

Pūharakekenui-Styx Catchment Stormwater Management Plan



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Pūharakekenui-Styx Catchment

Stormwater Management Plan

Draft

Three Waters Unit
Christchurch City Council

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List of Abbreviations

<u>Abbreviation</u>	<u>Definition</u>
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average recurrence interval, the long-term average interval between floods
BMP	Best Management Practice
CCC	Christchurch City Council
CHI	Cultural Health Index
CLM	Contaminant Load Model
DIN	Dissolved Inorganic Nitrogen
DRP	Dissolved Reactive Phosphorus
ECan	Environment Canterbury
E. coli	Escherichia coli
GIS	Geographic Information System
GWL	Groundwater Level
HAIL	Hazardous Activities and Industries List
IGSC	Interim Global Stormwater Consent
IPCC	Intergovernmental Panel on Climate Change
ISQG	Interim Sediment Quality Guidelines
LLUR	Listed Land Use Register
LTP	Long Term Plan
LWRP	Land and Water Regional Plan
ppb	parts per billion
PAH	Polycyclic Aromatic Hydrocarbon

1 Executive Summary

A Stormwater Management Plan for the Pūharakekenui-Styx River is a requirement of the Comprehensive Stormwater Network Discharge Consent (CRC231955). Its purpose is to limit the adverse effects of stormwater discharges on surface and groundwater quality and quantity and to improve the quality of rivers and streams. The stormwater management plan sets out methods the Council will implement to meet the consent targets in the consent.

Water quality and ecological health are typically higher than in other city waterways, although waterway values have declined as a result of changes in the catchment. Industrial activities and to a lesser extent farming activities have affected Kā Pūtahi Creek more than the main river, although it also is affected by urban discharges.

Stormwater from new developments will pass through detention basins to mitigate new contaminant generation. Some pre-existing development will also be treated. Treatment through basins and wetlands obtains good removal of particles (sediment) but less complete removal of dissolved metals such as copper and zinc. These metals, which mainly come from unpainted roofs, vehicle tyres and vehicle brakes would be better controlled at source, but it will be some time until the Council can effect such controls.

Developed areas are adequately protected from flooding because the catchment is small and the stormwater network is adequate. All runoff from new development will be detained for 48 hours, which is the critical duration for the lower river, to maintain the status quo. Ponding in the lower river following heavy rainfall will still occur when the Harbour Road tide gates are closed by high tides.

Information used in developing the SMP suggests that controlling contaminants at source is more sensible than removing them from stormwater through treatment systems. However, the control or elimination of contaminants at source will affect our buildings, means of transport, household products and the ways we do things. Source control is a journey we will need to travel together to protect the environment; tangata whenua, community groups, regulators, researchers, and local, regional and central government.

PART ONE:
Plan Initiation

2.1 Purpose and scope

The purpose of a Stormwater Management Plan (SMP) is defined in condition 6 of the Comprehensive Stormwater Network Discharge Consent (CSNDC), CRC214226, and includes contributing to meeting contaminant load reduction standards, setting (and meeting) additional contaminant load reduction targets and demonstrating the means by which stormwater discharges will be progressively improved toward meeting receiving environment objectives and targets.

The aim of the CSNDC is to limit the adverse effects of stormwater discharges on surface and groundwater quality and quantity. The CSNDC promotes progressive water quality improvement toward targets in the Land and Water Regional Plan through the use of best practicable options for stormwater quality improvement and peak flow mitigation.

Stormwater management plans set out the means by which the Council will comply with the conditions in the CSNDC. The SMP is given effect through the Council's Long Term Plan (LTP), which is a statutory process. The relative timing of LTP processes and the SMP limit initiatives to those that are already funded.

The SMP process includes:

1. Identify the existing state of the environment in the catchment.
2. Identify the contributions by existing and future activities to stormwater quality and quantity.
3. Estimate trends on water quality and quantity from urban growth, technology, lifestyle, climate, etc.
4. Develop measures to control or mitigate effects (including planning, education, enforcement, source control, etc as funded in the LTP).
5. Estimate the effectiveness of chosen mitigation measures through contaminant load and flood modelling.

The Surface Water Implementation Plan process includes:

- Prepare a plan that will permit the Council to meet or exceed consent condition targets.
- Engage with Council teams and external stakeholders responsible for contaminant generating activities; obtain agreement about control measures.

2.2 Stormwater Management Plan Catchments

This SMP is one of seven plans being prepared over the period 2020 to 2024 for the Ōpāwaho-Heathcote, Huritini-Halswell, Ihutai-Estuary and Coastal and Ōtūkaikino catchments and Settlements of Te Pātaka-o-Rākaihautū-Banks Peninsula, and Ōtākaro-Avon and Pūharakekenui-Styx catchments. Figure 1 illustrates the boundaries for each SMP.

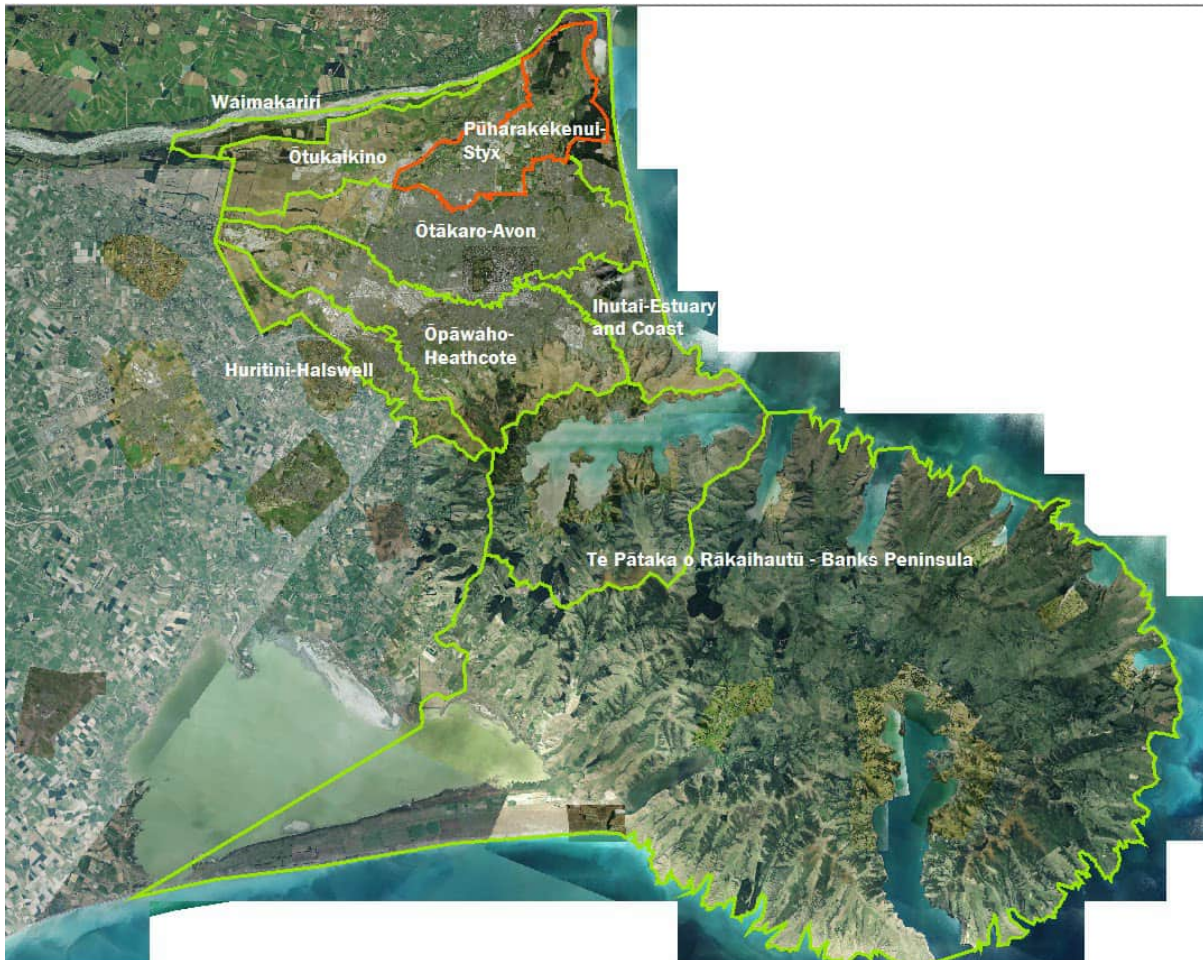


Figure 1: Area Covered by the Comprehensive Stormwater Network Discharge Consent.

2.3 Regional Planning Requirements

2.3.1 Canterbury Regional Policy Statement

The Canterbury Regional Policy Statement (CRPS) sets out how natural and physical resources are to be sustainably managed in an integrated way. The needs of current and future generations can be provided for by maintaining or improving environmental values. The CRPS requires that objectives, policies and methods are to be set in regional plans, including the setting of minimum water quality standards.

2.3.2 Land and Water Regional Plan

The Land and Water Regional Plan 2015 encourages the development of stormwater management plans under Rule 5.93. The intention of the rule is that SMPs will be developed to show how a local authority will meet the relevant policy on water quality.

2.3.3 Greater Christchurch Urban Development Strategy

The Greater Christchurch Urban Development Strategy (UDS) Partnership has been working collaboratively for over a decade to tackle urban issues and manage the growth of the city and its surrounding towns.

The strategy was prepared under the Local Government Act 2002 and it is to be implemented through various planning tools, including:

- Amendments to the Canterbury Regional Policy Statement (CRPS);
- Changes to regional and district plans to reflect the CRPS changes;
- Stormwater planning to give effect to the Land and Water Regional Plan (LWRP); and
- Outline Development Plans for new development areas ('Greenfield areas') and existing re-development areas ('Brownfield areas').

Preparation of this SMP plays a role in implementing the UDS.

2.3.4 The Belfast Area Plan

The Belfast area is approximately 1,349 ha of land which sits within the Pūharakekenui-Styx catchment. The Belfast area is identified in the UDS and Plan Change 1 of the CRPS as a major growth area for Christchurch City. The Belfast Area Plan (BAP) is one of the implementation methods for the growth strategies outlined in the UDS and CRPS, and provides the framework for land use planning in the Belfast area. Belfast is signalled as the second largest Greenfield development for Christchurch.

2.4 Non-Statutory Documents

- Integrated Water Strategy 2019
- Surface Water Implementation Plan (to be developed)
- Mahaanui Iwi Management Plan 2013
- Ngai Tahu Freshwater Policy Statement (Te Rūnanga O Ngai Tahu 1999)
- Infrastructure Design Standard (Christchurch City Council 2010)
- Waterways, Wetlands and Drainage Guide (Christchurch City Council 2003)
- Erosion and Sediment Control Toolbox for Canterbury (Environment Canterbury)
- Estuary Management Plan 2020 – 2030 (Avon-Heathcote Estuary Ihutai Trust)

2.5 The Council’s Strategic Objective for Water

The Christchurch City Council has adopted community outcomes to promote community wellbeing.

The Green and liveable Outcome includes:

“... and protect and regenerate the environment, especially our biodiversity, water bodies and tree canopy.”

2.6 The District Plan

The Christchurch District Plan promotes responsible stormwater disposal through Policy 8.2.3.4 – Stormwater Disposal, which states:

- a. District-wide:
 - i. Avoid any increase in sediment and contaminants entering water bodies as a result of stormwater disposal.
 - ii. Ensure that stormwater is disposed of in a manner which maintains or enhances the quality of surface water and groundwater.
 - iii. Ensure that any necessary stormwater control and disposal systems and the upgrading of existing infrastructure are sufficient for the amount and rate of anticipated runoff.
 - iv. Ensure that stormwater is disposed of in a manner which is consistent with maintaining public health.
- b. Outside the central city:
 - i. Encourage stormwater treatment and disposal through low-impact or water-sensitive designs that imitate natural processes to manage and mitigate the adverse effects of stormwater discharges.
 - ii. Ensure stormwater is disposed of in stormwater management areas so as to avoid inundation within the subdivision or on adjoining land.
 - iii. Where feasible, utilise stormwater management areas for multiple uses and ensure they have a high quality interface with residential activities or commercial activities.
 - iv. Incorporate and plant indigenous vegetation that is appropriate to the specific site.
 - v. Ensure that realignment of any watercourse occurs in a manner that improves stormwater drainage and enhances ecological, mahinga kai and landscape values.
 - vi. Ensure that stormwater management measures do not increase the potential for bird-strike to aircraft in proximity to the airport.
 - vii. Encourage on-site rain-water collection for non-potable use.
 - viii. Ensure there is sufficient capacity to meet the required level of service in the infrastructure design standard or if sufficient capacity is not available, ensure that the effects of development are mitigated on-site.

District Plan Policies 8.9.2.2 and 8.9.2.3 make earthworks subject to a consent. Conditions of consent for earthworks over a threshold include the requirement for an Erosion and Sediment Control Plan (ESCP). An ESCP is submitted and approved with a consent application and its implementation is verified by building consent officers.

2.7 Bylaws

The Stormwater and Land Drainage Bylaw 2022 will restrict discharges of any material, hazardous substance, chemical, sewage, trade waste or other substance that causes or is likely to cause a nuisance, into the stormwater network.

The Traffic & Parking Bylaw 2017 allows the Council to require an offender to remove material spilled onto roads.

2.8 Building Act

The Council can use powers under the Building Act to require ESCPs to be submitted when an associated land use consent is not required.

2.9 Integrated Water Strategy

Objectives 3 and 4 of the Christchurch City Council’s draft Integrated Water Strategy are summarised as *“enhancement of ecological, cultural and natural values and water quality improvement.”*

The preferred strategy option for achieving the objectives is to *“continue ... the implementation of the current approach to stormwater management (embodied by the development of the Stormwater Management Plans) ...”*

2.10 Mahaanui Iwi Management Plan

The Mahaanui Iwi Management Plan *“... is an expression of kaitiakitanga and rangatiratanga...(It) provides a values-based, ... policy framework for the protection and enhancement of Ngāi Tahu values, and for achieving outcomes that provide for the relationship of Ngāi Tahu with natural resources across Ngā Pākihi Whakatekateka o Waitaha and Te Pātaka o Rākaihautū (the Canterbury Plains and Banks Peninsula)”*. The Ihutai-Estuary and Coastal SMP acknowledges the Iwi Management Plan policies and can contribute to policies which fall within the scope of a stormwater management plan (SMP). There is more detail in Section 10.5.

2.11 Infrastructure Design Standard

The Infrastructure Design Standard 2016 (IDS) is the Council’s development code and is a revision of the Christchurch Metropolitan Code of Urban Subdivision 1987. The IDS promotes environmental protection via a values-based design philosophy and consideration of bio-diversity and ecological function. Refer to the IDS Section 5.2.3: Four Purposes for more details.

2.12 Goals and Objectives for Surface Water Management

The Pūharakekenui-Styx SMP and the Surface Water Implementation Plan are intended to be consistent with the *Integrated Water Strategy 2019* which identifies overall goals and objectives for surface water management. Jointly these plans will support so far as is practicable the *Mahaanui Iwi Management Plan* objectives for the Waimakariri and Ihutai/Avon-Heathcote Estuary catchment (Jolly, Lobb, & Ngā Papatipu Rūnanga, 2013).

The Council's high-level goals in the Integrated Water Strategy are:

GOAL 1: The multiple uses of water are valued by all for the benefit of all.

GOAL 2: Water quality and ecosystems are protected and enhanced.

GOAL 3: The effects of flooding, climate change and sea level rise are understood, and the community is assisted to adapt to them; and

GOAL 4: Water is managed in a sustainable and integrated way in line with the principles of kaitiakitanga.

Te Rūnanga o Ngāi Tahu Freshwater Policy (Ngāi Tahu, 1999), lists several water quality and water quantity policies that apply throughout the Ngāi Tahu Takiwā. The Iwi Management Plan (Jolly et al, 2013) has objectives for the Waimakariri and Ihutai/Avon-Heathcote Estuary catchment that are directly relevant to the Pūharakekenui-Styx catchment. These are objectives numbered:

- (2) The discharge of contaminants to the Waimakariri and its tributaries is eliminated.
- (3) Water quality and flows in the Waimakariri and its tributaries are improved to enable whānau and the wider community to have places they can go to swim and fish.
- (4) The mauri and mahinga kai values of the Waimakariri and its tributaries and associated springs, wetlands and lagoons are protected and restored; mō tātou, ā, mō kā uri ā muri ake nei.
- (7) Urban development reflects low impact design (LID) principles and a strong commitment to sustainability, creativity and innovation with regard to water, waste and energy issues.

The CSNDC sets freshwater outcomes based on Land and Water Regional Plan targets. The CSNDC Environmental Monitoring Programme (EMP) will assess the ecological and cultural health of waterways and coastal areas, and progress made under the SMP. The EMP assesses a range of parameters, and progress can be measured against LWRP guidelines for macroinvertebrate indices, macrophytes, periphyton, siltation and a range of water quality parameters.

The SMP programme will contribute toward delivery on these objectives through improving water quality in the rivers and streams. Other plans and programmes must play a part in restoring riparian margins and protecting and restoring springs and mahinga kai site in order to deliver on tangata whenua and LWRP objectives.

Stormwater quantity effects considered in this SMP include mitigation of additional runoff generated by urban intensification and the reduction in network level-of-service in the east of the catchment as sea levels rise over the SMP planning period.

Other sources and reports that have informed the SMP include:

- State of the Takiwā,
- Surface water and sediment quality monitoring,
- Listed Land Use Register (ECan),
- Groundwater and springs study,
- Ecological survey,
- Flood management planning for the Waimakariri River (Environment Canterbury),
- Contaminant load model.

The duration of this stormwater management plan is 10 years. Water quality has been its primary focus. To maintain the existing good water quality in receiving waters, it will be necessary to mitigate any adverse effects from new urban growth and to improve stormwater quality from existing developed areas.

3.1 Water Quality and Ecological Health

Water quality and ecological health have significantly deteriorated over 160 years of urban development. Stormwater runoff containing metals can be detrimental to various species in waterways, sediment accumulation suffocates biota habitats and can be polluted or oxygen-depleted, and the presence of *E. coli* poses a risk to human health during recreational water activities.

Failure to meet indicator values in the Canterbury Land and Water Regional Plan for urban spring-fed plains rivers is reported in water quality, sediment quality and ecological surveys carried out for the SMP (Section 6). Contaminants of concern include sediment, zinc, copper and *E. coli* (an indicator of faecal contamination). Suspended sediment, zinc, and copper have notably higher levels during wet weather. Additionally, excessive growth of aquatic weeds can occur due to elevated levels of nitrogen and phosphorus, which can originate from sources other than stormwater.

The recorded levels of these contaminants of concern have adverse effects on biota, result in excessive growth of aquatic weeds, or pose risks to recreational water activities, depending on the specific contaminant. Despite ongoing urban development, the challenge for the SMP lies in finding ways to reverse the decline in surface water quality and ecological health within the Pūharakekenui-Styx catchment.

3.2 Flood Risk

A few properties in the Brooklands area regularly experience flooding, and houses located in low-lying areas are prone to flooding during major events. The land subsidence caused by the 2010/11 earthquakes has increased the vulnerability of some properties to flooding. With significant urban growth expected in the upper catchment, there will be an increase in both the volume and speed of stormwater runoff, which needs to be effectively managed. Therefore, any projected urban growth in this catchment must take into account these low-lying areas to ensure that there is no significant increase in the risk or cost of flood damage to the community.

The impacts of the earthquakes on the increased vulnerability to flooding have been investigated as part of the Land Drainage Recovery Programme. The goal of this program is to reduce the flooding risk to houses in the area to pre-earthquake levels. Additionally, a floodplain and river model is currently being updated to enhance our understanding of the risks faced by houses located on the floodplain. This model will also incorporate the effects of sea level rise over the planning period of the SMP for improved accuracy.

PART TWO:
The Catchment

4.1 Geography

The Pūharakekenui-Styx River Catchment encompasses an area of approximately 7,000 hectares situated on the northern urban periphery of Christchurch. The Pūharakekenui-Styx River, a spring-fed system, stretches for 22 km from its headwaters in the Harewood area to the sea. It meanders in a north-easterly direction, passing through reserves, pastures, horticultural areas, and residential developments before reaching the sea via Te Riu o Te Aika Kawa-Brooklands Lagoon and the Waimakariri River.

The principal tributaries are the Kā Pūtahi Creek and Smacks Creek, but there are many significant constructed drains, and natural springs, and the Brooklands and Cranford Basin ponding areas.

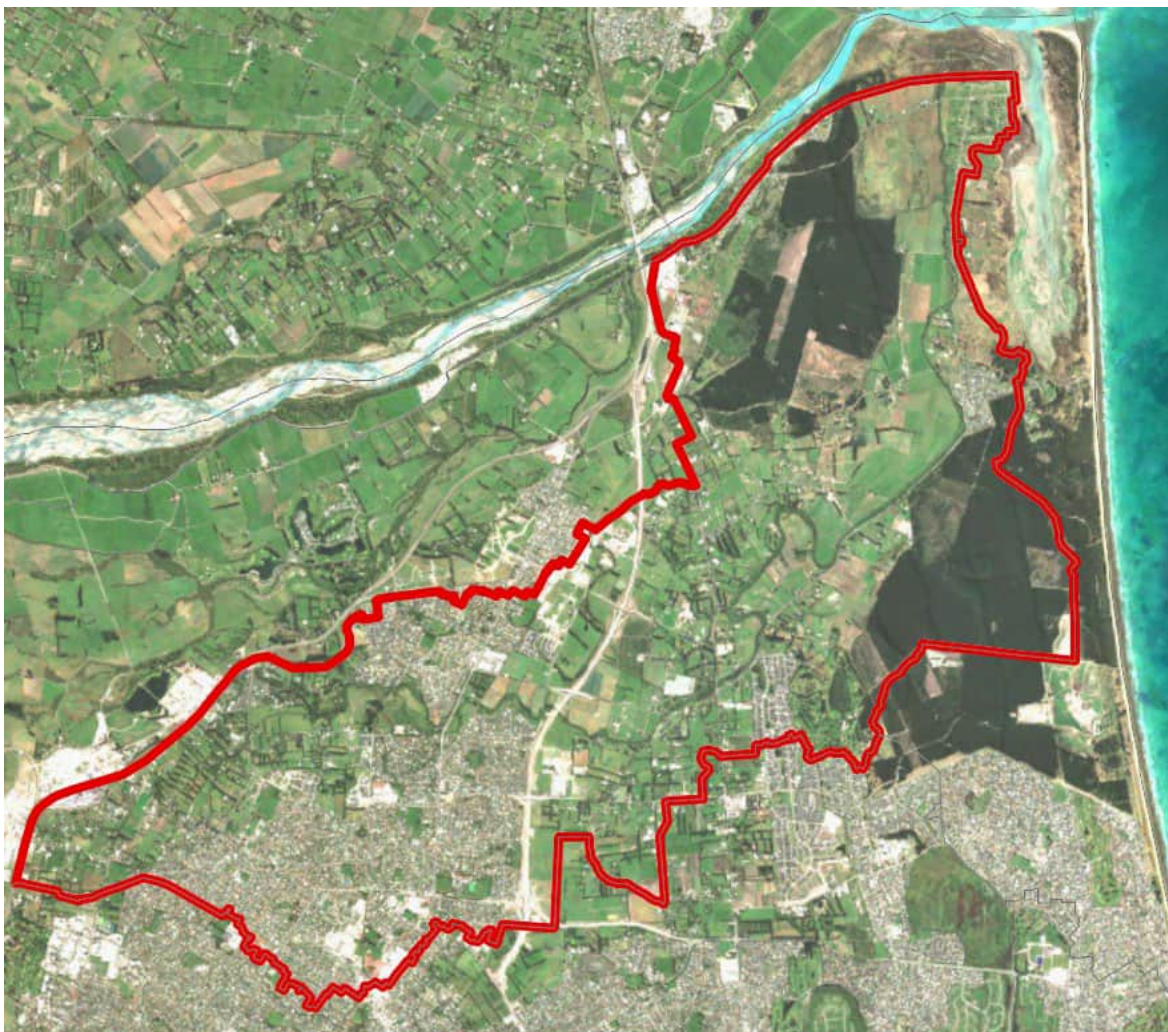


Figure 2: Pūharakekenui-Styx Catchment Boundary

The catchment is partly urbanized, which accounts for 39% of the total area, in a mix of residential, industrial, amenity, and transportation land uses. The urban areas are primarily

situated in the southwestern region of the catchment, including the suburbs of Harewood, Northwood, Redwood, Northcote, and Casebrook.

A larger percentage (42%) of the catchment is rural, mostly with pastoral and horticultural activities, and the remainder is mostly open space.

4.2 Geology

The catchment is characterised by deposits of free-draining highly permeable gravels associated with the Waimakariri River in the west, interspersed with lower permeability overbank silt and free-draining sand deposits that thicken toward the coast. The permeable alluvial gravel strata form a sequence of productive gravel aquifers, which have been utilised by bores as deep as 222 m in the Pūharakekenui-Styx catchment. At the centre and eastern side of the catchment, several discrete gravel aquifers occur at depth, which are separated by lower permeability silty and sandy deposits formed in a marine or coastal environment. (Pattle Delamore Partners Ltd, 2008).

4.3 Soils

Soils are predominantly recent soils, with areas of gley¹ soils around Redwood extending to the north and south along Hills Road. Marshlands Road also contains an area of isolated organic peaty soils in the horticultural areas. To the east of Marshland Road and extending to the coastline, the soil type is predominantly yellow brown sand.

Soils are described as saline gley recent (SAGYRE) in vicinity of the river mouth (Golder Associates, 2009) also. Tonkin & Taylor comment that the soil map of Christchurch and the soil layer of the Christchurch City Council Hazards Register show a distribution of soil types which correlates to the underlying geology. They comment further that silt and clay soils extend across the area with soils containing a notable organic content found in low-lying areas and soil cover over alluvium gravels being thin to non-existent in the flood channel areas (Tonkin & Taylor, 2007).

The soil properties within the Smacks Creek sub-catchment are suitable for a proposed treatment train including soakage facilities to ground although this form of stormwater disposal is not anticipated in this area to avoid risks of groundwater contamination. The soil types in this sub-catchment are:

- Te Kakahi shallow and stony sandy loam
- Taitapu deep fine sandy loam
- Selwyn stony loamy sand
- Waimakariri deep fine sandy loam

In past times great quantities of dust from the riverbeds were lifted by strong north-west winds and deposited over the plains. This dust was sandy near the rivers, but the sediments became finer as distance from the rivers increased. Waimakariri series soils in the upper catchment received a heavy dressing of sandy material.

¹ a sticky, waterlogged soil lacking in oxygen, typically grey to blue in colour.

4.4 Drainage Network

4.4.1 Streams and Drainage Channels

The most significant tributary of the Pūharakekenui-Styx River is Kā Pūtahi Creek, however many tributaries drain present and future urban areas south of the river. There are various man-made drains, as well as natural springs and a ponding area (the Lower Styx ponding area) upstream from the Harbour Road tide gates. The tide gates exclude high tides which would otherwise flood farm land.

In pre-European times the catchment mostly consisted of wetlands. However, significant urbanization has heavily modified certain areas of the catchment. Despite this, remnants of native vegetation can still be found within the core wetland habitat, as well as in rare wetland habitats such as the small remaining fens at Styx Mill and the Groynes.

4.4.2 Stormwater System

The public stormwater network begins with roadside channels that receive discharges from private properties and the road itself. The main purpose of these side channels is to ensure dry traffic lanes. From there, the side channels lead to street sumps, also known as catchpits, which then discharge into the pipe network. The pipe network is designed to provide a level of service where road drainage can effectively prevent traffic hazards during rainfall events with an average recurrence interval of five years or less. However, occasional flooding of roads and properties may occur due to sump blockage or system capacity limitations.

The majority of stormwater is discharged into surface water bodies. However, there are two small infiltration basins in the Upper-Kaputone sub-catchment where discharge to the ground occurs. These basins were specifically approved for use when they were installed and they serve only a small residential catchment. The basins meet current best practice design criteria.

