediment trap "rule of thumb" design.

Figure 13: Sediment Trap Design

Source: Dr Henry Hudson *"Scoping Strategy for the Three Brooks and Channel Enhancements in the Middle Cam River and Tuahiwi Stream",* August 2017.

Alternatively, a number of natural sediment traps have been identified in many of the district drains. These can be excavated out as needed when sediment removal is being planned in upstream drains, to provide some downstream sediment trapping.

During any legacy sediment removal activities in any drain, where practicable it is recommended that any steep drain banks will be simultaneously reshaped to provide a gentle grade, as proposed in the "bank reshaping" section. If limited land is available the Council will seek to reform any "U" shaped drain that has a flat bed and steep or vertical sides into a V shape. This should have a grade of at least 1:1 or more gentle (1:2) where possible. This will assist to stabilise drain banks in future, enabling riparian vegetation to more readily establish on less steep surfaces and reduce future erosion.

For isolated areas of sediment removal in wet drains, a combination of silt fences or turbidity curtains can isolate the areas of works, reducing sediment dispersal and retaining a clear area of fish passage. Alternatively a coffer dam may be constructed, if feasible, to enable works to be undertaken in dry conditions.

The measures used will be appropriate for the type and scale of activities in the particular area and include undertaking works in dry weather or low flows whenever possible. Works may include use of geotextile cloth and use of mulch on worked surfaces to stabilise them.

9.1.3. Sediment Control During Works in Dry Drains

Sediment removal in dry drains is best undertaken in an extended period of dry weather. This reduces the risk of disturbed sediment being dispersed into the waterway during rainfall over the time of the works. Disturbed surfaces will be reinstated as soon as practicably possible after the works are complete.

9.1.4. Works Site Reinstatement

Upon completion of any activity, all sites will be reinstated to similar or better quality than existed before the works.

All disturbed areas will be stabilised to minimise the chance of ongoing sediment generation. This may include replanting with grass, flood protection vegetation, or where site conditions and funding allow, native plant species. Revegetation responsibilities extend beyond the initial grassing and/or planting of areas and include sufficient time to achieve suitable grass strike or plant establishment.

9.1.5. Erosion and Sediment Control- Best Practice

During removal of large areas of legacy sediment from wet drains the Council will install a downstream sediment trap or excavate a natural sediment trap, where practicable. In this context large areas of legacy sediment are defined as drain lengths of at least 100m.

Isolated areas of sediment removal from wet drains will have the works area protected or isolated by a silt fence or turbidity curtain as a sediment control method used within the flowing drain/stream. Alternatively if practicable a coffer dam may be constructed. An area of clear water within the drain will be protected where practicable to provide for fish passage.

During any legacy sediment removal activities in any drain, the Council will consider whether it is feasible to reshape drain banks to provide bank battering to a gentle grade, in line with options proposed in the “bank reshaping” section. If limited land is available the Council may seek to reform any “U” shaped drain that has a flat bed and steep or vertical sides into a V shape. This should have a grade of at least 1:1, or grade of 1:2 (or even more shallow) is preferred, where practicable. This will assist to stabilise drain banks in future and enable riparian vegetation to more readily establish, reducing future erosion.

WDC undertakes to ensure that, for any works in wet drains, discharges of sediment, other contaminants or organic material from the site into a waterbody (as defined by the RMA) will not occur for more than 10 hours in any 24 hour period, or for more than 40 hours in any calendar month.

Works in wet drains should only occur during dry weather. Machinery should be sited on the banks rather than within the watercourse wherever possible.
The Waimakariri District Council will refer to the Erosion and Sediment Control Toolbox for Canterbury in determining a suitable erosion control method for each activity.

Sediment discharge will be monitored to ensure that except for the first 4 hours of the discharge, the change in visual water clarity or turbidity downstream of the discharge shall not exceed 20% after reasonable mixing.

Monitoring will be carried out 10m upstream of the activity and downstream after reasonable mixing. Reasonable mixing is defined as the Mixing Zone specified in Schedule 5 of the Land and Water Regional Plan.

Clarity will be measured using a secchi disc or clarity tube where practicable, or where turbidity is measured, portable probes shall be used, calibrated for NTU or FNU

Records will be included in the summary of annual works provided to Environment Canterbury.

9.2. Management of Fish Passage

Usual drain cleaning activity will disturb fish passage and fish habitat from time to time. Effects may include release of suspended sediment and also vibration and noise associated with operation of machinery.

A report on "*Ecological Values in the Waimakariri District; and their sensitivities to minor works in waterways*" by AEL 2017, p. 5 explains that sea access is critical for most of the fish species in the district. This can be easily inhibited by long culverts, various water control structures and weirs. They state that *"in respect to river works, extended periods of flow over-pumping and velocity traps caused by coffer dam intrusion into the channel can inhibit fish passage, to and from, the sea".*

The management works for flowing drains discussed in this review will have impacts on fish passage. Therefore reducing the duration of these works wherever practicable will be beneficial.

A study referenced by Hudson and Harding described effects on aquatic fish species in streams six weeks after mechanical weed control treatment, when compared to surveys prior to treatment. The findings were that mechanical cleaning significantly reduced plant coverage but did not cause significant changes in individual fish species, or in water depth, velocity, or in median substrate size six weeks after treatment. No difference was found in fish species richness or density six weeks after treatment (Hudson and Harding *Drainage Management in New Zealand: A review of existing activities and alternative management practices"* 2004, p. 16).

