Ōpāwaho
Heathcote River

Draft Stormwater Management Plan 2021

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Christchurch
City Council

Ōpāwaho / Heathcote River

Stormwater
Management Plan

Draft for consultation

Three Waters & Waste Unit
Christchurch City Council

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Cover photo: Ōpāwaho/Heathcote River opposite Princess Margaret Hospital

List of Acronyms

Acronym	Definition
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average recurrence interval
BPO	Best Practicable Option
CCC	Christchurch City Council
CHI	Cultural Health Index
CLM	Contaminant Load Model
ColourSteel(G)	A generic term for painted, zinc/aluminium coated, corrugated steel roofing
CSNDC	Comprehensive Stormwater Network Discharge Consent 2019
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
IPCC	Intergovernmental Panel on Climate Change
ISQG	Interim Sediment Quality Guidelines
LDRP	Land Drainage Recovery Programme
LLUR	Listed Land Use Register
LTP	Long Term Plan
LWRP	Land and Water Regional Plan
ppb	parts per billion
PAH	Polycyclic Aromatic Hydrocarbon
QMCI	Quantitative Macroinvertebrate Community Index
RL	Reduced Level (CCC Datum)
RMA	Resource Management Act
SMP	Stormwater Management Plan

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1. Executive Summary

Water quality and ecological health in the Ōpāwaho / Heathcote River and tributaries have declined as a result of urban development. Contaminants of concern to waterways include copper, sediment and zinc. Metals in stormwater can harm many instream species, sediment smothers habitat for biota and can be anoxic or contaminated. The ecological health of most waterways in this catchment is classified as poor.

The cultural health of the Ōpāwaho catchment is also poor. Food gathering sites contain high levels of pollution and are deemed unsafe for food gathering and in some cases unsafe for swimming. Other indicators of cultural degradation and modification are also widespread. Low scores for indigenous vegetation diversity and cover are commonplace, and coastal and estuarine sites typically contain limited native vegetation in the riparian zone, which is often dominated by exotic species.

River-side roads experience regular flooding and low lying houses can be flooded in large events. Land level changes during the 2010/11 earthquakes increased the flooding vulnerability of many properties, some of them distant from the river. Significant urban growth in the upper catchment will generate more and faster stormwater runoff unless it is controlled.

The Christchurch City Council has developed a Stormwater Management Plan (SMP) for the Ōpāwaho / Heathcote River to comply with conditions of the Comprehensive Stormwater Network Discharge Consent 2019. The goal of the Consent is progressive stormwater improvement. Part of the task of progressive stormwater improvement will occur through the SMP and part will be effected through a future Surface Water Strategic Plan (SWSP) c2021. This is because funding for some stormwater improvements cannot be confirmed in time for the delivery of the SMP, but will occur later through the statutory processes of the Long Term Plan.

In combination the SMP and SWSP will set out methods the Council will implement to progressively improve stormwater toward meeting standards and receiving environment targets in the consent. Mitigation strategies have been considered for contaminants that regularly exceed water quality targets and cause poor stream health, principally metals and sediment. Also, a flooding mitigation plan commenced in 2015 through the Land Drainage Recovery Programme is substantially complete.

The preferred strategy for the future is that the Council prioritise the control of contaminants at source. This should principally occur through education and regulation. Capture and treatment of contaminants (where necessary) will be implemented as close to source as practicable and operational methods such as street sweeping will be used in situations where they can be effective.

Stormwater treatment systems and operational activities will play a part in water treatment, depending on the outcome of efficiency investigations. Stormwater detention basins will continue to have a dual role in improving water quality and slowing urban runoff. Planning measures, source control techniques, education and enforcement also need to be part of an integrated strategy.

Under the SMP the Council will:

- Continue to build or require facilities to mitigate the quality and quantity effects of urban development.

- Ensure the quality of stormwater from all new development sites or re-development sites is treated to best practice, and control sediment from consented construction activities

- Consult with key stakeholders to identify a long term zinc strategy consistent with current technologies.

- Collaborate with local and regional government in a joint approach to central government seeking national measures and industry standards to reduce the discharge of building and vehicle contaminants.

- Investigate the feasibility of a District Plan rule to discourage the use of copper and zinc claddings.

The SMP programme will contribute over time, with other strategies, toward delivering on Ngāi Tahu and Regional Plan objectives by stopping some contaminants from entering rivers and streams. However waterway restoration, sediment removal and riparian planting (for temperature control, bank stability, shading, ecological habitat and recreational uses) also need to occur to create a healthy environment.

The floodplain management strategy continues to prioritise the mitigation of growth effects and the avoidance of damage through elevating new floor levels. Stormwater detention basins will also continue to be built to mitigate growth effects.

Figure 1: Milns Wetlands

Section One

Plan Initiation

2. Background to the Stormwater Management Plan

2.1. Purpose and Scope

The purpose of an 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 (SMPs) set out the means by which the Council will comply with the conditions in the CSNDC. However due to governance processes the SMP can not address all environmental improvement targets signalled in the consent. 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 do not permit this SMP to commit to unfunded, new initiatives to achieve aspirational targets.

The Council proposes to respond to the CSNDC by adding a second stream of improvement planning:

COMPLIANCE STREAM	***IMPROVEMENT STREAM***
Comprehensive Stormwater Network Discharge Consent (standards and targets)	Integrated Water Strategy 2019 (aspirations, improvements)
⇩	⇩
Stormwater Management Plan	**Surface Water Improvement Plan** (anticipated delivery end of 2021)
⇩	⇩
A plan to meet standards and targets set by consent conditions to limit contaminant discharges into waterways	A plan identifying best practicable options to deliver at-source contaminant control and desired improvements in ecology and stream health over the long term.
⇩	⇩

Both plans inform and are funded through the **Long Term Plan**

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 from urban growth, technology, lifestyle, climate, etc on water quality and quantity.

4 Devise a suite of measures (including planning, education, enforcement, source control, etc as funded in the LTP) to control or mitigate effects.

5 Confirm the effectiveness of chosen mitigation measures through contaminant load and flood modelling.

The Surface Water Strategic Plan process includes:

6 Prepare a plan that will permit the CCC to meet or exceed consent condition targets.

7 Engage with Council teams and external stakeholders responsible for contaminant generating activities; obtain agreement about control measures.

2.2. Areal Extent of this SMP

This Stormwater Management Plan is one of seven plans being prepared over the period 2020 to 2023 for the Ōpāwaho / Heathcote, Huritini/Halswell, Pūharakekenui/Styx, Ōtākaro/Avon, Ihūtai/Estuary and Coastal, and Ōtukaikino catchments and Te Pātaka-o-Rākaihautū/Banks Peninsula settlements.

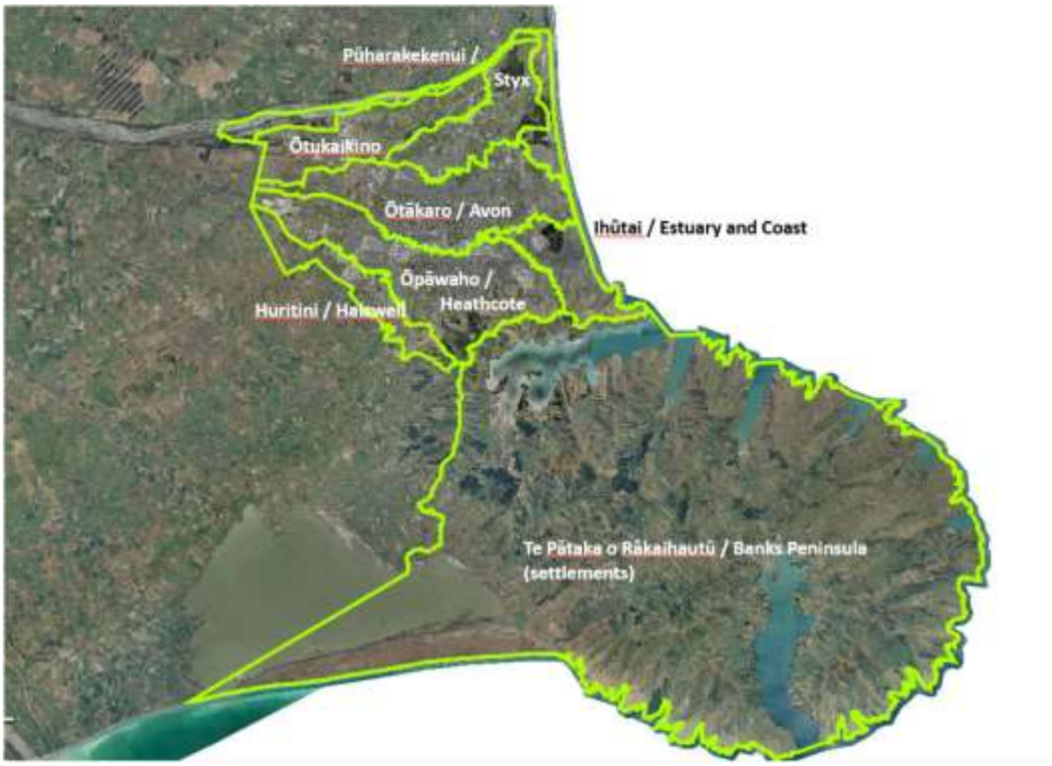

Figure 2: Area covered by the Comprehensive Stormwater Network Discharge Consent

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 an SMP will be developed to show how a local authority will meet the relevant policy on water quality (Policy 4.16).

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 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. Non-Statutory Documents

- Integrated Water Strategy 2019
- Surface Water Strategic Plan 2021 (to be developed)
- Mahaanui Iwi Management Plan 2013
- Ngai Tahu Freshwater Policy Statement (Te Runanga 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)
- Greater Christchurch Urban Development Strategy (UDS) (Christchurch City Council 2007)

2.4. The Council's Strategic Objective for Water

The Christchurch City Council has adopted Community Outcomes to promote community wellbeing. The water outcome Healthy Environment includes:

Healthy water bodies	"Surface water quality is essential for supporting ecosystems, recreation, cultural values and the health of residents."

2.5. 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 birdstrike 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.

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 (ESC) Plan. An ESC Plan is submitted and approved with a consent application and its implementation is verified by building consent officers.

2.6. Bylaws

A reviewed Stormwater Bylaw (in preparation) 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. Minimum standards will be specified for discharge of selected contaminants into the stormwater network. Other minimum standards can be applied by resolution of the Council.

2.7. 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 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) …"

2.8. 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)". (Iwi Mgmt Plan) The Ōpāwaho/Heathcote SMP acknowledges the Iwi Management Plan policies, and can contribute to policies which fall within the scope of a stormwater management plan. There is more detail in section 10.3.

2.9. 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 (5.2.3 Four Purposes)

Figure 3: Treatment basin, Hayton Stream

2.10. Goals and Objectives for Surface Water Management

The *Ōpāwaho/Heathcote Stormwater Management Plan* and the *Surface Water Strategic Plan* will together be consistent with the *Integrated Water Strategy 2019* which identifies overall goals and objectives for surface water management. Jointly these plans will supportso far as is practicable the *Mahaanui Iwi Management Plan* objectives for the Ihūtai/Avon-Heathcote Estuary catchment (see Jolly et al, 2013).

The Council's high-level goals in the integrated water strategy are to:

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

Goal 4: Water is managed in a sustainable and integrated way in line with the principle of kaitiakatanga

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) lists objectives for the Ihūtai catchment that are directly relevant to the Heathcote SMP. These are:

4) Discharges of wastewater and stormwater to waterways in the urban environment are eliminated, and a culturally appropriate alternative to the discharge of urban wastewater to the sea is developed.
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 for both spring-fed urban plains and hill waterways, based on *Land and Water Regional Plan* targets. The success of the Ōpāwaho/Heathcote SMP can be measured against LWRP guidelines for macroinvertebrate indices, macrophytes, periphyton, siltation and a range of water quality parameters.