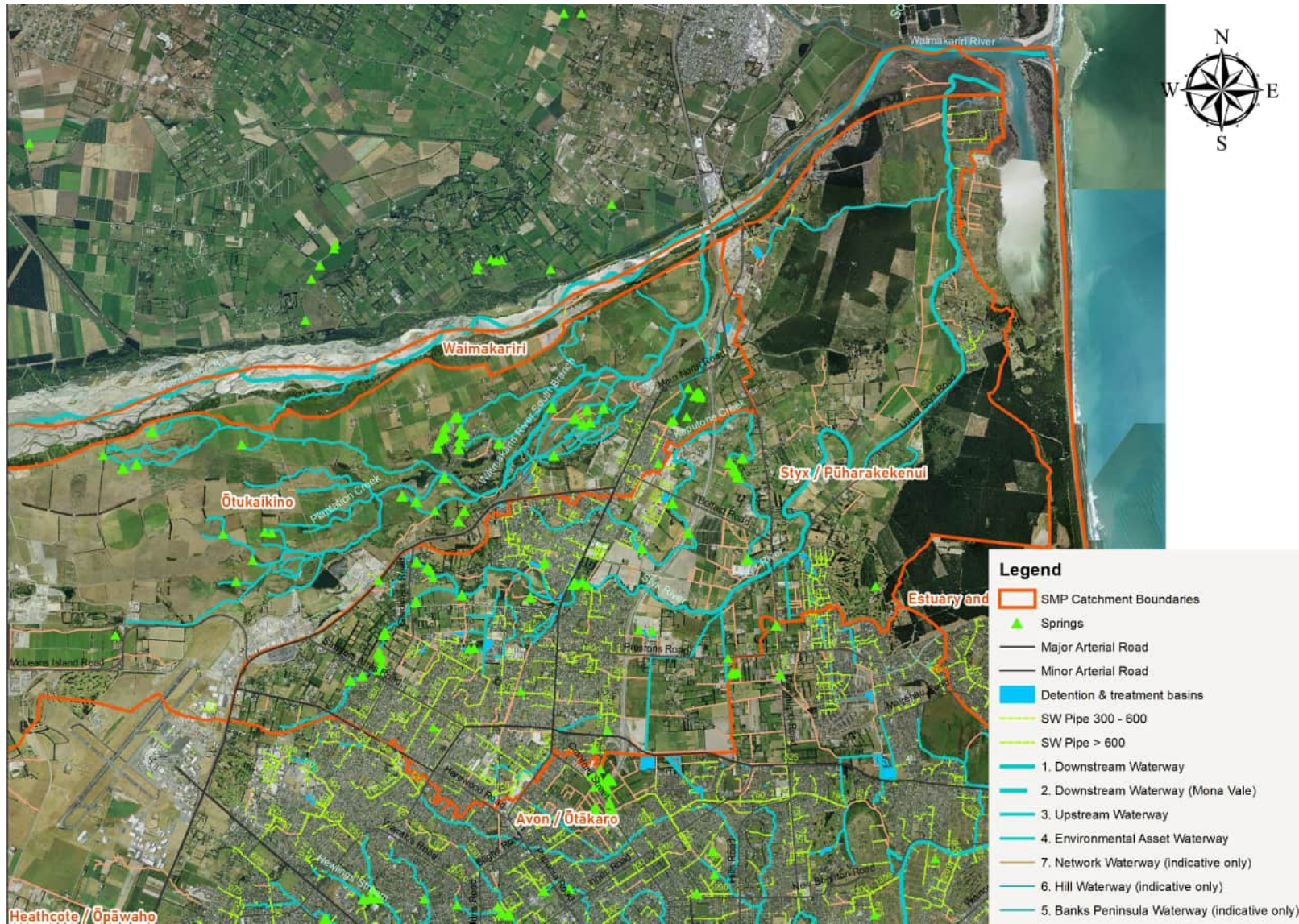


Figure 3: Pūharakekenui-Styx Catchment and Stormwater Network

4.5 Groundwater – Physical

The water table is generally shallow across the catchment, as evidenced by the number of surface waterways that are spring-fed. There is a small portion of the western side of the Styx catchment has low groundwater levels.

The location and discharge rates of the springs vary throughout the year in response to groundwater level fluctuations. Fluctuations in ground water level and spring discharge can result from urban development, for example by groundwater drainage. There are significant land development activities in the area which have shown spring flow fluctuations as a result of construction dewatering, diversion of springs, new stormwater management areas and discharge locations (Pattle Delamore Partners Ltd, 2008). River flows within the Pūharakekenui-Styx are also impacted by general seepage and land drainage.

Groundwater quality is generally good due to the rapid through-flow of seepage water from the Waimakariri River (Christchurch City Council, 2017), although it can be more variable at shallow depths due to the impacts of land use activities (Pattle Delamore Partners Ltd, 2008).

Pūharakekenui-Styx catchment waterways are most sensitive to these effects at the western end of the catchment where there is the highest degree of hydraulic connection between groundwater and surface flow. Stormwater soakage systems are not appropriate in majority of the catchment, excepting a relatively small area in the west, shown cross-hatched in Figure 4.

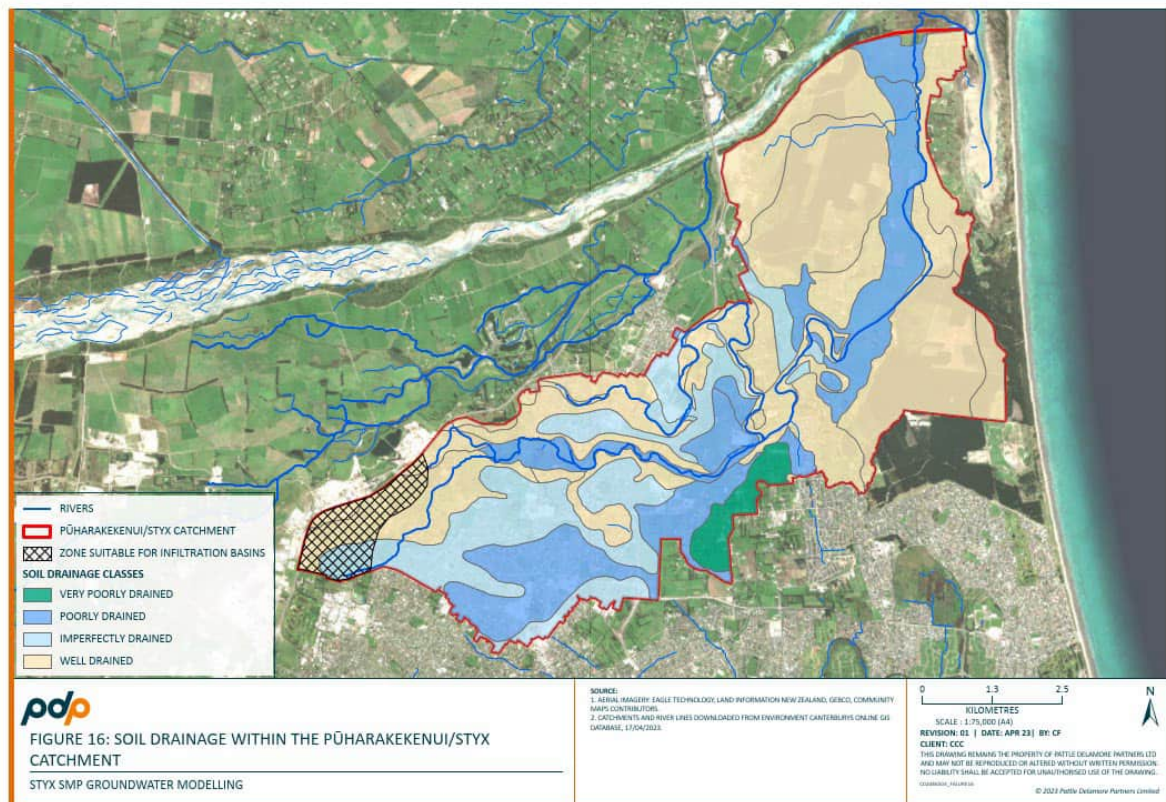


Figure 4: Soil Drainage within the Pūharakekenui-Styx Catchment (PDP, 2023)

4.5.1 Depth to groundwater

Water level records held by Environment Canterbury (Environment Canterbury, 2020) indicate that groundwater is generally shallow within this catchment. Regularly measured groundwater level monitoring wells have not shown any long-term change in groundwater levels. A review of monitoring data in April 2011 showed some monitoring wells exhibited no effect from the earthquake, whereas some others show a short term spike of around 0.75 m which recovered to around background levels within a few days.

4.5.2 Springs

Following the 2010 - 2011 earthquakes, new springs have been reported in places including southern Christchurch near the margin with the Port Hills, and within the Redwood area. The two springs in Redwood are in an area of pre-existing springs and are likely to represent a relatively small change to the overall groundwater situation (Golder Associates, 2015).

Figure 3 illustrates the known spring locations within the Pūharakekenui-Styx catchment.

4.5.3 Groundwater flow pattern

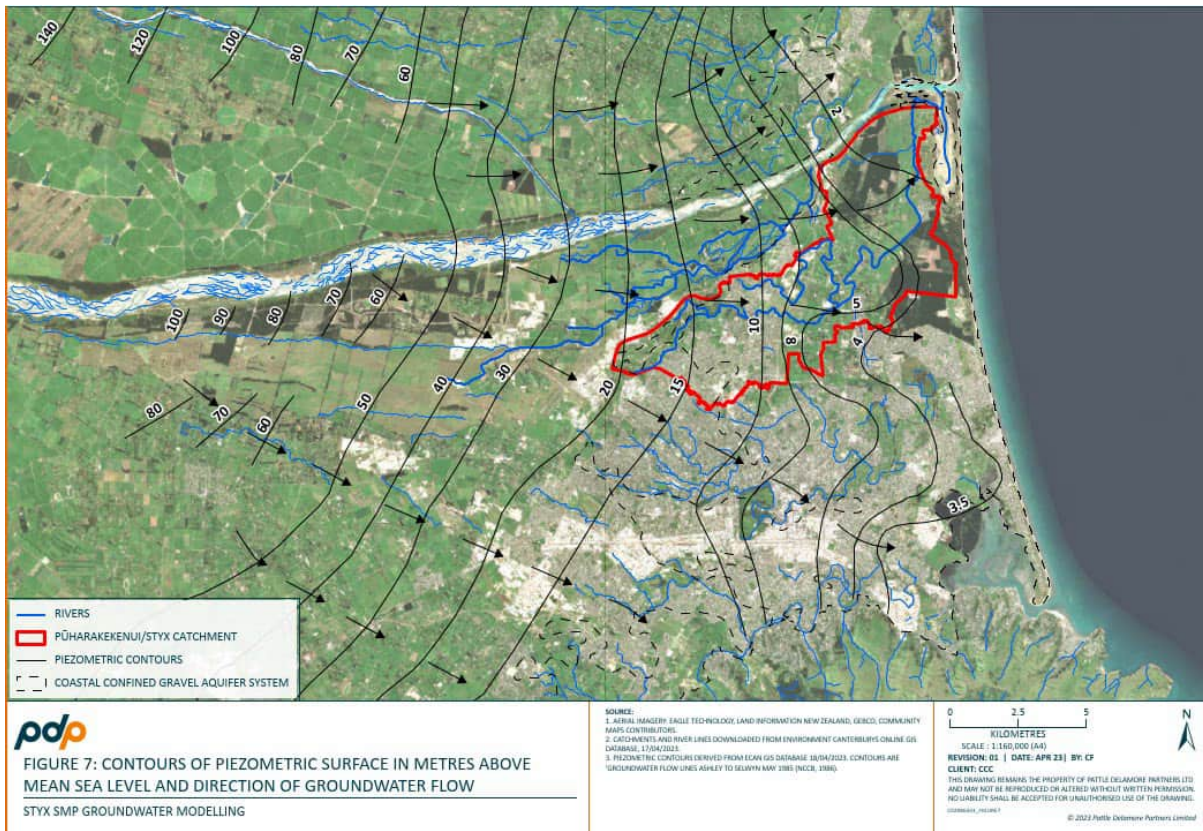


Figure 5: Groundwater Flow Pattern (PDP, 2023)

5.1 Wai Maori

Ko te wai te oranga o ngā mea kātoa

Water is the life giver of all things

Water is a significant cultural element that connects Ngāi Tahu to the landscape and the culture and traditions of tūpuna. All water originated from the separation of Rangī and Papatūānuku and their mourning for one another. Rain is Rangī's tears for his beloved Papatūānuku and mist is regarded as Papatūānuku's tears for Rangī.

For tāngata whenua, the current state of cultural health of the waterways and groundwater is evidence that water management and governance in the takiwā has failed to protect freshwater resources. Surface and groundwater resources are over-allocated in many catchments and water quality is degraded as a result of urban and rural land use. This has significant effects on the relationship of Ngāi Tahu to water, particularly with regard to mauri, mahinga kai, cultural wellbeing and indigenous biodiversity.

A significant kaupapa that emerges from (the Mahaanui Iwi Management Plan) is the need to rethink the way water is valued and used, including the kind of land use that water is supporting, and the use of water as a receiving environment for contaminants such as sediment and nutrients. Fundamental to tāngata whenua perspectives on freshwater is that water is a taonga, and water management and land use should reflect this importance. Because of the fundamental importance of water to all life and human activity, Ngāi Tahu maintain that the integrity of all waterways must be jealously protected. This does not preclude the responsible use of water, but merely states the parameters which Ngāi Tahu believe any such use should remain within. The utilisation of any resource for the benefit of the wider community is encouraged, providing that it is done with the long-term welfare of both the community and the resource in mind." Refer to Part 5.3 Wai Māori in the Mahaanui Iwi Management Plan for more details (Jolly, Lobb, & Ngā Papatipu Rūnanga, 2013).

5.2 Ngāi Tahu Site Specific Cultural Values

5.2.1 Historic Values

Water is a taonga (a natural resource of utmost value) and represents the life blood of the environment. Traditional values and controls on water are included in spiritual beliefs and practices. Māori hold absolute importance to water quality in relation to mahinga kai and hygiene.

The maintenance of water quality and quantity is perhaps the paramount resource management issue for tangata whenua. Each waterway is a predominant feature within the landscape and

should remain as such. To say that some waterways are more important than others would miss the significance of those waterways that feed into and are part of the main waterway. A holistic approach culturally is that all waterways are significant. Waterways begin as rain drops connecting together as streams, lake estuaries, and wetlands, all leading out to the coast. All is one.

5.2.2 Whakapapa

The concept of whakapapa underpins all others and gives rise to the context in which all other Maori life-ways find their meaning. Whakapapa may be loosely translated as the genealogical relationships that bind and connect both human and non-human worlds. It establishes the origins of all things and connects people to their ancestors and the land and natural resources around them. Natural elements including people are believed to have originated from the atua (gods); all parts of the Māori world are unified by spiritual connections and common ancestry, binding tangata whenua to the natural environment.

Whakapapa binds tangata whenua to the mountains, lands, waters, and other resources in their rohe. Impacts on any element or resource connected with tangata whenua have a cultural impact.

The whakapapa of a waterway determines its use in Tohunga (spiritual), Waiwhakaheketupapaku (burial sites), Waitohi (Tohunga use i.e. removal of Tapu), Waimataitai (coastal mix of fresh and salt water, estuaries), Waiora (Tohunga healing water), and Mahinga kai (food source).

5.2.3 Mauri

Mauri is the physical life force inherent in each element of the natural world. The mauri of individual entities is inter-dependent on the mauri of the greater system. A Māori view of environmental management sees that protection of the mauri of natural systems is essential for their survival. It is also seen as reflecting on the mana of the people who are associated with it. Mauri can be harmed by the actions of people. The overall purpose of resource management for Ngāi Tahu is the maintenance of the mauri of natural and physical resources, and to enhance mauri where it has been degraded by the actions of humans.

5.2.4 Ki Uta Ki tai

Ki Uta Ki Tai (from the mountains to the sea) is a holistic approach to resource use by Ngāi Tahu. It is best expressed by considering the environment as a whole rather than discrete parts. From a Māori perspective this also includes cultural and spiritual dimensions.

5.2.5 Mahinga Kai

Mahinga kai is a core aspect of the traditional way of life and relates to food and other resources. Resource interests include seasonal timetables and other practices to best utilise the resources available. Therefore mahinga kai includes the process of food gathering, the way it is gathered, the place it is gathered from, and all aspects of the actual resource itself and the management of that resource.

The Pūharakekenui area has been an important source of mahinga kai for manawhenua, with many of its species recognised as taonga species in the Ngāi Tahu Claims Settlement Act 1998. The fertile lands and waters supported bountiful resources in a mosaic of ecosystems that provided

rich habitat. Vegetation in the area included swamps and wetlands interspersed with areas of tutu, fern and toetoe, grass lands and forest. Mahinga kai species included raupo, harakeke (flax), aruhe (fern), and toetoe. Forested areas provided food sources such as the roots and young stems of tī kōuka (cabbage tree), medicinal plants, and habitat for other species. Bird species abundant in the area included putangitangi (paradise shelduck), parera (grey duck), weka and kiwi. Waterways provided habitat for tuna (eel), inanga (whitebait), waikakahi (freshwater mussels), and waikoura (freshwater crayfish).

The land, water and resources in a particular area are representative of the people who reside there. They relate to the origin, history and tribal affiliations of that group, and are for them, a statement of identity.

The links to natural resources directly determined the welfare and future of the tribe. Those with resources flourished, while those without perished. Therefore, the management and maintenance of resources was the foremost concern. This acknowledged inter-dependence with the environment is central to Māori creation stories, spiritual belief, and resource management techniques.

5.2.6 Current Values

The Pūharakekenui-Styx River is a significant waterway and important source of mahinga kai for Ngāi Tūāhuriri. Foods gathered from the river include tuna (eel), kanakana (lampreys), kēkewai (freshwater crayfish), as well as other native fish, plants and waterfowl. Mahinga kai practices within the catchment still continue today.

Te Riu o Te Aika Kawa / Brooklands Lagoon is a significant area within the catchment being an important mahinga kai where a variety of shellfish, fish and plants can be gathered. In 1868 the Crown granted the Pūharakekenui Māori Reserve (MR 892) located between Pūharakekenui-Styx River and Te Riu o Te Aika Kawa-Brooklands Lagoon. Te Hapū o Kāti Urihia Ahuwhenua Trust represents the owners of the Māori reserve and work with the council through the Brooklands Lagoon / Te Riu o Te Aika Kawa Area Parks Master Plan.

The Mahaanui Iwi Management Plan also provides guidance on the management of the river and its catchment and outlines the importance of working with Te Ngāi Tūāhuriri Rūnanga and Mahaanui Kurataiao Ltd to achieve cultural outcomes (Christchurch City Council, 2017).

5.3 Te Ngāi Tūāhuriri Rūnanga Position Statement / Cultural Impact Assessment

Te Ngai Tuahuriri Rūnanga is the papatipu rūnanga for the Pūharakekenui-Styx catchment. Te Ngai Tuahuriri Rūnanga neither approves nor criticises the SMP, but provides a statement of the rūnanga's views and position (a Position Statement) on matters specific to this catchment that arise from the Mahaanui iwi Management Plan.

A Position Statement will be delivered after the final SMP has been considered by the rūnanga.

5.4 Cultural Monitoring

Cultural monitoring enables the Council and Ngāi Tāhu to compare present and potential future conditions against the State of the Takiwā Report (Ngāi Tahu, 2007). Cultural monitoring will be carried out as part of the Environmental Monitoring Programme. Sites will be sampled five-yearly in conjunction with the monitoring of surface water quality, instream sediment quality and aquatic ecology.

The first round of cultural monitoring in Pūharakekenui-Styx Catchment is expected to start in 2023 and depending on report writing and approval by Te Ngai Tuahuriri Rūnanga is may be ready for inclusion in the final SMP.

6.1 Monitoring Sites

6.1.1 Council Owned

The Council monitors water quality monthly at 47 sites across the district, including eight within the Pūharakekenui-Styx catchment as outlined in Table 2 and Figure 6. Most sites have been monitored since approximately 2007. All sites are located within waterways classified in the Land and Water Regional Plan as ‘spring-fed – plains’.

Table 1: Council Water Quality Monitoring Sites within the Pūharakekenui-Styx catchment

Site Name	Site ID	Monitoring Instigated
Smacks Creek at Gardiners Road near Styx Mill Road	STYX01	January 2007
Styx River at Gardiners Road	STYX02	January 2007
Styx River at Main North Road	STYX03	January 2007
Kā Pūtahi Creek at Blakes Road	STYX04	January 2007
Kā Pūtahi Creek at Belfast Road	STYX05	January 2007
Styx River at Marshlands Road Bridge	STYX06	January 2007
Styx River at Richards Bridge	STYX07	October 2008
Styx River at Harbour Road Bridge	STYX08	January 2008

6.1.2 Styx Living Laboratory Trust

An additional eleven sites within the Pūharakekenui-Styx River catchment are monitored by the Styx Living Laboratory Trust (SLLT). These sites are outlined in Table 3 and located within waterways classified as spring-fed – plains.

SLLT volunteers have analysed water in the field for pH (Eutech pH pocket testers 30), conductivity (Eutech Cybernetics TDScan 3), water clarity (clarity tube) and water temperature (glass spirit thermometer) since 2004. These results are also presented within this report.

Water clarity results should be viewed with caution, as the clarity tube is only 1m long and readings may be somewhat subjective.

SLLT samples were aimed to be taken every third Saturday of the month, but as this was based on volunteer availability, the number of samples taken annually at each site ranged from 6 – 11. Of note:

- There were no data available for 2016;
- 2015 and 2017 had a small number of recordings; and
- pH readings changed from using test strips to a handheld meter in February 2010; therefore, pH data prior to this time have been excluded from this report.

Table 2: SLLTs Water Quality Monitoring Sites

Site Name	Site ID
Smacks Creek at Wilkinsons Road	SLLT01
Styx River at Willowbank	SLLT02
Styx River at Styx Mill Conservation Reserve	SLLT03
Styx Drain at Redbrook Road	SLLT04
Rhodes Drain at Hawkins Road	SLLT05
Horner's Drain at Hawkins Road	SLLT06
Styx River at Radcliffe Road	SLLT07
Kā Pūtahi Creek at Blakes Road	SLLT08
Kā Pūtahi Creek at Ouruhia Domain	SLLT09
Kā Pūtahi Creek at Everglades Golf Course	SLLT10
Styx River at Brooklands	SLLT11

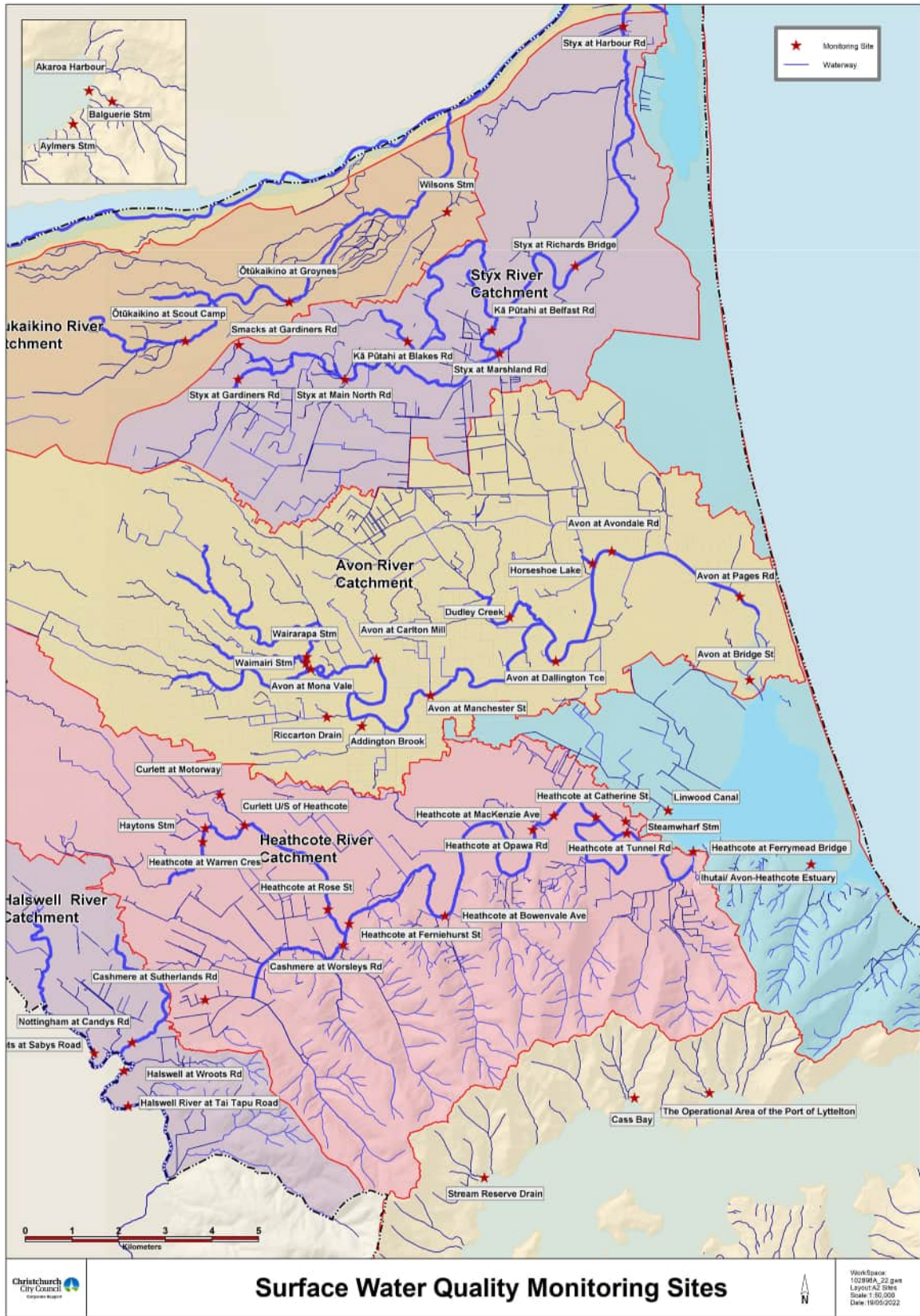


Figure 6: Council Water Quality Monitoring Sites (Burrell, 2023)

6.2 Water Quality

The most recent summary of monitoring data was presented by (Poudyal & Margetts, 2022) which covered data up to the end of 2021. The following paragraphs summarise relevant results from (Poudyal & Margetts, 2022).

Council water quality samples are analysed for over 20 individual water quality parameters. A water quality index (WQI) is used to consolidate data from 11 individual water quality parameters into a single index value that ranges from 0 to 100, with 100 representing high water quality. The WQI is comprised of the following parameters: dissolved copper, dissolved zinc, pH, total suspended solids, dissolved oxygen, temperature, 5-day biochemical oxygen demand, total ammonia, nitrate-nitrogen, dissolved reactive phosphorus, and the faecal pollution indicator *Escherichia coli* (*E. coli*).

In 2021, WQI scores at Pūharakekenui sites ranged from a low of 76.9 (indicating 'fair' water quality) at the Harbour Road site, to a high of 92.5 (indicating 'very good' water quality) at the Gardiners Road site (Figure 7). The median WQI score across the catchment was 84, which put it in the 'good' water quality category. By comparison, the less developed Ōtūkaikino River catchment had the highest overall WQI, with a median WQI of 94, putting it in the 'very good' category. The more urbanised Ōpāwaho–Heathcote River catchment had the lowest overall WQI, with a median score of 59, putting it in the 'poor' category. The WQI is affected by the number of component water quality parameters that exceed guidelines. Within the Pūharakekenui-Styx catchment, the *E. coli* guideline of ≤ 550 CFU/100 ml (95th percentile) was not met for *E. coli* at all eight sites, the dissolved reactive phosphorus guideline of ≤ 0.016 mg/L was not met at five sites, and the dissolved oxygen guideline of ≥ 70 % was not met at two sites.

The CSNDC Environment Management Plan requires that Council assesses monitoring results against the consent Objectives and Attribute Target Levels (ATLs) for key urban stormwater contaminants, namely total suspended solids, copper, lead, and zinc. Failure to meet any of the ATLs triggers investigations to determine whether the water quality is due to stormwater inputs. While 31 of the 51 sites monitored across the district did not meet the ATLs in 2021, none of these sites fell within the Pūharakekenui-Styx catchment. This reflects the relatively low proportion of untreated urban stormwater entering the catchment, compared to other catchments, such as the Ōpāwaho-Heathcote, where much of the urban development predated modern stormwater treatment.

6.3 Sediment Quality

Stormwater contaminants such as metals can accumulate in stream bed sediments, which can adversely affect the health of invertebrates and fish. The most recent summary of sediment monitoring data from the Pūharakekenui-Styx catchment was presented by Instream Consulting (Instream Consulting, 2018), which included data collected from 11 sites at varying intervals from 1980 to 2018. Sediment concentrations of common stormwater contaminants exceeded ANZECC & ARMCANZ guidelines (2000) at a number of sites in 2018, but there were no increasing trends at most of the sites, and contaminant concentrations were overall much lower than in other urban catchments, including the Ōpāwaho, Ōtākaro, and Huritini. In the Pūharakekenui-Styx catchment, zinc is the contaminant of most concern in sediments, as it is the only parameter to regularly exceed the DGV-high guideline (Figure 8). Sediment zinc concentrations have been consistently elevated over time at the three tributary sites monitored, reflecting their generally more urbanised sub-catchments compared to the other mainstem sites. Water quality monitoring at the Kā Pūtahi at Blakes Road site has also shown elevated zinc concentrations, but values are typically within guidelines, so do not trigger investigations (Poudyal & Margetts, 2022).

The apparent disparity between water and sediment quality monitoring data, in terms of compliance with guidelines, highlights the different time scales the two monitoring methods operate over. While both methods involve collecting discrete samples, water quality samples represent the water quality at that location and point in time, whereas sediment samples effectively integrate water quality over time, as contaminants bind to and accumulate in fine sediment deposits. In a city like Christchurch, where there is very low rainfall, there is a low probability that monthly sampling is unlikely to occur at the critical ‘first flush’ of a rainfall event, when the majority of urban contaminants are typically washed into waterways. It can even be difficult capturing the first flush during manual collection of wet weather samples, given that the likelihood that the first flush will occur outside of normal work hours. For these reasons, Council has begun using automated stormwater samplers to characterise first flush stormwater and to assess effectiveness of stormwater treatment facilities.