However other studies they referenced, including effects of mechanical clearance on invertebrates found significant disturbance of benthic invertebrate communities, with potential for direct removal of large numbers of individuals, and increased drift rates (Hudson and Harding *Drainage Management in New Zealand: A review of existing activities and alternative management practices"* 2004, p.17). They noted that where bed disturbance occurred, invertebrate recovery may be slow, however if little or no bed disturbance occurred then rapid recovery has been recorded (p.17).

Fish require invertebrate fauna for food, therefore protection of invertebrate habitat is critical for the management of fish habitat. Minimising bed disturbance therefore improves availability of food for fish.

This finding implies that the effects of mechanical weed clearance are only experienced temporarily within each drain. Mechanical clearance has no lasting measurable impacts on its aquatic fauna provided bed disturbance does not occur. Therefore management of fish passage is appropriate in managing these temporary effects, in combination with applying the best practice mechanical drain cleaning techniques as outlined in the report. With these activities no long term adverse effects of mechanical weed clearance are anticipated in the district drains.

However, as the waterway velocity or water depth also did not change significantly six weeks after the completion of mechanical weed clearance when compared to velocity and depth prior to works, it is also unclear that the weed clearance activity itself is achieving its objective of reducing flood risk. This management plan also confirms that the Council intends to trial a "less intervention" approach, not undertaking its usual summer weed clearance in selected drains. It can instead allow natural seasonal

temperature and light level reductions to reduce the intensity of weeds during the winter when there is a higher risk of flooding.

When undertaking works in wet channels where fish are present, the Council will ensure that fish recovery is conducted for the duration of the works. Recovery is undertaken by Ngāi Tūāhuriri and is usually completed on the afternoon or evening of the day of the works. Where the fish recovery is not able to be undertaken by Ngāi Tūāhuriri it will instead be completed by trained Council staff or contractors.

Although Environment Canterbury recommend fish recovery continues up to at least one day after drain cleaning, this timeframe cannot be guaranteed by the Council. This is because the programme is directly managed and undertaken by Ngāi Tūāhuriri. Fish recovery will be conducted both instream (for suffocating fish) and bank side (for stranded fish). Recovered fish will be returned to an upstream area.

It may be possible to provide for fish passage around an area of debris, obstruction or legacy sediment removal in a stream or drain. This is by, for instance, isolating the works area from the main channel with a silt fence or silt curtain or similar sediment control device.

Fish spawning areas will be avoided during spawning periods whilst drain cleaning.

9.2.1. Management of Fish Passage – Best Practice

Any stranded fish during drain cleaning works are recovered where practicable during or following the cleaning operation and returned to an undisturbed area upstream of the works. The cleanings on the drain banks are monitored by Ngāi Tūāhuriri after the cleaning work is completed. The extent and period of monitoring is determined by the cultural monitor as per agreed practice.

The preferred approach is to have Ngāi Tūāhuriri undertake the aquatic fauna relocation.

However, to avoid non-compliance with the pending consents CRC 195096 - 67, the Council will train and arrange for a suitable team of staff and /or contractors to be available to assist with aquatic fauna relocation as a backup option, if/when needed. This will follow a method as agreed with Ngāi Tūāhuriri, including relocating fish or invertebrates to an upstream reach of waterway on the afternoon or evening following raking, if Ngāi Tūāhuriri representatives are unavailable to perform this work.

Wherever practicable, fish passage will be provided around an area of debris, obstruction or legacy sediment removal in a stream or drain. This is by, for instance, isolating the works area from the main channel with a silt fence or turbidity curtain or similar sediment control device, or possibly with a coffer dam, if works need to be undertaken in a dry area to minimise sediment dispersal. The selected method will be determined considering effects of each, including extent of intrusion of the sediment control device into the channel, degree of protection provided, and extent of release of sediment and other effects. This will be undertaken in accordance with the Erosion and Sediment Toolbox for Canterbury.

9.3. Management of Fish Spawning Habitat

The protection of fish spawning habitat is currently provided by local knowledge of the Council drainage staff and drainage contractor. Known spawning sites, as specified in the Canterbury Land and Water Regional Plan are avoided during the spawning seasons for the affected species (trout, salmon and inanga).

There are particular effects on spawning habitat of the various drain cleaning works for each fish species. These are described in the report "*Ecological Values in the Waimakariri District; and their sensitivities to minor works in waterways AEL*", 2019, p.5, which summarises the following species specific effects:

Brown trout: Spawn from May to October, in stream bed gravel. The risk to spawning redds is that eggs are disturbed/killed by crushing from foot pressure or machinery contact with the drain bed, or high sediment loads released during drain cleaning. Emergent fry move into the riparian margins after hatching in October / November, where they congregate in large numbers. Maintenance and minor works during this period could disturb the fish and reduce fish refuge.

Inanga: Inanga are the adult life stage of the most common whitebait in Canterbury. Inanga spawn annually in the tidally-inundated riparian vegetation of lower rivers in the period February through to the end of May. Their spawning vegetation includes introduced grasses, native rushes, sedges or raupo thickets. The disturbance or removal of this vegetation can disrupt the spawning cycle.

The actual spawning location may change year to year, depending on the location of the upstream extent of the saltwater intrusion into freshwater. For instance, "*The saline wedge is regarded as an important cue for spawning inanga, therefore determining the location of the wedge with a conductivity meter is an important shortcut for finding the general location of spawning grounds*…".