The SMP and SWSP will contribute toward delivery on these objectives through improving water quality in the rivers and streams, restoring some riparian margins, and protecting and restoring springs and mahinga kai sites. Other CCC programmes will also need to play their part in delivering 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 on the Ōpawāho/Heathcote catchment that have informed the SMP include:

- State of the Takiwā;
- Surface water and sediment quality monitoring;
- Contaminated sites database (ECan);
- Groundwater and springs study;
- Ecological survey;

- Review of flood management matters through the various chapters of the District Plan.
- Contaminant load model;

The stormwater management plan provides a direction for surface water management for the duration of the Comprehensive Stormwater Network Discharge Consent. Water quality has been the primary focus of the investigations and reports. Flooding, particularly in areas where potential flood damage has increased as a consequence of land movement during the earthquakes, is being investigated in detail through the Land Drainage Recovery Plan (LDRP). The LDRP Programme is discussed further in section 9.8   Water quantity (and quality) effects of new growth and urban intensification falls under the SMP, however.

To make a difference to the existing fair to poor water quality in receiving waters, it will be necessary to not only mitigate any adverse effects from new urban growth, but also implement stormwater quality mitigation measures in existing developed areas.

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3. Principal Issues

3.1. Water Quality and Ecological Health

Water quality and ecological health have declined greatly during 160 years of urban development. Metals in stormwater can harm many instream species, sediment smothers habitat for biota and can be anoxic or contaminated, and *E. coli* poses a risk to human health during contact recreation.

Failure to meet indicator values in the LWRP for urban spring-fed plains rivers is reported in water quality, sediment quality and ecological surveys carried out for the SMP (Section 5). Contaminants of concern include sediment, zinc, copper and *E. coli* (an indicator of faecal contamination). Suspended sediment, zinc and copper levels are high especially during wet weather. Elevated levels of the nutrients nitrogen and phosphorus, which are partially derived from sources other than stormwater, can result in excessive aquatic weed growth.

The contaminants of concern at the levels recorded have an adverse effect on biota, result in excessive aquatic weed growth, or pose a risk to contact recreation, depending on the contaminant. The issue for the SMP is how to reverse the decline in surface water quality and ecological health of waterways in the Ōpāwaho/Heathcote catchment despite continuing urban development.

3.2. Flood Risk

River-side roads experience regular flooding and low lying houses can be flooded in large events. Land subsidence during the 2010/11 earthquakes increased the flooding vulnerability of many properties, some of them distant from the river. Significant urban growth in the upper catchment will generate more and faster stormwater runoff which must be controlled.

Impacts of the earthquakes on increasing vulnerability to flooding have been investigated through the Land Drainage Recovery Programme with the aim of returning the flooding risk to houses to levels that existed before the earthquakes. A floodplain and river model continues to be developed to improve understanding of the risks to houses on the floodplain. The model will better represent the effects of sea levels rise over the SMP planning period.

Figure 4: Flooding, likely near Eastern Terrace, 1970s

Section Two

The Catchment

4. Catchment Description

4.1. Overview

The catchment of the Ōpāwaho/Heathcote River is 10,230 hectares in area comprising 70% plains and 30% Port Hills. The waterway network is somewhat sparse because the upper catchment is permeable and flat, and the climate is dry.

The headwaters of the Ōpāwaho/Heathcote River are Paparua Stream in the Hei Hei area, , and Cashmere Stream. Paparua Stream stream was probably fed from spring flows at one time, but groundwater is no longer high enough for this to occur. Paparua Stream now receives the terminal flow from a water race at Delamain Drive. During dry weather Cashmere Stream is fed by springs in the Sutherlands Road area.

4.2. Geography

The river (Figure 4) skirts the Port Hills for much of its length. It was formed by flood spillage and sediment deposition originating from from the Waimakariri River during plains-building episodes. Occasional (Waimakariri) flood spillage through the Islington Channel helped to flush away loess deposits washed from the hills that might otherwise have built extensive fans. It seems likely that the narrow river corridor is explained by preferential deposition of incoming sediment on the north bank of the river.

The Port Hills, which consist of basalt lava and agglomerate, form the northern rim of a volcanic crater centred in Lyttelton Harbour. The Hills rise from sea level to 500 m with the greater part of the summit rim over 400 m. Northern slopes are disected into steep-sided valleys though the streams are small and only flow intermittently. Stream divides are narrow at high levels but below 300 m they broaden into smooth rolling spurs. Valley heads are steep and rocky but at low levels the valley sides are short and broken by basalt bluffs. Runoff from the hills carries sediment from surface erosion, under-runners and slips, such that the Ōpāwaho/Heathcote River is often discoloured. It seems likely that this has been the situation since early Polynesian times when the forest cover was burnt (T Partridge, pers comm).

4.3. Soils

4.3.1. Soils of the Port Hills

Wind-blown silt (loess) mantles all the hill slopes and is the principal material from which soils on rolling and hilly lands are derived. It lies deepest on the sides and tops of spurs and on rolling slopes at high levels but it is thin and discontinuous where slopes increase from rolling to steep. Consequently, steep-land soils are derived from mixtures of basaltic materials with loess. The marginal plain includes river flats, estuarine marshes, sand dunes and fans. Alluvial fans which occupy the floors of the valleys of the Port Hills consist of material derived from basalt and loess and can be distinguished from other types of alluvium by the brownish colour.

In some valleys, the lower ends of the fans are buried by alluvium deposited by the larger rivers but in most places, the fans rise to heights over 15 m above the flood plains. (Fitzgerald).

Rural hill catchments can be slow to respond to rainfall until the large soil moisture capacity of the underlying loess – equivalent to 25 - 30 mm of rain – has been filled.

4.3.2. Soils of the Plains

In the past great quantities of dust from the river-beds 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.

A sequence from well-drained levee in the west to poorly drained low-lying plain comprises the following soils: Waimakariri sandy loam (generally west of Hillmorton), Kaiapoi sandy and silt loam (much of the middle Ōpawāho/Heathcote Catchment from Sockburn to Woolston) and Taitapu deep silt loam (Hendersons Basin, Hoon Hay/Somerfield river corridor, and a flat east-west channel through Spreydon). In Woolston and the Heathcote Valley the Motukarara deep silt loam is similar to Kaiapoi silt loam but more poorly drained and saline. The above soils are classified as 'Recent soils' because development of profile features has been prevented by the repeated additions of alluvium during floods. On the river flats, soils formed on alluvium of mainly greywacke origin and their textures are predominantly silt loams. Clay loams occur in Cashmere and Bowenvale valleys and fine sands occur on the levees of the rivers. Reducing or gley conditions are produced in Taitapu soils by the presence of high water tables over long periods. Kaiapoi series are similar to Waimakariri except that they contain adequate moisture and are therefore much more fertile.

4.3.3. Physical Properties of Soils

Some Port Hills soils are very prone to erosion due to a tendency for shrinkage cracking and dispersive character. Loess possesses dispersive characteristics that vary by location and in different layers (Evans). Dispersive loess is unusually susceptible to erosion. Rain water that enters shrinkage cracks can erode either over or under resistant layers (forming rills or tunnels respectively). Reduced vegetation cover influences shrinkage cracking and increased water flows are likely to initiate erosion.

The feature of most interest in plains soils is permeability. Permeability affects the rate of runoff and the soil's effectiveness as an infiltration layer in a treatment facility. Soils are more stony and permeable west of Wigram and of decreasing permeability toward the east.

4.4. Drainage Network

4.4.1. Streams and drainage channels

Plains tributaries (Paparua Stream, Hayton Stream, Awatea Stream, Curletts Stream) have been realigned, modified or piped in the course of urban development. There are fewer natural middle catchment waterways, as much of the area was swampy, but numerous open drains have been created, mostly lined or piped to facilitate urban development. The capacity of these tributaries is limited, and widespread surface flooding can occur, infrequently, on the flat floodplains.

The Cashmere Stream, emerging from swampier ground, is spring and groundwater fed and flows continuously. Although straightened west of Penruddock Rise, Cashmere Stream retains more natural fauna and values than many other waterways.

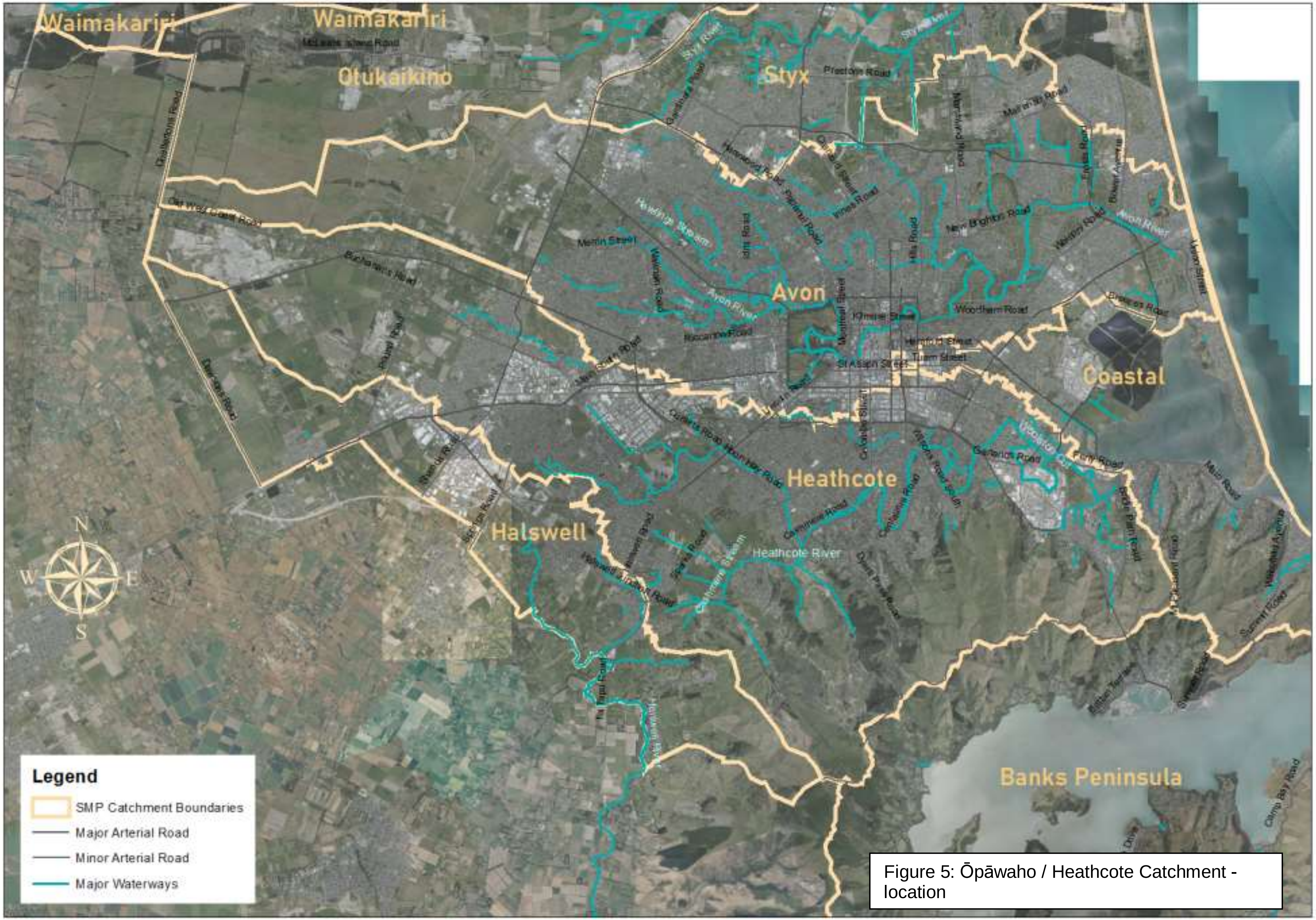

Figure 5: Ōpāwaho / Heathcote Catchment - location

Hill waterways are very erosion-prone and for this reason are mostly lined or piped within built-up areas. Port Hills waterways are normally dry due to the area’s dry climate and the intervals between rainfalls. Detention tanks are used on hill development sites to reduce the impact of frequent flashy runoff events on the stability of the erosion prone steep hill waterways

The river channel has a narrow, incised floodplain scarcely wider than the river-side roads. The river today is deeper, by approximately a metre, and wider than originally but overtops its banks frequently and in places rather deeply. Early development within the river corridor occurred without full understanding of potential flood levels, and frequent major floods from the 1940s to the 1980s prompted the joint CCC/Ecan Heathcote River Floodplain Management Strategy (1998) whose components are still being implemented through the District Plan and by the former Land Drainage Recovery Programme.