6.4 Aquatic and Riparian Habitat

The most recent ecology monitoring report for the catchment found that riparian and instream habitat quality was unchanged compared to previous years at most of the 5-yearly monitoring sites (Instream Consulting, 2018). All the upper Pūharakekenui-Styx River sites, the two Kā Pūtahi Creek sites and the Smacks Creek site are located within reserve areas of varying sizes. The Horners Drain site has the most highly modified riparian and bank habitat, being a timber-lined waterway located within road reserve. Sites within Smacks Creek and the Pūharakekenui-Styx River site at Claridges Road were the best shaded, with complete canopy cover along sections of the waterway. The character of the river changes with distance downstream, becoming broader, more open and slow-flowing, with a mixture of pasture and willows in the riparian zone. The greatest change in riparian habitat was observed at the Kā Pūtahi Creek monitoring site at Blakes Road. This section of waterway was recently realigned and enhanced to make way for the Northern Arterial Motorway. The new alignment includes a mix of run, riffle and pool habitat,

wood and boulders for fish habitat, and extensive native plantings within a very wide riparian zone.

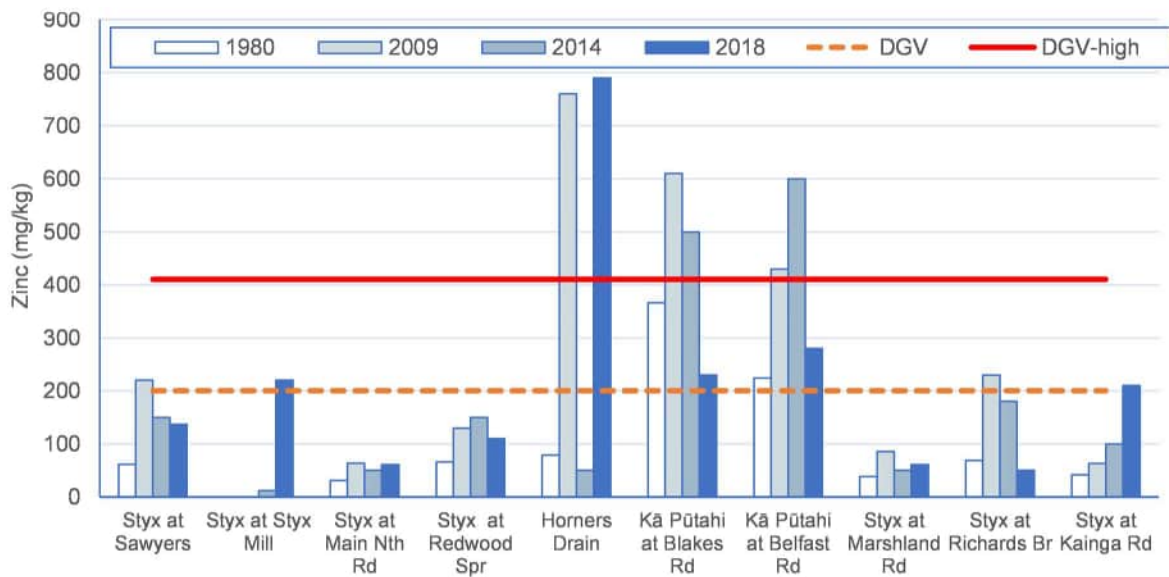


Figure 8: Concentrations of Zinc within Bed Sediment (Burrell, 2023)

Most of the monitored wadeable sites (i.e., upstream of Marshland Road) have relatively low cover with macrophytes, reflecting the combination of reasonable shading (because the monitoring sites are in reserves) and predominantly coarse bed sediments.

Aquatic macrophyte cover is relatively low at most of the monitored sites upstream of Marshland Road, and comply with the ATL of $\leq 50\%$ total macrophyte cover (Instream Consulting, 2018). This reflects the combination of reasonable shading, because most of the monitoring sites are in reserves, and predominantly coarse substrates. However, macrophyte cover nearly always exceeds 50% cover in unshaded sections of the mainstem of the Pūharakekenui. In these areas, introduced aquatic weeds have a large impact on aquatic habitat, by clogging the channel, reducing habitat and water quality. This is especially an issue from around Marshland Road downstream, where a weed cutter boat is regularly deployed to reduce the flood risk. Recent investigations commissioned by the Council confirmed that dense native plantings along both banks of the river would substantially reduce aquatic weed growth rates and channel ‘clogginess’ (Taikoro Nukurangi NIWA, 2021). Dense native plantings would be a sustainable long-term alternative to regular weed cutting, and they would contribute improved to native biodiversity.

6.5 Aquatic Invertebrates

Invertebrates are animals that lack backbones, such as worms, snails and insect larvae. Some aquatic invertebrates are sensitive to pollution, so their relative abundance can be used as an indicator of waterway health. Examples of pollution-sensitive invertebrates include the ‘EPT taxa’, which are the larvae of aquatic insects belonging to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The Quantitative Macroinvertebrate

Community Index (QMCI) measures the relative abundance of pollution-sensitive species at a site, with higher QMCI scores reflecting higher dominance of pollution-sensitive species, and therefore better quality water and habitat. The CSNDC has an ATL of 5 for QMCI scores in the Pūharakekenui-Styx catchment.

The most recent summary of aquatic invertebrate monitoring data was presented by Instream Consulting (Instream Consulting, 2018), and included data collected from 12 sites across the catchment, including nine wadeable sites and three non-wadable sites downstream of Marshland Road. Invertebrate community composition in 2018 was similar to previous years at the 5-yearly monitoring sites, being dominated by pollution-tolerant snails and crustaceans that are common in rural and urban Christchurch waterways. QMCI scores ranged from a low of 2.3 at the Pūharakekenui-Styx River at Kainga Road site to a high of 5.6 at the monitoring site in the Pūharakekenui-Styx River at the dog park in Styx Mill Reserve. The QMCI Attribute Target Level of 5 was not met at 10 of the 12 sites, with most sites having QMCI scores indicative of poor to fair quality (i.e., scores less than 5; Figure 9). The two sites with QMCI scores above 5 (Sites 15 and 16) were both located on the mainstem of the river, towards the upper catchment and within Styx Mill Reserve, where there is reasonable water quality and dominance of silt-free gravels that are preferred by clean-water invertebrates.

The abundance and diversity of pollution-sensitive EPT taxa was greater in the Pūharakekenui-Styx catchment than in the Ōtākaro–Avon, Ōpāwaho–Heathcote, and Huritini–Halswell Rivers. Although QMCI scores have varied within sites over the years, there has been no overall increasing or decreasing trend in QMCI scores evident across the sites monitored (Instream Consulting, 2018). This indicates that the overall ecological health of the Pūharakekenui is stable and that there is no indication of a declining trend that could be attributable to stormwater discharges or other landuse impacts.

Kākahi – freshwater mussels (*Echyridella menziesii*), and wai kōura or kēkēwai – freshwater crayfish (*Paranephrops zealandicus*), are both At Risk aquatic invertebrate species (Grainger, et al., 2018) that are found in the Pūharakekenui catchment. Wai kōura are often captured during electric fishing wadeable reaches of the mainstem, but they are also present in deeper sections too (even if they can be trickier to sample in those locations). Kākahi are abundant in the mainstem of the Pūharakekenui downstream of Marshland Road. Less is known about the distribution of kākahi further upstream, although Council has recently commissioned a survey of kākahi throughout the catchment. The presence of kākahi and wai kōura in this catchment is significant because they are less abundant in or absent from many of the city’s urban waterways.

6.6 Fish

Instream Consulting (Instream Consulting, 2018) reported a total of nine fish species in the catchment in 2018, comprising eight native species and one introduced species, brown trout (*Salmo trutta*). Shortfin eel (*Anguilla australis*) was the most widespread species and they were found at all 12 sampling sites. Longfin eel (*A. dieffenbachii*) were found at seven sites, but they were less abundant at each site. Common bully (*Gobiomorphus cotidianus*) were found at five sites and they were particularly abundant at the two most downstream Pūharakekenui-Styx River sites, as were juvenile bullies. Inanga (*Galaxias maculatus*) were only recorded from the three non-

wadeable Pūharakekenui-Styx River sites in the lower river. The lack of inanga at sites further upstream may reflect different sampling methods at wadeable and non-wadeable sites. Inanga are more readily caught by the combination of fyke nets and minnow traps used at the non-wadeable sites than by electric fishing used at the wadeable sites.

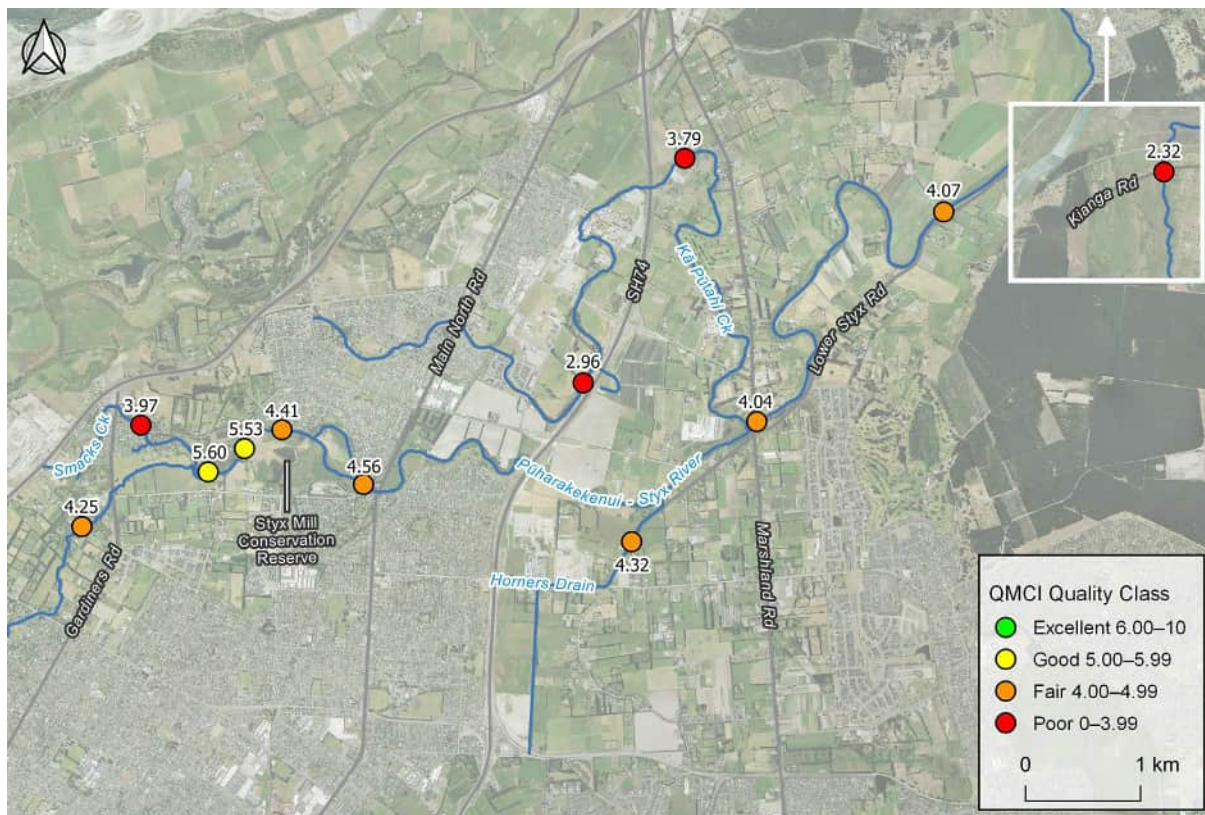


Figure 9: QMCI scores for the Pūharakekenui - Styx Catchment Sampling Sites (Burrell, 2023)

Fish species present in the catchment with an At Risk or Threatened conservation ranking (Dunn, et al., 2017) include At Risk longfin eel, inanga, and giant bully (*Gobiomorphus gobioides*), as well as Threatened lamprey (*Geotria australis*). Particularly noteworthy is the exceptionally high density of juvenile lamprey found in the lower reaches of Canal Reserve Drain, which indicates lamprey spawning in this highly modified, timber-lined waterway. Lamprey spawning also occurs in the mainstem of the Pūharakekenui-Styx River, based on results of recent fish surveys.

Factors affecting the distribution and abundance of fish in this catchment include barriers to fish passage (e.g., tide gates, weirs, and culverts), access to suitable habitat for adults, juveniles and spawning, water quality, and river flows. All native fish (including kākahi and wai kōura) have legal protection under the Conservation Act (1987), including explicit protection of native fish spawning habitat. Formal protection of native fish spawning habitat in the Pūharakekenui catchment is limited to provisions of the Canterbury Land and Water Regional Plan that recognise inanga spawning habitat near the tide gates in the lower river. The Council also holds global resource consents for works in waterways that restrict work to outside of the spawning season for inanga and brown trout. However, there is currently no formal protection of spawning habitat for any other native fish species in the catchment, including Threatened lamprey or at risk kākahi. Greater protection of these species could start by adding known lamprey spawning locations and kākahi

populations as Sites of Significance in the district plan. This could be coupled with their inclusion as schedules to the Land and Water Regional Plan and the Council's global consents. Associated rules would restrict certain activities within the significant habitats.

6.7 Ecologists Recommendations to Improve Waterway Health

The Pūharakekenui-Styx catchment may be considered to overall have 'fair' to 'good' ecological health, depending on what component parts of waterway health are looked at. For example, it remains one of the few catchments in the city where pollution-sensitive mayflies are still found, which is good, but mayflies are absent from some locations affected by sedimentation and lack of riparian trees for the adult phase of their life cycle. Similarly, the abundance of Threatened lamprey in some locations is good, but their spawning habitat is poorly protected. There is good protection of riparian zones from land development, via the use of waterway setback rules in the district plan, but poor levels of tree shading within the waterway setbacks contribute to nuisance aquatic weed growth. Protecting and improving overall waterway health requires addressing the multiple causes of degradation, including aspects of water quality, hydrology, habitat, and connectivity between habitats, and this will all take time and determination. As indicated in the previous section, protection will also likely require changes to regional and district rules, and global consents for works in waterways.

Both through the CSNDC and the long-term plan, Council has committed to addressing many of the factors contributing to impaired waterway health across the city. The primary investment in waterway health the Council is making in the Pūharakekenui-Styx catchment is via building stormwater treatment facilities and the associated naturalisation of timber-lined waterways. A significant example of this is the Highsted development near Styx Mill Road, where new stormwater basins are being built by the Council and developers, and over 2 km of timber-lined drains are being replaced with naturalised waterways and their banks planted with native species. Another example is the Council's ongoing project of identifying potential barriers to fish passage and prioritising them for remediation. Major fish barriers, such as tide gates, weirs and perched culverts will be progressively retrofitted or replaced with fish-friendly alternatives over time, which will help improve native fish diversity throughout the catchment (Burrell, 2023).

7.1 Present Situation

Pūharakekenui-Styx catchment land zonings include rural zones (RuW and RuUF, 2470 ha), residential (RS, RNN, 1320 ha), industrial (IH, 195 ha), commercial (various, 46 ha), specific purpose e.g. cemeteries, golf resort (SPG, 297 ha), mixed use (380 ha) and open space (OCM, OCN, OCP, OCWM, 768 ha).

Approximately 7% of the catchment is zoned for future urban development.

7.1 Vegetation

Grass and grass-like plants make up 48 % of the vegetated areas within the Pūharakekenui-Styx River catchment. A large part of the river is bounded on at least one side by willows. Only 3.6 % of the catchment is covered by native trees and shrubs. Native vegetation is mostly found within reserves, or land managed by the Christchurch City Council (e.g., Styx Mill Reserve and Janet Stewart Reserve). It is likely that private gardens, street plantings and parks would also contain some native vegetation.

7.2 Development and Trends

Christchurch City's population is expected to grow by around 23,000 people between 2015 and 2025 and by a further 40,300 people between 2025 and 2046 (Price, 2014). In the 2015 to 2025 period household growth is expected to be 18,000 households.

Belfast South, Aidanfield, Travis Wetland and Wigram are the localities with the highest levels of growth, reflecting developing greenfield areas. Growth continues in Prestons area east of Marshland Road and is beginning in Highfields north of Queen Elizabeth II Drive, and south Belfast.

7.2.1 Residential Growth

New residential areas represent an increasing proportion of the total urban area, such as at the source of the Kaputone Creek in the north of the Styx Mill basin. The undeveloped area is mainly on the banks of the Pūharakekenui-Styx River and in the Styx Mill Basin Reserve.

7.2.2 Industrial Growth

Within the Pūharakekenui-Styx catchment the current area zoned for Business is 329 ha. Much of this land is vacant. The development scenario adopted for the Blueprint increases the Business area to 437 ha total. The industrial land under this scenario is located in a corridor extending between Main North Road and the railway line north-east of Belfast Road to Chaney's and Kainga.

Belfast has a long history of freezing works and other water-using industries processing agricultural products. These industries have been located east of old Belfast between the Main North Railway Line (for transport convenience) and Kaputone Creek (for waste and stormwater discharge convenience). Agricultural industries have scaled down their operations in the last decade and there has been improved stormwater site control.

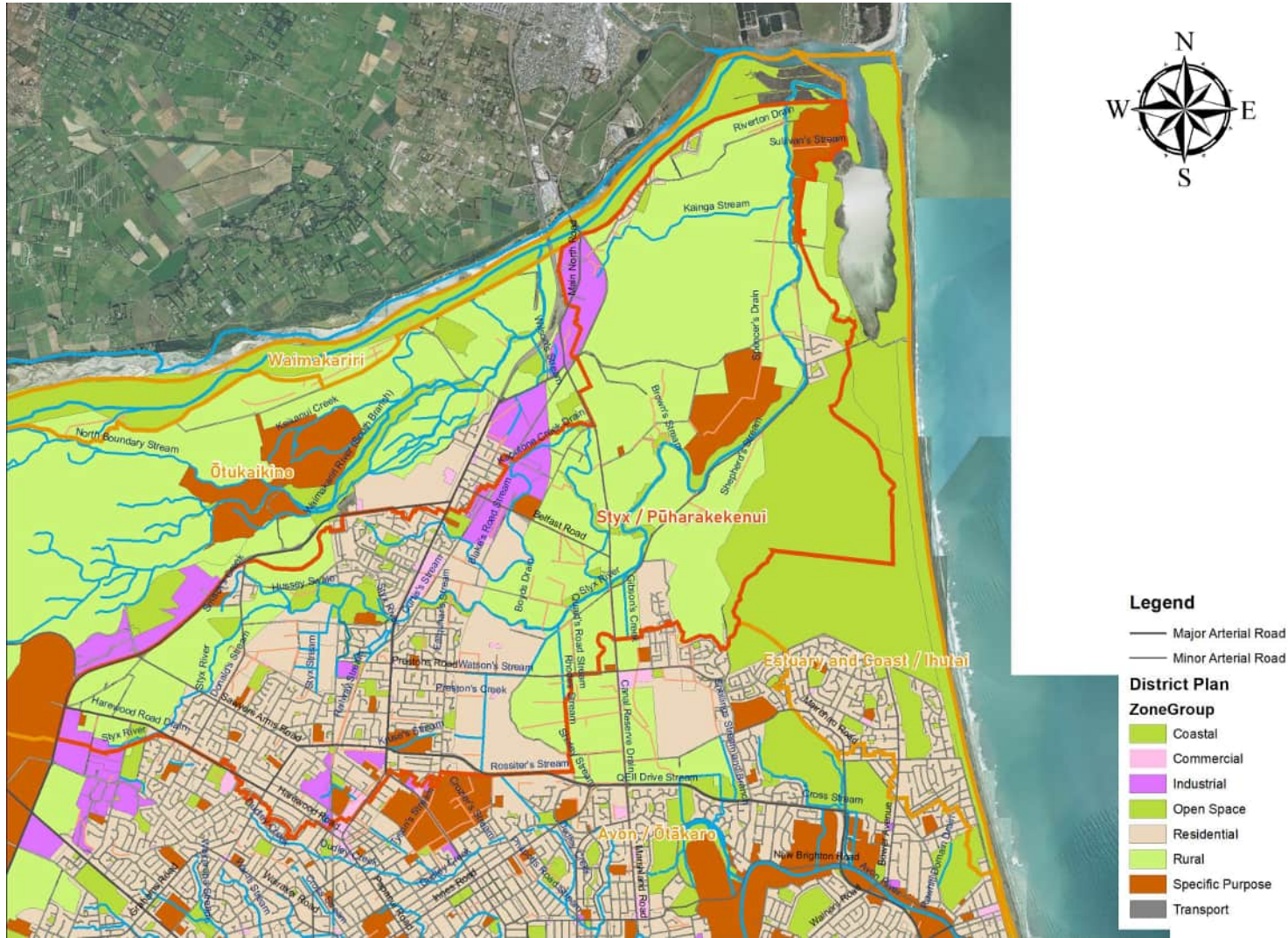


Figure 10: District Plan Zones

7.3 Contaminated Sites and Stormwater

7.3.1 Background

Contaminants may be released from two types of sites:

- Sites with in-ground contaminants that may be entrained in stormwater, typically when soil is disturbed and;
- Sites where on-site activities, usually industrial in nature, may release chemical or metal contaminants into stormwater (or into the ground).

The National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health Regulations (NES) help to identify potentially hazardous activities and industries which are listed in the Hazardous Activities and Industries List (HAIL), found at

<http://www.mfe.govt.nz/land/hazardous-activities-and-industries-list-hail#hail-web>

Such sites are listed in a Listed Land Use Register when they become known to the Regional Council either through a consent application (to ECan or the CCC) or through investigations. Sampling, excavation, subdivision, removal of fuel storage tanks and changing land use on these sites may require a resource consent and remedial action.

7.3.2 Low Risk Sites

A Memorandum of Understanding (MoU) was agreed between the Council and ECan in July 2014 to allow stormwater discharges from low-risk residential rebuild sites listed on the LLUR and/or identified as having had HAIL activities to be processed by the Council rather than ECan. It is anticipated that as confidence grows over time in the operation of the MoU, the list of “low risk” situations that the Council can process will be extended. For example, sites on the LLUR, where only a portion of the site has had a hazardous activity and the construction will not disturb that part of the site, are considered low risk.

Parts of the Pūharakekenui-Styx Catchment are listed on the LLUR because of old landfills, asbestos containing residential properties and chemical storage. Persistent chemicals may be associated with these sites, however they are generally at low risk of discharging contaminants into stormwater unless the sites are disturbed (e.g. during development). Many of these sites have been investigated as part of subdivision and site development and remediated as necessary.

7.3.3 Higher Risk Sites

“High risk” is generally a reference to sites with persistent or hazardous chemicals in the soil or in use on site. High-risk sites include contaminated sites and some industrial sites.

Many contaminants adhere to sediments and can be mobilised into surface or groundwater when soils are disturbed. These contaminants can be managed by using good sediment control during earthworks and taking care with where soil is disposed of. More specific measures, including on-site treatment, may be needed for more mobile contaminants that cannot be controlled by typical sediment control practices.

All land-use consent applications are checked against the LLUR. Where development is proposed on a site listed in the Listed Land Use Register the application is referred to the Council's Environmental Health Team. Conditions are attached to the resource consent to deal with short term and long-term exposure of contaminants, often requiring site remediation.

7.3.4 Industrial Sites

Industrial sites will be managed in accordance with CRC214226 Conditions 47 and 48 in a process that will occur in parallel to SMPs. The Council will:

- Gather information about and develop a desktop-based identification of industrial sites, ranking sites for risk relative to stormwater discharge;
- Audit at least 15 (principally high-risk) sites per year;
- Inform audited industries of the results of audits and work closely with these industries to achieve outcomes in line with the Stormwater Bylaw;
- Communicate with industries about stormwater discharge standards and the means of meeting these standards.

The Council will be empowered to do these actions by the Stormwater and Land Drainage Bylaw 2022.

7.3.5 Historic Landfills

There are three known closed landfills in the catchment at Bottle Lake, Englefield Road and Kainga Road.

The pre-existing Burwood Landfill in Bottle Lake Forest was opened in 1984 and operated until 2005. It was reopened urgently following a request from Civil Defence immediately after the September 2010 earthquake, to process liquefaction material and mixed demolition material arising from the earthquake. Though the landfill ceased receiving earthquake waste after 20 December 2019, it continued processing and sorting waste and burying non-recyclable inert waste for a further year. Subsequently, extensive landscaping commenced in 2021. The site has been handed back to CCC with added walking, cycling and horse tracks through the forest park and improved beach access. This site is now known as a recreational space called Bottle Lake.

The historical Waimairi rubbish dump is located in the Kainga Forest south of the Waimakariri River. The landfill was operated by Waimairi District Council and took general domestic rubbish.

The historic Englefield Road Landfill site contains organic rubbish including stream channel sludge.

The main risk factor for landfills from stormwater is the inundation of previously dry landfill by groundwater mounding associated with infiltration and detention basins. This can cause leaching of contaminants from the landfill into groundwater.

The locations of the closed landfills means that the risks to groundwater quality associated with groundwater mounding from infiltrations is extremely low. It is not anticipated that large-scale infiltration basins will be installed near the old landfills.

7.3.6 Facilities Built Near Contaminated Sites

Treatment facilities are typically built on greenfields sites because there is land available and because they are mitigating the effects of urban expansion into a rural area. There may be soil contamination from farming activities (e.g. agricultural chemicals) and lead paint or asbestos associated with old buildings. However, reference to the Listed Land Use Register indicates that stormwater facilities can be sited clear of known or suspected contaminated land.

Appendix C contains comments about the proximity of proposed treatment facilities to sites where land contamination might be present.

8.1 Introduction

Urban activities cause environmental effects either by shedding more or faster stormwater runoff or by discharging contaminants into stormwater that are harmful to the environment. Most urban surfaces have some form of coating (e.g. paint or galvanising) and a transient layer of wind-blown dust, combustion products, cleaning compounds, etc. Most of these substances are soluble or slightly soluble in rainwater and are transported in dissolved and particulate form into the stormwater network.

8.2 Contaminants and Contaminant Sources

The Christchurch City Council and Environment Canterbury monitor rivers, streams and stormwater for a range of water quality indicators. These include total suspended solids (dust, sediment, grit, and particles of all types), heavy metals, a range of hydrocarbons, bacteria and dissolved oxygen among other indicators. From time to time the Council samples for newly discovered (“emerging”) contaminants, and both councils are aware of the likelihood that there are unknown, harmful substances in stormwater.

The Council’s monitoring programme is largely based on the Land and Water Regional Plan’s

- Schedule 5 Table S5A and Table S5B Indicators and Toxicants, and
- Schedule 8 Region-wide Water Quality Limits

Contaminants of most concern in the Christchurch District are:

- Dust, sediment, grit and particles of all types capable of being transported in stormwater, referred to as total suspended solids (TSS). TSS include metal particles, aggregates of metallic compounds, and charged (e.g. clay) particles with attached metal ions.
- Dissolved and particulate zinc
- Dissolved and particulate copper
- Polycyclic aromatic hydrocarbons (PAHs)
- Pathogens
- Nutrients (mostly phosphorus)

Lesser contaminants, which generally do not exceed guidelines, are:

- Hydrocarbons (oil and grease)
- Cadmium and lead

8.3 Suspended Solids

Particle sources include streambank erosion, animal waste, construction activity, land cultivation, combustion, industrial products, tyre and brake wear and paint coating breakdown. Some particles are natural and some such as paint chips are artificial. Natural soil particles contain metals and may carry adsorbed chemicals.

Suspended solids are damaging because they deposit on stream beds and fill the spaces between stones, greatly reducing the refuge options for instream life. Fine particles can release attached toxic compounds which harm the food chain.

The most important sources of particles in waterways in this catchment are likely to be road runoff in the urban parts of the catchment (from a combination of road surface wear and vehicle emissions). Within the rural areas, particles are most likely to enter the waterways through stock moving to and into waterways.

8.4 Metals

Results from Councils monthly water quality monitoring were extracted to present the incidences of metal exceedances above target levels in the environmental Monitoring Programme.

The number of copper, zinc and lead exceedances is plotted in Figure 11. Zinc exceeds more frequently than other metals at monitoring sites in the Pūharakekenui-Styx catchment.