Spawning areas are located by an ecologist that will "*undertake an egg search once the high tide has sufficiently receded, starting at suitable vegetation near the upstream extent of the saltwater intrusion, and working downstream through suitable vegetation, mapping both the distribution of eggs and the distribution of suitable/unsuitable vegetation*" (*Ecological values in the Waimakariri District, and their sensitivities to minor works in waterways*; AEL Taylor and Marshall 2017, p. 7).

It is intended that protection of fish spawning habitat in future will be provided through compliance with the pending drainage management consents CRC 195096 -67.

9.3.1. Protection of Fish Spawning Habitat – Best Practice

Drainage management works will not be undertaken in the flowing channel at the spawning sites during the spawning season, identified on spawning maps held by the Council and as specified in consents CRC 195065 – 67.

This requirement applies during the trout/salmon spawning period of 1 May to 31 October for all watercourses. It applies at identified inanga fish spawning sites during 1 February to 31 May. These limitations and timeframes apply unless a work site specific spawning survey by a qualified ecologist indicates that there are no spawning sites present that would be adversely affected by the works.

The requirement for inanga spawning sites shall extend to include work on the banks. Work in January in areas identified as inanga spawning habitat will be restricted to instream weed removal only.

At least once every five years, the Council will generate a new spawning map based on any new spawning surveys undertaken. Its surveys will include all new spawning survey data published by the North Canterbury Fish and Game Council or other agencies in the previous five years.

Any new spawning survey prepared for the Council will be supplied to the North Canterbury Fish and Game Council and the Canterbury Regional Council compliance and enforcement team within 30 days of completion of the survey.

9.4. Management of Bird Nesting Habitat

The protection of bird nesting habitat is currently provided by local knowledge of the Council drainage staff and drainage contractor. It is intended that protection of bird nesting habitat in future will be provided through compliance with the pending drainage management consent (CRC 195065 - 67).

The required protections usually relate to works on braided rivers. However bird nesting habitat protection is noted in this report as the Council may undertake periodic works on tributary drains near braided river beds and should be aware of any implications of works in these areas for nesting indigenous birds.

9.4.1. Protection of Bird Nesting – Best Practice

Drainage management works will not occur within 100 metres of colonies of indigenous birdlife that are nesting or rearing their young in river bed gravels from 1 September to 31 January of the following year. This is unless a survey by a qualified ecologist indicates that there are no sites that would be adversely affected by the works.

There are no drains or braided river channels currently regularly maintained by the Council where nesting of rare or threatened indigenous bird species occurs (as defined by the Department of Conservation threat classification system). These conditions however apply when unplanned works occurs on a drain which is not regularly monitored. In these circumstances checks for bird nesting will be undertaken as required in the consent.

9.5. Management of Mahinga Kai, Wāhi Tapu and Wāhi Taonga

The Council is actively working with Ngāi Tūāhuriri and Mahaanui Kurataiao Ltd to protect and enhance safe mahinga kai areas.

This takes into account the value of sites for previous generation's mahinga kai collection, current and potential value of the food resources available, distance from Tuahiwi, the water quality at the site and ease of access (e.g. public land or private Maori Reserve).

9.5.1. Ecosystem Values

The Waimakariri drainage system includes a number of mahinga kai food resource areas and supporting ecosystems of great value to Ngai Tūāhuriri.

In terms of regular scheduled drainage management, key mahinga kai species which the Council discusses regularly with Ngai Tūāhuriri for purposes of protection and enhancement are koura, kākahi, eels, inanga and watercress.

The streams and rivers of the Kaiapoi River and Taranaki Stream catchments in particular were historically significant resource gathering areas and accessways for Ngai Tūāhuriri. Fish harvested from the rivers included tuna (eels), kanakana (lamprey), kōkōpu (giant kokopu), koukoupara (bullies) and īnanga (whitebait).

Several bird species were also caught for food, such as pūkeko, putakitaki (paradise shelduck), pārera (grey ducks) and weka.

Different areas (wakawaka) of the catchment were important for different kai species. Gathering rights were held by whanau or hapū groups, who lived in the kainga (settlements) of the area. Many of the kainga were

adjacent to the streams and rivers of the Kaiapoi catchment. Today, the township of Tuahiwi is adjacent to the Ruataniwha Cam River.

9.5.2. Wāhi Tapu & Wāhi Taonga

The Council is aware that some of the rural drains and waterways are located within Silent File areas where wāhi tapu or wāhi taonga sites are present.

The Council and contractor work proactively with Ngāi Tūāhuriri when undertaking works within Silent File areas. This includes making Ngāi Tūāhuriri aware of usual drain maintenance timeframes in summer, in order to plan dates for fauna relocation following weed raking.

It may be the wish of Ngāi Tūāhuriri to not publish the location of wāhi tapu or wāhi taonga sites, particularly if these are burial areas or are the location of other significant cultural activities. Therefore any minor works locations within Silent File areas will be advised to Ngāi Tūāhuriri in advance of the works. Plans of the activity will be provided so that Ngāi Tūāhuriri can advise the Council or contractor if there are any effects or sites to be avoided.

9.5.3. Kōura (freshwater crayfish) and kākahi (freshwater mussels)

Weed clearance, if required, will most likely be provided by mechanical weed rake in areas which have high mahinga kai collection value. This includes drains where kōura or kākahi are known to be present. One drain with significant habitat value is crayfish creek in Rangiora, where a high kōura population has been found.