4.4.2. Stormwater system

The stormwater system includes roadside channels, pipes, waterways and treatment facilities, typically detention basins. Side channels receive discharges from private property and the carriageway and must function to maintain dry traffic lanes. Street sumps (catchpits) drain surface water into the pipe network. The pipe network is optimised to convey flow without retaining sediment. Its level of service is set to avoid traffic hazards in a 5 year average recurrence interval rainfall. Occasional road and property flooding occurs due to intake grill or sump blockage or system capacity. Separate levels of service protect houses by ensuring that new builds are above a 50 or 200 year return period flood level (dependingon location).

Stormwater quality treatment was not provided for in the network before 1993. The Wigram Basin (1993) was the first purpose-built water quality treatment facility and has been followed by many others, mostly associated with greenfields residential development. Stormwater from approximately one third of the developed catchment receives some degree of stormwater treatment, as shown in figure 6.

4.5. Groundwater

4.5.1. Groundwater

The near surface geology of the Ōpāwaho / Heathcote catchment is comprised of unconsolidated gravel, sand, silt and clay sized particles deposited since the Ice Ages. Coarser grained gravel and sand deposits are derived from alluvial fans, which have spread out from the Southern Alps in the west, forming the Canterbury plains by river action. River processes laid down zones of permeable water-bearing aquifers which reach the surface at the western edge of the catchment and are in more discrete, deeper, layers further east. Gravels are interspersed with zones of alluvial (river) sand and silt associated with depositional processes and finer grained overbank flood deposits. These alluvial deposits occurred during alternating periods of glacial and inter-glacial climatic conditions and associated sea level change. At times of higher sea level, finer grained estuarine and marine sediments and dune sands were deposited as far inland as Spreydon.

Groundwater occupies the pore spaces in gravels and sands. Where a water-bearing stratum extends to the ground surface it is classified as an unconfined aquifer and surface water can

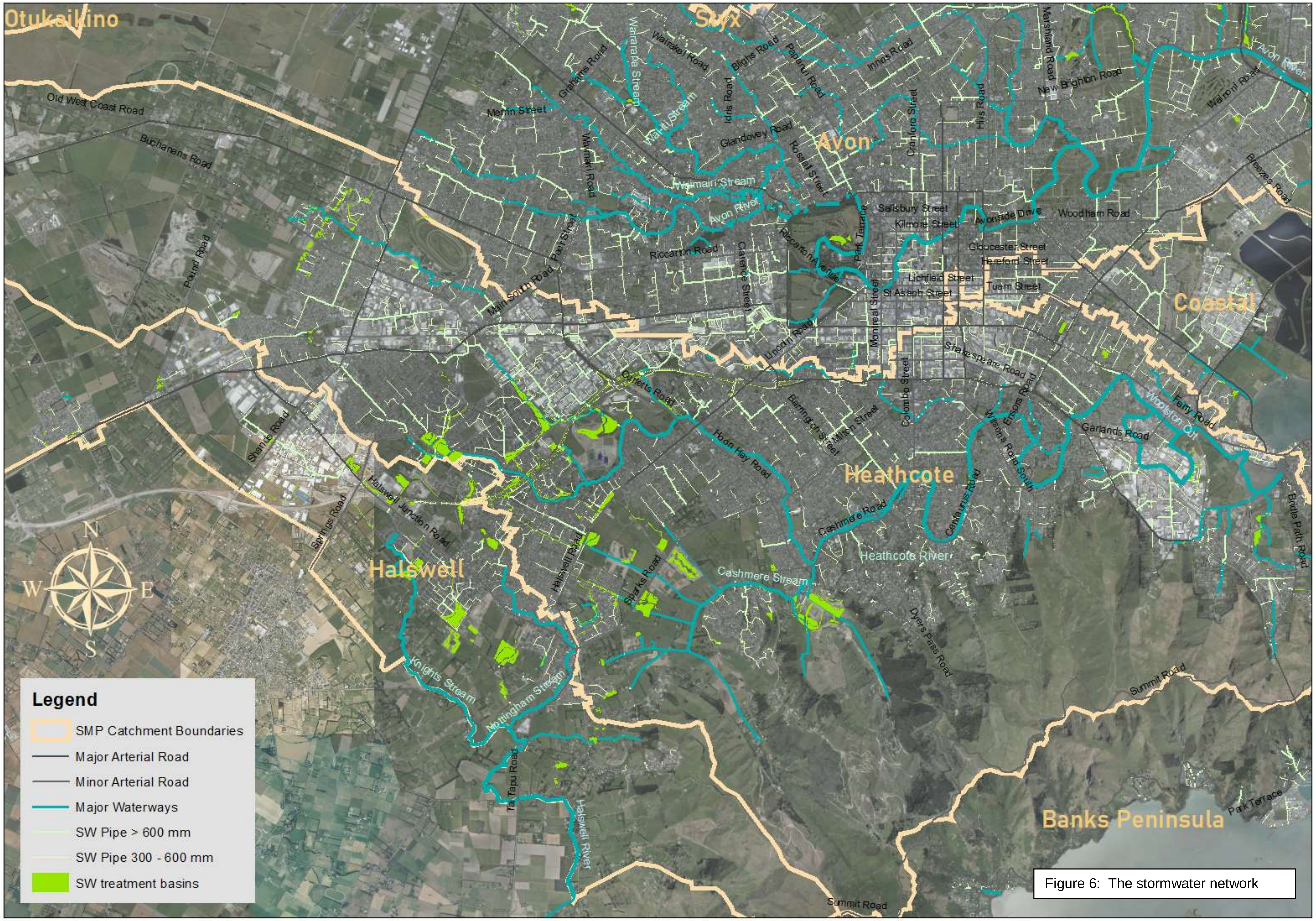

Figure 6: The stormwater network

infiltrate relatively unimpeded. Where finer grained estuarine and marine strata lie over gravels they form a low permeability layer that confines water within the gravel below, in a confined aquifer. Deep below the central and eastern parts of the catchment the gravels and capping layers form a layered sequence of discrete aquifers, separated by marine and estuarine deposits.

The groundwater system in the Ōpāwaho / Heathcote catchment is recharged mainly by seepage losses from the Waimakariri River and rainfall infiltration on the inland plains. Groundwater moves in an easterly direction in response to the hydraulic gradient between the Plains and the coast. Groundwater levels respond to the rate of recharge entering the groundwater system and the permeability of the aquifers. It is deepest at the western end of the catchment (typically around 6 m deep) and becomes shallower toward the east, approaching ground level where springs feed the Cashmere Stream. Shallow (unconfined) groundwater is mostly discharged into springfed waterways. Groundwater trapped within the confined aquifers further east develops artesian pressures.

4.5.2. Springs

The distribution of springs is controlled by the distribution and characteristics of the confining layer over the upper confined aquifer. Artesian pressure can force groundwater up through this layer until it emerges as springs. There are numerous springs in the headwaters of Cashmere Stream and springs contribute significantly to baseflows in Cashmere Stream and the upper Ōpāwaho / Heathcote River. Reference fig 7

Groundwater and groundwater pressures are lower to the north-west and there are no springs. To the east of the zone of springs the surficial, low-permeability confining layers are generally too thick to allow spring flows to penetrate. There may still be a diffuse groundwater seepage discharge, however (PDP 2004).

4.5.3. Groundwater use

Water abstraction wells draw extensively from aquifers to supply the Christchurch reticulated water supply (45% of maximum consented daily abstractions), as well as individual supplies for industrial/ commercial uses (36% of consented abstractions), agricultural (12%) and other smaller use activities. Groundwater levels fluctuate in response to changes in recharge and abstraction. They show a typical seasonal pattern with higher water levels in winter and spring (less abstraction from bores and more rainfall recharge) and lower levels in late summer and autumn (higher abstraction from bores and less rainfall recharge). These seasonal fluctuations are greatest in the west (more than 3 m between seasonal highs and lows) and become smaller in the central and eastern city where they are constrained by the discharges to waterways.

4.5.4. Protection of Groundwater

Groundwater quality can be affected by a number of land uses (such as farm nutrients and chemicals, old landfills, septic tanks) and the quantity of groundwater can be enhanced or reduced by stormwater diversion or infiltration. The Council promotes the infiltration of stormwater into the ground to maintain spring flows in stream headwaters and stream base flows. Groundwater must be protected by treating stormwater to a high standard before discharging it into the ground

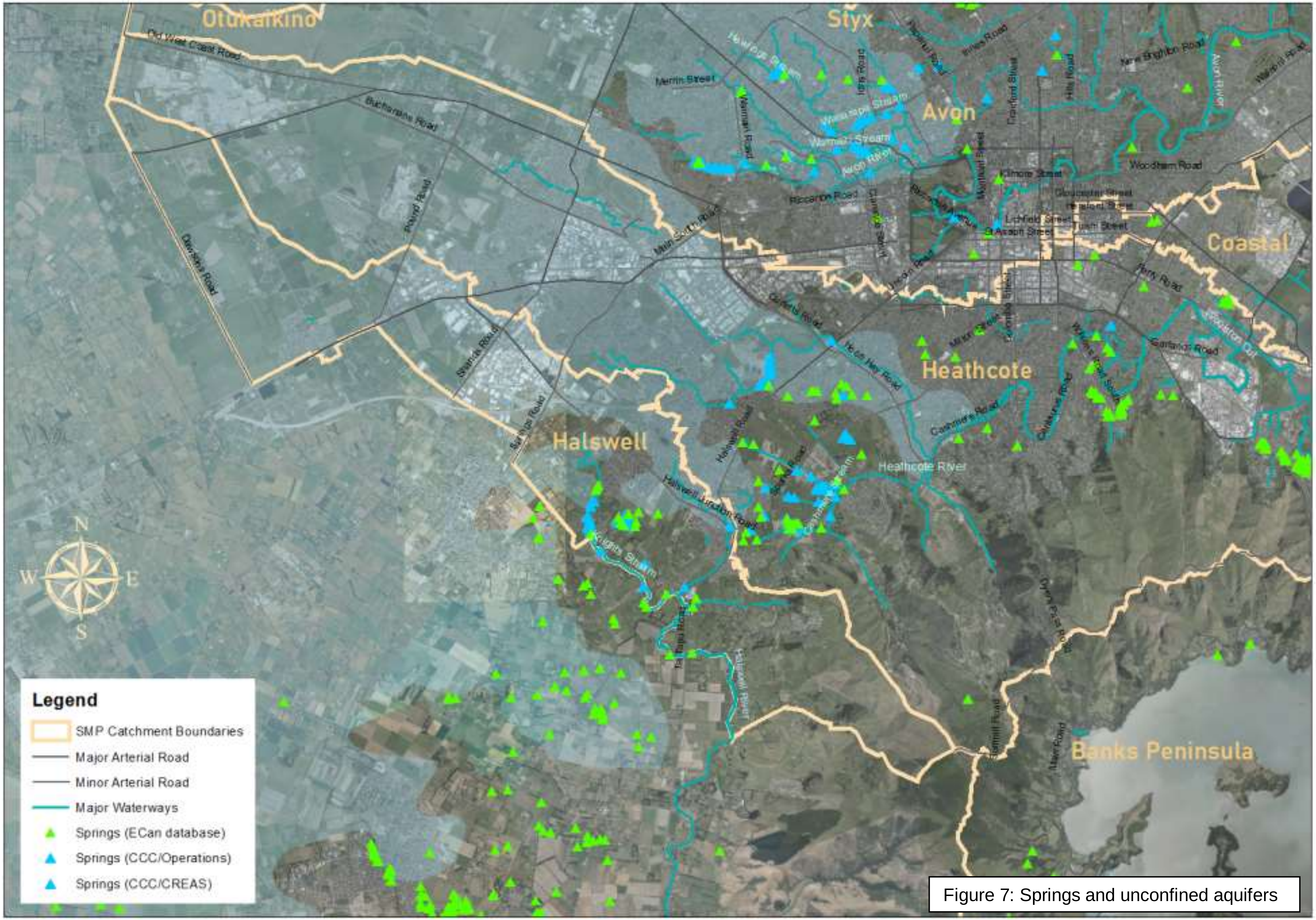

Figure 7: Springs and unconfined aquifers

5. Tangata Whenua and Cultural Values

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

The maintenance of water quality and quantity is perhaps the paramount resource management issue for tangata thenua. All waterways are a predominant feature within the landscape and should remain as a feature. A few would say that some waterways are more important than others because tangata whenua Whakapapa directly relates to it, and is part of their identity. However, to do so would be to miss those waterways that feed into, and are part of the main waterway. A holistic approach culturally then 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.