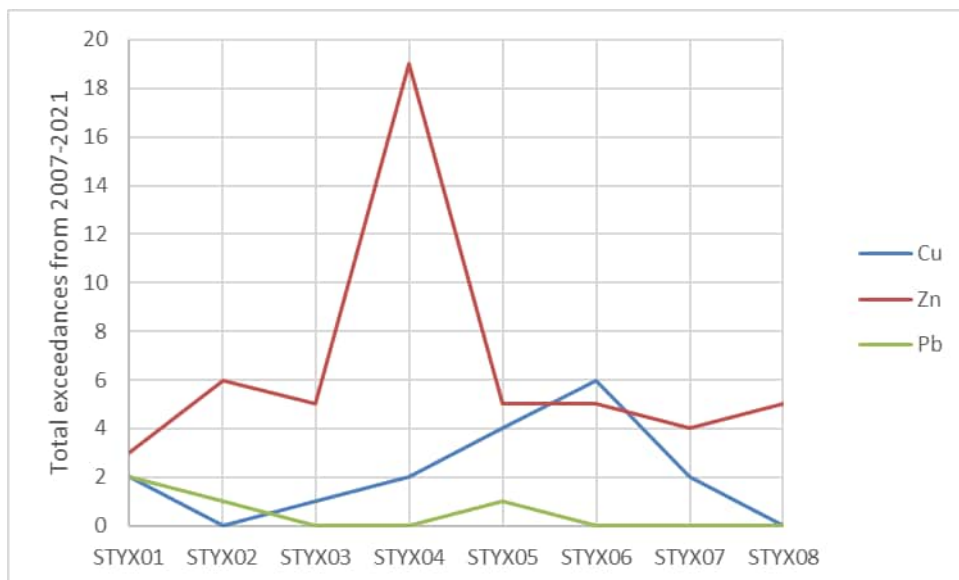


Figure 11: Total Exceedances of Dissolved Copper, Zinc and Lead

8.4.1 Copper

The predominant copper source in urban stormwater is thought to be vehicle brake pad wear.

Dissolved copper was not reported as a contaminant of concern in the 2021 Christchurch City Surface Water Quality Annual Report. It has been found above consent target levels in more recent monthly water sampling. The reason for the exceedance is not known and no potential sources have yet been identified, although the Council is investigating.

Dissolved copper exceeding target in monthly monitoring is rare – one exceedance in 2020 at Marshland Road. Copper may discharge into the river with stormwater runoff between monitoring visits.

On the west of these monitoring sites, there is rural land, used mostly for horticultural and orchards. Further west of the Kaputone, there stream travels through an industrial area. East of

the sampling locations is a subdivision area, and further east is Bottle Lake. It is likely that some of the exceedances in 2012 and 2013 are attributed to the subdivision build, in particular the period after the developer has completed earthworks, and builders are constructing buildings.

Table 3: Exceedances of Dissolved Copper (>0.0014mg/l) in Monthly Water Quality Monitoring

Year	STYX01	STYX02	STYX03	STYX04	STYX05	STYX06	STYX07	STYX08
2007	ns	ns	ns	ns	ns	ns	ns	ns
2008	ns	ns	ns	ns	ns	ns	ns	ns
2009	ns	ns	ns	ns	ns	ns	ns	ns
2010	ns	ns	ns	ns	ns	ns	ns	ns
2011	0	0	0	0	0	0	0	0
2012	0	0	0	0	1	2	0	0
2013	1	0	1	0	2	2	0	0
2014	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0
2016	0	0	0	1	0	0	0	0
2017	0	0	0	0	0	0	0	0
2018	0	0	0	1	1	1	1	0
2019	0	0	0	0	0	0	0	0
2020	1	0	0	0	0	1	1	0
2021	0	0	0	0	0	0	0	0
2022								

ns = no sampling

8.4.2 Zinc

Zinc is used as a protective coating for steel on corrugated iron roofs, rooftop ventilators, chain link fencing, lighting poles and various barriers and fences. Although a zinc layer is long-lived it is slowly being dissolved by rainwater. Industrial and farm buildings often have unpainted galvanised roofs and can be significant sources of zinc. Residential areas typically have painted or tile roofs, but many of these have older paint coatings in poor condition and can be significant sources of zinc.

Roofs create approximately 75% of urban zinc. Roads create approximately 25%, much of which is from tyres. Zinc makes up about 0.8% by weight of tyres in which zinc oxide is a vulcanising catalyst. Zinc released onto roads is very fine and can dissolve easily and be transported readily in stormwater.

Many sources such as (Timperley, Bailey, Pattinson, & Kuschel, 2003) report that tyre-derived zinc is transported onto other surfaces, including roofs, by wind. Stormwater sampling in Christchurch supports this, showing zinc runoff from nominally zinc-free surfaces such as concrete tile roofs.

Zinc is the main contaminant exceeding targets in this catchment,. Monthly water quality monitoring has found a number of exceedances, with STYX04 monitoring site showing the most exceedances overall.

Table 4: Exceedances of Dissolved Zinc (>0.01172mg/l) in Monthly Water Quality Monitoring

Year	STYX01	STYX02	STYX03	STYX04	STYX05	STYX06	STYX07	STYX08
2007	ns	ns	ns	ns	ns	ns	ns	ns
2008	ns	ns	ns	ns	ns	ns	ns	ns
2009	ns	ns	ns	ns	ns	ns	ns	ns
2010	ns	ns	ns	ns	ns	ns	ns	ns
2011	0	0	0	0	0	0	0	0
2012	0	0	0	1	0	0	0	0
2013	1	1	2	4	0	0	0	1
2014	0	2	0	3	0	0	1	2
2015	1	2	1	2	2	1	1	1
2016	1	1	1	3	2	2	1	1
2017	0	0	0	1	0	1	0	0
2018	0	0	0	1	0	0	0	0
2019	0	0	1	2	1	1	1	0
2020	0	0	0	2	0	0	0	0
2021	0	0	0	0	0	0	0	0
2022								

ns = no sampling

8.4.3 Lead

Since the discontinuation of lead-based products, lead contamination in stormwater has become less of a concern. However, there are still instances where lead levels exceed the recommended limits, particularly in the upstream catchment. The exact source of this lead contamination remains unknown, but it is speculated that older rural residential properties might be contributing to the presence of lead in stormwater. Further investigations and monitoring are necessary to pinpoint the sources of lead and implement appropriate measures to address and mitigate this issue.

There are several potential sources of lead in waterways, including:

- Lead based paints used to seal the timber weather boards in older homes. The weathering and deterioration of these products over time can release lead particles into the environment. It is suspected that a large quantity is suspended during sanding and demolition of an old weather home.
- Atmospheric deposition from certain industrial processes such as metal smelting, battery manufacturing, and recycling operations
- Historical lead which has settled in the sediment/sludge at the bottom of waterways and are re-suspended due to agitation and dissolve over time.

Table 5: Exceedances of Dissolved Lead (>0.00601mg/l) in Monthly Water Quality Monitoring

Year	STYX01	STYX02	STYX03	STYX04	STYX05	STYX06	STYX07	STYX08
2007	ns	ns	ns	ns	ns	ns	ns	ns
2008	ns	ns	ns	ns	ns	ns	ns	ns
2009	ns	ns	ns	ns	ns	ns	ns	ns
2010	ns	ns	ns	ns	ns	ns	ns	ns
2011	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0
2013	2	1	0	0	0	0	0	0
2014	0	0	0	0	1	0	0	0
2015	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0
2022								

ns = no sampling

8.5 Polynuclear aromatic hydrocarbons

Polycyclic Aromatic Hydrocarbons (PAHs) are created when products like coal, oil, gas, and garbage are incompletely burned. PAHs are a concern because they do not break down very easily and can stay in the environment for long periods of time. PAHs may come from coal tar sealants and diesel or industrial combustion.

8.6 Pathogens

Monthly water quality monitoring measures the numbers of *E. coli* as an indicator bacterium for the presence of faecal pathogens. Bacteria are most concerning if they are from human sources, representing a risk of communicable diseases. *E. coli* counts are usually caused by waterfowl (ESR, 2015). Potential sources in this catchment could include farm animals and dogs.

8.6.1 Pūharakekenui-Styx River

E. coli counts exceed safe levels for contact recreation (550 counts/100 ml), within the Pūharakekenui-Styx River catchment sampling sites 34% of the time.

8.6.2 Kā Pūtahi Stream

Kā Pūtahi stream has a higher exceedance rate than the other monitoring sites. Pathogen exceedances in monthly sampling shows that Kā Pūtahi Stream exceeds the safe levels for contact recreation in more than 50% of samples. At the upstream end (STYX04), there is 50% exceedance rate, and there is an 83% exceedance rate downstream at (STYX05). The location where the Kā Pūtahi discharges into the Pūharakekenui-Styx River shows a 50% exceedance rate.

8.7 Nutrients

International research indicates that important nutrient sources include decaying leaves, sediment, fertiliser and bird and animal faeces. Nutrients can lead to excessive aquatic plant growth.

8.7.1 Phosphorus

Phosphorus exceeds the LWRP guideline (0.016 mg/L) 61% of the time in monthly sampling since 2007. It regularly exceeded (>70%) from the STYX04, 05, 06 and 08 catchments, with the highest exceedance rate (98%) being at STYX05. The lower catchment is showing higher DRP, indicating further nutrient sources as the water travels downstream.

8.7.2 Dissolved Inorganic Nitrogen DIN

Nitrogen levels in the catchment are only of concern in the STYX04 and STYX05 monitoring sites. LWRP guidelines for dissolved inorganic nitrogen (DIN < 1.5 mg/l), is exceeded 37% of the time in the STYX04 and 12% of the time in STYX05. The remaining sites show low exceedances of 1% to 4%.

8.8 Dissolved Oxygen

The running water within a stream dissolved more oxygen compared to a still pond/lake. It is the amount of oxygen that is present in water.

DO is essential for the survival of fish, and with different fish species prefer different levels of DO within the water.

A water body can receive oxygen from atmosphere, aquatic plants and aeration action from wind or current.

9.1 CCC Levels of Service

The city's drainage systems are principally designed to meet expectations of safe vehicle travel and flood-free housing. Stormwater networks comprising side channels, pipes and drains keep properties and traffic lanes free of ponded water in frequent events. In more extreme rainfalls the lower lying parts of roads and private properties store water in excess of system capacity until it can be drained away. New houses are expected to be built sufficiently high to remain dry in all but the most extreme events.

- Road drainage, pipes and minor drains are designed so that the 5 year annual recurrence interval rainfall does not cause a nuisance to traffic.
- Hillside drainage must ensure that a 20 year annual recurrence interval rainfall does not endanger property.
- Finished floor levels are normally set 150mm above the natural ground in non-flood risk areas to ensure that any local ponding does not wet the floor.

Within Flood Management Areas (FMAs) minimum floor levels are set 400mm above the 200 year annual recurrence interval flood level. FMAs are District Plan zones which would be inundated by the 200 year ARI flood level plus a 250mm additional freeboard allowance. (The necessary 400 mm floor height above flood level includes the 250 mm freeboard plus an assumed 150 mm minimum foundation height above the natural ground.)

- There are development restrictions for "High Flood Hazard Management Areas" defined as areas where, in a 500 year annual recurrence interval flood the water would be more than 1m deep or the product of velocity times depth is greater than 1.
- Otherwise a 50 year average recurrence interval event is used to set minimum floor levels as has been required since the Building Act 1991.

9.2 Flood Modelling

The CCC developed a hydraulic model of the Pūharakekenui-Styx catchment in 2010-12 as part of planning for residential and industrial growth in the Belfast area. The model assesses the expected response of the stormwater network, streams, rivers and floodplains to prolonged rainfall.

The model uses the Danish Hydraulic Institute (DHI) suite of software, MOUSE, MIKE 21, MIKE 11 and MIKE Flood to create a 1-D model of waterways and a 2-D model of floodplains (GHD, 2012). Land cover under existing development and maximum probable development were modelled as separate scenarios for both 50 year average recurrence interval (ARI) and 200 year ARI rain events.

9.2.1 Calibration and Verification of the Model

The August 2008 rainfall event was used to calibrate the model against records for flow and level at Radcliffe Road, and against water levels at the Lower Styx Road and Harbour Road water level recorders.

9.2.2 Partial Detention and Full Detention

The catchment's response to rainfall is modified by detention basins and wetlands (facilities). Stormwater runoff from all new and some older developments is routed through facilities which reduce the rate at which runoff enters streams and rivers and remove some urban contaminants.

Until 2019 the Council's design manual specified:

- Detention and treatment of the first 25 mm of runoff (the "first flush"²).
- Tertiary treatment through a wetland.
- Permissible use of wetlands to store an additional 500 mm of storm runoff in storms exceeding 10 year ARI.

This design strategy is referred to as partial storm detention.

The 2012 Pūharakekenui-Styx River and floodplain hydraulic model assumes a partial storm detention strategy. Subsequently, conditions of the Comprehensive Stormwater Network Discharge Consent (CSNDC, CRC231955) required the Council to adopt full storm detention. i.e. to detain all runoff from new development in basins or wetlands for 48 hours. 48 hours is the storm duration having the greatest effect in the Lower Styx ponding area, which is rural land that floods during combined rainfall and high tides.

Model results quoted below represent the partial detention scenario. An upgrade of the model is under development, for likely delivery in 2024. The upgraded model will include the full storm detention scenario. Even partial storm detention allows Council infrastructure to meet consent conditions that constrain the effects of development (by limiting permissible future water level increases). A full storm detention model is expected to show improvement on an already compliant situation.

9.2.3 Measuring Flood Level Compliance

Compliance is measured against Condition 7, Schedule 10 in CRC231955. Schedule 10 is copied in Appendix G. Compliance with Schedule 10 is summarized in Table 7.

Table 7 also proposes the west side of the Northern Arterial Motorway as a site where modelled assessments of water levels and volumes will be made. At this site the river's influence on the urban area can be assessed.

² The first flush is recognised as containing a large part of the contaminant load generated during a storm.

Table 6: Schedule 10 Tolerance for Water Level Increases Post-development

2012 Pūharakekenui-Styx River hydraulic model (GHD Ltd).					
The development scenario is maximum probable development. Sea level: allowance for 0.5 m sea level rise.					
Receiving Environment	Monitoring Location	Baseline Year	Annual Exceedance Probability	Maximum allowable increase	Modelled increase
Pūharakekenui-Styx River	Harbour Road Bridge	2012	2%	100 mm	80 mm
Pūharakekenui-Styx River	Northern Arterial Motorway (upstream)	To be decided after 2023/4 model is run	2%	To be decided	
Kā Pūtahi Creek	Northern Arterial Motorway (upstream)	To be decided after 2023/4 model is run	2%	To be decided	

9.2.1 Effect of Weed Growth on Water Levels

Dry weather water levels in the lower river are affected by aquatic weed growth. Weed growth is most prolific from summer to autumn when the water is warmest and sunshine hours are longest. Weed growth can elevate base flow (dry weather) water levels in river reaches between Radcliffe and Lower Styx Roads by an average of 0.3 metre and (less often, after extreme aquatic weed growth) by up to 0.7 metre. Aquatic weed growth also has some effect on flood levels outside of urban areas. Aquatic weed growth does not affect water levels at Harbour Road Bridge and does not affect compliance with Consent Condition 7, Schedule 10.

The Council is investigating potential weed management practices as required by Condition 7 Schedule 4r. through 4x. These investigations, trials and possible management options are being carried out separately from the SMP in conformance with the consent condition.

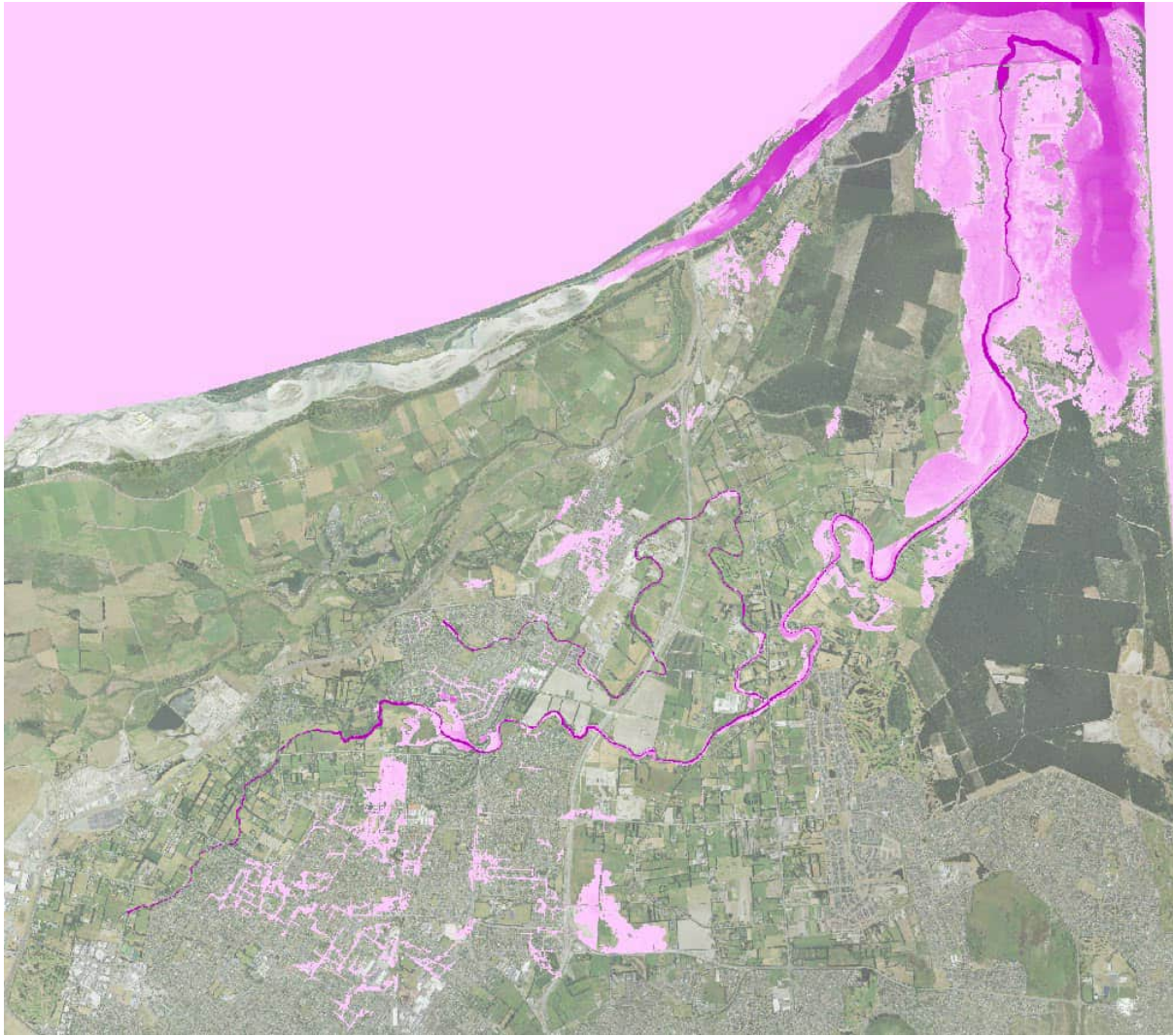


Figure 12: Max of Max 50-year ARI Flood Extents in the Pūharakekenui - Styx Flood Model

9.3 Finished Floor Levels

Properties within the District Plan Flood Management Areas are required to build their floor level to provide protection from the predicted 200 year ARI flood level. Flood Management Areas were identified during the District Plan process through modelling of the highest flood impacted locations.

Since 2014 all new house floors have been assigned floor levels 400 mm above the modelled 200 year ARI flood level as determined from hydraulic modelling.

For example, in the Earlham Street Brooklands, houses have been constructed more than 2m above ground to isolate the home from the regular flooding which occurs within this area. This allows flood water from the Brooklands Lagoon to pass through the foundation without flooding the house.



Figure 13: Earlham Street Residents Have Built Homes with Finished Floor Levels Greater Than 2m Above Ground To Deal With The Regular Flooding

9.4 Floodplain Management Strategy

River flooding is not a significant risk to built-up areas because the catchment is relatively small and the drainage network is adequate. The Lower Pūharakekenui-Styx floodplain is protected from tidal flooding by tide gates set into the Waimakariri River stopbanks and maintained by Environment Canterbury. Without the tide gates the lower river would flood approximately as much on a daily basis as currently occurs in a 20 to 50 year ARI flood.

The flooding risk in internal waterways and drains is dealt with by:

- Avoidance: built-up areas are located on high ground or on the outer side of stopbanks.
- District Plan rules.
- New builds within Flood Hazard Management Areas are required to have a floor level above the 200 year average recurrence interval (ARI) flood level plus 400 mm. (A full definition including tidal influences found in the Christchurch District Plan section 5.4).
- Rules under the Building Act 2004
- Outside the Fixed Minimum Floor Level Overlay all new builds are required to have a floor level that is above the 50-year ARI flood level plus 400 mm.
- An appropriately designed and managed stormwater network where pipes and drains should have capacity to convey a 20% annual exceedance probability rain event.

9.5 Sea Level Rise

Chapter 11 Natural Hazards in the Canterbury Regional Policy Statement 2013 recommends:

“As of 2012, Ministry for the Environment guidance for local authorities is to plan for the effects of 0.5m sea level rise out to the year 2100 and to assess the effects of 0.8m sea level rise.”

Subsequent 2017 MfE advice recommends a risk-based approach considering adaptation pathways over time. The advice also includes the information on rates of sea level rise depending on how climate change is managed worldwide.

Sea level rise trends and post-earthquake land settlement trends are being monitored. High tide statistics have been recently reviewed with the sea level rise trend isolated so that tidal variability and sea level rise can be considered independently

Council operations staff have access to detailed tide forecasting about 2 days ahead enabling tidal flooding preparations to be made.

9.5.1 Effects of Sea Level Rise on Land

The potential impacts of sea level rise in this catchment are:

- That higher tides will hold the Harbour Road tide gates closed for longer and slightly lengthen the duration of ponding after floods.
- Ingress of high tides from Te Riu o Te Aika Kawa-Brooklands Lagoon through the foreshore sand dunes and into the previous Brooklands settlements.
- Impeded drainage from land surrounding and south of Brooklands settlement.

Around Te Riu o Te Aika Kawa-Brooklands Lagoon & Pūharakekenui-Styx River there is expected to be increased frequency of inundation over time with about 1,640 ha expected to be flooded by a 1% annual exceedance probability storm tide including sea level rise (Tonkin & Taylor, 2013).

9.5.2 Effects of Sea Level Rise on the Stormwater Network

Rising sea levels are not expected to impact most stormwater networks in this catchment because they are remote from and higher than the coast.

Natural hazard planning processes are under way and will consider a range of options including engineering solutions, planning solutions and retreat where advisable – as the Council has done in several ways to alleviate property flooding in the lower Ōpāwaho-Heathcote – however future retreat may be managed differently according to the circumstances at the time.

9.6 Major Structures

Four major stormwater management structures are within or have an effect on the Pūharakekenui-Styx catchment. These are the Harbour Road tide-gates, Winters Road Detention Basin, Cranford Basin and Horner's Drain.

9.6.1 Winters Road Detention Basin

The 4.36 ha Winters Road Detention Basin (50,000 m³ capacity) was built in 1981 at the intersection of Winters and Phillpotts Roads. Its primary function is to provide detention for the flows which would otherwise direct more flood water into the Pūharakekenui-Styx catchment via Horners Drain, or east to Bullers Drain.

9.6.2 Cranford Basin

Cranford Basin sits immediately to the south of the Pūharakekenui-Styx catchment and detains some stormwater that would otherwise enter the catchment via Horners Drain. Cranford Basin was created by settlement of a deep layer of peat that is continuing to settle to the point that it has become unsuitable for its previous horticulture activities. Future management will seek to keep this area wet to reduce settlement and stabilize the land. It is being developed as a

stormwater management area and urban forest, with significant associated environmental benefits.

9.6.3 Horner’s drain

Horner’s drain extends north from Winters Road and joins the Pūharakekenui-Styx River near Kā Pūtahi Creek. The drain will be naturalised over time as stormwater treatment basins and wetlands are constructed on adjacent land.

9.6.4 Harbour Road tide-gates

The Harbour Road tide-gates are large, twin double-hinged gates set into the Waikakariri River stopbanks west of the river mouth at Te Riu o Te Aika Kawa-Brooklands Lagoon. The tide gates are owned by Environment Canterbury. High tides affect water levels in the river. The tide gates are designed to isolate the Brooklands/lower Styx ponding area from extreme high tides. Storm runoff is held behind the gates during high tides and released to the sea during low tides.

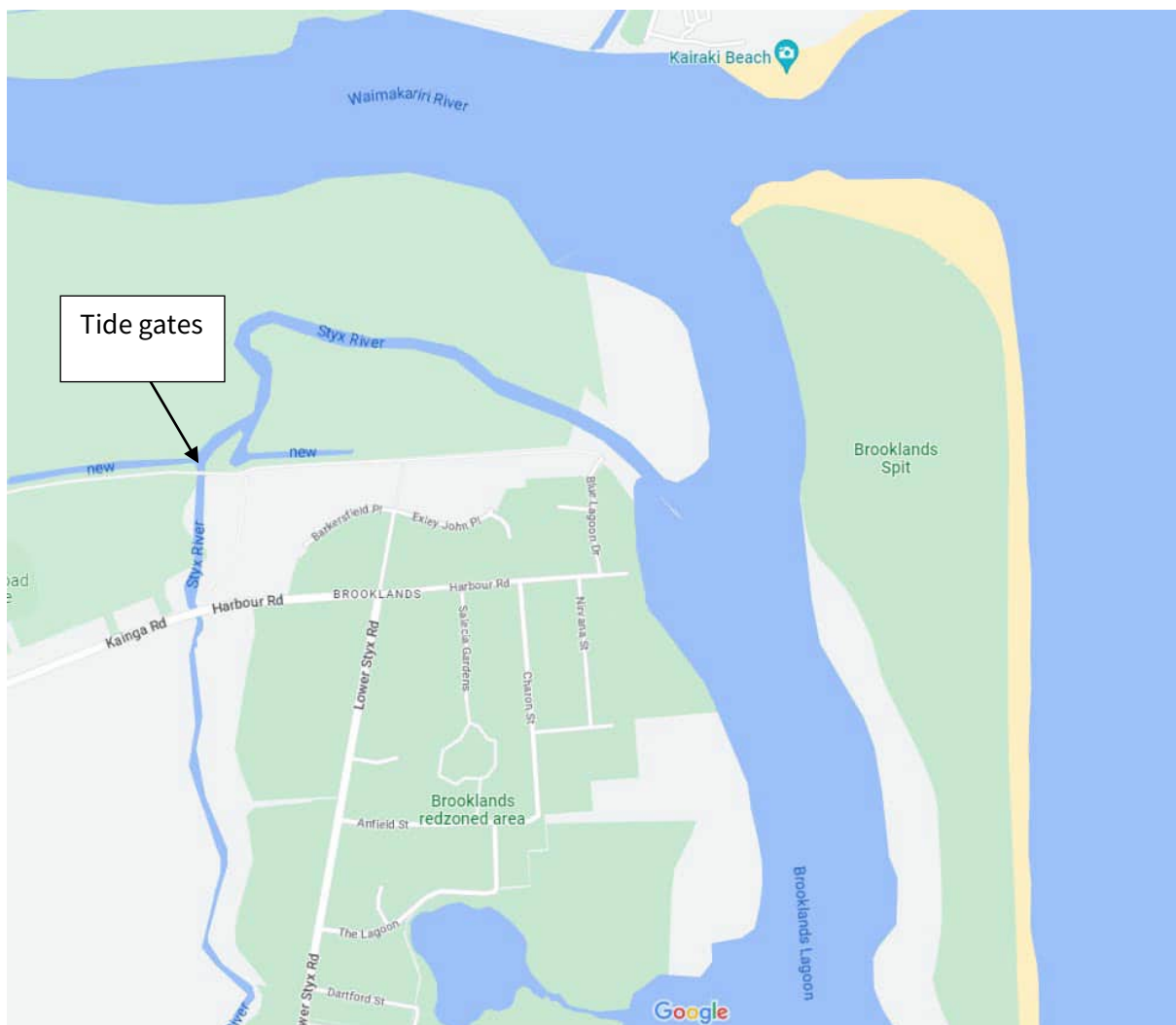


Figure 14: Location of the Harbour Road Tide Gates

9.6.5 Stopbanks – Waimakariri River

“The existing Waimakariri River primary stopbanks have hydraulic capacity to contain up to a 500 year return period flood (4,730 cumecs) with freeboard, however there is a significant risk of stopbank breach during (various) flood events due to the very high energy of the floodwaters, significant bed material movement, and the risk of an altered river course and/or berm erosion.

A risk assessment determined that there is some risk of stopbank breach during a 100-year flood (4,000 cumecs), as occurred at Coutts Island in 1957 (3,900 cumec peak flow). This risk increases with the size of flood, and ... on antecedent flood events, so a failure is almost certain somewhere (probably on the Christchurch rather than the Kaiapoi side) for a 500-year flood.