Mahinga kai areas are also able to be cleared by hand by the drainage contractor, subject to a site specific health and safety risk assessment. However hand clearance can be disruptive if the contractor is required to walk within the bed of the drain. The preferred option is however to avoid undertaking any weed clearance on drains that have a high mahinga kai value. Instead the Council will seek to establish weed control for these drains via shading and naturalisation where practicable.

9.5.4. *Nasturtium officinale* (Watercress)

Watercress harvest sites have been identified by Ngāi Tūāhuriri located on Council or other public reserve land.

These sites, where managed by the Council, will be protected from future drainage management mechanical or chemical weed clearance as far as is practicable.

A location and access plan of the Cam River (Topito Road - Bramleys Road harvest site near Tuahiwi is included below:

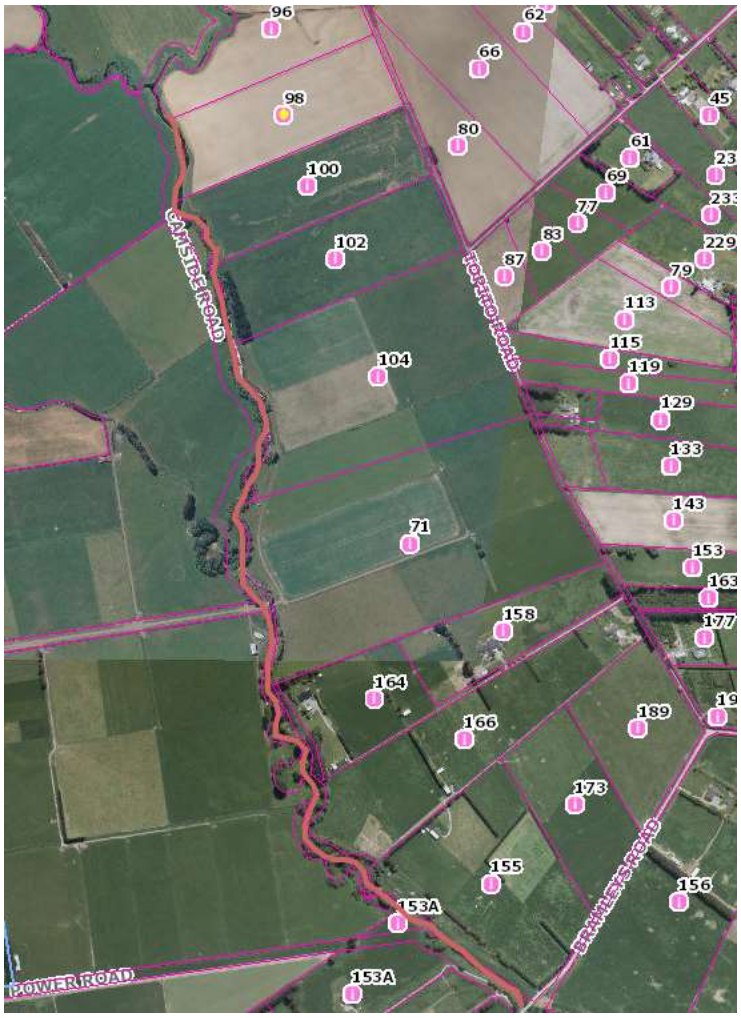


Figure 14: Watercress Harvest Cam River main stem (Topito Road - Bramleys Road) Location Plan

The Council has confirmed it will provide signage for public access to the site. It will also ensure that no spraying is undertaken at this site.

There is a potential risk of cyanobacterial bloom and pathogen contamination when harvesting watercress from the Cam River mainstem (Topito Rod - Bramleys Road). As community awareness of this site's designation for watercress increases, more people may choose to harvest from the site. Notification of the health risks will be coordinated with Environment Canterbury via signs at the site and/or via an email to the Tuahiwi Marae office, when health alerts for these contaminants are in place, as necessary.

Ngāi Tūāhuriri members will weed out Monkey Musk from the site, if desired, as this weed is possibly competing with the watercress. They will also work with WDC to provide more suitable access for kaumatua, such as mowing a path or forming rough steps using a hand tool, cut into the upper river bank.

Planned future activities to improve water quality at the site include implementation of the Cam River Enhancement Fund projects and implementation of the Rangiora stormwater network discharge consent. These projects should assist to improve water quality in the Cam River over time.

In addition, management of bacteria input from farms and wastewater overflows from Rangiora are key components to enable safe future harvesting of watercress from the Cam River. The former is being managed by Environment Canterbury, whilst the latter is currently addressed through the Rangiora wastewater capacity upgrade and other ways.

9.5.5. Inanga spawning

The Council has a Waimakariri Zone Implementation Programme Addendum (ZIPA) projects to improve inanga spawning areas such as in tributaries of the Kaiapoi River. This will support the future harvest of inanga (whitebait) in the Waimakariri / Kaiapoi system, which is a key fishing area for Ngāi Tūāhuriri. Drainage maintenance works that have the potential to disturb sediment or bank vegetation in inanga spawning areas, will not be undertaken during the inanga spawning season.

9.6. Management of HAIL sites or activities

There are no known HAIL activities or LLUR sites directly affecting any of the drains that are currently part of the Councils' regular scheduled drain management programme, based on past visual observations of drain water quality, soil texture and any water or soil discolouration or odour observed during drain cleaning.