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.

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.

In pre-European times Ōtautahi/Christchurch provided freshwater and saltwater fish species and shellfish. There was an abundance of bird life for kai and raranga (decorative weaving), numerous plant and natural materials for building whare, waka, and rongoa species. The estuaries and swamps provided raupo, harakeke and pingao, mud, soils, tree bark and berries for dyes, and plant seeds for oils. Tangata whenua also used plants and birds as Tohu (sign) to stop harvesting a species such as titi, change of season, or, a marking spot for Wahi Tapu or Nga Wahi Taonga sites, such as a special placement of a number of cabbage trees.

5.2. Mana Whenua

The first settlers were the Waitaha iwi who lived in two main Kāinga around the estuary, known today as Ihūtai, where Raekura and Te Kai o Te Karoro built whare from local harakeke, raupo and rakau. Then in 1500, Ngāti Māmoe iwi had a settlement near the estuary on Tauhinu Korokio (Mt Pleasant). About one hundred years after this Ngāi Tahu, under the chief Turakautahi, established a pa north of the Waimakariri called Kaiapoi. While Ngāi Tahu did not live alongside the estuary itself they visited and used the area as a mahinga kai, in a similar way to their predecessors.

The Christchurch area has traditionally been a mahinga kai of the Kaiapoi Ngāi Tahu and the rangatira all claimed mahinga kai in the area before the 1868 Native Land Court hearing. The claims were made on behalf of the Kaiapoi Ngāi Tahu, and other Hapu did not dispute this.

The Ngāi Tahu philosophy, is of Ki uta ki tai (from the mountains, Te Tiritiro o te Moana, and ka-Kohatu-Whakarakaraka-a-Tamatea-Pokai-Whenua to the sea Te Kaikai a Waro), meaning the whole resource chain from mountain top to ocean floor,

South Island Māori were hunters and gatherers following nomadic seasonal trails on a schedule determined by the seasons, and the maturation of food resources. The Ngāi Tahu establishment of Kaiapoi pa branches out to other districts, each one specialising in particular materials and skills for trade, Kaihaukai.

Hūtai to Ōtākaro, and Waimakariri to Te Waihora, and Ōpāwaho were important connections to the extensive wetlands. Ngāi Tahu followed these main waterways and their tributaries in its maintenance of the food-rich wetlands. Today, it is a different story due to drainage; the great wetlands are no longer evident. However, "When flying into Christchurch airport you can still make out the different wetlands that are visible from the air only" (Dr Terry Ryan July 2008). Because of the importance of this area as a Mahinga kai to Ngāi Tahu, the lands were divided into wakawaka and controlled by the rangatira of certain hapu and whanau. This practice is still maintained today.

The Ōpāwaho formed part of a waka route between Kaiapohia Pa and Te Waihora/Lake Ellesmere. Waka could be portaged overland between the Ōpāwaho/Heathcote River and Huritini/Halswell River at Owaka.

Therefore, Ōpāwaho is to be considered as part of the wider dynamic of the wetland systems - not in isolation. It was an area of importance for healing, rest, Mahinga kai, transport and communications of the whanau, using the waterway to and from the other main water bodies.

5.3. Ōpāwaho

Ōpāwaho is named from the Ōpāwaho pa, which refers to its function as a waho (outpost). It was a resting place for Ngāi Tahu traveling between Kaiapoi and Horomaka. The land in this area was once marshy and covered in grasses, raupo and tussock. The area known today as Opawa derives its name from this pa which once stood on the banks of the river where present-day Judges Street and Vincent Place intersects.

Poho Areare, meaning pigeon-breasted, was the name of an original chief of Ōpāwaho and his name is given to the old Māori track that led over the sand hills from Ōpāwa to South New Brighton. Turaki Po was its later chief. Other sections flowing through Ōpāwa are O Hika Paruparu, the muddy fishing place from the reaches near the estuary, and O Pa Waho, the outward and seaward pa.

The swamps draining the Ōpāwaho were called Te Kuru. The upper reaches of the awa (river) at Spreydon bore the name Wai Mokihi after a smaller pa located there called O Mokihi, meaning place of the flax staff rafts. This area was important for Mahinga kai, a source of plentiful food, especially tuere (blind eel) and Kanakana (lamprey).

Tangata whenua had a close relationship with the estuaries and its tributaries for protection, transport and food. Shellfish, inanga, flounder and tuna came from the waterway. In the lower reaches inanga would come and spawn along the awa on the river grass. Tangata whenua were skilled in aquaculture and night fishing. Hunters would carry no lights at night, and yet could spear the tuna by listening for them. Food species were seeded and cultivated as well as harvested.

The swamp forest around small streams such as Streamwharf provided gathering grounds for water fowl and forest birds including pukeko, weka and tui. The estuaries were a nursery area for many fish species and provided vital access to a network of waterways stretching from Waihora to the Kowai Awa, and, the estuary channel provided an opening to the fishing grounds of Te Kaikai a Waro (Pegasus Bay).

Ōpāwaho has seen four centuries of fishing. The awa is susceptible to flooding within its catchment. With sufficient time and intensity the Ōpāwaho will ultimately overflow its banks and flood the adjacent land. However, the floodplains were a good place to settle as they were flat and fertile and adjacent to a water supply, and means of transportation.

> *[Sections 5.1 to 5.3 are taken from a report by AspxZ Limited. Although approved at the time of writing in 2008 the cultural information is no longer approved by Te Ngāi Tūāhuriri Rūnanga. The Rūnanga is to supply alternative cultural information which can be substituted.]*

5.4. Cultural Impact Assessment

A draft cultural impact assessment of the Stormwater Management Plan has been received from Manaaki Kurataio, although it is yet to be ratified by Te Ngāi Tūāhuriri Rūnanga. The provisional recommendations of the assessment are addressed as follows:

Table 1: Response to Cultural Impact Assessment

Recommendation	Action Taken	Reason
Engage with mana whenua prior to any proposed changes, enhancements, translocations and/or diversions as opposed to being consulted retrospectively.	Yes, the Council expects to engage with mana whenua in this way	
Ensure mana whenua are able to implement their own management strategies which include practices such as rahui, or other customary tools and therefore is also in keeping with treaty principles.	Where mana whenua management strategies can be effected through stormwater management plans the Council will engage with mana whenua in good faith and will implement what is achievable	
Increase riparian planting throughout the catchment, especially including trees for shade cover to reduce macrophyte overgrowth	Council Units will be made aware of this recommend-ation directly and through the proposed freshwater improvement plan.	
Adopt alternative methods of weed control (eg. Shade trees) to prevent the need for manual in-stream weed removal	Planting for shade is unable to be implemented through the SMP. Will be one of many measures in the proposed freshwater improvement plan.	The SMP is a compliance plan responding to the consent CRC214226. There are no consent conditions relating to planting and shade.
Ensure that all waterways in the catchment are treated to	We understand that this recommendation means “all	Agreement with the principle

Recommendation	Action Taken	Reason
the same standard and managed for mahinga kai collection in the future	waterways are equally important", and agree. More contaminated waterways are likely to be treated differently to capture contaminants, with the intention to raise water quality standards everywhere.	of Ki uta ki tai.
Conduct studies to investigate the effectiveness of current stormwater treatment facilities e.g. Stormwater basins	Yes, this is happening	The Council is required to do this by a consent condition.
Ensure the protection and enhancement of known spring sites		
Where stormwater treatment facilities can't be installed, ensure that stormwater is diverted into the wastewater system, especially in industrial areas	This should be effective in principle. The Council is investigating feasibility, however it seems unlikely to become widely used.	Stormwater flows are much larger than wastewater flows and there is generally insufficient capacity in the wastewater network.
Commence monitoring in Cashmere Stream of kākahi population	Yes	Part of the Environmental Monitoring Programme
Support State of the Takiwā reporting in the catchment; however this requires more sites that the four sites suggested in the stormwater management plan in order to capture ki uta, ki tai cultural values. An additional monitoring site should be added at Garlands Rd bridge as this is a traditional settlement and mahinga kai site.	A State of the Takiwā framework is being developed in consultation with Mahaanui Kurataio and a MKT employee is being funded to do this (and other duties). An additional monitoring site at Garlands Rd bridge will be considered for inclusion next year.	Part of the Environmental Monitoring Programme
Conduct a survey of stormwater basins to ensure fish passage	Existing stormwater basins are being surveyed and a recommendation will be made listing priorities for fish passage improvement. There is a legal requirement to maintain fish passage in all new structures.	

5.5. Mahaanui Iwi Management Plan

Alignment between this SMP and Mahaanui Iwi Management Plan objectives are discussed in section 10.5

5.6. Monitoring for Mana Whenua Values

Three sites (at Rose St, Colombo St and Garlands Rd) are to be sampled five-yearly in conjunction with the monitoring of surface water quality, instream sediment quality and aquatic ecology for mana whenua values. The sites to be monitored are based on previous State of the Takiwā sites, with some additional sites proposed. Some sites coincide with other monitoring sites (e.g. instream sediment and aquatic ecology).

Cultural monitoring will occur under CSNDC Condition 49 and the Environmental Monitoring Programme, to enable the CCC and Ngāi Tāhu to compare future condition against the State of the Takiwā Report, 2007. It will be based on the methodology and sites for the State of the Takiwā. The State of the Takiwā monitoring system was developed by Te Rūnanga o Ngāi Tahu to facilitate tangata whenua to gather, store, analyse and report on information relevant to the cultural health of waterways within their takiwā (tribal areas).

6. The Receiving Environment

6.1. Background

Waterways in the Ōpāwaho/Heathcote catchment are classified in the Land and Water Regional Plan as ’spring-fed – plains – urban’, with the exception of the the Cashmere Stream and hill tributaries which are classified as ‘Banks Peninsula’ waterways. Banks Peninsula waterways generally have higher biodiversity values.

The Council monitors water quality monthly at fourteen sites within the catchment (displayed in Figure 6.) The results from the 2019 annual monitoring report for the Ōpāwaho/Heathcote River catchment (Margetts & Marshall, 2020) are summarised below. This monitoring is part of the Council’s state-of-the-environment monitoring. Additional wet weather sampling occurs every year at selected monthly monitoring sites using grab sampling.

Section 6.2 compares surface water quality to ANZECC standards, which are quality targets in the Land and Water Regional Plan. Section 6.2 does not report on compliance with consent conditions.

6.2. Water Quality

Water quality within this catchment is generally poor, and on the whole is poorer than other catchments within the City (**Error! Reference source not found.**). Poor water quality negatively affects the ecology of waterways (plants, macrophytes, invertebrates and fish). Specifically, nutrients (nitrogen and phosphorus) are likely to encourage prolific growth of aquatic plants and algae, while other contaminants (e.g. copper, zinc, sediment, oxygen and ammonia) cause negative effects on the physiology and behavoiur of instream biota.

In total, 27% of the 2,454 samples analysed from the Heathcote catchment during the 2019 monitoring year exceeded the guideline value and all sites exceeded the guideline values for at least one parameter (Table 2). NNN had the highest rate of samples exceeding guidelines at 88%, with Haytons Stream and Curletts Road Stream at Motorway the only sites to meet the guideline recommendations. Other parameters often exceeding the guidelines included DIN and DRP. The parameters that never exceeded their respective guideline values were dissolved lead and ammonia.