A secondary stopbanking system has been designed to capture the primary stopbank breach flows and return them to the river at two points (upstream of State Highway 1).” (Ian Heslop, ECan, 2015)

The secondary stopbanking system is indicated in Figure 15

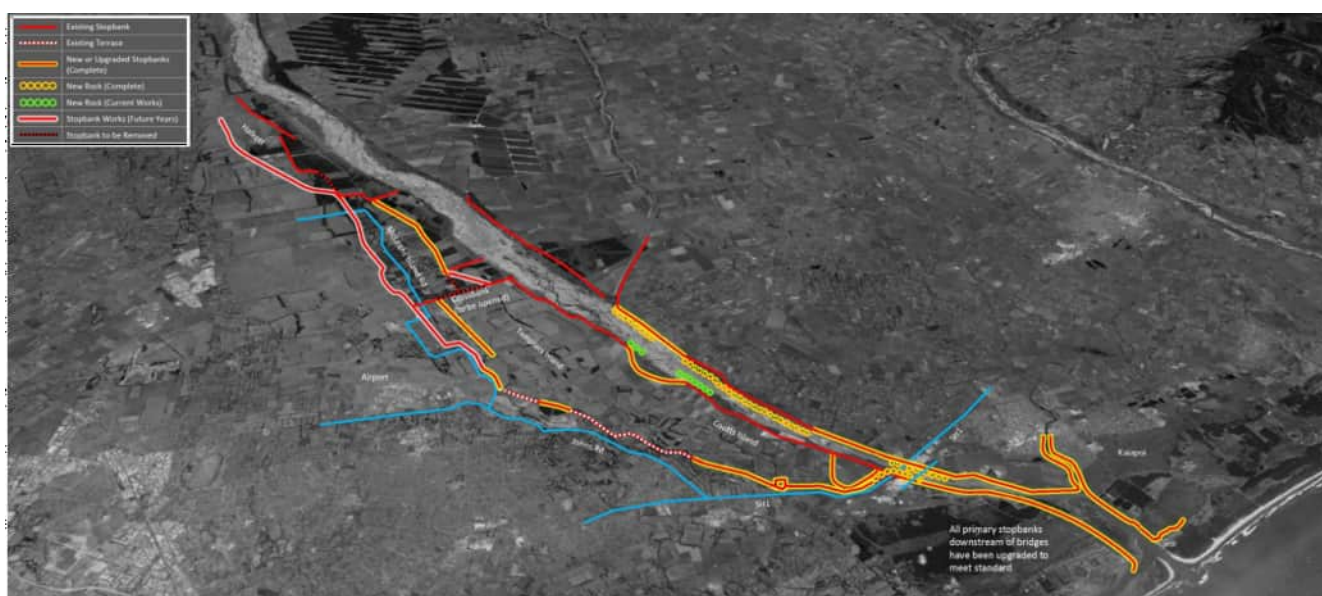


Figure 15: Waimakariri River Scheme, Primary and Secondary Stopbanks

9.7 Weed Management

The Comprehensive Stormwater Network Discharge Consent (CSNDC) Schedule 4 item (r) requires the Christchurch City Council (CCC) to investigate the impediment to drainage of excessive aquatic weed growth. This includes assessment of various options for managing river channel weed to mitigate these effects.

9.7.1 Management

The Council continuously monitors water levels in a water level recorder at Radcliffe Road. The record shows that water levels are strongly affected by weed growth in the river channel, particularly over the summer months. As the river is spring-fed, base flow conditions tend to dominate, with periodic short duration high flow events due to rainfall.

Aquatic weed is managed by cutting and removal. A weed cutting barge cuts weed as close to bed level as possible 2 to 4 times per year. Anecdotal observations suggest that this management method has been less effective in recent years, and that the weed growth has been more vigorous.

9.7.2 NIWA Investigation

NIWA undertook an investigation from November 2020 to July 2022 to provide information on weed suppression which primarily focused on 14.6km between Redwood Springs and the tide gates.

Key findings of the investigation are summarised below:

- Water level increases (and flood risk) are likely a result of increasing trend of discharge, exacerbated by increased flow impedance caused by aquatic weed and sediment accrual.
- There is a risk of an aggressive aquatic weed (*Egeria*) colonising the Pūharakekenui-Styx River, as it has done the lower Ōtākaro-Avon River. The weed harvester used in the Ōtākaro-Avon is also used for the Pūharakekenui-Styx, so a disinfection plan is required.
- Riparian planting to increase shade of the river could reduce aquatic weed growth in places and hence increase conveyance of the channel, mitigating flood risk even with higher discharges.
- Application of an aquatic herbicide (Diquat) resulted in a small reduction in weed nuisance. It was noted that trial conditions were not ideal, and further evaluation was recommended (Taikoro Nukurangi NIWA, 2021).

PART THREE:

Objectives and Principles

10 Developing a Water Quality Approach

10.1 Introduction

Mitigation options have been considered for contaminants that are considered harmful or exceed water quality targets. Commonly detected contaminants that can be mitigated through methods promoted in the SMP are:

- TSS (sediment and particulates, by means specified in consent conditions)
- Copper and zinc
- Oils, cleaning compounds, nitrates/nitrites, chemicals, etc in industrial discharges (section 11.4)

Metals typically exceed water quality targets for relatively short periods during and after rainfall. It is believed that they affect ecosystem health but the relationship between concentrations, durations and effects has yet to be quantified.

10.2 Contaminant model

A contaminant load model (CLM) for this catchment was developed by Golder Associates for the Comprehensive Stormwater Discharge Consent hearing. The model is a version of the Auckland Regional Council CLM adjusted for Christchurch conditions. “Adjusted” means that TSS loads per hectare are judged to be 60% of Auckland loads due to proportionately lower rainfall in Canterbury. Christchurch TSS loads were then reduced in the ratio of Christchurch annual rainfall to Auckland annual rainfall, nominally 600mm to 1000mm. The model assigns an annual load of TSS, zinc and copper to each impervious urban surface and calculates the total annual load of the three contaminants for each sub-catchment. Unit annual loads are found in Appendix G: Consent targets: schedules 7 to 10.

The C-CLM estimates the annual load of three contaminants, total suspended solids (TSS), copper and zinc for each of the 13 sub-catchments mapped in Appendix B.

The Council considered developing a new contaminant model and has commissioned DHI to develop a MEDUSA³ model for every catchment in the Christchurch District. Development has taken longer than expected because of complications with defining the catchments of treatment facilities: an automated routine proved difficult to implement. Results from the new model will be forwarded to Environment Canterbury when completed.

10.3 Contaminant Load Model Results

All sub-catchments were modelled, with model results reported in Table 18, Appendix F. Table 18 indicates contaminant reductions in the sub-catchments whose stormwater will be treated after the 2018 reference year; those sub-catchments being

- Kā Pūtahi

³ Modelled Estimates of Discharges for Urban Stormwater Assessments, by the University of Canterbury

- Kruses Drain
- Middle Styx
- Prestons Creek
- Rhodes Drain
- Styx Drain, and
- Upper Styx

The timing of treatment may differ from timings indicated in Table 20 because in some cases development (and the associated stormwater treatment facilities) as occurred earlier than anticipated.

10.4 Lessons from monitoring of treatment basins

Treatment facilities are being monitored during wet weather to measure treatment performance. Treatment efficiencies obtained from 2020/21 wet weather monitoring of Curletts, Wigram, Prestons and Knights Stream facilities (PDP, 2021 and NIWA, 2022), indicate the potential for a high percentage of TSS and metals removal. Monitoring results for Prestons and Knights Drain in the 2022/23 year are awaited. For the C-CLM presented at the 2019 consent hearing model incorporated treatment efficiencies from sources including NIWA 2008. A comment on previous monitoring is made in a memorandum titled Inferences from Performance of Treatment Basins 1993-2020 (TRIM 22/490757).

The Council is not yet confident to adopt these limited data for modelling and places more reliance on NIWA 2008, WWDG guidelines, Auckland Regional Council guidelines, and international research. However, treatment efficiency data continues to be collected in wet weather monitoring.

10.5 Role of Monitoring and Tangata Whenua Values in Setting Targets

10.5.1 Environmental Drivers

Waterways in the rural part of the catchment are in good condition. Monitoring indicates that Kā Pūtahi Creek is more likely to exceed contaminant targets than the Pūharakekenui-Styx River because of occasional discharges from industries and farmland.

10.5.2 Mahaanui Iwi Management Plan Objectives

This plan recognises and is intended to help support the policies and objectives for water and the environment from the Mahaanui Iwi Management Plan 2013 as detailed in Table 8.

Table 7: Response to the Maahanui Iwi Management Plan

Iwi Management Plan	Pūharakekenui - Styx SMP response
<p>Policy WAI1.1 To require the elimination of all industrial, stormwater and agricultural discharges into the Waimakariri as a matter of priority. The river must be able to be used for mahinga kai and recreation without concerns for human health.</p>	<p>The SMP contributes toward Policy WAI1.1 to the extent that it treats stormwater to reduce the amount of non-point source pollution.</p>
<p>Policy WAI2.1 To consistently and effectively advocate for a change in perception and treatment of lowland waterways in the catchment: from public utility and unlimited resource to wāhi taonga.</p>	<p>The SMP can be consistent with this policy.</p>
<p>Policy WAI2.2 To require that the value of lowland waterways in the Waimakariri catchment as mahinga kai is protected and restored, including but not limited to:</p> <ul style="list-style-type: none"> (a) Management focused on mauri and mahinga kai; (b) Management according to Ki Uta Ki Tai, and therefore the maintenance of fish passage from source to sea; (c) Elimination of point and non-point source pollution; (d) Protection of whitebait spawning areas (kōhanga), via rāhui; and (e) Provisions for the connections between waterways, wetlands and waipuna. 	<p>The SMP can contribute toward Policy WAI2.2(c) by treating stormwater to reduce the amount of non-point source pollution. (Road runoff from Clearwater is attenuated through the ponds but is not otherwise treated at this time.) SMP activities do not affect (a), (b), (d) and (e).</p>
<p>Policy WAI2.6 To require that all wetlands and waipuna in the Waimakariri catchment are recognised and provided for as wāhi taonga, as per general policy on Wetland, waipuna and riparian margins.</p>	<p>Waipuna are recognised and protected by District Plan processes and the WWDG.</p>
<p>WAI3.3 To protect groundwater resources in the Waimakariri catchment from effects as a result of inappropriate or unsustainable land use and discharge to land activities.</p>	<p>Minimal effects on groundwater from this SMP</p>

10.6 Potential controls

Table 8: Contaminant Sources, Significance and Possible Mitigation Methods.

Mitigation methods colours define effectiveness:

Green = Likely to be effective, Yellow = Sometimes effective, Red = Difficult or slow to get effects.

Source	Contribution	Possible Mitigation Methods
Sediment		
Farm animals trample stream banks	Significant	Stock exclusion (fence waterways)
Farm animals' faeces enter waterways	Unknown	Stock exclusion (fence waterways and dense planting)
Construction sites	Unknown, mitigated to some extent	Sediment & erosion controls First flush basins Wetlands As conditions on subdivision, resource or building consents Minimum Requirements for Developed Sites
Road works	Low; usually adequately controlled	On-site sediment controls
Atmospheric deposition	Low	Riparian tree cover
Plants (leaves, etc.)	Low (seasonal)	None
Vehicle emissions	Low	Treat road runoff
Visitor activity (stream access)	Medium	Signage
Deposition on roads via vehicles, pedestrians, private property runoff and wind.		Rain Garden (generic in-ground bio-filter) Cartridge filters (e.g. Stormfilter by Stormwater 360) Filterra (proprietary in-ground bio-filter) Catchpit filter (e.g. Litta Trap) Street sweeping

Source	Contribution	Possible Mitigation Methods
Zinc		
Bare galvanised roofs	Relatively few galv. roofs discharging to waterways in this catchment. (High city-wide.)	<p>Replace with alternative roofing Material (clay tile, non-metal roofs or pre-coated Zn-Al or paint with: Low zinc paint)</p> <p>Downpipe filters (e.g. Storminator by University of Canterbury)</p> <p>Divert first flush to the wastewater network</p>
Ageing painted roofs	High city-wide. Could be an issue as new pre-coated roofs age.	Replace with alternative roofing Material (clay tile, non-metal roofs or pre-coated Zn-Al or paint with: Low zinc paint)
Bare Zn-Al[1] roofs	Moderate in this catchment due to limited roof numbers.	Paint roofs
Vehicle tyres	High city-wide. Most road runoff into ground in this catchment	<p>Treat runoff from busiest roads, carparks and manoeuvring areas using: Wetlands</p> <p>First flush basins</p> <p>Rain Garden (generic in-ground bio-filter)</p> <p>Cartridge filters (e.g. Stormfilter by Stormwater 360)</p> <p>Filtterra (proprietary in-ground bio-filter)</p> <p>Catchpit filter (e.g. Litta Trap)</p> <p>Street sweeping</p>
Industrial discharges (inferred from monitoring)	Medium	<p>Industrial site management plan</p> <p>Monitoring discharges</p> <p>Enforcement</p>
Copper		
Brake pads	High city-wide. Most road runoff into ground in this catchment	Advocate with NZ Government for legislation change for copper-free brake pads. Copper content of brake pads anticipated to reduce from 2025 following USA legislation.

Source	Contribution	Possible Mitigation Methods
		Educate local auto industry and residents about the value of low/no copper brake pads, noting some low-Cu pads are currently available in NZ market.
Particulate deposition on roads		Treat runoff from busiest roads, carparks and manoeuvring areas using: Wetlands First flush basins Rain Garden (generic in-ground bio-filter) Cartridge filters (e.g. Stormfilter by Stormwater 360) Filterra (proprietary in-ground bio-filter) Catchpit filter (e.g. Litta Trap) Street sweeping
Roofs, cladding, spouting, downpipes	Low but increasing	Advocate with NZ Government for legislation on copper cladding. Investigate the feasibility of a District Plan rule to discourage the use of copper claddings. Divert first flush to the wastewater network Educate residents Onsite treatment of the copper stormwater runoff (e.g. copper sculpture filters thought grass prior to entering SW system, or retrofit planter box to treat runoff) Transparent sealer applied to copper surfaces
Lead		
Paint flakes/chips from old buildings	Unknown but more likely to contaminate soil than water	Site remediation during development
Lead flashings on roofing	Low	Education
Building material in older homes (pipes, roofing)	Low, as homes are renovated, demolished and maintained, the quality of lead is reducing.	Wait for lead to be phased out
Pathogens/ bacteria		

Source	Contribution	Possible Mitigation Methods
Ducks, geese	Major bacteria source	Reduce water fowl numbers. Would need to be implemented outside the SMP. CCC not empowered by the consent to control waterfowl
Wastewater overflows	Major	CCC Wastewater team are actively reducing wastewater overflow with controls such as renewals, capacity upgrades, reduction of vented manhole and code of practice guidelines.
Dog Access	Unknown	Signage and education
Other Organic Material		
Ducks, geese	Major source	Reduce water fowl numbers. Would need to be implemented outside the SMP. CCC not empowered by the consent to control waterfowl
Leaf Litter and Grass Clipping	Minor	Education
Industrial discharges		
Deliberate spills or poorly controlled sites	Unknown	Regulation, monitoring and enforcement
Polynuclear aromatic hydrocarbons		
(Old) coal tar street surfaces.	Unknown	Encapsulation. Removal.
Combustion	Likely low	Monitor
Nitrate and nitrite		
Probable agricultural sources (via groundwater)	Moderate	Investigate sources Education and enforcement
Fertiliser	Believed low	Education
Phosphate		
Industrial sources	Moderate	Enforcement
Fertiliser	Believed to be a minor source	Education
Leaf Litter and Grass Clipping	Unknown contribution	Education

Table 9: Assessing options as potential Best Practicable Options

Mitigation Option		Contaminants Treated	Assessment as a Best Practicable Option
First flush basins		TSS, Cu, Zn	Combines TSS removal with essential flow detention. Some metals removal. Traditional treatment approach.
First flush basins and wetlands		TSS, Cu, Zn, hydrocarbons	Good removal of TSS, metals and other contaminants. Combines treatment with essential flow detention. Most widely used current method.
Methods above this line more suitable for developments where land is readily available.			
Methods below this line have smaller footprints and are more suitable for use within redevelopments.			
Rain Garden (generic in-ground bio-filter)		TSS, Cu, Zn, hydrocarbons	Good TSS and metals removal. Appears to be a more expensive means of removing metals than basin + wetland
Cartridge filters (e.g. Stormfilter by Stormwater 360)		TSS, Cu, Zn, hydrocarbons	Good TSS and metals removal. Appears to be a more expensive means of removing metals than basin + wetland Similar metals removal cost to rain garden
Filterra (proprietary in-ground bio-filter)		TSS, Cu, Zn, hydrocarbons	Good TSS and metals removal. Better suited to new or re-development.
Catchpit filter (e.g. Litta Trap)		TSS, some Cu & Zn, litter, organic material	Good removal of particles larger than 100 µm (sand size). Some metals removal. Better suited to new or re-development
Street sweeping		TSS, particulate Cu & Zn	Good removal of particles larger than 100 µm (sand size). Some metals removal.
Downpipe filters (e.g. Storminator™ by University of Canterbury)		Zn, roof-sourced TSS	Very good zinc removal. Council can require downpipe treatment in some cases.
Roof painting		Zn	Very good barrier to zinc discharge. Council does not have powers to

			require roof painting.
Low-copper brake pads		Cu	Potentially the most effective and efficient copper mitigation. Government support needed.

10.7 Factors affecting option selection

Options considered are listed in Table 8.

All new areas will be treated through basins and wetlands. In addition the Council has purchased land to treat some existing areas in basins and wetlands. Basins and wetlands remove TSS effectively, although they are less effective against dissolved metals from roofs and roads. As TSS and metals are discharged in some measure from every impervious urban surface, basins can be useful controls where they treat extensive areas.

Contaminants (including metal contaminants) could be eliminated at source by substitution of non-contaminating materials. This could involve methods in Table 8 such as substitution of building material, substitution for zinc oxide in tyres, or low-copper brake pads.

The Council's powers to require these forms of treatment are limited, and new legislation may be needed before the Council can use them.

Contaminants could be reduced at or near source by, for example, painting or repainting roofs, or treating roof runoff at the downpipe.

Street sweeping picks up litter, stones and sand but is less effective at removing fine particles that contain the majority of metal contaminants (Depree, 2011). A street sweeping trial has occurred under Condition 7, Schedule 4 c. and when results are available they may influence future options selection.

Sump inserts (filter bags) are being trialled. Sump inserts are known to effectively trap litter and stones but have variable effectiveness trapping fine contaminants.

Some contaminant discharges can be reduced voluntarily through education. The Council is developing an education programme through its Community Waterways Partnership. An education programme is expected to have effects in the long term, and to be more effective for some contaminants (e.g. domestic chemicals, dog poo) than others such as vehicle emissions.

Although mitigation at source should be more effective than treatment of stormwater there are significant barriers to implementing source controls. In the present day the government or local and regional authorities are likely to have to demonstrate that source controls to be effected by land owners are both necessary and the best practicable option. The Council has initiated an economic analysis of the costs and benefits of stormwater treatment city-wide to try to answer this question.

More information, such as the long-term costs and benefits of maintaining roof coatings, substituting roof materials or installing stormwater filters, will need to be developed for the

economic analysis so that the Council can evaluate, consult on and select best practicable options.

10.8 Options in the SMP

Stormwater from new development is usually managed in detention basins which both limit discharge increases and serve as treatment facilities. Based on modelling, environmental drivers and tangata whenua values, and considering best practicable options, the first eight contaminant load reduction options below will be implemented in this catchment.

1. (As is normal in present day) all new residential roofs are expected to be coated (i.e. painted) or non-steel.
2. Stormwater from the new developments in Styx Drain, Highfield, Oakbridge, Middle Styx and Kā Pūtahi sub-catchments will be treated through first-flush basins and wetlands.
3. Stormwater from fully developed Kruses Drain and Prestons Creek sub-catchments will be treated in first-flush basins and wetlands between Prestons Road and Queen Elizabeth II Drive.
4. Stormwater generated from hardstanding areas within each industrial allotment to be pre-treated using an approved gross pollutant trap (GPT), vegetated swale or other proprietary pre-treatment device.
5. All new industrial roofs are required to be coated (painted).
6. Erosion and sediment control on development and construction sites, (Section 12 Goal 1.3).
7. Auditing high-risk industrial sites and working with occupiers to remediate contaminated stormwater discharges, (Section 12 Goal 4.2 to 4.4).
8. Working with community groups and the public to educate the community about the effects of and mitigation of stormwater contaminants, (Section 12 Goal 5.1).

These options can be implemented by the Council using its powers under the Local Government Act.

Source control options such as roof painting could be desirable but at present are not within the Council's powers under the Local Government Act.

10.9 Contaminant Mitigation Targets

Annual load reduction targets are taken from contaminant load reductions estimated by the C-CLM for the consent hearing. The C-CLM reductions for the Pūharakekenui-Styx catchment are in Table 19, Appendix F, presented by sub-catchment and in total.

Estimated contaminant load reductions in

Table 19: Christchurch Contaminant Load Model 2018 (C-CLM) results for the Pūharakekenui-Styx catchment are somewhat indicative because:

- a. Model result years do not coincide with the delivery year and end year of this SMP and
- b. Some basins are being constructed earlier than predicted for the model due to the timing of urban development.

Facility construction dates will be adjusted in the new city-wide model.

Table 11 below is derived from Table 19 and sets targets for annual contaminant load mitigation after full development (assuming the normal event of concurrent facilities construction).

Table 10: Contaminated Load Reduction Targets for the Pūharakekenui-Styx Catchment

Contaminant	Contaminant load reduction in 2018 compared to no treatment.	Contaminant load reduction in 2023 compared to no treatment	Contaminant load reduction in 2028 compared to no treatment	Contaminant load reduction in 2043 compared to no treatment
Total suspended solids	12.0%	19.1%	22.3%	29.6%
Total zinc	10.0%	20.3%	29.0%	44.5%
Total copper	16.0%	27.2%	34.5%	53.1%

Council staff will propose treatment systems (not included in the list of facilities proposed to the CSNDC Hearing) for Railway Drain and Redwood sub-catchments for inclusion in the 2024-27 Long Term Plan. If these facilities are not funded they will be proposed in subsequent LTPs. If approved and constructed to treat the full sub-catchments these facilities are estimated to achieve contaminant load reductions in Table 12.

Table 11: Aspirational Contaminated load reduction targets for Railway Drain and Redwood sub-catchments

Contaminant	Contaminant load reduction in 2018 compared to no treatment.	Contaminant load reduction in 2023 compared to no treatment	Contaminant load reduction in 2028 compared to no treatment	Contaminant load reduction by 2043 compared to no treatment
Total suspended solids	n.r.	n.r.	n.r.	4%
Total zinc	n.r.	n.r.	n.r.	5%
Total copper	n.r.	n.r.	n.r.	5%

n.r. means not reliable or meaningful in this context

10.10 Other contaminants

Contaminants that currently appear to be of less significance are sometimes detected at low levels, but do not have a mitigation strategy because they either do not exceed guidelines or have a non-stormwater source. These include:

- *E. coli*: implies a risk of other pathogens harmful to humans. (There are no pathogen targets in the consent. Pathogen controls are likely to be considered in the Surface Water Implementation Plan).
- Polycyclic aromatic hydrocarbons (PAHs): no consent targets. Seldom or never exceed LWRP guidelines.
- Nitrate and nitrite: no direct consent targets. Non-stormwater sources.
- Phosphorus: no direct consent target. Believed to be predominantly animal sources in this catchment.
- Ammonia: no consent target. Not known to exceed LWRP guidelines from stormwater sources.

11 Mitigation Plan

11.1 New Development

The SMP assumes that the city will extend through new development in the residential and commercial zones indicated in Figure 10.

Contaminants, particularly sediments, generated by development will be controlled by:

- rules in the district plan,
- the Stormwater and Land Drainage Bylaw 2022,
- the Erosion and Sediment Control Toolbox for Canterbury
- actions and requirements of this SMP.

In order to comply with section 8.4.7.3.c in the Christchurch District Plan, stormwater must:

- be detained in storage so that post-development peak flows do not exceed pre-development peaks up to the 2% ARI critical duration event for the catchment.
- be treated by the best practicable option as measured against Receiving Environment Attribute Target Levels in CRC214226 Schedule 7.
- be discharged into the ground by infiltration where practicable.

The minimum standards for stormwater detention and treatment associated with new development follow in Table 13.

Stormwater treatment facilities can serve both new developments, normally funded by developers, and established areas funded by the Council. Both existing and proposed treatment facilities, existing and under construction, are mapped in Figure 16 and Figure 17. Most facilities are detention basins, which treat stormwater and release a reduced flow rate into watercourses. Some smaller private facilities are infiltration basins that treat stormwater by filtration through a soil liner. All stormwater from infiltration basins up to (typically) a 50-year ARI event goes into the ground.

A rationale for basin sizing is in Table 14.

11.2 Mitigating individual site stormwater

Individual developments are required to treat stormwater to mitigate any change in quantity or quality arising from the development. The minimum standard for stormwater treatment is in Table 13 which is extracted from (Christchurch City Council, 2021). The guide includes information about on-site storage and treatment for small to medium sites.

Table 12 Minimum Requirements for New Development Sites.

Source of Stormwater Discharge(s)	Total area of disturbance does not exceed 1,000m ²	Total area of disturbance equals or is greater than 1,000 m ²
From/during land disturbance activities	An approved Erosion and Sediment Control Plan is required	An approved Erosion and Sediment Control Plan is required
From new / re-development residential roof and hardstand areas	<p>No discharge onto or into land where the slope exceeds 5 degrees.</p> <p>Sumps collecting runoff from new hardstand areas shall be fitted with submerged or trapped outlets wherever practicable.</p> <p>Sites increasing impervious by 150m² or more to a total coverage in excess of 70% are required to mitigate water quantity effects according to the Christchurch City Council On-site Mitigation Guide.</p> <p>An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required for sites in the flat (2).</p> <p>On-site rain water storage is required for new and redevelopment sites on the hills.</p>	<p>No discharge onto or into land where the slope exceeds 5 degrees.</p> <p>First flush treatment is required for stormwater runoff from new hardstand areas in excess of 150m² and buildings with copper or uncoated galvanised metal roofs or guttering/spouting (1).</p> <p>Sites increasing impervious by 150m² or more to a total coverage in excess of 70% are required to mitigate water quantity effects according to the Christchurch City Council On-site Mitigation Guide.</p> <p>An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required for sites in the flat (2).</p> <p>On-site rain water storage is required for new and redevelopment sites on the hills.</p>
From new / re-development non-residential roof and hardstand areas	<p>No discharge onto or into land where the slope exceeds 5 degrees</p> <p>First flush treatment is required for stormwater runoff from new hardstand areas in excess of 150m², buildings with copper or uncoated galvanised roofs or guttering/spouting and high-use sites</p> <p>Sites increasing impervious by 150m² or more to a total</p>	<p>No discharge onto or into land where the slope exceeds 5 degrees</p> <p>First flush treatment is required for stormwater runoff from new hardstand areas in excess of 150m², buildings with copper or uncoated (3) galvanised roofs or guttering/spouting and high-use sites</p> <p>Sites increasing impervious by 150m² or more to a total</p>

Source of Stormwater Discharge(s)	Total area of disturbance does not exceed 1,000m ²	Total area of disturbance equals or is greater than 1,000 m ²
	<p>coverage in excess of 70% are required to mitigate water quantity effects according to the Christchurch City Council On-site Mitigation Guide.</p> <p>An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required (4)</p> <p>Site management and spill procedures required for sites that engage in hazardous activities (5)</p>	<p>coverage in excess of 70% are required to mitigate water quantity effects according to the Christchurch City Council On-site Mitigation Guide.</p> <p>An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required (4)</p> <p>Site management and spill procedures required for sites that engage in hazardous activities (5)</p>
Any land use with Canterbury Land and Water Regional Plan Schedule 3 activities.	An application for approval under the Stormwater and Land Drainage Bylaw 2022 must be made to authorise connection and discharge into the Council network.	An application for approval under the Stormwater and Land Drainage Bylaw 2022 must be made to authorise connection and discharge into the Council network.

Explanatory notes:

1. *The first flush is the first 25 mm of runoff*
2. *The Council has discretion to waive the requirement for first-flush treatment of hardstand areas on large residential sites with a low impervious percentage where the amount of pollution-generating hardstand being added is considered to have less than minor effect.*
3. *“Uncoated” means without a painted or enamelled coating. Council has discretion to waive the requirement for first flush treatment of hardstand areas on large residential sites where the amount and type of pollution-generating hardstand being added is considered to have a less than minor effect.*
4. *Quantity assessment and mitigation -The effects of the discharge on the stormwater network capacity and/or the extent or duration of flooding on downstream properties are to be assessed. Where Council considers an increase (including cumulative increases) has a more than minor effect, on-site stormwater attenuation or stormwater network upgrade shall be provided. The details of storage volume and peak discharges or network capacity required to mitigate effects on flooding or network capacity constraints shall be determined by the Christchurch City Council planning engineer.*
5. *Site management and spill procedures –Procedures are to be implemented to prevent the discharge of hazardous substances or spilled contaminants discharging into any land or surface waters via any conveyance path.*

11.3 Operational controls on stormwater and sediment

The management of sites which may experience erosion and/or discharge sediment during development works is controlled by conditions of either resource consents or building consents, as applicable, for earthworks and building. The Stormwater and Land Drainage Bylaw 2022 specifies some standards for activities not controlled by consents.

Standards for sediment discharges are set by the Sediment Discharge Management Plan 2021 (SDMP). The sediment discharge management process should work as follows:

1. Allowable TSS (total suspended solids) concentration trigger levels for discharges to the stormwater network are set by the SDMP.
2. An erosion and sediment control plan (ESCP) is prepared by a 'suitably qualified and experienced professional' as determined by a site risk assessment
3. The TSS concentration trigger levels for the site are included in authorisations or conditions where possible.
4. The ESC measures are implemented on site and monitored.