Within one year of the commencement of these consents (CRC 195065), all regularly maintained drains where scheduled maintenance is undertaken will be checked against the LLUR and the Canterbury Land and Water Regional Plan Schedule 3 HAIL activities list in accordance with the procedure below. The steps required to identify and manage contamination risk from such sites / activities will be followed in accordance with the procedure.
Every site where minor works or unscheduled drain maintenance is proposed to be undertaken will be checked, prior to commencement of works, against Environment Canterbury's LLUR. In addition, sites will be also be checked to determine whether the Schedule 3 Hazardous Industries and Activities list of the LWRP is triggered.

This check of potentially contaminated land will include any HAIL activity located up to 50m upstream or up-gradient of any proposed minor works or drain maintenance activity.

If identified, any LLUR sites or HAIL activities in the locations described above will be further investigated by a Suitably Qualified and Experienced Contaminated Sites Practitioner (SQEP), or advice will be sought from the Environment Canterbury Contaminated Sites Management team to determine if the site has been previously investigated.
For work proposed on any LLUR site or within 50m of a HAIL activity as specified above, a Preliminary/ Detailed Site Assessment will be undertaken by an SQEP. This is unless sufficient information is provided by or agreed with Environment Canterbury to indicate that the LLUR site is not contaminated, or the upstream HAIL activity does not pose any environmental risk in terms of commencing the proposed drainage activity.

The site details and any assessments undertaken will be recorded on or attached to the Site Assessment Notice.

If the SQEP determines that further onsite investigation is required prior to commencement of the activity, then the SQEP will inspect the works site prior to commencement. The SQEP will direct the collection of laboratory samples of TSS, heavy metals or other possible contaminants that could be associated with current or previous activities associated with the LLUR site or HAIL activity, as deemed necessary.

If a contamination risk is identified, the SQEP may direct mitigations or adjustment to the scope of the activity as deemed necessary to prevent any contaminated material from being re-suspended or recirculated into a waterway during the works. If suitable mitigation / amendment to the activity cannot be confirmed, then the activity will be excluded from the consent.

If contaminated soils are proposed to be removed from any stream margin or stream bed these will be disposed of at a facility that is licensed to receive contaminated material. The removal and disposal of any contaminated material will be overseen by an SQEP.
An Unexpected Soil Contamination Protocol will be included with all drainage contracts. This will ensure that the contractor can recognise contamination on site and also provide a procedure to manage any unexpected contamination.

Advice Note: A SQEP is defined as a person with a relevant tertiary qualification and at least 5 years' experience in contaminated land matters, including the identification and assessment of contaminated soils and groundwater. These procedures are referenced in conditions of CRC 195065.

9.7. Managing Effects of Climate Change

The review acknowledges that climate change may cause an increase in future severe weather events in the Waimakariri District. This may cause an increase in flood frequency, and an increase in the severity of future flood events. This may in turn cause an increase in soil erosion and sedimentation of drains during future storms.

The consequences and risks of climate change are captured in localised district flood hazard modelling. These factors are also incorporated into the decision-making process for drain management options proposed in the review.

The review decision framework includes an assessment of hydraulic capacity of each drain. This considers all historic, recent and future potential flood risk for the drain including effects of climate change for that drainage scheme. All of these factors will be taken into account when determining options for future management options.

10. General Requirements

10.1. Refuelling and Accidental Spills Procedure

All refuelling and handling of hazardous materials is carried out to avoid the potential for fuel or hazardous materials to enter the drain. Any fuel or hazardous materials will not be stored within 20 metres of a drain.

10.1.1. Accidental Spills Procedure

For all management works involving fuel or hazardous materials storage, a written spill response plan will be provided by the contractor, and communicated to all persons responsible for fuel storage and refuelling on site. A copy will be kept on site at all times.

10.1.2. Chemical Spills Removal Procedure

If a spill occurs, the following steps should be undertaken, in addition to any actions required under the site's spill response plan:

a) Be safe
b) Identify the spilt material
c) Put on the necessary personal protective equipment
d) Stop the source if you can to prevent the spill getting any worse or spreading
e) Try to soak as much of the spill up with appropriate absorbent material

f) If the spilt material has soaked into the ground, the area of the spill should be scooped up and removed off site and disposed of at a suitable disposal facility

g) Complete the spill response form and send it to Environment Canterbury

h) If the spill is more than 1 litre or has the potential to cause harm, contact the Incident Response Hotline immediately (0800 76 55 88).

10.2. Traffic Management Implications of Roadside Drainage Works

The Council has an approved traffic management programme in place for its drainage management activity. This is documented within the drainage management contract specifications and required by Council to be adhered to by contractors.

The contract compliance with traffic management requirements is actively monitored by the 3 Waters Drainage operations staff.

10.3. Personal Qualifications

The various components of the drainage management activity are undertaken by personnel with the appropriate skills, with certification documented as required.

Within the drainage maintenance contract, specific requirements apply for activities such as entering a waterway, operation of a chainsaw or operation of heavy machinery near a waterway. This is documented within the contract specifications and required by Council to be adhered to by contractors. The contractor compliance with all certification requirements is actively monitored by 3 Waters Drainage operations staff.

Any personnel using chemicals to undertake aquatic or riparian weed removal are required to hold current and appropriate certification.