Parameter levels have generally remained stable in the Heathcote catchment since monitoring began in 2007, with water quality neither getting better nor worse at 70% of sites. However, 23% of sites showed improving water quality.

The Curletts Stream, Heathcote River at Tunnel Road, Haytons Stream and Heathcote River at Ferrymead Bridge sites have the worst water quality in the Ōpāwaho/Heathcote River catchment and in Christchurch City overall. Between them, Curletts and Hayton Streams have particular issues with copper, zinc, sediment, dissolved oxygen, phosphorus and *E. coli*. Cashmere Stream at Sutherlands Road has the best water quality in the catchment, particularly for sediment/turbidity, phosphorus and *E. coli*.

Waterway condition generally is considered typical of urban waterways within Christchurch, New Zealand and internationally (termed ‘the Urban Stream Syndrome’; Walsh et al., 2005). The Ōpāwaho/Heathcote River in particular was historically polluted by industrial waste principally fromthe Woolston District (Canterbury Drainage Board, 1988; and summarised in McMurtrie & Burdon, 2006). A number of activities potentially affect the water quality of the catchment, including discharges (wastewater overflows, stormwater, industrial/commercial discharges, dewatering water and construction phase sediment-laden stormwater), faeces from waterfowl and dogs, nitrogen-rich spring water and sediment inputs from unstable Port Hills.

Figure 8 Surface water quality monitoring sites

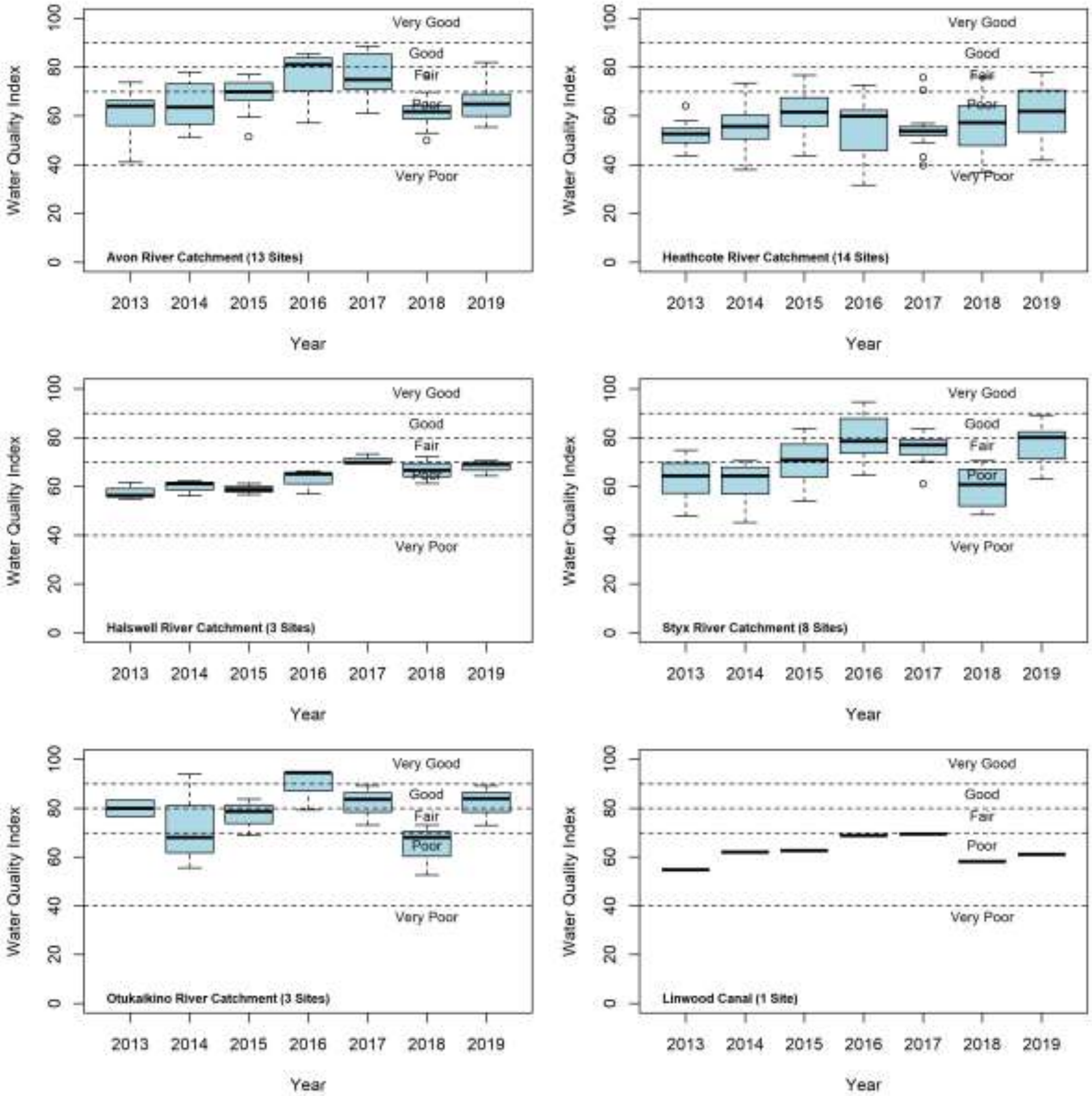

Figure 9: Boxplots of Water Quality Index for each catchment for the 2013 to 2019 monitoring years

6.3. Sediment Quality

Stormwater contaminants such as metals and hydrocarbons can accumulate in stream sediments. Contaminated sediments can adversely affect the health of stream biota.

Stream bed sediment was sampled at 13 sites across the Ōpāwaho/Heathcote River catchment in mid 2015 and these samples were analysed for metals, Polycyclic Aromatic Hydrocarbon (PAHs), phosphorus, organic carbon and grain size. The highest concentrations of metals were found at sites close to Curletts Stream and in the lower reaches. The lowest concentrations were found at the most upstream Ōpāwaho /Heathcote River site and at sites in the tributaries - Cashmere Stream, Cashmere Brook and Steamwharf Stream. Sites in the middle reaches of the Ōpawāho/Heathcote River contained moderate metal concentrations compared to other sites in this survey. PAH concentrations showed a similar pattern with the exception of an extremely elevated concentration of total PAHs downstream of Colombo Street (614 mg/kg), likely due to the presence of coal tar, and a site in the lower section measuring 77 mg/kg. Sites were ranked for overall sediment quality and the three sites downstream of Aynsley Terrace had the worst overall quality, along with the site downstream of Colombo Street.

Lead, zinc and PAHs concentrations exceeded ANZECC sediment quality trigger values at 3 – 6 sites, showing these are the major contaminants of concern (Table 2). One or more of these trigger values was exceeded at 9 of the 13 Ōpawāho/Heathcote catchment sites sampled. There was also one site where the ISQG-high value was exceeded. A particularly high value of PAHs was recorded in the Ōpāwaho/Heathcote River downstream of Colombo Street, measuring 212 mg/kg when normalised to 1% Total Organic Carbon. Copper, arsenic, cadmium, chromium and nickel concentrations in the sediment did not exceed their respective trigger values at any sites and were generally well below the guidelines.

A comparison of the present survey results with a prior survey 30 years ago suggested that lead concentrations have decreased, whilst zinc concentrations appear to have increased, at least in some locations. This is in keeping with previous findings for the Ōpāwaho/Heathcote River catchment. There has been no clear increase or decrease. in copper, cadmium, chromium and nickel The survey found the sediment metal concentrations within the range previously measured in urban stream sediments from elsewhere in Christchurch and around New Zealand.

Table 2: Ōpāwaho/Heathcote River sampling related to ANZECC and LWRP guidelines

Parameter	**Guideline**	**Number of Sites Monitored**	**Number of Samples Analysed**	**Number of Samples Not Meeting Guideline**	**Number of Sites Not Meeting Guidelines**
Nitrate Nitrite Nitrogen	Median <0.444 mg/L	14	166	146 (88.0%)	12
Dissolved Inorganic Nitrogen	Banks Peninsula: median <0.09 mg/L All other sites: median <1.5 mg/L	14	166	113 (68.1%)	10
Dissolved Reactive Phosphorus	Banks Peninsula: median <0.025 mg/L All other sites: median <0.016 mg/L	14	166	102 (61.4%)	10
Escherichia coli	95%th percentile <550/100ml	14	166	41 (24.7%)	10
Dissolved copper	Banks Peninsula: 95%th percentile ≤0.001 mg/L All other sites: 95%th percentile ≤0.0018 mg/L	14	166	30 (18.1%)	9
Dissolved zinc	Banks Peninsula: 95%th percentile ≤0.00634 mg/L All other sites: 95%th percentile ≤ 0.03960 mg/L	14	166	30 (18.1%)	7
Turbidity	Median <5.6 NTU	11	130	64 (49.2%)	6
Dissolved oxygen	Banks Peninsula: median >90% All other sites: median >70%	14	166	64 (38.6%)	5
Total Suspended Solids	Median <25 mg/L	14	166	36 (21.7%)	2 (Heathcote at Tunnel Rd, Heathcote at Ferrymead Bridge)

Nitrate	Median <3.8 mg/L and/or 95%ile <5.6 mg/L	14	166	11 (6.6%)	1 (Heathcote at Templetons Rd)
Biochemical Oxygen Demand	Median <2 mg/L	14	166	11 (6.6%)	0
Water temperature	Median: <20°C	14	166	5 (3.0%)	0
pH	Median 6.5 to 8.5	14	166	2 (1.2%)	0
Dissolved lead	Banks Peninsula: 95%th percentile ≤0.00427 mg/L All other sites: 95%th percentile ≤0.02388 mg/L	14	166	0 (0%)	0
Total ammonia	Banks Peninsula: 95th percentile <0.32 mg/L All other sites: 95%th percentile <1.75 mg/L	14	166	0 (0%)	0
Total	-	14	2,454	655 (26.7%)	14 of 14 (100%) (for at least one parameter)

6.4. Sediment Quality

Stormwater contaminants such as metals and hydrocarbons can accumulate in stream sediments. Contaminated sediments can adversely affect the health of stream biota.

Stream bed sediment was sampled at 14 sites across the Ōpāwaho/Heathcote River catchment in May 2020 and these samples were analysed for metals, Polycyclic Aromatic Hydrocarbon (PAHs), phosphorus, organic carbon and grain size (Instream, 2020a). The highest concentrations of metals were from the Curletts Road Stream at Motorway site, where zinc was over 23 times higher than the ANZG (2018) default guideline. At this site all metal concentrations also exceeded the ANZG (2018) guideline value-high, the only site to do so. The lowest concentrations of metals were found at the most upstream site in Cashmere Stream, where all concentrations were below the ANZG (2018) default guidelines. PAH concentrations showed a different pattern, where the highest concentration was in the Heathcote River at Tunnel Road site. This was also the only site to exceed the ANZG (2018) PAH default guideline.

Copper, lead and zinc concentrations exceeded their respective ANZG (2018) default guidelines at 4 – 11 sites, showing these are the major contaminants of concern, while the PAH default guideline was exceeded at one site (Table 3). The ANG (2018) guideline value-high for copper and lead was exceeded at the Curletts Road Stream at Motorway site, while guideline value-high for zinc was exceeded at six sites.

A comparison of survey results over time suggest that lead concentrations have decreased by 78% since the 1980s, as a result of the removal of lead from petrol. There has been no apparent change in catchment wide copper and zinc concentrations.