11.4 Industries and High Risk Site Discharges

The Council will manage industrial sites through its Stormwater and Land Drainage Bylaw 2022. The bylaw requires industrial contaminants to be controlled to meet best practice. The Christchurch City Council's expectation is that stormwater entering its network is managed according to best practice, especially where the discharge occurs directly into a waterway. On-site pre-treatment may be required unless contaminant levels are less than LWRP Schedule 5 standards.

Where industrial site occupiers do not meet the required standards for discharge into the network, the site will be removed from the CSNDC and will require a separate resource consent from ECan for its discharge. A condition is included in the CSNDC for this process and all industrial sites excluded from the resource consent will be listed on Schedule 1 attached to the consent.

In managing high-risk sites the Council will:

- Audit at least 15 high-risk sites per year;
- Inform audited industries of the results of audits and work closely with these industries to achieve outcomes in line with the Stormwater Bylaw;
- Communicate with industries about stormwater discharge standards and the means of meeting these standards.

Change will be sought through a combination of education and enforcement.

- Education will be carried out through an industry liaison group.
- Enforcement will happen as pollution prevention officers identify and visit high-risk industrial sites and work with industries to improve site management.

Contamination risks are limited to a degree by acceptance of trade wastes into the wastewater system. This is authorised through Trade Waste Consents and the monitoring of consents permits a degree of oversight and site control.

Future needs include:

- More interaction with industries by the Council; communication, awareness and education
- Improved knowledge of the environmental effects of compounds discharged by industrial sites
- Ongoing site checks until the Council is confident that all risky sites are controlled adequately
- Upgrades on non-compliant sites

11.5 Expectations for Industrial Area Stormwater Discharges

Stormwater from the industrial zone west of The Groynes is discharged to ground on individual sites or groups of sites. These discharges have been consented by Environment Canterbury (ECan) and will continue to be consented by ECan under the current stormwater consent CRC214226.

According to the CSNDC (CRC214226) Conditions the Council will authorise roof stormwater discharges into land under this consent and ECan will continue to authorise discharges into land.

All discharges into its network must be authorised by the Christchurch City Council.

Because of the sensitivity of the receiving water, the Council will manage industrial stormwater as follows:

- No industrial sites will discharge into surface water.
- The Council will advocate and in some cases require the use of painted zinc/aluminium coated steel OR non-steel roofing by means of a direct request accompanying every LIM and PIM, supported by a technical statement detailing the environmental effects of zinc.
- Roof runoff from painted zinc/aluminium roofs may be discharged into the ground without treatment.
- At least the 25mm first-flush will be treated; or the 25mm first flush from hard stand and landscape areas if roof water goes to ground separately.
- Off-site treatment will occur in facilities vested in Council and serving as large an area as practicable.
- On-site treatment will be in soil infiltration basins designed in accordance with the Waterways Wetlands and Drainage Guide, chapter 6.

Where industrial site owners (or occupiers) cannot meet the required standards for discharge into the network, the site will be removed from the CSNDC and will require a separate resource consent from ECan for its discharge. A condition is included in the CSNDC for this process and all industrial sites excluded from the resource consent will be listed on Schedule 1 attached to the consent.

11.6 New Treatment Facilities

Stormwater from new developments will be treated. The Pūharakekenui-Styx River has fair to good ecological status, so this SMP seeks that urban stormwater will be treated to best practice before discharge to surface water. At least the 25mm first flush will be detained and treated.

11.6.1 New facilities and land contamination

Condition 7, Schedule 2(f) requires a description and justification for separation distances between proposed storm-water facilities and contaminated sites. Contaminated sites are identified as sites appearing in the Environment Canterbury Listed Land Use Register.

In general, new basins and wetlands will be situated on pastoral land which may have residues of agricultural chemicals at low levels. There is usually limited flexibility in where basins and wetlands are sited: basins are typically located in the low point of a development on land already purchased by a private developer. Known or suspected contaminated sites can sometimes be avoided, however intensive site testing will be undertaken and contaminated soils will be dealt with according to accepted environmental protocols.

A schedule of basins, sites and site descriptions is in Table 17, Appendix C.

11.6.2 Designing basins to minimise bird-strike on aircraft

Christchurch District Plan Policy 6.7.2.1.2 – Avoidance or mitigation of navigational or operational impediments – is a policy to avoid or mitigate the potential effects of activities that could interfere with the safe navigation and control of aircraft, including activities that could interfere with visibility or increase the possibility of bird-strike. Plan provisions include:

1. 5 Natural Hazards - for activities and earthworks in the Waimakariri Flood Management Area (5.4.3.3 RD3, matter k.);
2. 8 Subdivision - general matters of control in relation to new ponding areas (8.7.4.3(f)) and Policy 8.2.3.4(b., vi.) Stormwater Disposal;
3. 8 Subdivision - Development Requirements for stormwater for South Masham and Yaldhurst ODP areas (Appendices 8.10.5.D(5)(b) and 8.10.28.D(a)(5)(d));
4. 11 Utilities - matters of discretion for new ponding areas (11.10.6(j))

New stormwater facilities within the Christchurch International Airport Bird Strike Management Area, a defined zone extending 3km from airport runway thresholds (mapped in District Plan Appendix 6.11.7.5) must meet activity standards in section 6.7.4.3 of the Christchurch District Plan (see Figure 18).

Assessments should consider any actual or potential effects relating to bird strike where relevant to an application, regardless of whether or not the proposal is located within the Bird Strike Management Area (6.7.3(c.)). Depending on the facts of the particular application:

1. Strategic objective 3.3.12 Infrastructure, policy 6.7.2.1.2 Avoidance or mitigation of navigational or operational impediments, and policy 8.2.3.4 Stormwater disposal, are relevant to activities that have the potential to increase the risk of bird strike whether they are within or outside of the CIABSMA;
2. Chapters 5, 6, 8, 11, 13 & 17 contain matters of assessment or control to manage bird strike risk for particular activities; Bird strike risk may be a relevant consideration when the Council considers a discretionary or non-complying activity.

Basin planners and designers are also required to consider the potential for new water bodies within 13 kilometres of airport runway thresholds to increase the risk of bird strike. New water bodies can provide habitat that will attract waterfowl and high risk species and bring their flight

lines into intersection with aircraft flight lines. The risk potential should be quantified and, where required, managed in a manner indicated via a Bird Strike Risk Assessment carried out by a person with suitable ornithological training. Guidance material is contained as Appendix G. Persons developing stormwater facilities within 13 km of airport runway thresholds (identified in Figure 18) should consult with CIAL.

11.6.3 Avoiding groundwater mounding beneath infiltration basins

Groundwater rises locally to some degree (mounding) when an infiltration basin is discharging. Adverse effects (either waterlogging of adjacent land or impeded drainage) can be avoided by carefully locating basins with reference to groundwater depth. Mounding is not relevant to proposed Council basins in this catchment as they discharge to surface water. If a private infiltration basin were to be proposed it would likely be consented by ECan.

11.6.4 Effects of stormwater on groundwater

New stormwater management systems created during urban development will only be detention basins because impermeable soils and high groundwater levels make large scale storm-water infiltration impracticable. Stormwater treatment mechanisms are expected to have minor effects on groundwater quality.

11.6.5 Changes to springs and baseflow

Most future development is projected to take place in the western two-thirds of the catchment. As development occurs there will be an increase in impervious surfaces, which will impact the drainage of rainwater into the underlying aquifer. This could have consequences for baseflows in the Kā Pūtahi Creek and Pūharakekenui-Styx River.

The eastern part of the Pūharakekenui-Styx catchment has a high groundwater table and poorly draining soils, making infiltration into the ground generally unfeasible. However, a small portion of the western side of the Pūharakekenui-Styx catchment is suitable for stormwater disposal into the ground due to its low. These locations are shown within in Figure 4.

As the majority of the catchment can only feasibly dispose of stormwater runoff into waterways following treatment in detention basins and wetlands. The effects of future development on groundwater were considered by Pattle Delamore (PDP, 2023).

Pattle Delamore carried out a water balance calculation for the present day and future situations considering groundwater inflows from outside the catchment, rainfall and infiltration, increased imperviousness, stormwater capture, diversion and treatment and ground compaction during development. Because the majority of baseflow comes from the Waimakariri River (outside the catchment) the rezoning identified in the District Plan is expected to reduce baseflow by an estimated 0.4% (PDP 2023).

Table 13: Sizing rationale for proposed treatment facilities

Sub-catchment and Facility	Contributing area (ha) (Total area)	Land Use	Runoff vol. coeff. ⁴ & First Flush volume ⁵	Indicative FF Basin Area	Indicative Wetland Area	Potential extra wetland flooding vol. ⁶	References / comments
Hussey Swale Glen Oaks Basin	(141 ha)	Ex residential					Glen Oaks Basin 2003
Kainga Kainga Basin	65.8 ha 11.0 ha (907 ha)	Business Residential	(0.81) (0.7) 14,500 m ³	18 ha	3.9 ha	19,000 m ³	
Ka Putahi Works 1 Works 4 Arterial FF & wetland Guthries/Thompsons FF & wetland	43 ha 12 ha 32.0 ha 1.79 ha 20.5 ha (497 ha)	Business Business Residential Business Business	(0.81) 8,600 m ³ (0.81) 2,500 m ³ (0.7) (0.81) 4,700 m ³ (0.81) 4,200 m ³	0.86 ha 0.27 ha 0.47 ha 0.42 ha	2.3 ha 0.66 ha 1.25 ha 1.1 ha	11,400 m ³ 3,300 m ³ 6,200 m ³ 5,500 m ³	

⁴ Runoff volume coefficient from WWDG Table 6-10

⁵ FF volume and expected FF basin volume

⁶ Wetlands may be flooded up to an additional depth of 500 mm in events exceeding 10 year ARI. Over-flooding increases effective detention storage without significant compromise to wetland treatment effectiveness.

Kruses Drain, Prestons Creek, Rhodes Drain (Highfield) Selkirk Barclay Highfield North Highfield SE basins Highfield SW basins Kruses/Prestons Hills Road	28 ha 9 ha 22 ha 20 ha 13 ha 479 ha 25 ha (548 ha)	Gf residential Gf residential Gf residential Gf residential Gf residential Ex residential/ind Gf residential (Gf = Greenfields)	0.7 0.7 0.7 0.7 0.7 0.65 0.63 61,000 m ³	0.33 Ha 0.1 ha 0.26 ha 0.24 ha 0.15 ha 6.2 ha 0.3 ha 52 ha 1.7 ha	0.7 ha 0.23 ha 0.56 ha 0.51 ha 0.33 ha 13.3 ha 0.63 ha 	3,500 m ³ 1,100 m ³ 2,800 m ³ 2,500 m ³ 1,600 66,500 m ³ 3,100 m ³ 	Likely wetland area > 30 ha
Lower Styx	(1781 ha)						
Middle Styx	(274 ha)						
Northwood	73 ha (73 ha)	Ex residential	no mitigation in SMP				Treatment via Linton swale & infiltration basin
Railway Drain	(148 ha)	Mostly residential	no mitigation in SMP				Future mitigation to be proposed for inclusion in LTP
Redwood	(118 ha)	Residential	no mitigation in SMP				
Smacks Creek	23 ha (57 ha)	Ex residential Rest rural, cemetery	no mitigation in SMP				
Upper Styx and Styx Drain Gardiners basin & wetland	(Provisional areas) 25 ha 50 ha	Gf residential Ex residential	(0.7) 4,000 m ³ (0.7) 5,000 m ³	2.4 Ha (incl.)	1.36 Ha	2,700 m ³	

Highsted Wetland	4.4 Ha	Business	(0.81) 900 m ³	1.5 ha	3 ha	15,000 m ³	
	15 ha	Ex residential	(0.7) 2,300 m ³	(incl.)			
	15 ha	Gf residential	(0.63) 1,600	(incl.)			
Highsted/Styx Mill Wetland	100 ha	Gf residential	m ³	4.0 ha			
Sw BasinID 683	12.5 ha	Ex residential	(0.63) 15,700	0.8 ha			
SwBasinID 775	5 ha	Ex residential	m ³	0.5 ha			
	5 ha	Gf residential	(0.63) 2,000 m ³	(incl.)			
	(723 ha)		(0.7) 500 m ³				
			(0.7) 800 m ³				
Upper Styx	(380 ha)						
Styx Headwaters							
Sawyers	121.8 Ha	RNN	0.63	8.7 Ha	7.0 Ha	70,000 m ³	
Cavendish	11.5 Ha	Bus	0.81				
			52,400 m ³				

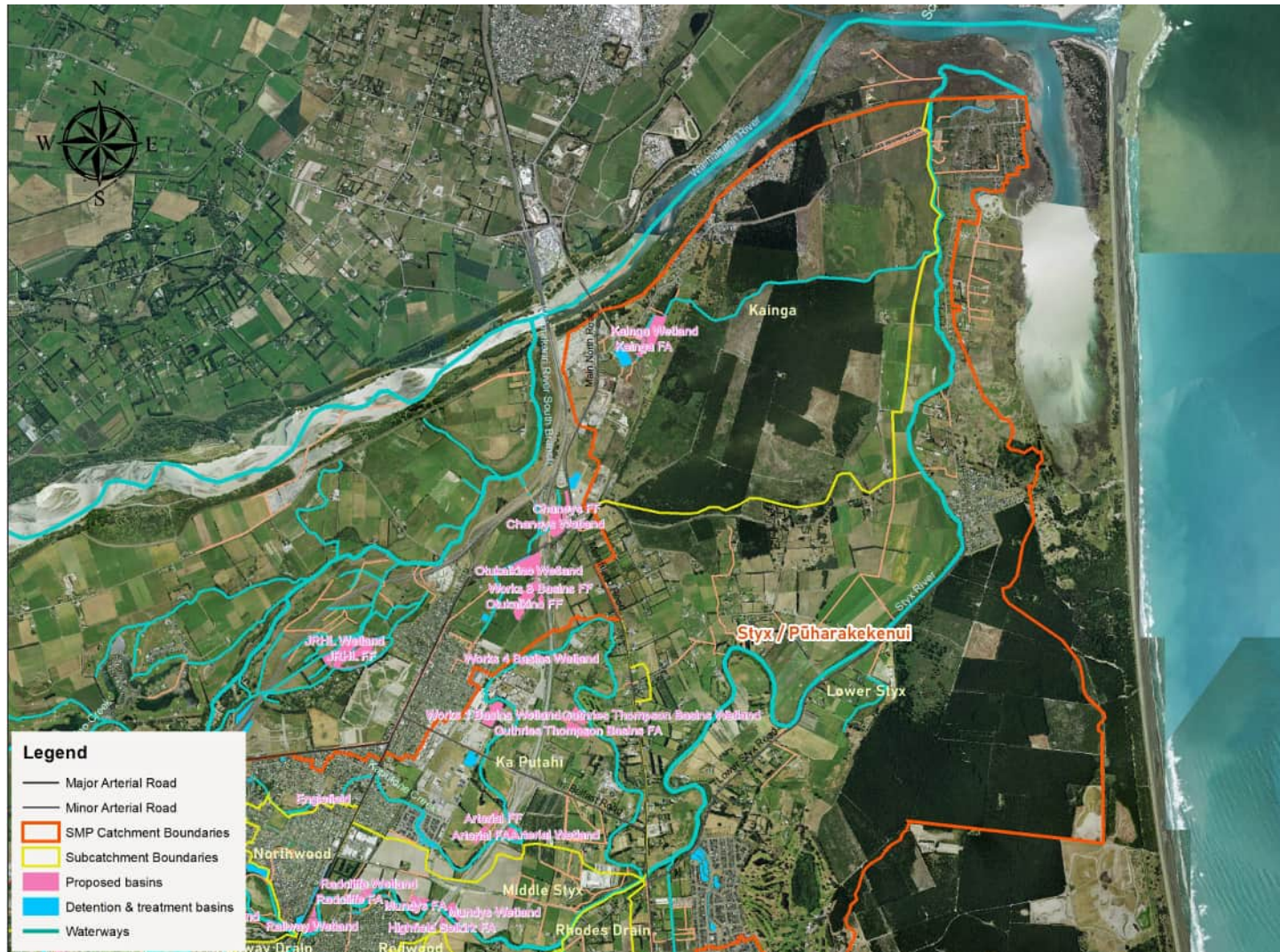


Figure 17: Existing and Proposed Treatment Facilities in the Eastern Pūharakekenui-Styx Catchment

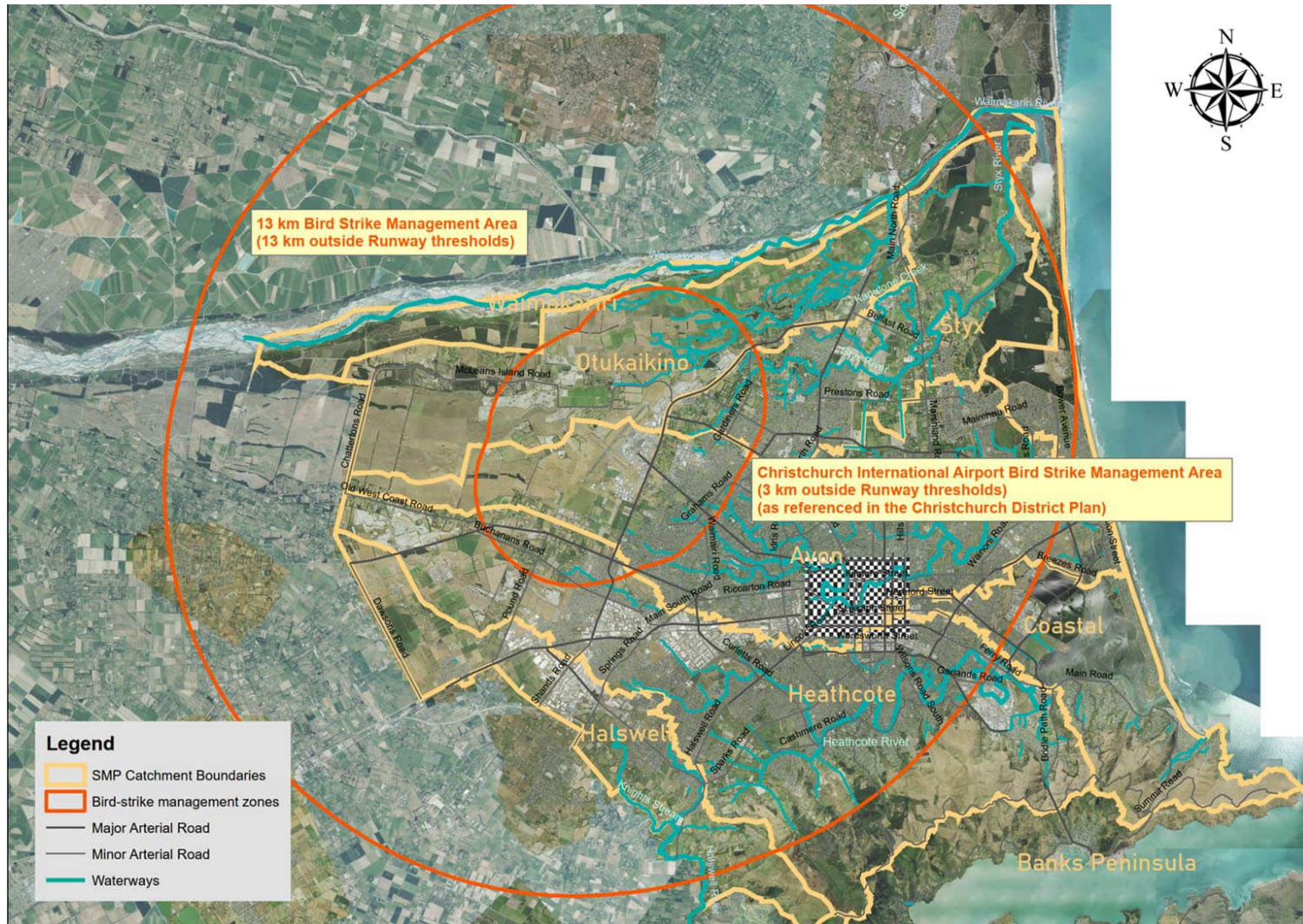


Figure 18: Bird Strike Management Zones

11.7 Changes in response to public submissions

This section will be completed after the public consultation period.

11.8 Environmental Monitoring

The Council carries out “state of the environment” monitoring monthly at 46 sites within the Christchurch district. Three sites are within this catchment. State of the environment monitoring is not time or rainfall related and does not often coincide with wet weather.

To better quantify contaminant concentrations and track the effects of contaminant mitigation strategies the Council could increase the amount of monitoring during wet weather. The characteristics of the Christchurch water network are different from other cities and local information is needed. Short term monitoring is needed to refine knowledge about zinc loads from different road types and the difference between first-flush and steady-state concentrations. Long term monitoring of treatment systems is needed to verify the performance of basins, swales, rain gardens and filters.

11.9 Pathogens – for information

This section is for information because pathogens are mostly sourced from rural activities and wastewater overflows that are controlled by other resource consents.

outside the control of Pathogens can be minimised in the rural parts of the catchment by excluding stock from waterways and, ideally, by introducing planted buffer strips. Some bacteria will continue to be introduced by waterfowl and runoff from pastoral land.

Within the urban areas of the catchment, pathogens can enter the waterway by wastewater overflows. A wastewater overflow is when sewage flows out from the pipes or manholes into the stormwater system, which then drains into a stream, river or the sea. There are two types of wastewater overflows; dry weather overflows and wet weather overflows.

Dry weather overflows are usually caused by something blocking the wastewater mains which cause wastewater to back-up behind the blockage and fill the pipes and overflow out of the manholes upstream of the blockage. To manage the dry weather overflows, the Council monitors and maintains the types of pipe that are more likely to block to help prevent dry weather overflows, such as flushing lines prone to blocking with fat.

Wet weather overflows are caused by the wastewater system becoming inundated with stormwater and groundwater during wet weather events which can cause its capacity to be exceeded. Wet weather overflows are a mix of wastewater, rainwater, and groundwater, with the majority being rainwater.

Council must manage to minimise the risk to human health and balance with the risk of pollution entering waterways, hence constructed overflow points to streams and rivers prevent wastewater from entering streets and private properties.

The Council has a continuing programme of work to reduce wastewater overflows, by reducing the amount of inflow and infiltration into its wastewater network as well as increasing the capacity of the network.

All dry and wet weather overflows are reported on the recent and historic wastewater overflows webpage. Signs are put out in the area surrounding the overflow warning of pollution and testing is carried out on the receiving body of water (stream or river) until the amount of pollution has reduced enough to remove the signs.

Since 2018 in the Styx catchment, there have been 2 total incidents of dry weather flow flows in 2018 and 2019, and 3 total incidents of wet weather over flows in 2019 and 2021. More information regarding these incidents is available online.

11.10 Nutrients

Nutrient inputs in this catchment are mostly of rural origin and do not fall within the scope of this plan.

The Council will cooperate with Environment Canterbury to develop and implement a catchment management plan for rural parts of the catchment.

12 Plan Objectives

These objectives address the issues arising from Sections 3 and 5 through 11.

12.1 Objective 1. Control sediment discharges

Our goals are:

- 1.1 Ensure the quality of stormwater from all new development sites or re-development sites is treated to best practice (with Table 12 Minimum requirements for new development sites. Table 12, section 11.2 being the minimum standard)
- 1.2 100% of stormwater treatment facilities contributing to Contaminated load reduction targets for the Pūharakekenui-Styx catchment (consent condition 6b) are constructed and conform to WWVG standards.
- 1.3 Sediment from 95% of consented construction activities on the flat is treated to best practice by 2025
- 1.4 Analyse options for carrying out street sweeping, sump cleaning, and diversion to wastewater trials in 2020/21 (Schedule 4b & d)

Action Plan for Urban Sediment				
Goal	Action	Mechanism	Action Components	Timing
Sediment (urban)				
1.1 New developments	Plan and oversee installation of detention basins, wetlands & swales	District Plan (Development contributions) and Long Term Plan	Normal planning processes.	Ongoing
1.2 New treatment facilities	Ensure new facilities are built to best practice	Designs should conform to the Infrastructure Design Standard	Normal Council planning, design and procurement process.	Ongoing
1.3 Construction & excavation sites	On-site sediment and erosion control effected through Erosion and Sediment Control Plans	Council enforcement powers under the Building Act 2004.	Train Building Inspectors. Implement an enforcement process. Contractor(s) on standby for clean-up when	ESC now part of resource consents for earthworks and building

Action Plan for Urban Sediment				
Goal	Action	Mechanism	Action Components	Timing
			breaches occur.	
1.4 Road runoff contains sediment	Investigate & develop methods to treat runoff from arterial roads,	Increase frequency of street sweeping, rain gardens	Street sweeping trials. Construct rain gardens where feasible.	Commencing 2021

Recommended for consideration through the Surface Water Strategic Plan

1.5 Road sediment is reduced by a best practicable option determined by the results of street sweeping, sump cleaning and alternative treatment trials (Schedule 4c, f, g & h.)

12.2 Objective 2. Control zinc contaminants

Our goals are:

- 2.1 [repeats Goal 1.2] All the facilities required to meet the Table 10 targets are constructed.
- 2.2 By 2025 the Council will have investigated zinc mitigation measures and carried out cost/benefit analyses toward identifying their effectiveness as best practicable options.
- 2.3 By 2025 the Council has consulted with key stakeholders and identified a long-term zinc strategy consistent with current technologies.
- 2.4 The CCC collaborates with local and regional government in a joint submission to central government seeking national measures and industry standards to reduce the discharge of building and vehicle contaminants.

Action Plan for Zinc				
Goal	Action	Mechanism	Action Components	Timing
Zinc				
2.1				
Same as 1.1				
2.2 & 2.3 Bare steel roofs emit zinc	Investigate/consult acceptable material for new roofs. (Choices non-metallic or pre-painted zinc/aluminium.)	District Plan rule (if possible) otherwise investigate Regional Rule or legislation	Investigate environmental harm and costs/benefits of alternative materials. Consult widely.	Under way
2.3 Ageing Colorsteel® likely to emit zinc	Research zinc emissions from ageing Colorsteel®	Sampling roof runoff	Sample runoff from ageing roofs, monitor trends, liaise with industry.	
2.4 Vehicle (tyre) zinc	Research and implement best practicable means of zinc removal from busy roads	Catchment scale filtration systems. Wetlands & rain gardens if space	Research and trials	Under way 2022

Action Plan for Zinc				
Goal	Action	Mechanism	Action Components	Timing
		is available		
2.4 National measures and industry standards	National measures and industry standards to reduce the discharge of building and vehicle contaminants.	Represent Council position to Ministry for the Environment	Regular meetings with MfE staff	ongoing

Recommended for consideration through the Surface Water Implementation Plan

2.5 The Council engages in research and trials into means of trapping roof-sourced zinc on site.

2.6 The Council adopts a zinc limitation strategy based on identified best practicable options.

12.3 Objective 3. Control copper contaminants

Our goals are:

- 3.1 The Council consults with the government, through the Ministry for the Environment, about legislation to limit the copper content in vehicle brake pads.
- 3.2 The Council does not permit stormwater discharges into the network from unprotected copper cladding, spouting or downpipes.
- 3.3 The Council will investigate the feasibility of a district plan rule to discourage the use of copper claddings.

Action Plan for Copper				
Goal	Action	Mechanism	Action Components	Timing
Copper				
3.1 Vehicle brake pads	Request legislation requiring low/no copper in brake pads	Combined regional and local authority approach to government re legislation to apply nation-wide.	Liaison between local and regional councils. Representation to government via NZTA, MfE	Unknown
3.2 & 3.3 Architectural copper (roofs, spouting, downpipes)	Prohibit the use of unprotected architectural copper. Seek to limit or eliminated the use of architectural copper.	District Plan rule; NZ-wide legislation; and possible District Plan rule; other-wise investigate Regional Rule	Liaise with government thru MfE. Investigate and consult.	Unknown

12.4 Objective 4. Control industrial site contaminants

Our goals are:

- 4.1 A database of industrial sites considered to be medium or high risk is compiled, based on the best available information, by 2025
- 4.2 High risk industrial sites are audited by the approved procedure under the CSNDC

Action Plan for Industrial Sites				
Goal	Action	Mechanism	Action Components	Timing
4.1 Information about industrial sites.	Continue to improve database of industrial site information.	Desktop analysis, questionnaires, Chamber of Commerce	Desktop analysis, mailouts, questionnaires, industry liaison	ongoing
4.2 Industries unaware of effects of discharges to stormwater	Develop awareness among all industries of the harmful effects of contaminated discharges.	Educate via mail-outs. Educate during site audits.	Inspect sites in risk order. Communicate results and expectations	ongoing
4.3 Some industries failing to control harmful substances	Ensure that harmful substances are contained, tracked, and disposed of safely	Audit sites and follow up with education and enforcement.	Protocols for site controls developed jointly by CCC, ECan and industry. Site audits.	ongoing
4.4 Non-compliant discharges	Trace and eliminate discharges	Audit sites and follow up with education and enforcement.	Communicate the issue to industry & visit industries. Generate improvement plan. Engage and obtain compliance.	ongoing

12.5 Objective 5. Engagement and education

Our goals are:

- 5.1 By 2025 the Council will be working with community groups to engage with the public to educate participants about current stormwater practice and enable the public to take action to stop contaminants at source.
- 5.2 By 2025 the Council will be engaging regularly with the Ministry for the Environment to collaborate on contaminant reduction initiatives.