10.4. Managing Fire Hazard

In drought periods it is recognised that drain side riparian planting may contribute to a fire hazard. This will be managed by the following:

a) Maintaining a set-back when planting adjacent to any utility or other structure on the road reserve.
b) Creating a break between each planting area and adjoining exotic farm shelter belt.
c) Ensuring any riparian drain plantings do not overhang any road shoulder or vehicle crossing area where they could be set alight by sparks from engines or during operation of rural farm machinery on nearby farm tracks
d) Maintain fire-fighting access to wet drains near rural dwellings for use of flowing water as a backup water supply

10.5. Health and Safety

All aspects of the drainage management activity involve various health and safety risks. These include risk of operating heavy machinery on unstable drain banks or on wet, saturated ground. There is a risk of an excavator sliding into or overturning within a drain.

These risks are managed through specific Council operating procedures or as requirements for operators set out within the Drainage Maintenance Contract.

11. Alternative Management Option – Reduce Scheduled Maintenance and Monitor

This section introduces discussion of a potential new management technique which could be incorporated into the drain maintenance activity. This is an option to reduce maintenance of rural drains that are not known to cause recurrent flooding. This option is currently being trialled by the Ohoka Drainage Advisory Group.

This "low impact" management option is recommended because the literature review (see attached Drainage Review for full discussion) shows that aquatic weed cutting of dense macrophyte growths in summer/ autumn has no material effect on drain hydraulic capacity in winter, for plant species that usually die back over winter. It is recommended therefore that the Council trial non-management of selected drains (e.g. less intervention), allowing natural seasonal temperature and light variation to control aquatic plant growth. The Council should monitor and evaluate the effects of this approach as a part of the trial.

The literature review shows that the peak growth season and other physical characteristics (e.g. degree of plant stiffness) of dominant macrophytes in a drain or stream determines the flooding effects that may occur. Potential flood risk arises during times of peak macrophyte growth which causes increase in water level or loss of velocity. However these effects and their associated flood risk is not carried over to seasons when plant biomass is low.

From review of available New Zealand and international literature, there is consensus that macrophyte biomass during peak growing seasons increases water level and sedimentation and decreases flow velocity. However, the increased flood risk is limited to/contained within the same time period of the peak growing season of dominant plants in each drain or waterway. The literature review shows that flood risk in New Zealand associated with peak macrophyte biomass affects mainly the summer and autumn seasons for most plants studied. Most prevalent New Zealand south island aquatic plants were not considered likely to cause flood risk during winter and spring.

The exception is certain aquatic weeds such as *Lagarosiphon major* that do not die back in winter. The effects of *Lagarosiphon major* on water depth and velocity and associated flood risk continue year round as peak plant biomass does not seasonally decline.

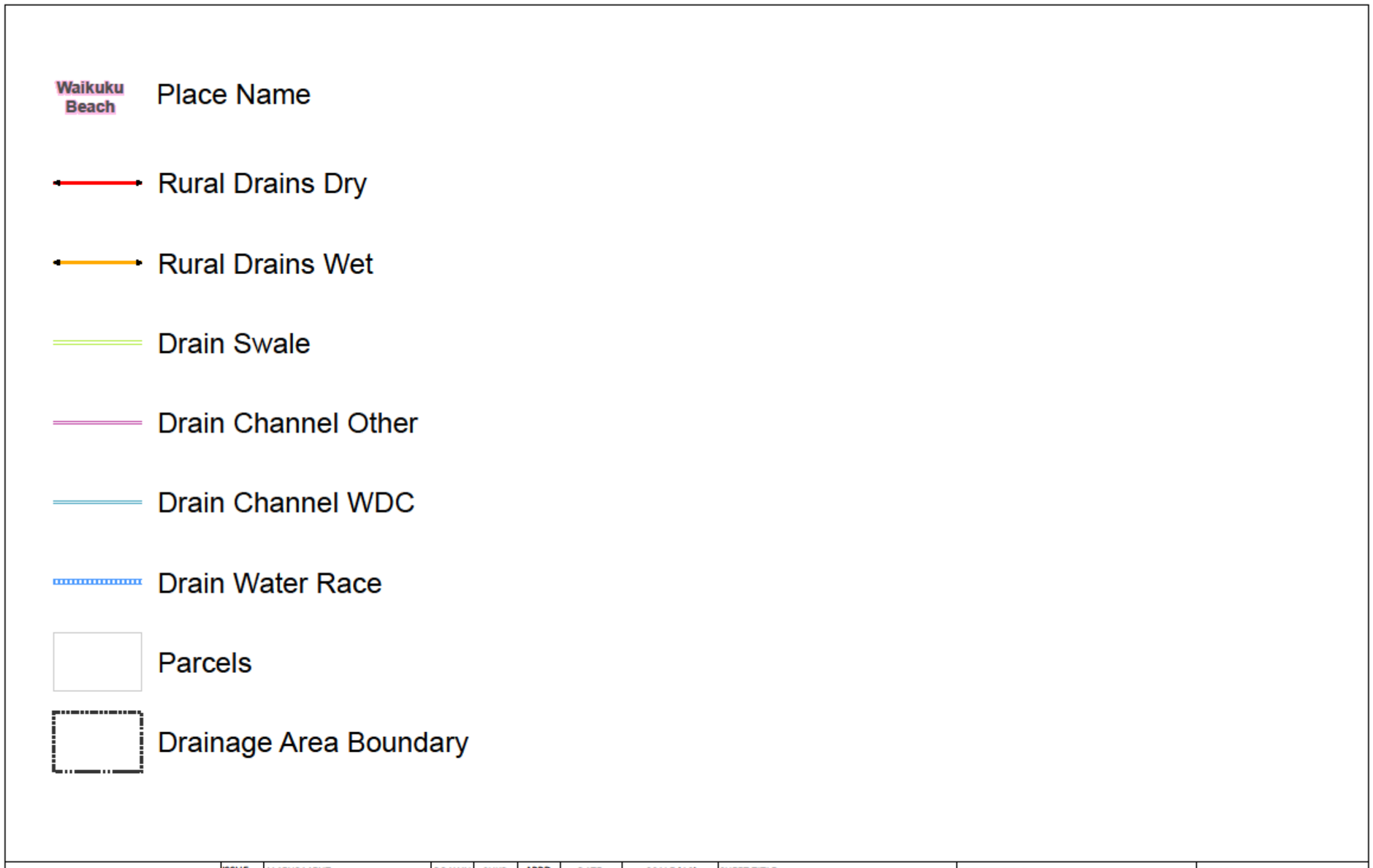
The trial of reduced or ceased maintenance of some reaches of drain could be undertaken in combination with adding shade to other reaches to maximise aquatic habitat diversity.