Table 3: Ōpāwaho/Heathcote River sampling and ANZG (2018) sediment guidelines

Parameter	Default guideline	Number of Sites Monitored	Number of Sites Not Meeting Guidelines
Copper	<65 mg/kg dry weight	14	4 (29%)
Lead	<50 mg/kg dry weight	14	7 (50%)
Zinc	<200 mg/kg dry weight	14	11 (79%)
Total PAHs	<10 mg/kg dry weight	14	1 (7%)

The pattern of contaminant distribution indicates that:

- The sources of cadmium, copper, lead, and zinc are likely to be the same, with different sources for organic carbon, phosphorus, arsenic, chromium, nickel and PAHs.
- Arsenic, chromium, lead and nickel in sediment are likely to be sourced primarily from soils. Soils contain elevated concentrations of lead compared to rural areas as a result of the historical use of lead additives in petrol.
- Rural landuse was associated with lower concentrations of metals in sediment whereas residential and residential/business landuse was associated with somewhat higher copper, lead and zinc concentrations, though this relationship was not statistically significant.
- Elevated PAHs (higher than all other sites and above trigger values) in the Ōpawāho/Heathcote River downstream of Colombo Street are likely due to historical use of coal tar in road sealing.
- Liquefaction sediments may have influenced the quality of sediments in Steamwharf Stream, however the influence on contaminant concentrations at other locations was not clear.

Gadd and Sykes (2015) comment that (a) zinc is the contaminant of most concern for stormwater management in the Ōpāwaho/Heathcote River catchment and (b) source control should be considered where possible to reduce inputs and prevent further increases, particularly in sub-catchments being developed from rural landuse.

6.5. Aquatic Ecology

An aquatic ecology survey of 14 sites within the Ōpāwaho/Heathcote River catchment was carried out in 2020 by Instream Consulting (Instream, 2020a, interim). The survey was designed to describe the current ecological condition of these waterways, compare how these conditions have changed over time, and identify areas with high or low ecological health to inform the development of waterway management strategies and the SMP.

Ecological surveys included assessment of riparian and in-stream habitat conditions, and macroinvertebrate and fish communities. Monitoring data indicated that instream and riparian habitat quality was similar to previous years at most sites. The banks and beds of most waterways were comprised of natural earth and stone substrates. However, most sites had minimal buffering from riparian vegetation and low levels of channel shading. Consent targets for macrophyte cover and filamentous algae cover were met at most sites during the last ten years). In contrast, consent targets for fine sediment cover were not met at most of the sites). Compliance with macrophyte cover is largely achieved due to contractors weeding most waterways two to three times a year. The primary cause for excessive macrophyte growth in city waterways is a lack of shade from trees.

This ecological assessment indicated that the waterways within the catchment were generally of poor ecological health. Nevertheless, it is important to remember that sites did provide habitat for some ecologically important native macroinvertebrate and fish species.

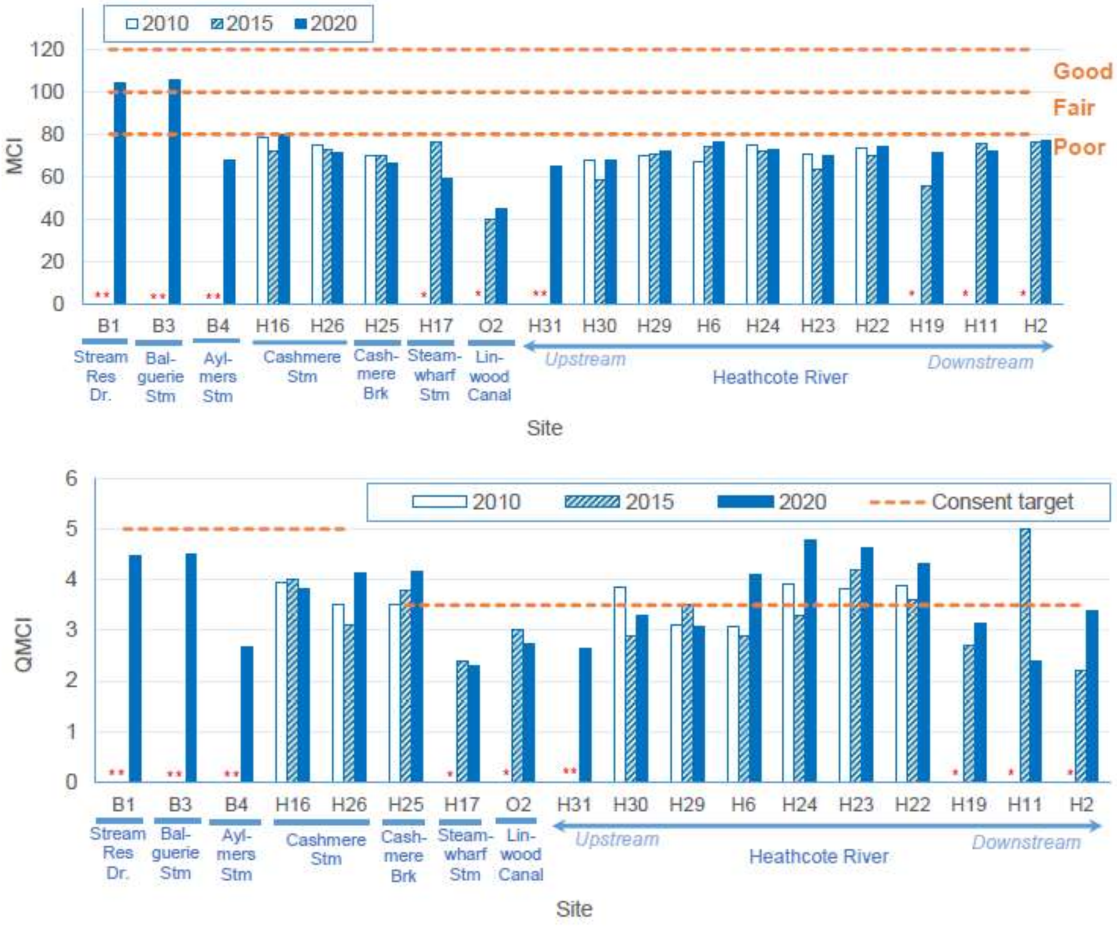

Figure 10: Macroinvertebrate Community Index (MCI) scores (top) and QMCI scores (bottom) for the 14 sites surveyed in the Ōpāwaho/Heathcote River catchment in 2020. The dashed lines indicate the consent targets. Note: the graph also includes data from sites within Banks Peninsula and Linwood Canal, which are not relevant to this Stormwater Mangement Plan and are therefore not discussed.

6.5.1. Macroinvertebrates

Based on MCI scores 13 out of 14 sites had “poor” stream health, while Cashmere Stream at Sutherlands Road recorded the minimum score required for “fair” stream health (Figure 10). The CSNDC requires a minimum QMCI score of 3.5 for the Ōpāwaho/Heathcote River catchment, except for Cashmere Stream, which has a minimum QMCI score of 5. Of the 14 sites surveyed, only five met the consent requirement (Figure 9); these sites were located in Cashmere Brook and the Ōpāwaho/Heathcote River. Sites that did not meet the consent target were located in Cashmere Stream, Steamwharf Stream, and the Ōpāwaho/Heathcote River. The highest QMCI score was recorded from the Heathcote River downstream of Barrington Street site (4.79).

Numerically, crustaceans and snails dominated the macroinvertebrate community. The abundance and diversity of pollution-sensitive EPT taxa were extremely low in the

Ōpāwaho/Heathcote and Ōtākaro/Avon River catchments, lower than any other catchments monitored in the district (Instream, 2019; Instream, 2020a). Pollution-sensitive mayflies and stoneflies have not been recorded at any site in the Ōpāwaho/Heathcote River catchment for at least the last decade. Mayflies and stoneflies were last recorded from the Heathcote catchment during a survey in 1989-91, where they were found in Cashmere Stream (Robb 1994). It is clear from repeated sampling at multiple sites that mayflies and stoneflies are locally extinct in Christchurch's two major urban rivers. There was no clear declining or improving trend in invertebrate community composition over time at any site.

Kōura (freshwater crayfish) and kākahi (freshwater mussels) are valued as kai species and have "at risk" conservation status (Grainger et al. 2018). Kōura were recorded in low numbers during electric fishing at several sites in the Ōpāwaho/Heathcote River and Cashmere Stream in 2015 and 2020. Although no kākahi were located during the 2020 ecology survey, a separate study found kākahi to be widespread in the lower 2.2 km of Cashmere Stream, and of higher density higher in 2020 than the previous survey in 2007 (Instream 2020b). Comparison of size distribution data over time indicates that the proportion of small individuals is increasing, and therefore there is reasonable recruitment occurring (Instream 2020b). Live kākahi were recently recorded from the Ōpāwaho /Heathcote River for the first time (Instream unpublished data). The kākahi populations of Cashmere Stream and the Ōpāwaho /Heathcote River are of local ecological significance, given the relative lack of kākahi in Christchurch urban streams.

6.5.2. Fish

Eleven species were captured from the 14 sites surveyed within the Ōpāwaho/Heathcote River catchment in March–May 2020. The ecological monitoring period was extended due to the nation-wide lockdown caused by the COVID-19 global pandemic. The recorded species have conservation status of "at risk" (bluegill bully, giant bully, inanga, longfin eel), "not threatened" (common bully, upland bully, shortfin eel, black flounder, yelloweye mullet, estuarine triplefin) and "introduced and naturalised" (brown trout) (Dunn et al., 2018). The range of fish species caught in the Ōpāwaho/Heathcote River catchment in 2020 was similar to previous years.

Species richness was sometimes depauperate, with two to seven species present at a site. Shortfin eels were the most widespread species, being present at all sites, while common bullies were the most abundant. The least widespread freshwater fish were black flounder and brown trout which were recorded at one site, followed by bluegill bullies which were present at two sites. A similar core of fish species was caught in 2015 and 2020. However, species richness declined at seven sites between 2015 and 2020, and increased at only two sites over the same period. Electric fishing occurred later in the year, with cooler water temperatures in 2020, which may explain the population changes.

Other species recorded in this catchment in recent years that were not detected in the Instream (2020a) study were redfin bullies, banded kokopu and lamprey.

Table 4: Summary of Ōpāwaho/Heathcote River against CSNDC aquatic ecology guidelines

Parameter	Guideline	Number of Sites Monitored	Number of Sites Not Meeting Guideline
Fine sediment cover of streambed	Cashmere Stream: ≤20% Ōpāwaho/Heathcote catchment elsewhere: ≤30%	12	12 (100%)
QMCI	Cashmere Stream: ≥5 Ōpāwaho /Heathcote catchment elsewhere: ≥3.5	13	8 (61.5%)
Macrophytes	Cashmere Stream: ≤30% Ōpāwaho/Heathcote catchment elsewhere: ≤60%	13	0 (15.4%)

Filamentous algae (>20 mm length)	Cashmere Stream: ≤20% Ōpāwaho /Heathcote catchment elsewhere: ≤30%	13	0 (0%)