Action Plan for Engagement and Education				
Goal	Action	Mechanism	Action Components	Timing
5.1 Valuing Water Resources	Education and engagement to empower community groups Each new generation values waterways	Joint partnership prog to effectively co-ordinate existing education and engagement of community groups	Partner delivery (Council, ECan, Ngāi Tahu, CWMS) with stream care and other community groups	Ongoing
5.1 Communication strategy	Develop a long term communication strategy	Strategy development	Understand community thinking about waterways. Agree message and means of communicating.	Ongoing
5.1 Promote community action	Encourage supportive community groups	More direct support for active groups. Provide information and involve in planning	Assist groups to develop goals and action plans. Share Council planning. Fund and track funding. Monitor results.	Ongoing
5.2 CCC and MfE engaged re heavy metals reduction.	CCC to seek regular contact with relevant MfE planning team(s).	The anticipated mechanism is regulation or national education campaign.	Council to contact MfE, starting at executive level, progressing to staff level	Ongoing

Action Plan for Engagement and Education				
Goal	Action	Mechanism	Action Components	Timing
			contacts	

12.6 Objective 6. Manage flooding

Our goals are

- 6.1 The quantity of stormwater from all new development sites or re-development sites will be attenuated to at least the minimum standard of section 11.5
- 6.2 Protection for property will continue to be achieved through controls on development and controls on new floor levels.

Action Plan for Flooding				
Goal	Action	Mechanism	Action Components	Timing
6.1 Control extra stormwater from new development	Limit the increase in peak stormwater runoff.	Stormwater from new subdivisions is controlled through full storm detention. Stormwater from larger individual sites attenuated on site.	Normal planning processes	Ongoing
6.2 Minimise flooding caused by city growth & change	Monitor changes to impervious areas and stormwater network capacity and compensate if necessary	Regular computer-based flood modelling.	Keep models up-to-date as the city changes. Compare models with flood events. Plan for flood mitigation as necessary.	Ongoing

PART FOUR:
Stormwater Outcomes

14 Conclusion

The purpose of the Comprehensive Stormwater Network Discharge Consent is to drive planning and actions that will progressively improve the quality of stormwater discharges.

Actions the Council can take through the stormwater management plan must be accompanied by other actions if the Council’s Community Outcome (Healthy Environment) and the Mahaanui Iwi Management Plan objectives are to be realised. Further actions, by the Council and others, include:

- Raise awareness and educate citizens on how to stop contaminants from entering stormwater at source.
- Eliminate or reduce contaminants at source (e.g. by choosing or specifying non-contaminating building materials).
- Remove contaminants from stormwater before they enter natural water.
- Restore waterway corridors to a natural state.
- Restore and plant riparian margins.
- Improve instream habitat by sediment removal, riparian tree planting (for temperature control, bank stability and shelter).
- Improve biodiversity to improve food sources for instream life.
- Performance monitoring of treatment facilities.

Information used in developing the SMP suggests that controlling contaminants at source is more sensible than removing them from stormwater through treatment systems. However, the control or elimination of contaminants at source will affect our buildings, means of transport, household products and the ways we do things. Source control is a journey we will need to travel together to protect the environment; tangata whenua, community groups, regulators, researchers, and local, regional and central government.

Progressive improvement can occur through further activities in Table 15.

Table 14: Areas for Improvement Outside of the Stormwater Management Plan

Activity	Motivation for the Activity
The Council regulating and acting under regulations to stop the discharge of contaminants.	As required by conditions of CRC214226 (CSNDC)
The Council investigating new means of controlling contaminants at source (e.g by materials substitution or innovative means of treatment).	As required by conditions of CRC214226 (CSNDC)
The Council and others implementing new or improved contaminant mitigation practices.	Through the proposed Surface Water Implementation Plan 2021 (referred to in section 2.1)
The Council and others making progressive environmental improvements such as restoring	Community Outcome

waterways and their corridors to a natural state.	(Healthy Environment)
Citizen-based awareness and advocacy for clean water and improved biodiversity.	Kaitiakitanga
Advocacy by Ngāi Tahu for the mana of water and waterways.	Kaitiakitanga. Kawanatanga. Mahaanui Iwi Management Plan

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Appendix A Schedule 2 Responses

Table 15: Schedule 2 matters to be included in SMPs: CRC214226 Condition 7

No.	Matters for inclusion in SMPs	Addressed in which Section of the SMP
a	Specific guidelines for implementation of stormwater management to achieve the purpose of SMPs;	The SMP is the guideline
b	A definition of the extent of the stormwater infrastructure, that forms the stormwater network within the SMP area for the purposes of this consent;	4.4
c	A contaminant load reduction target(s) for each catchment within that SMP area and a description of the process and considerations used in setting the contaminant load reduction target(s) required by Condition 6(b) using the best reasonably practicable model or method and input data;	10.2 to 10.9
d	<p>A description of statutory and non-statutory planning mechanisms being used by the Consent Holder to achieve compliance with the conditions of this consent including the requirement to improve discharge water quality. These mechanisms shall include:</p> <p>Relevant objectives, policies, standards and rules in the Christchurch District Plan;</p> <p>Relevant bylaws; and</p> <p>Relevant strategies, codes, standards and guidelines;</p>	2.3 through 2.11
e	<p>Mitigation methods to achieve compliance with the conditions of this resource consent including the requirement to improve discharge water quality under Condition 23, and to meet the contaminant load reduction targets for each catchment as determined through the SMPs and the standards for the whole of Christchurch set in Condition 19. These methods shall include:</p> <p>Stormwater mitigation facilities and devices;</p> <p>Erosion and sediment control guidelines;</p>	11.

No.	Matters for inclusion in SMPs	Addressed in which Section of the SMP
	<p>Education and awareness initiatives on source control systems and site management programmes;</p> <p>Support for third party initiatives on source control reduction methods;</p> <p>Prioritising stormwater treatment in catchments: that discharge in proximity to areas of high ecological or cultural value, such as habitat for threatened species or Areas of Significant Natural Value under the Regional Coastal Environment Plan (Canterbury Regional Council, 2012); and areas with high contaminant loads;</p>	
f	<p>Locations and identification of Christchurch City Council water quality and water quantity mitigation facilities and devices; including a description and justification for separation distances between mitigation facilities or devices and any contaminated land;</p>	<p>Figures 16 & 17, section 11.6</p>
g	<p>Identification of areas planned for future development and a description of the Consent Holder's consideration to retrofit water quality and quantity mitigation for existing catchments through these developments where reasonably practicable;</p>	<p>7.2 and Figure 10</p>
h	<p>Identification of areas subject to known flood hazards;</p>	<p>9</p>
i	<p>A description of how environmental monitoring and assessment of tangata whenua values have been used to develop water quality mitigation methods and practices;</p>	<p>10.5</p>
j	<p>Results from and interpretation of water quantity and quality modelling, including identification of sub-catchments with high levels of contaminants;</p>	<p>10.3 and Appendix F</p>
k	<p>Mapping of existing information from Canterbury Regional Council and the Consent Holder showing locations where discrete spring vents occur;</p>	<p>Figures 2 and 3</p>
l	<p>Consideration of any effects of the diversion and discharge of stormwater n base-flow in waterways and springs and details of monitoring that will be undertaken of any waterways and springs that could be affected by stormwater management</p>	<p>11.6.4</p>

No.	Matters for inclusion in SMPs	Addressed in which Section of the SMP
	changes anticipated within the life of the SMP;	
m	A cultural impact assessment;	10.5.3
n	A summary of outcomes resulting from any collaboration with Papatipu Rūnanga on SMP development;	MKT advised that the cultural impact assessment was sufficient.
o	An assessment of the effectiveness of water quality or quantity mitigation methods established under previous SMPs and identification of any changes in methods or designs resulting from the assessment;	10.4
p	Assessment and description of any additional or new modelling, monitoring and mitigation methods being implemented by the Consent Holder;	10.2
q	A summary of feedback obtained in accordance with Condition 8 and if / how that feedback has been incorporated into the SMP;	Awaiting feedback from public consultation
r	If the Consent Holder intends to use land not owned or managed by the Consent Holder for stormwater management, a description of the specific consultation undertaken with the affected land owner;	Not applicable; no non-Council land to be used for stormwater management.
s	Identification of key monitoring locations in addition to those identified in Schedule 10 where modelled assessments of water levels and/or volumes shall be made. For all monitoring locations, water level reductions or tolerances for increases shall be set for the critical 2% and 10% AEP events in accordance with the objective and ATLS in Schedule 10 and shall be reported with the model update results required under Condition 55;	No key locations. Flooding is not a factor for CCC control in this SMP
t	Procedures, to be developed in consultation with Christchurch International Airport Limited, for the management of the risk of bird strike for any facility owned or managed by the Christchurch City Council within 3 kilometres of the airport;	11.6.1
u	A description of any relevant options assessments undertaken to identify the drivers behind mitigation measures selected; and	10.7
v	An assessment of the potential change to the overall water balance for the SMP area arising from the	11.6.3

No.	Matters for inclusion in SMPs	Addressed in which Section of the SMP
	change in pervious area and the stormwater management systems proposed.	

Appendix B Sub-catchment Map

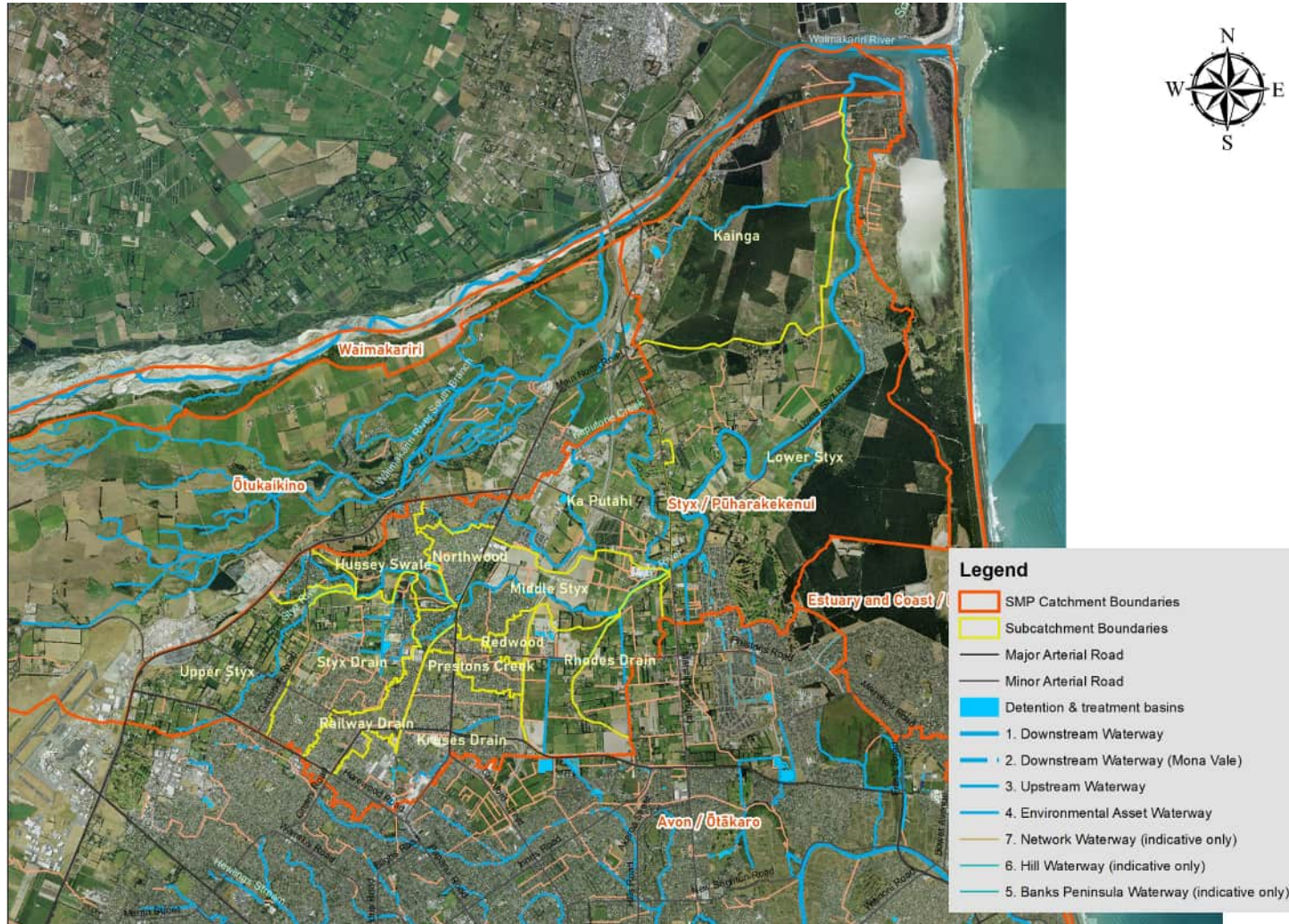


Figure 19: Ōtūkaikino Sub-catchments

Appendix C Basins and Land Contamination

Table 16: Proposed Basins and Land Contamination Information for the Basin Site.

Basin ID	Name & Address	Investigation report	Report Date	Findings	Justification for siting basin
1117, 1118	Gardiners Facility 315 Styx Mill Rd	No HAIL information		No entry in LLUR	No known contamination. Likely no significant contamination. Site will be investigated and remediated if necessary during basin construction.
1111, 1112, 1113, 1114, 1115, 1116	Cavendish basins and wetland 266, 274, 276, 280 Highsted Rd	No HAIL information		No entry in LLUR	No known contamination. Likely no significant contamination. Site will be investigated and remediated if necessary during basin construction.
1093	Works 1 55, 59 Blakes Rd	INV271527 SRAP Prelim. site investigation for ground contamination, Belfast Greenfield Bus. Area		Drain was discharge point for wool scour settling pond. Heavy metals and asbestos fragments in drain.	Basin site previously rural. Site to be investigated as part of consent process.
Private basin	Works 2 (Styx SMP 2013) 75 Belfast Rd			Not investigated	Not applicable
Discontinued	Works 3			Not investigated	Not applicable

Basin ID	Name & Address	Investigation report	Report Date	Findings	Justification for siting basin
basin	(in Styx SMP 2013)				
Private basin	Works 4 (in Styx SMP 2013) 10 Fords Rd			Not investigated	Not applicable
Discontinued basin	Works 5 (in Styx SMP 2013)			Not investigated	
1090, 1091, 1092	Arterial FF, FA, Wetland 88 Blakes Rd	INV2873 Soil contamination report. INV2910 “desk study”		Fmr Freezing Works. Most of site has contaminant concentrations below relevant GVs. Two small hotspots (banks of the Ka Putahi and southern corner of the site to the west of Blakes Road), and the areas of filled ground, all of the pasture areas comply with the residential guidelines	Site to be investigated as part of consent process.
1094, 1095, 1096	Guthries-Thompsons FF, FA, Wetland 42, 48, 62Q Guthries Rd	No HAIL information		Not investigated	Low risk. anticipate that the site will be investigated as part of consent process.
1089	Englefield 46 Englefield Rd	INV331853 PSI		HAIL A10 – persistent pesticide use: historical horticultural activities in the north eastern paddock of the site. • HAIL A17 – storage tanks:	Few other options for basin siting. Potential gains outweigh risks. Site to be investigated as part of consent process and

Basin ID	Name & Address	Investigation report	Report Date	Findings	Justification for siting basin
				<p>hydrocarbon contamination within tank pit from removed USTs.</p> <ul style="list-style-type: none"> • HAIL A18 – treated timber storage outside: the site inspection identified stockpiles of treated timber being stored outside. • HAIL G5 – waste disposal to land: areas of the site have been used for storage, potential burn areas are present across the site and the site inspection identified large volumes of imported fill material. • HAIL Class I – any other land: use of lead-based paint products and asbestos containing materials on several buildings present at the site. 	remediated as necessary.
1081	Mundys Wetland 140, 150, 150R, 170 Radcliffe Rd	INV331853 PSI		As above	The site is the obvious location for basin(s) due to topography. Potential gains outweigh risks. Site to be investigated as part of

Basin ID	Name & Address	Investigation report	Report Date	Findings	Justification for siting basin
					consent process and remediated as necessary.
1082, 1083	Mundys FF & FA basins 120 Radcliffe Rd	INV331853 PSI		As above	As above
1084/5/6	Radcliffe FF & FA basins & wetland 120 Radcliffe Rd	INV331853 PSI		As above	As above
1087/8	Railway FF basin & wetland 470 Main North Rd 480 Main North Rd	INV305466 SRAP INV259141 Assessment of Environmental Effects INV9408 Environmental Site Assessment INV307979 pre-purchase ground contamination assessment	12/12/21 19/06/20 7/12/11 31/05/19	A10 - Persistent pesticide bulk storage or use	Ideal site for basin(s) due to topography and preservation of some natural character. Potential gains outweigh risks. Site to be investigated as part of consent process and remediated as necessary.

FF = first flush (basin)

FA = flood attenuation (i. e. total storm detention basin)

DSI = Detailed site investigation

SRAP = Site remediation action plan

SVR = Site validation report

Appendix D Annual loads in the Christchurch Contaminant Load Model

Rainfall		Auckland	1 m																	
Christchurch		0.6 m																		
Model	Contaminant	Grassland		Roofs								Roads					Paved Surfaces			Construction
		Urban	Rural	Concrete	Galvanised Steel (unpainted)	Galvanised Steel (poorly painted)	Galvanised Steel (well painted)	Decramastic	Color Steel	ZincAlume	Unknown	Private Road	Local Road	Collector	Minor Arterial	Major Arterial	Residential	Commercial	Industrial	
(All loading rates in g/m ² /yr)																				
ARC CLM	TSS	45	21	16	5	5	5	12	5	5	10	21	28	53	96	158	32	32	22	2,500
	Zinc	0.0016	0.0007	0.0200	2.2400	1.3400	0.2000	0.2800	0.0200	0.2000	0.0200	0.0044	0.0266	0.1108	0.2574	0.4711	0.1950	0.0000	0.5900	0.0880
	Copper	0.0003	0.0001	0.0033	0.0003	0.0003	0.0003	0.0017	0.0016	0.0009	0.0020	0.0015	0.0089	0.0369	0.0858	0.1570	0.0360	0.0294	0.1070	0.0180
	TPH											0.0335	0.2013	0.8387	1.9474	3.5645				
CHC CLM	TSS	27	12.6	9.6	3	3	3	7.2	3	3	6	12.6	16.8	31.8	57.6	94.8	19.2	19.2	13.2	1500
	Zinc	0.0016	0.0007	0.0200	2.2400	1.3400	0.2000	0.2800	0.0200	0.2000	0.0200	0.0044	0.0266	0.1108	0.2574	0.4711	0.1950	0.0000	0.5900	0.0880
	Copper	0.0003	0.0001	0.0033	0.0003	0.0003	0.0003	0.0017	0.0016	0.0009	0.0020	0.0015	0.0089	0.0369	0.0858	0.1570	0.0360	0.0294	0.1070	0.0180
	TPH											0.0335	0.2013	0.8387	1.9474	3.5645				

Appendix E C-CLM Treatment Efficiencies

Table 17: Treatment efficiencies used in the C-CLM⁷

Treatment system	TSS treatment efficiency (% removal)				Zinc treatment efficiency (% removal)				Copper treatment efficiency (% removal)			
	Roofs	Roads	Paved Surface	Grassland	Roofs	Roads	Paved Surface	Grassland	Roofs	Roads	Paved Surface	Grassland
Single treatment systems												
Basin & wetland	50.0	80.0	80.0	80.0	25.0	60.0	60.0	60.0	30.0	70.0	70.0	70.0
Rain garden	70.0	80.0	80.0	80.0	60.0	70.0	70.0	70.0	70.0	75.0	75.0	75.0
Stormfilter	50.0	75.0	75.0	75.0	15.0	40.0	40.0	40.0	20.0	65.0	65.0	65.0
Wet pond	10.0	75.0	75.0	75.0	5.0	30.0	30.0	30.0	5.0	40.0	40.0	40.0
Basin	10.0	60.0	60.0	60.0	5.0	20.0	20.0	20.0	5.0	30.0	30.0	30.0
First flush Basin	10.0	60.0	60.0	60.0	5.0	20.0	20.0	20.0	5.0	30.0	30.0	30.0
Wetland	50.0	80.0	80.0	80.0	25.0	60.0	60.0	60.0	30.0	70.0	70.0	70.0
Soil adsorption basin	89.0	89.0	89.0	89.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0
Swale	30.0	75.0	75.0	75.0	15.0	40.0	40.0	40.0	20.0	50.0	50.0	50.0
Combined treatment systems												
Basin and basin & wetland	55.0	92.0	92.0	92.0	28.8	68.0	68.0	68.0	33.5	79.0	79.0	79.0
Basin and First flush basin	19.0	84.0	84.0	84.0	9.8	36.0	36.0	36.0	9.8	51.0	51.0	51.0
Rain garden and basin and wetland	85.0	96.0	96.0	96.0	70.0	88.0	88.0	88.0	79.0	92.5	92.5	92.5
Swale and basin and wetland	65.0	95.0	95.0	95.0	36.3	76.0	76.0	76.0	44.0	85.0	85.0	85.0
Swale and first flush Basin	37.0	90.0	90.0	90.0	19.3	52.0	52.0	52.0	24.0	65.0	65.0	65.0

⁷ The Christchurch Contaminant Load Model is the model presented to the consent hearing and used in this SMP.

Appendix F C-CLM Model Results

Table 18: Christchurch Contaminant Load Model 2018 (C-CLM) results for the Pūharakekenui-Styx catchment

		No treatment			CSNDC Baseline (2018)			5 year (2023) scenario			10 year (2028) scenario			25 year (2043) scenario		
Sub-catchment	Area	TSS no treatmt	Zn no treatmt	Cu no treatmt	TSS in base case	Zn in base case	Cu in base case	TSS in 5 yr case	Zn in 5 yr case	Cu in 5 yr case	TSS in 10 yr case	Zn in 10 yr case	Cu in 10 yr case	TSS in 25 yr case	Zn in 25 yr case	Cu in 25 yr case
	(Ha)				(t/yr)	(kg/yr)	(kg/yr)	(t/yr)	(kg/yr)	(kg/yr)	(t/yr)	(kg/yr)	(kg/yr)	(t/yr)	(kg/yr)	(kg/yr)
Hussey Swale	141	27.3	76.7	10.7	24	69	9	24	69	9	24	69	9	24	69	10
Ka Putahi	497	115.9	671.1	117.9	102	604	99	93	435	66	77	319	43	77	230	32
Kainga	907	185.2	516.7	95.2	163	465	80	163	421	73	164	373	65	154	423	19
Kruses Drain	389	106.8	615.6	92.9	94	554	78	94	551	78	83	477	76	24	246	30
Lower Styx	1781	456.8	230.0	83.3	402	207	70	402	206	70	402	201	70	402	191	72
Middle Styx	274	70.5	164.4	23.8	62	148	20	61	153	20	60	157	21	56	177	24
Northwood	73	2.3	40.0	4.8	2	36	4	2	36	4	2	35	4	2	33	4
Prestons Creek	90	26.1	132.2	16.7	23	119	14	23	120	14	18	113	14	5	45	5
Railway Drain	148	38.6	320.0	41.7	34	288	35	34	287	35	33	278	35	33	215	35
Redwood	118	39.8	62.2	9.5	35	56	8	18	54	7	12	52	6	6	34	4
Rhodes Drain	169	33.0	36.7	3.6	29	33	3	29	33	3	29	31	3	29	25	3

Smacks Creek	57	14.8	31.1	6.0	13	28	5	13	28	5	13	27	5	13	25	5
Styx Drain	343	93.2	366.7	39.3	82	330	33	28	213	13	28	209	13	26	137	13
Upper Styx	380	94.3	322.2	53.6	83	290	45	71	251	39	68	205	28	68	140	25
All Styx	5367	1304.5	3585.5	598.8	1148	3227	503	1055	2857	436	1013	2546	392	919	1990	281
Load Reduction					0	0	0	8.1%	11.5%	13.3%	11.8%	21.1%	22.1%	19.9%	38.3%	44.1%

Appendix G Attribute Target Levels, Schedules 7 to 10

Waterways, Coastal and Groundwater Receiving Environment Attribute Target Levels in Schedules 7 to 10 from Condition 23, Consent CRC214226.

Schedule 7: Receiving Environment Objectives and Attribute Target Levels for Waterways

The EMP outlines the methodology for the monitoring of Attributes and how these will be compared against Attribute Target Levels.

TBC-A = To Be Confirmed once a full year of monitoring allows hardness modified values to be calculated, in accordance with Condition 52.

TBC-B = To Be Confirmed following engagement with Papatipu Rūnanga, through an update to the EMP, in accordance with Condition 54.

Table 19: Waterways, Coastal and Groundwater Receiving Environment Attribute Target Levels

Objective	Attribute	Attribute Target Level	Basis for Target
Adverse effects on ecological values do not occur due to stormwater inputs	QMCI	Lower limit QMCI scores: <ul style="list-style-type: none"> • Spring-fed – plains – urban waterways: 3.5 • Spring-fed – plains waterways: 5 • Banks Peninsula waterways: 5 	QMCI is an indicator of aquatic ecological health, with higher numbers indicative of better quality habitats, due to a higher abundance of more sensitive species. QMCI scores are taken from the guidelines in Table 1a of the LWRP (Canterbury Regional Council, 2018). This metric is designed for wade able sites and should therefore be used with caution for non-wade able sites. These targets can be achieved through reducing contaminant loads and waterway restoration.

Objective	Attribute	Attribute Target Level	Basis for Target
Adverse effects on water clarity and aquatic biota do not occur due to sediment inputs	<p>Fine sediment (<2 mm diameter) percent cover of stream bed</p> <p>TSS concentrations in surface water</p>	<p>Upper limit fine sediment percent cover of stream bed:</p> <ul style="list-style-type: none"> • Spring-fed – plains – urban waterways: 30% • Spring-fed – plains waterways: 20% • Banks Peninsula waterways: 20% <p>Upper limit concentration of TSS in surface water: 25 mg/L</p> <p>No statistically significant increase in TSS concentrations in surface water</p>	<p>Sediment (particularly from construction) can decrease the clarity of the water, and can negatively affect the photosynthesis of plants and therefore primary productivity within streams, interfere with feeding through the smothering of food supply, and can clog suitable habitat for species. The sediment cover Target Levels are taken from the standards for the original Styx and South-West Stormwater Management Plan consents, and are based on Table 1a of the LWRP (Canterbury Regional Council, 2018). These targets should be used with caution at sites that likely naturally have soft-bottom channels. These targets can be achieved through reducing contaminant loads (particularly using erosion and sediment control) and instream sediment removal.</p>
Adverse effects on aquatic biota do not occur due to copper, lead and zinc inputs in surface water	Zinc, copper and lead concentrations in surface water	<p>Upper limit concentration of dissolved zinc:</p> <ul style="list-style-type: none"> • Ōtākaro/ Avon River catchment: 0.0297 mg/L • Ōpāwaho/ Heathcote River catchment: 0.04526 mg/L • Cashmere Stream: 0.00724 mg/L • Huritini / Halswell River catchment: 0.01919 mg/L • Pūharakekenui/ Styx River catchment: 0.01214 mg/L 	<p>These metals can be toxic to aquatic organisms, negatively affecting such things as fecundity, maturation, respiration, physical structure and behavior. The Council has developed these hardness modified trigger values in accordance with the methodology in the 'Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australia and New Zealand' (ANZG, 2018) guidelines, and the species protection level relevant to each waterway in the LWRP (Canterbury Regional Council, 2017). This calculation document can be provided on request.</p> <p>These targets can be achieved primarily through reducing</p>

Objective	Attribute	Attribute Target Level	Basis for Target
		<ul style="list-style-type: none"> • Ōtūkaikino River catchment: 0.00868 mg/L • Linwood Canal: 0.146 mg/L • Banks Peninsula catchments: TBC-A <p>Upper limit concentration of dissolved copper:</p> <ul style="list-style-type: none"> • Ōtākaro/ Avon River catchment: 0.00356 mg/L • Ōpāwaho/ Heathcote River catchment: 0.00543 mg/L • Cashmere Stream: 0.00302 mg/L • Huritini / Halswell River catchment: 0.00336 mg/L • Pūharakekenui/ Styx River catchment: 0.00212 mg/L • Ōtūkaikino River catchment: 0.00152 mg/L • Linwood Canal: 0.0175 mg/L • Banks Peninsula catchments: TBC-A <p>Upper limit concentration of dissolved lead:</p> <ul style="list-style-type: none"> • Ōtākaro/ Avon River catchment: 	contaminant loads.

Objective	Attribute	Attribute Target Level	Basis for Target
		<p>0.01554 mg/L</p> <ul style="list-style-type: none"> • Ōpāwaho/ Heathcote River catchment: 0.02916 mg/L • Cashmere Stream: 0.00521 mg/L • Huritini / Halswell River catchment: 0.01257 mg/L • Pūharakekenui/ Styx River catchment: 0.00634 mg/L • Ōtūkaikino River catchment: 0.00384 mg/L • Linwood Canal: 0.167 mg/L • Banks Peninsula catchments: TBC-A <p>No statistically significant increase in copper, lead and zinc concentrations</p>	
Excessive growth of macrophytes and filamentous algae does not occur due to nutrient inputs	Total macrophyte and filamentous algae (>20 mm length) cover of stream bed	<p>Upper limit total macrophyte cover of the stream bed:</p> <ul style="list-style-type: none"> j. Spring-fed – plains – urban waterways: 60% k. Spring-fed – plains waterways: 50% l. Banks Peninsula waterways: 	Macrophyte and algae cover are indicators of the quality of aquatic habitat. Targets are taken from Table 1a of the LWRP (Canterbury Regional Council, 2018). Improvement towards these targets can be achieved by reduction in nutrient concentrations and riparian planting to shade the waterways.