When combined these actions would: a) minimise long term management costs; b) enhance self-flushing of drains which would maximise hydraulic capacity within the existing drain footprint; and c) maximise aquatic biodiversity and range of habitat. These actions could assist to naturally establish the multi – stage channel concept endorsed within this plan. For instance, low flow channels of increased velocity would form in drain reaches where shading reduces some of the density.

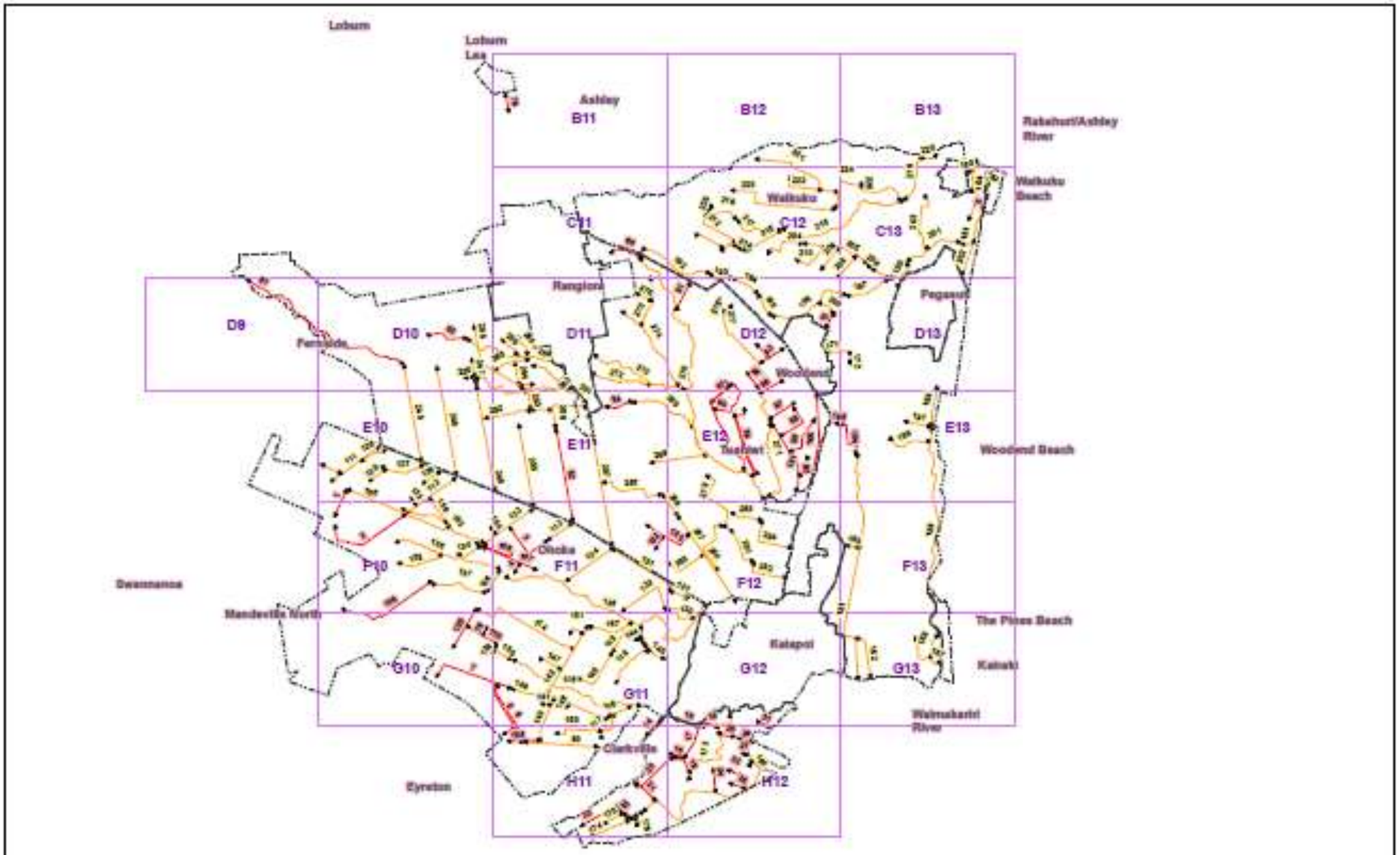
This approach would allow drains to naturally become more self-managing, as drains tend to naturalise over time once human intervention ceases.