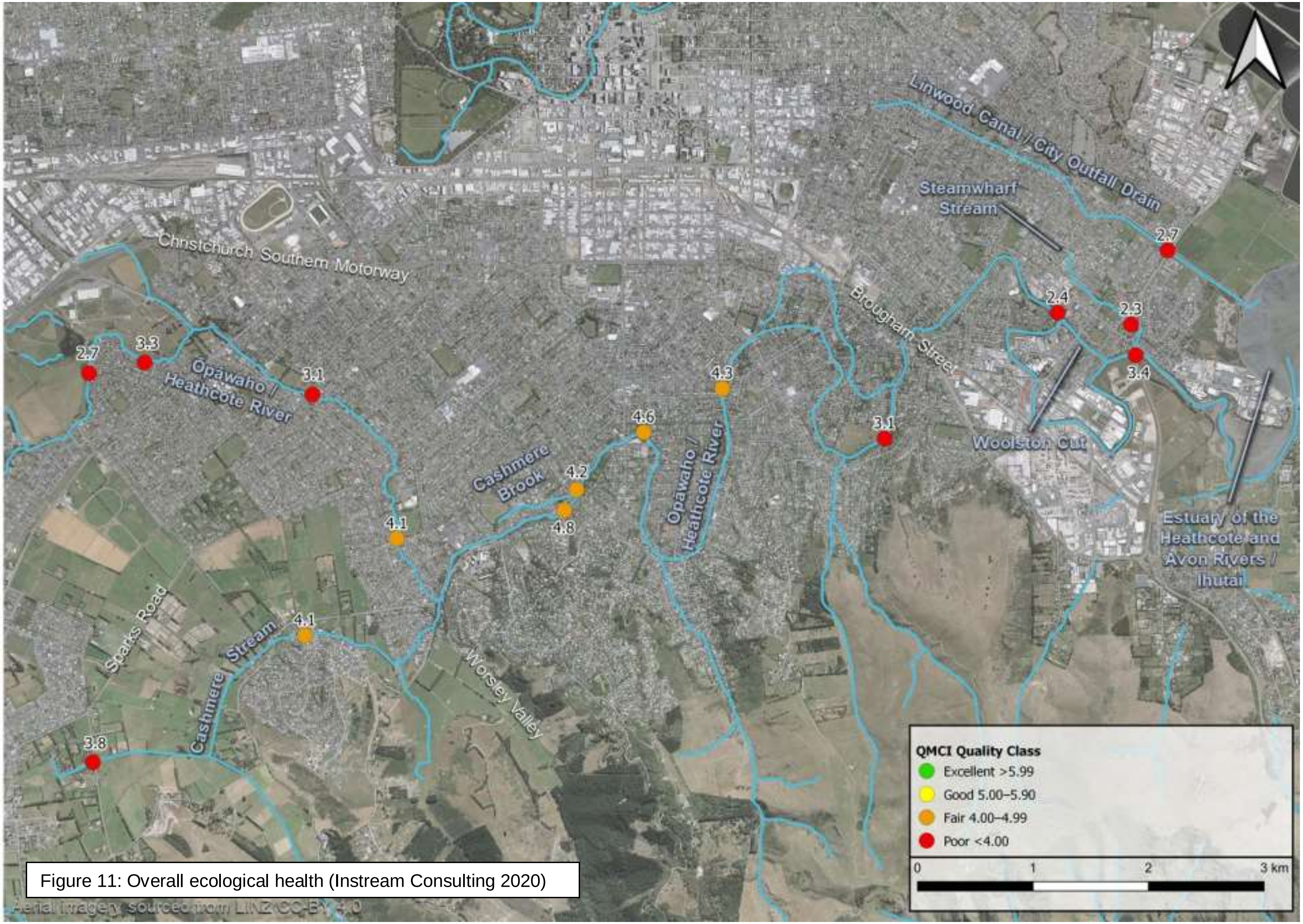

Figure 11: Overall ecological health (Instream Consulting 2020)

6.6. Groundwater Quality

Section 6.4 is abridged from *Groundwater Monitoring Report,* ECan (2013)

Each year about 35 wells in the Christchurch area are sampled by ECan for signs of changing groundwater quality.

Groundwater quality is generally very good and the majority of samples meet New Zealand Drinking Water Standards without treatment. This reflects the absence of bacteria and viruses, which is typical for water abstracted from a well-managed aquifer. The best water quality occurs across the northern part of the city thanks to seepage of clean water from the Waimakariri River into the aquifer. Groundwater quality in the south is still good, but the water contains more dissolved substances picked up during infiltration through the land surface. Some areas near the estuary and old coastal swamps have low dissolved oxygen, which causes naturally poorer groundwater quality.

Groundwater quality in the Ōpawāho/Heathcote catchment varies, in places showing the effects of past practices. Relatively widespread groundwater quality effects have resulted from historic burial of animal carcases and residential and industrial refuse in areas towards the western edge of the catchment. Those effects manifest themselves in higher conductivities and elevated nitrate nitrogen concentrations in bores less than 40 m deep. Groundwater quality in deeper bores from which the city draws its water supply appears to be generally better, as is groundwater quality in bores located towards the eastern edge of the catchment. This is because nitrogen from near-surface sources tends to stay within shallow groundwater and discharge into streams. Some constituents of groundwater such as nitrogen can be detrimental in spring and stream flow.

One-off sampling for cadmium and boron, which might indicate contaminants from fertiliser use, found only one well near an old landfill where boron concentrations were above the drinking-water MAV. Cadmium concentrations were below detection levels in all but one well, which still had very low concentrations. There was very little evidence of changing groundwater quality in Christchurch over the last ten years.

Four wells show a possible long-term decline in quality near the groundwater table to the west and south west of the city. Two of these wells target known contamination sources and the other two show a slow general change in quality.

Another five wells show improved groundwater quality in previously affected areas of southern Christchurch after better management of abstraction and discharges.

6.7. Ngāi Tahu Cultural Values Assessment

This section is extracted from the *State of the Takiwā 2012 Te Āhuatanga o Te Ihutai (*Lang et al 2012)

“When taking all results and assessments into consideration the cultural health of the Ihutai catchment is considered to be poor. The majority of sites contained high levels of pollution and were deemed unsafe to gather mahinga kai and in some cases, unsafe to swim. Other indicators of degradation and modification were also widespread. Low scores for indigenous vegetation diversity and cover were commonplace, and coastal and estuarine sites typically contained limited native vegetation in the riparian zone, which was often dominated by exotic species.

These results also indicate that the cultural health of the catchment is similar to that recorded in the 2007 State of the Takiwā programme. Despite this modest improvements in the cultural health of some sites are apparent. A greater number of sites were found to have improved cultural health … across the 30 sites originally surveyed in 2007. A comparison of Takiwā 2.0 Overall Site Health scores shows that 16 sites have improved and 10 sites have deteriorated with four sites returning the same score. Improvements were most notable at sites where riparian restoration actions have occurred such as at the Beckenham Library and Ōpāwaho sites.

The site with the poorest cultural health was located at the Woolston Industrial Estate. This is an area of heavy industry and no improvement in cultural health was recorded when compared to the 2007 results. At this site water quality and in-stream values remain very poor despite there being some indigenous species in the riparian zone.

Riparian planting was observed at a number of sites although in many cases this is spatially limited due to constraints from urbanisation. An example is at the Pioneer Stadium site where native riparian restoration has been undertaken but is limited primarily to one side of the bank and confined by residential properties

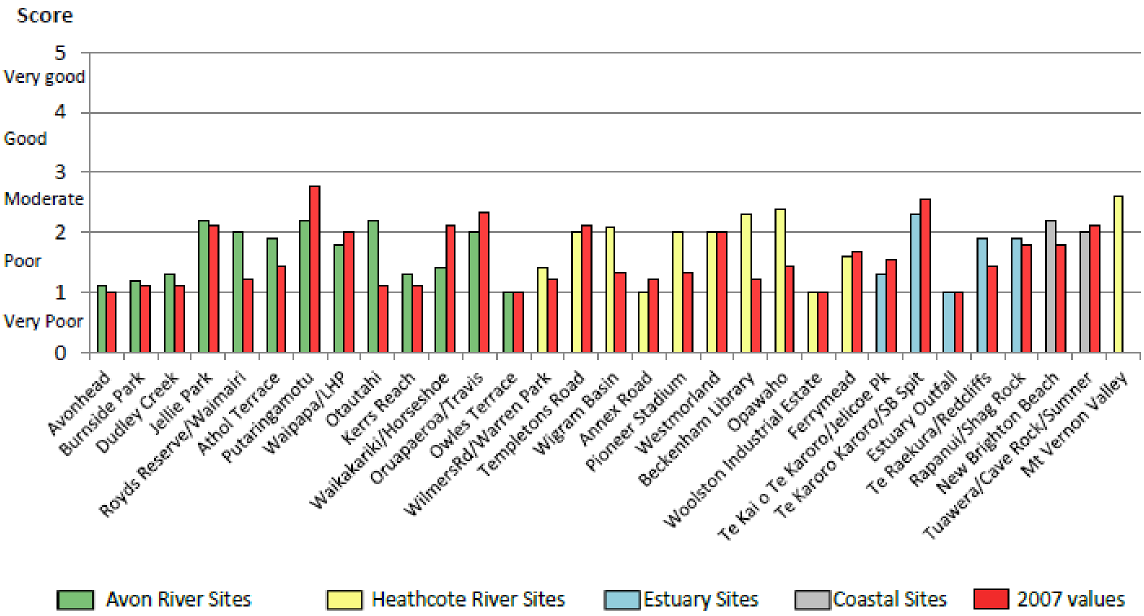

Figure 12: State of the Takiwa score

Of particular note in the upper reaches of the Ōpāwaho/Heathcote river was a loss of visible springs and water flow. The upper Ōpāwaho/Heathcote at Warren Park contained only stagnant water from storm water inputs.

As identified in Pauling et al. (2007) the impacts of past and present modification and intensification of land use has had dramatic impacts on the cultural health of waterways in the Ihutai catchment, particularly in relation to drainage, stormwater and wastewater discharges.

6.8. The effect of existing water quality measures

An estimate of the effectiveness of existing stormwater treatment facilities was made in the Christchurch Contaminated Load Model (C-CLM) developed for the consent hearing (van Nieuwkerk, 2018). The estimate is made on a city-wide basis using typical treatment efficiencies in the absence of other information. The C-CLM indicates that existing treatment facilities (see figures 5 & 6) effect the following contaminant reductions in the modelled catchments, Avon, Heathcote, Halswell and Styx:

- TSS: 12% reduction of TSS load in 2018 compared to no treatment
- Zinc: 10% reduction of total zinc load in 2018 compared to no treatment
- Copper: 16% reduction of total copper load in 2018 compared to no treatment

In-stream improvements from the reduced annual contaminant load (if any) are not yet able to be assessed.

The Council will monitor actual TSS, zinc and copper reduction performance of selected stormwater treatment devices as required by Schedule 3(i).

7. Land Use

7.1. Development and Trends

Christchurch's growth, unless artificially stimulated, is expected to be relatively modest over the next 20 years. Significant changes to city form and environment could occur through, for example: surges in economic activity, changed housing preferences ranging from inner city living to rural life style blocks, or an influx of migrants.

The present population is expected to increase by between 62,000 and 117,000 over the period from 2020 to 2043 [https://figure.nz/chart/CLaMLJ4sqPsSQMCU-YrMdDF0zWjNHR4fB Statistics New Zealand, depending upon whether a medium or high population projection is assumed. The number of households is expected to increase by between 28,000 and 48,000 over the same period, (from https://ccc.govt.nz/assets/Documents/Culture-Community/Stats-and-facts-on-Christchurch/fact-packs/HouseholdProjections-Households-docs.pdf 2006-31 extrapolated to 2043)

7.1.1. Residential Growth

Between 2015 and 2020, residentially zoned land in this catchment has been taken up at an average rate of 15 hectares per year. At this rate of development, currently zoned vacant residential land will be sufficient for 45 years[1].

Household projections prepared in May 2015 for CCC's Development Contributions Policy predicted 17,968 new houses in the Ōpawāho/Heathcote catchment during the forty year period from 2016 to 2056. Greenfields areas were expected to absorb 8,082 of the new houses (which is less than what is indicated by the vacant land estimate) implying that some land is expected to remain vacant after forty years.

7.1.2. Industrial Growth

Between 2015 and 2020, industrial land in this catchment has been taken up at an average rate of just over 6 hectares per year. At this rate, currently zoned vacant industrial land will be sufficient to meet anticipated needs for 20 years .

Within the Ōpāwaho/Heathcote catchment the area of land zoned Business is overwhelmingly industrial rather than commercial. Existing industrial areas within the catchment include Islington, Hornby, Sockburn, Wigram, Middleton, Sydenham, Phillipstown and Woolston. No significant rezoning for the anticipated modest future industrial growth is planned. Vacant zoned land is available in Islington and Wigram to accommodate growth projections.

The Christchurch City Council has no plans at this time to expand beyond the current urban boundary. Christchurch City has sufficient development capacity to meet housing demand over the next 30+ years through redevelopment of the existing urban area and planned greenfield areas (referred to as Residential New Neighbourhoods under the Christchurch District Plan). Should urbanisation beyond the current urban limit be considered to address higher than expected (particularly residential) demand, a change will be required to the Canterbury Regional Policy Statement and the Christchurch District Plan and any proposal.