Objective	Attribute	Attribute Target Level	Basis for Target
		<p style="text-align: center;">30%</p> <p>Upper limit filamentous algae cover of the stream bed:</p> <ul style="list-style-type: none"> • Spring-fed – plains – urban waterways: 30% • Spring-fed – plains waterways: 30% <p>Banks Peninsula waterways: 20%</p>	
Adverse effects on aquatic biota do not occur due to zinc, copper, lead and PAHs in instream sediment	Zinc, copper, lead and PAHs concentrations in instream sediment	<p>Upper limit concentration of total recoverable metals for all classifications:</p> <ul style="list-style-type: none"> • Copper = 65 mg/kg dry weight • Lead = 50 mg/kg dry weight • Zinc = 200 mg/kg dry weight • Total PAHs = 10 mg/kg dry weight <p>No statistically significant increase in copper, lead, zinc and Total PAHs</p>	Meta Metals can bind to sediment and remain in waterways, potentially negatively affecting biota. These trigger values are based on the ANZG guidelines (ANZG, 2018). These targets can be achieved through reducing contaminant loads and instream sediment removal.

Objective	Attribute	Attribute Target Level	Basis for Target
Adverse effects on Mana Whenua values do not occur due to stormwater inputs	Waterway Cultural Health Index and State of Takiwā scores	<p>Lower limit averaged Waterway Cultural Health Index and State of Takiwā scores for all classifications:</p> <ul style="list-style-type: none"> • Spring-fed – plains – urban waterways: TBC-B • Spring-fed – plains waterways: TBC-B • Banks Peninsula waterways: TBC-B 	<p>The Waterway Cultural Health Index assesses cultural values and indicators of environmental health, such as mahinga kai (food gathering). These indices are on a scale of 1 - 5, with higher scores indicative of greater cultural values. No guidelines are available currently for the different types of waterways, so these targets will be developed specifically for this consent, with higher targets for waterways with higher values. These targets can be achieved through reducing contaminant loads and habitat restoration.</p>

Schedule 9: Receiving Environment Objectives and Attribute Target Levels for Groundwater and Springs

The EMP outlines the methodology for the monitoring of Attributes and how these will be compared against Attribute Target Levels

Table 20: Attribute Target Levels for Groundwater and Springs

Objective	Attribute	Attribute Target Level	Basis for Target
Protect drinking water quality	Copper, lead, zinc and <i>Escherichia coli</i> concentrations in drinking water	<p>Concentration to not exceed:</p> <ul style="list-style-type: none"> Dissolved Copper: 0.5 mg/L Dissolved Lead: 0.0025 mg/L Dissolved Zinc: 0.375 mg/L <p>No statistically significant increase in the concentration of <i>Escherichia coli</i> at drinking water supply wells</p>	<p>The most important use of Christchurch groundwater is the supply of the urban reticulated drinking water supply. Contaminants in stormwater that infiltrate into the ground could impact on the quality of water supply wells and/or springs. The compliance criteria for a potable and wholesome water supply are specified in the Drinking Water Standards for New Zealand 2005 (Revised 2008). Metals and <i>E. coli</i> were chosen for these targets, as these are contaminants present in stormwater. The target values for copper and lead are a quarter of the Maximum Acceptable Value (MAV) or Guideline Value (GV) taken from the Drinking Water Standards for New Zealand 2005 (revised 2008). This is to ensure investigations occur before the water quality limits in the LWRP are exceeded, which are that concentrations are not to exceed 50% of the MAV. An equivalent criteria has also been applied to the zinc target, which is not included in the LWRP water quality limits, but has a guideline in the drinking water standards.</p>
Avoid widespread adverse effects on shallow groundwater quality	Electrical conductivity in groundwater	<ul style="list-style-type: none"> No statistically significant increase in electrical conductivity 	<p>Contaminants in stormwater that infiltrate into the ground could impact on groundwater quality. Long term groundwater quality at monitoring wells is undertaken by Canterbury Regional Council. Those monitoring points that occur within the urban area could be impacted by Council stormwater management activities. Electrical conductivity is to be used as an indicator for identifying any general changes in groundwater quality related to recharge.</p>

Appendix H Consent targets: schedules 7 to 10

Waterways, Coastal and Groundwater Receiving Environment Attribute Target Levels in Schedules 7 to 10 from Condition 23, Consent CRC231955.

Schedule 7: Receiving Environment Objectives and Attribute Target Levels for Waterways

The EMP outlines the methodology for the monitoring of Attributes and how these will be compared against Attribute Target Levels.

TBC-A = To Be Confirmed once a full year of monitoring allows hardness modified values to be calculated, in accordance with Condition 52.

TBC-B = To Be Confirmed following engagement with Papatipu Rūnanga, through an update to the EMP, in accordance with Condition 54.

Objective	Attribute	Attribute Target Level	Basis for Target
Adverse effects on ecological values do not occur due to stormwater inputs	QMCI	Lower limit QMCI scores: Spring-fed – plains – urban waterways: 3.5 Spring-fed – plains waterways: 5 Banks Peninsula waterways: 5	QMCI is an indicator of aquatic ecological health, with higher numbers indicative of better quality habitats, due to a higher abundance of more sensitive species. QMCI scores are taken from the guidelines in Table 1a of the LWRP (Canterbury Regional Council, 2018). This metric is designed for wade able sites and should therefore be used with caution for non-wade able sites. These targets can be achieved through reducing contaminant loads and waterway restoration.

<p>Adverse effects on water clarity and aquatic biota do not occur due to sediment inputs</p>	<p>Fine sediment (<2 mm diameter) percent cover of stream bed</p> <p>TSS concentrations in surface water</p>	<p>Upper limit fine sediment percent cover of stream bed:</p> <p>Spring-fed – plains – urban waterways: 30%</p> <p>Spring-fed – plains waterways: 20%</p> <p>Banks Peninsula waterways: 20%</p> <p>Upper limit concentration of TSS in surface water: 25 mg/L</p> <p>No statistically significant increase in TSS concentrations in surface water</p>	<p>Sediment (particularly from construction) can decrease the clarity of the water, and can negatively affect the photosynthesis of plants and therefore primary productivity within streams, interfere with feeding through the smothering of food supply, and can clog suitable habitat for species. The sediment cover Target Levels are taken from the standards for the original Styx and South-West Stormwater Management Plan consents, and are based on Table 1a of the LWRP (Canterbury Regional Council, 2018). These targets should be used with caution at sites that likely naturally have soft-bottom channels. These targets can be achieved through reducing contaminant loads (particularly using erosion and sediment control) and instream sediment removal.</p>
<p>Adverse effects on aquatic biota do not occur due to copper, lead and zinc inputs in surface water</p>	<p>Zinc, copper and lead concentrations in surface water</p>	<p>Upper limit concentration of dissolved zinc:</p> <p>Ōtākaro/ Avon River catchment: 0.0297 mg/L</p> <p>Ōpāwaho/ Heathcote River catchment: 0.04526 mg/L</p> <p>Cashmere Stream: 0.00724 mg/L</p> <p>Huritini / Halswell River catchment: 0.01919 mg/L</p> <p>Pūharakekenui/ Styx River catchment: 0.01214 mg/L</p> <p>Ōtūkaikino River catchment: 0.00868 mg/L</p> <p>Linwood Canal: 0.146 mg/L</p> <p>Banks Peninsula catchments: TBC-A</p>	<p>These metals can be toxic to aquatic organisms, negatively affecting such things as fecundity, maturation, respiration, physical structure and behavior. The Council has developed these hardness modified trigger values in accordance with the methodology in the ‘Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australia and New Zealand’ (ANZG, 2018) guidelines, and the species protection level relevant to each waterway in the LWRP (Canterbury Regional Council, 2017). This calculation document can be provided on request.</p> <p>These targets can be achieved primarily through reducing contaminant loads.</p>

		<p>Upper limit concentration of dissolved copper:</p> <p>Ōtākaro/ Avon River catchment: 0.00356 mg/L</p> <p>Ōpāwaho/ Heathcote River catchment: 0.00543 mg/L</p> <p>Cashmere Stream: 0.00302 mg/L</p> <p>Huritini / Halswell River catchment: 0.00336 mg/L</p> <p>Pūharakekenui/ Styx River catchment: 0.00212 mg/L</p> <p>Ōtūkaikino River catchment: 0.00152 mg/L</p> <p>Linwood Canal: 0.0175 mg/L</p> <p>Banks Peninsula catchments: TBC-A</p>	
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Objective	Attribute	Attribute Target Level	Basis for Target
		<p>Upper limit concentration of dissolved lead:</p> <p>Ōtākaro/ Avon River catchment: 0.01554 mg/L</p> <p>Ōpāwaho/ Heathcote River catchment: 0.02916 mg/L</p> <p>Cashmere Stream: 0.00521 mg/L</p> <p>Huritini / Halswell River catchment: 0.01257 mg/L</p> <p>Pūharakekenui/ Styx River catchment: 0.00634 mg/L</p> <p>Ōtūkaikino River catchment: 0.00384 mg/L</p> <p>Linwood Canal: 0.167 mg/L</p> <p>Banks Peninsula catchments: TBC-A</p> <p>No statistically significant increase in copper, lead and zinc concentrations</p>	
Excessive growth of macrophytes and filamentous algae does not occur due to nutrient inputs	Total macrophyte and filamentous algae (>20 mm length) cover of stream bed	<p>Upper limit total macrophyte cover of the stream bed:</p> <p>Spring-fed – plains – urban waterways: 60%</p> <p>Spring-fed – plains waterways: 50%</p> <p>Banks Peninsula waterways: 30%</p>	Macrophyte and algae cover are indicators of the quality of aquatic habitat. Targets are taken from Table 1a of the LWRP (Canterbury Regional Council, 2018). Improvement towards these targets can be achieved by reduction in nutrient concentrations and riparian planting to shade the waterways.

		<p>Upper limit filamentous algae cover of the stream bed:</p> <p>Spring-fed – plains – urban waterways: 30%</p> <p>Spring-fed – plains waterways: 30%</p> <p>Banks Peninsula waterways: 20%</p>	
Adverse effects on aquatic biota do not occur due to zinc, copper, lead and PAHs in instream sediment	Zinc, copper, lead and PAHs concentrations in instream sediment	<p>Upper limit concentration of total recoverable metals for all classifications:</p> <p>Copper = 65 mg/kg dry weight</p> <p>Lead = 50 mg/kg dry weight</p> <p>Zinc = 200 mg/kg dry weight</p> <p>Total PAHs = 10 mg/kg dry weight</p> <p>No statistically significant increase in copper, lead, zinc and Total PAHs</p>	Metals can bind to sediment and remain in waterways, potentially negatively affecting biota. These trigger values are based on the ANZG guidelines (ANZG, 2018). These targets can be achieved through reducing contaminant loads and instream sediment removal.
Adverse effects on Mana Whenua values do not occur due to stormwater inputs	Waterway Cultural Health Index and State of Takiwā scores	<p>Lower limit averaged Waterway Cultural Health Index and State of Takiwā scores for all classifications:</p> <p>Spring-fed – plains – urban waterways: TBC-B</p> <p>Spring-fed – plains waterways: TBC-B Banks Peninsula waterways: TBC-B</p>	The Waterway Cultural Health Index assesses cultural values and indicators of environmental health, such as mahinga kai (food gathering). These indices are on a scale of 1 - 5, with higher scores indicative of greater cultural values. No guidelines are available currently for the different types of waterways, so these targets will be developed specifically for this consent, with higher targets for waterways with higher values. These targets can be achieved through reducing contaminant loads and habitat restoration.

Objective	Attribute	Attribute Target Level	Basis for Target
Adverse effects on Mana Whenua values do not occur due to stormwater inputs	Waterway Cultural Health Index and State of Takiwā scores	<p>Lower limit averaged Waterway Cultural Health Index and State of Takiwā scores for all classifications:</p> <p>Spring-fed – plains – urban waterways: TBC-B</p> <p>Spring-fed – plains waterways: TBC-B Banks Peninsula waterways: TBC-B</p>	<p>The Waterway Cultural Health Index assesses cultural values and indicators of environmental health, such as mahinga kai (food gathering). These indices are on a scale of 1 - 5, with higher scores indicative of greater cultural values. No guidelines are available currently for the different types of waterways, so these targets will be developed specifically for this consent, with higher targets for waterways with higher values. These targets can be achieved through reducing contaminant loads and habitat restoration.</p>

Schedule 9: Receiving Environment Objectives and Attribute Target Levels for Groundwater and Springs

The EMP outlines the methodology for the monitoring of Attributes and how these will be compared against Attribute Target Levels

Objective	Attribute	Attribute Target Level	Basis for Target
Protect drinking water quality	Copper, lead, zinc and Escherichia coli concentrations in drinking water	<p>Concentration to not exceed:</p> <p>Dissolved Copper: 0.5 mg/L</p> <p>Dissolved Lead: 0.0025 mg/L</p> <p>Dissolved Zinc: 0.375 mg/L</p> <p>No statistically significant increase in the concentration of Escherichia coli at drinking water supply wells</p>	<p>The most important use of Christchurch groundwater is the supply of the urban reticulated drinking water supply. Contaminants in stormwater that infiltrate into the ground could impact on the quality of water supply wells and/or springs. The compliance criteria for a potable and wholesome water supply are specified in the Drinking Water Standards for New Zealand 2005 (Revised 2008). Metals and E. coli were chosen for these targets, as these are contaminants present in stormwater. The target values for copper and lead are a quarter of the Maximum Acceptable Value (MAV) or Guideline Value (GV) taken from the Drinking Water Standards for New Zealand 2005 (revised 2008). This is to ensure investigations occur before the water quality limits in the LWRP are exceeded, which are that concentrations are not to exceed 50% of the MAV. An equivalent criteria has also been applied to the zinc target, which is not included in the LWRP water quality limits, but has a guideline in the drinking water standards.</p>
Avoid widespread adverse effects on shallow groundwater quality	Electrical conductivity in groundwater	No statistically significant increase in electrical conductivity	<p>Contaminants in stormwater that infiltrate into the ground could impact on groundwater quality. Long term groundwater quality at monitoring wells is undertaken by Canterbury Regional Council. Those monitoring points that occur within the urban area could be impacted by Council stormwater management activities. Electrical conductivity is to be used as an indicator for identifying any general changes in groundwater quality related to recharge.</p>

Schedule 10: Receiving Environment Attribute Target Levels for Water Quantity

MODELLED CATCHMENTS				
Objective for the management of stormwater quantity:				
To mitigate the risk of inundation, damage to downstream property or infrastructure or human safety through management of stormwater run-off volumes and peak flows. The extent of mitigation shall be assessed against the achievement of attribute target levels for each receiving environment.				
Attribute Target Level:				
Modelled flood levels for the relevant AEP for the assessment year critical duration event shall not increase more than the Maximum Increase listed below when compared to the same modelled AEP for the baseline year impervious scenario critical duration, as determined using CCC flood models. The baseline year scenario and assessment year scenario shall be identical except for changes to the impervious area, mitigation measures and the inclusion of any new network(s) that has arisen between the dates of the two scenarios and within the city limits. All non-variant scenario parameters shall be as at the assessment year scenario. The critical duration shall be assessed at the monitoring location of the attribute target level. Non-variant scenario parameters include, but are not limited to, channel cross-sections, roughness and floodplain shape. Prior to undertaking the assessment the appropriateness of the non-variant scenario parameters shall be assessed and updated if necessary.				
WATER LEVEL REDUCTIONS OR TOLERANCES FOR INCREASES				
Receiving Environment	Monitoring Location	Baseline Year	AEP	Maximum Increase (mm)
Ōtākaro-Avon River	Gloucester Street Bridge	2014	2%	50
Pūharakekenui-Styx	Harbour Road Bridge	2012	2%	100
Ōpāwaho-Heathcote	Ferniehurst Street	1991	2%	30
Huritini-Halswell River	Minsons Drain confluence*	2016	2%	0
NON-MODELLED CATCHMENTS				
Receiving Environment	Attribute Target Level	Basis for Target		Notes
	Discharges from all new greenfield development into the Christchurch City Council network are mitigated using the "Partial Detention" strategy outlined in the Pūharakekenui-Styx SMP until such time as a monitoring location can be set during review of the SMP.	As measured through the CCC discharge authorisation compliance process for Resource and Building Consents until such time as a baseline Year can be set during review of the SMP.		CCC has just begun monitoring the Ōtukaikino at Dickeys Road Bridge. Council does not currently model flooding in the Ōtukaikino River. Flooding occurs primarily due to backwater effects in the Waimakariri River. Therefore, a best practice approach to mitigation of development will be implemented until such time as a Maximum Increase can be set during review of the SMP.

Appendix I Guidelines for Bird Strike Management

Bird Strike Management In Stormwater Basin/Water Body Design

Purpose of Design Guidelines

Bird strike is defined in the Christchurch District Plan as when a bird or flock of birds collide with an aircraft and is a key threat to the safe operation of Christchurch International Airport. It is of particular concern throughout the Ōtūkaikino catchment, which lies immediately to the north of the main Christchurch Airport runway. Bird strike is a significant safety risk which requires diligent management and collaboration between Christchurch International Airport Ltd (CIAL/ the airport), local government and surrounding landowners.

Strategies for reducing the risk of strikes at the airport focus on managing wildlife populations on and surrounding the airport. There are provisions in the District Plan addressing issues arising out of incompatible land uses relating to the avoidance of bird strike risk introduced in Chapter 6, Section [6.7 Aircraft Protection](#), supported by Policy 6.7.2.1.2. Section 6.7.4.3 Activity status tables – Bird strike Management Areas outlines activities and specific standards aimed at managing the establishment of new land uses such as water bodies and stormwater basins that might provide new and additional habitat that is attractive to birds, such that it may increase the movement of birds across flight paths. Appendix [6.11.7.5](#) outlines controls related to water bodies and stormwater basins within the 3km radius, however considerations for bird strike must also be taken into account up to 13km from the airport runway thresholds, in collaboration with CIAL.

Parameters

Bird strike risk can be avoided or minimised appropriately using best practice guidance provided below, in the District Plan, in collaboration with CIAL⁸

Bird use of stormwater management basins are similar to those of natural water bodies. Parameters to minimise bird strike are similar for both basins and water bodies, and include minimising facility surface area as much as practicable, and design considerations such as:

- maximisation of drainage to avoid standing water,
- increased bank gradients to deter bird nesting,
- avoidance of permanent island features which can provide perching sites for birds,
- appropriate landscape design considering perimeter plant species selection and densities (diagrammed in Figure 20 below).

Ongoing bird strike risk management also extends beyond design and implementation to water body or basin operations, maintenance and/or monitoring.

The risk of bird strike will vary from site to site and may be influenced by factors such as proximity to the airport, the flight patterns of specific bird species, surrounding land uses and natural factors such as season, species ecology, and landscape features.

⁸ Rules in the District Plan specifically control the creation of new stormwater basins or water bodies within identified Birdstrike Management Areas (i.e., Rule [6.7.4.3.1](#) Activity P3). Other plan provisions also deal with bird strike, and are generally referenced in Section 11.6.2 of this management plan.

Some general guidelines for design of stormwater basins / water bodies to minimise the risk of bird strike are shown in

Figure 18. Specific implementation of these guidelines will vary on a site-by-site basis and should be undertaken in consultation with CIAL and on receipt of ornithologist advice.

Additional guidelines are:

1. Minimising open water and vegetative cover that provides food, shelter or roosting for birds are the primary habitat features of focus for bird risk management near the airport.

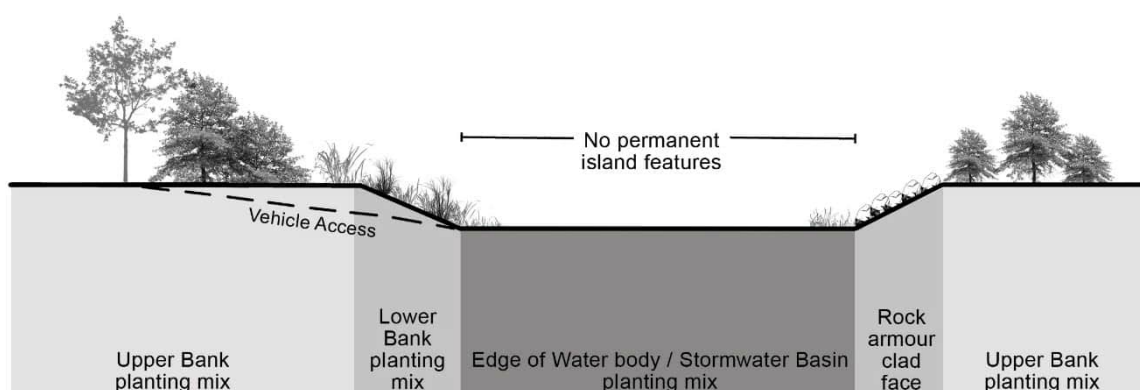


Figure 20: Typical Basin Section

2. Landscape planting plans must limit the attractiveness of basins to birds using suitable non-attracting plant species. Vegetation with berries, nuts, desirable forage, attractive flowers, edible tubers or roots, or large, abundant or high-nutrient seeds should be avoided as a potential wildlife attractant. In general, using low diversity planting strategies and avoiding high-nutrient organic soil amendment (which can attract invertebrates that attract certain birds) is important. Plant species should be limited to those listed in Table 21 (and Appendix 6.11.9 of the District Plan).

Table 21: Plant Species for Water Bodies /Stormwater Basins in the Ōtūkaikino Catchment

Edge of Water body / Stormwater basin	
Botanical name	Common name
<i>Schoenoplectus validus / tabernaemontani</i>	lake club rush / kapungawha
<i>Eleocharis acuta</i>	spike sedge
<i>Carex germinata</i>	makura
<i>Schoenus pauciflorus</i>	bog rush
<i>Polystichum vestitum</i>	prickly shield fern
<i>Juncus pallidus</i>	tussock rush / wiwi
<i>Cyperus ustulatus</i>	umbrella sedge
Lower Bank	
Botanical name	Common name

<i>Anemanthele lessoniana</i>	wind grass
<i>Astelia fragrans</i>	bush lily / kakaha
<i>Coprosma propinqua</i>	mikimiki
<i>Dianella nigra</i>	ink berry / turutu
<i>Plagianthus divaricatus</i>	swamp ribbonwood
Upper Bank	
Botanical name	Common name
<i>Aristotelia serrata</i>	makomako / wineberry
<i>Carpodetus serratus</i>	marbleleaf / putaputaweta
<i>Coprosma rotundifolia</i>	roundleaved coprosma
<i>Dodonea viscosa (frost tender)</i>	akeake
<i>Eleocarpus hookerianus</i>	pokaka
<i>Griselinia littoralis</i>	kapuka / broadleaf
<i>Hebe salicifolia</i>	koromiko
<i>Hoheria angustifolia</i>	narrow leaved lacebark
<i>Kunzea ericoides</i>	kanuka
<i>Leptospermum scoparium</i>	manuka
<i>Lophomyrtus obcordata</i>	rohutu / NZ myrtle
<i>Myrsine australis</i>	mapou
<i>Myrsine divaricata</i>	weeping mapou
<i>Pittosporum eugenioides</i>	lemonwood
<i>Pittosporum tenuifolium</i>	matipo
<i>Plagianthus regius</i>	lowland ribbonwood
<i>Podocarpus totara</i>	totara
<i>Prumnopitys taxifolia</i>	matai
<i>Pseudowintera colorata</i>	peppertree
<i>Sophora microphylla</i>	kowhai

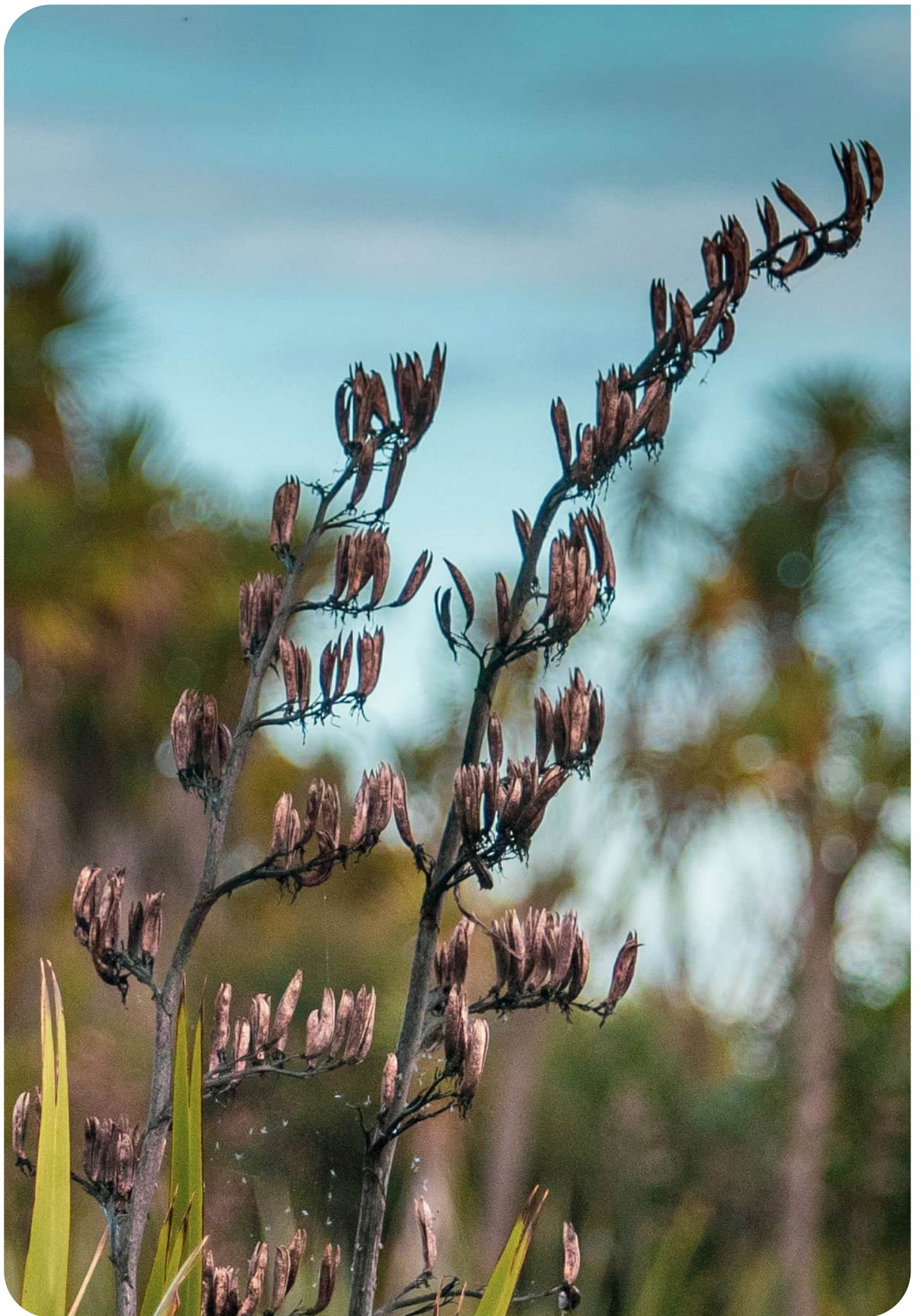
3. High risk bird species of particular concern to aircraft bird strike are summarised in Table 22. Flexibility or adaptability is needed as birds may modify their behaviour in response to installation of new stormwater facilities in ways that were not anticipated during design, resulting in an aviation safety problem. Continued collaboration between stormwater facility designers and CIAL is recommended.

Table 22: Bird Species Causing Particular Risk of Bird Strike (Dr. Leigh Bull, 2021)

Bird Species	Habitat Characteristics
Southern black-backed gull (<i>Larus dominicanus</i>)	Found in most habitats. Colonies can occur on islands, steep headlands, sand, or shingle spits or on islands in shingle riverbeds.
Canada goose (<i>Branta canadensis</i>)	Graze on pasture, young crops, and aquatic plants. Prefer pastoral land adjacent to a lake or large pond.
Feral pigeon/ Rock pigeon (<i>Columba livia</i>)	Variety of habitats. Roost and nest in buildings, under bridges/wharves, and on ledges of cliffs and caves. Occupy open habitats, usually near water (e.g. riverbeds, sea and lake shores, agricultural pasture, and urban parklands).
Spur-winged plover (<i>Vanellus miles</i>)	Move in response to availability of wetlands. Use temporary and recently constructed artificial wetlands, and leave a drying wetland or diminished food supply.

Stormwater basin designers should make early contact with CIAL for referral to an ornithologist familiar with aviation operations.





Pūharakekenui-Styx Catchment Stormwater Management Plan

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