The Council should also maintain a high level of biosecurity monitoring. It should monitor the spread of *Lagarosiphon major* and other macrophytes which don't die back in winter. It should respond with aquatic weed removal where necessary to maintain drain hydraulic conveyance.

APPENDIX A. Drainage Maps and Indexes – District Overview



	ISSUE	AMENDMENT	DRAWN	CHKD	APPD	DATE	SCALE (A3)	SHEET TITLE	PROJECT TITLE	PLAN No
WAIMAKARIRI DISTRICT COUNCIL	A	FIRST ISSUE	MO	MO	JM	11.01.2017	1:80,000	Legend	Rural Drainage: Maintenance Maps	AIM JOB: 3815
										FILE Rural Drainage to Ramm Project.MXD
										VERSION A / SHEET 01



ISSUE	AMENDMENT	DRAWN	CHKD	APPD	DATE
A	FIRST ISSUE	WC	JM		11.01.2017

SCALE (A3): 1:60,000

SHEET TITLE: Eastern District Overview

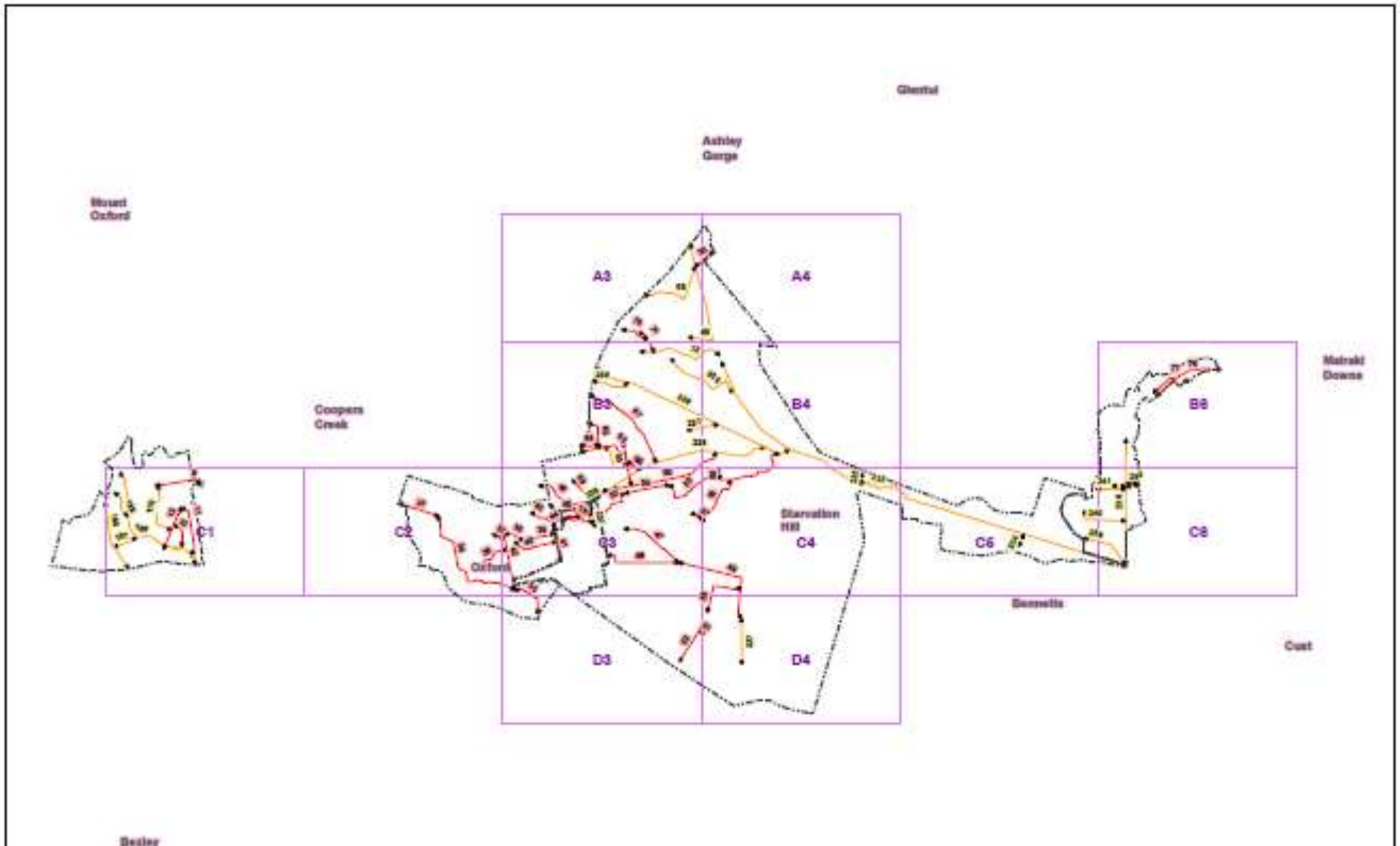
PROJECT TITLE: Rural Drainage: Maintenance Maps

PLAN No: Aim Job: 3815

FILE:

VERSION: A

SHEET: 03



ISSUE	AMENDMENT	DRAWN	CHKD	APPD	DATE
A	FIRST ISSUE	MO	JM	XXX	11.01.2017

WAIMAKARIRI DISTRICT COUNCIL

SCALE (A3) 1:70,000

SHEET TITLE: Western District Overview

PROJECT TITLE: Rural Drainage: Maintenance Maps

PLAN No: Aim Job: 3815

FILE:

VERSION: A

SHEET: 02