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[1] Data supplied by the Research and Monitoring Team, CCC

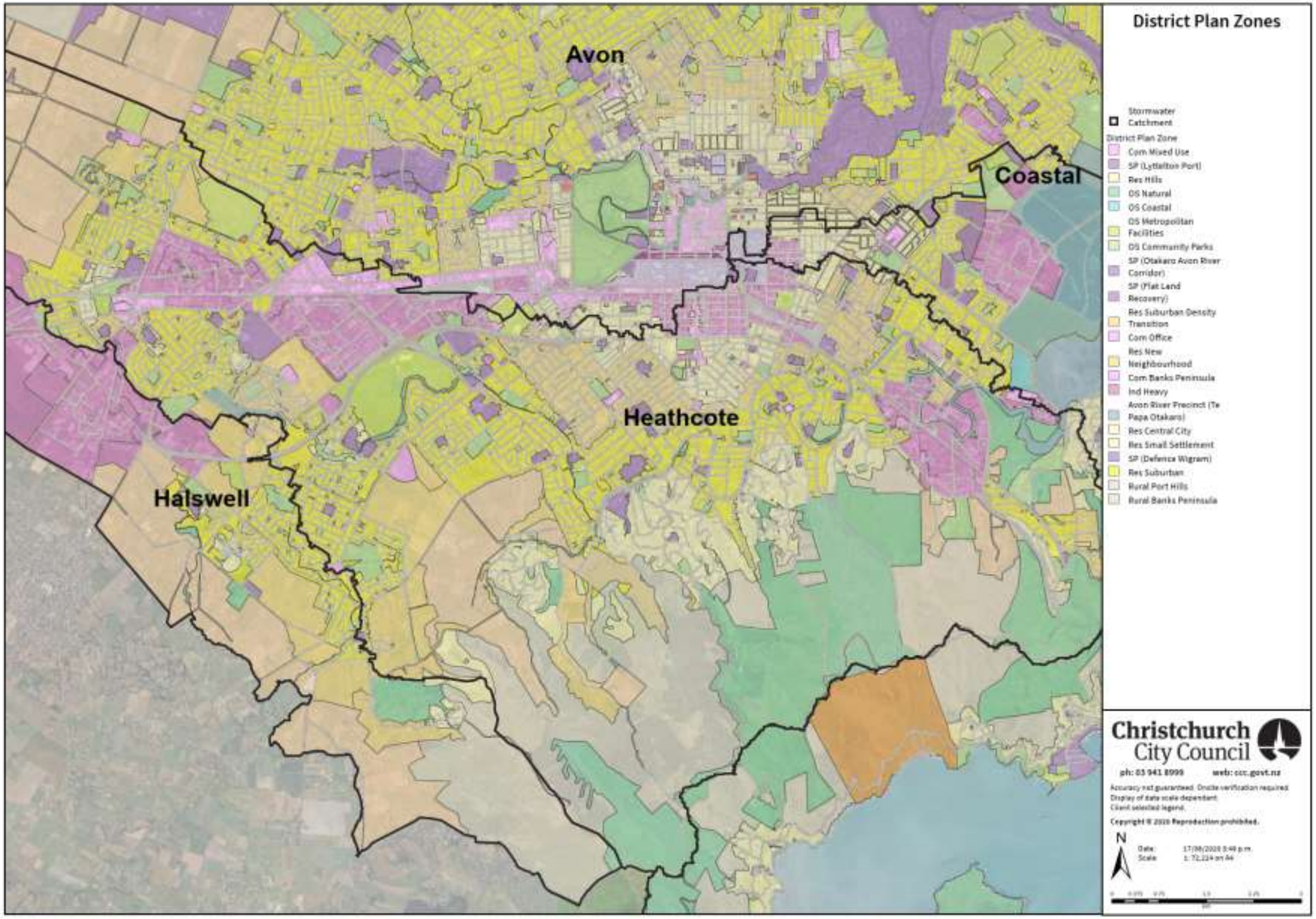

Figure 13: Land use (District Plan zones)

will be examined in terms of its appropriateness in achieving the purpose of the Resource Management Act (Sarah Oliver, Principal Advisor Planning, CCC)

7.2. Contaminated Sites and Stormwater

7.2.1. Background

The SMP considers two types of contaminated sites:

- Sites with in-ground contaminants of human origin that may move off-site with soil particles 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 such sites may require a resource consent and remedial action.

7.2.2. Low Risk Sites

A Memorandum of Understanding (MoU) was agreed between CCC 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 CCC 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 CCC 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 is considered low risk. Stormwater consents for the management of all but the most extreme risk sites will progressively transfer to CCC from 2025 as required in the CSNDC

A large proportion of the Ōpāwaho/Heathcote catchment is listed on the LLUR because of previous horticulture and market gardening with associated persistent pesticides and herbicides. The number of sites listed under these activities is approximately 400, which collectively cover approximately 240 Ha. These sites are generally at low risk of discharging contaminants into stormwater unless the sites are disturbed (e.g. during development).

7.2.3. Higher Risk Sites

“High risk sites” generally refers to sites with persistant or hazardous chemical 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 ground-water when soils are disturbed. These contaminants can be managed if there is good sediment control during earthworks and by 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 practises.

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.

7.2.4. Facilities Built Near LLUR Sites

No new facilities are proposed in the SMP.

7.2.5. Industrial Sites

Industrial sites will be managed in accordance with CRC214226 Conditions 47 and 48 in a process that will occur in parallel to this SMP. 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 Bylaw (which is currently under review).

7.3. The Port Hills as a Sediment Source

7.3.1. Deforestation History

"With post-glacial warming of the climate (pre-existing) tussock grassland was gradually replaced by forest which reached its maximum extent between 7,000 and 3,000 years ago. The climate became more variable and drought-prone about 3,000 years ago with subsequent occasional natural fires. Forest was probably significantly reduced on exposed, north facing slopes but probably continued to dominate the harbour basin and wetter higher elevation areas of the south-west hills.

Māori settlement brought about the first major wave of human induced landscape change. Much of the remaining Port Hills forests were burned… Tussock grassland, shrubs and kanuka are likely to have formed the dominant plant cover, especially on northern faces. European settlement resulted in another wave of environmental modification. Grazing animals and plants such as cocksfoot, clovers, gorse and broom were introduced. Burning to promote young palatable tussock growth for grazing increased fire frequency, and the remaining forest areas of Lyttelton Harbour and the south west hills were largely logged to support the growth of Christchurch." (McMillan)

"The predominant (present day) vegetation of the rural part of the Port Hills is a mixture of oversown and topdressed short tussock (mainly silver tussock) grasslands, with some limited indigenous bush remnants, as well as small areas of exotic forest." (ECan).

(Despite the current land cover) the Port Hills are still situated in a forest climate and in natural post glacial circumstances would be largely forest or shrub covered." (McMillan)

Most Port Hills grassland is owned by the CCC, the Port Hills Park Trust Board, and the Department of Conservation, however there are significant privately owned areas above Avoca Valley and Mt

Pleasant. Those parts of the Port Hills in public or trust board ownership are protected from development in order to

- protect remnant indigenous biodiversity
- enhance biodiversity
- conserve landscape values and the city's rural backdrop
- increase recreation opportunities.

"The majority of the Port Hills grasslands have been classified as an outstanding natural landscape in the 2015 District Plan review. 'Natural' in this context largely relates to the unbuilt character, topographical features and large areas of indigenous tussock." (McMillan)

"Grazing management of the Port Hills has been the norm for over 150 years" (McMillan). Council land is leased for grazing with the purpose of controlling weeds and limiting fire danger. Pastoral use continues largely because of the cost of native forest revegetation but also because the risk and consequences of fire are considered to be reduced in grassland areas.

7.3.2. Erosion

"By the mid-20th century, it was apparent that conversion of otherwise fertile and productive lowland hill country from indigenous forest to pasture had triggered severe soil erosion in many parts of New Zealand" (Bloomberg & Davies). The role of deforestation in accelerating erosion on the Port Hills is not well documented, however Trangmar comments that "Man-induced factors that may lead to tunnel gullies (believed to be the major contributor of sediment to streams that drain the Port Hills) include uncontrolled discharge of stormwater (e.g. off the Summit Road, Rapaki Track) onto loessial soils; depletion of vegetation cover by heavy grazing; disturbance of subsoils during site preparation … and use of recompacted unstabilised loessial materials for fill" (Trangmar 2003).

Bruce Trangmar of Landcare Research was engaged to assess erosion risk on the Port Hills after the October 2000 storm had caused many large slips. His report mapped approximately 600 hectares within the Heathcote Catchment at severe risk of tunnel gully or slip erosion. Trangmar's "severe" erosion areas coincide with sediment sources known to Port Hills Rangers. Since year 2000 an ongoing revegetation programme has planted 79 Ha of native trees and plants on selected "severe risk" sites. Some of this 79 Ha was burned in the Port Hills fires of 2017.

7.3.3. The Value Of Replanting For Land Stabilisation

"From the onset of a nationally-based soil conservation programme in the 1940's, reforestation of pastoral land with exotic tree species has been a preferred method for control of erosion. This policy has resulted in significant areas of plantation forests in NZ located on land with high or very high erosion susceptibility." (Bloomberg et al. 2011).

"Vegetation works in many ways; it stabilises soil by its root system, it provides a ground cover that improves microclimate and soil conditions as well as acting as a protective layer for bare soil against rain splash, it may enrich the soil by fixing nitrogen in its roots, and it may act as a filter or barrier to sediment-laden runoff." (Phillips). Phillips also comments that "…research and investigation on the use of indigenous vegetation specifically for erosion and sediment control has, in general, received little attention in New Zealand." Nevertheless permanent native forest is considered to be a desirable and stable land cover for New Zealand hillslopes (Walls). Native plants contribute to biodiversity and landscape character, are adapted to the climate and do not pose a risk of invasive species spread.

Regional Parks Rangers have carried out replanting on unstable areas since c2004, at an average rate of 5 Ha per year, achieving a total planted area of 80 Ha. The planting programme is continuing.

8. Contaminants in Stormwater

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 cleaning compounds, combustion products, wind blown dust, etc. Most of these substances are 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. Contaminants of most concern are:

- Dust, sediment, grit, and particles of all types capable of being transported in stormwater, referred to as total suspended solids (TSS). Suspended solids 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)
- Bacteria
- Nutrients (phosphorus and nitrogen)

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

- Hydrocarbons (oil and grease)
- Cadmium and lead

8.2.1. Suspended Solids

Particle sources include construction activity, land cultivation, combustion, industrial products, tyre and brake wear and paint coating breakdown. Some particles are natural materials and some are artificial (e.g. paint chips). Natural particles are not necessarily non-polluting, as they often 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 release attached toxic compounds which harm the food chain.

The most important particulate sources in the Ōpawāho/Heathcote Catchment are considered to be:

- Construction sites
- Road works
- Unstable parts of the Port Hills

Many construction sites and road works lose sediment into stormwater runoff by erosion or via truck wheels onto roads, from where it enters the stormwater network. Most Port Hills sediment enters streams in overland flow from slips and tunnel gullies. Roads convey sediment into the stormwater network. Vehicular traffic is not major a sediment generator by quantity, but generates a large proportion of the city's toxic copper and zinc.

8.2.2. 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 rain water. Industrial and commercial areas have large areas of unpainted galvanised roofs and are a major source of zinc. Residential areas typically have painted or tile roofs, but many of these have older paint coatings in poor condition. Because residential areas are so extensive these old roofs are also a major source of zinc.

Zinc makes up about 1% by weight of tyres in which zinc oxide is a vulcanising catalyst. Tyre wear releases zinc onto roads. Roofs create approximately ¾ of urban zinc. Roads create approximately ¼, much of which is from tyres.

Other zinc sources include galvanised fencing and posts, fungicides, paint pigments and wood preservatives.

Many sources such as Timperley et al (2005) report that tyre derived zinc is transported onto other surfaces, including roofs, by wind. Stormwater sampling in Christchurch supports this, showing zinc runoff occurring from nominally zinc-free surfaces such as concrete tile roofs.

8.2.3. Copper

The largest amount of exposed urban copper is a binding and anti-vibration element in brake pads where it may comprise from a few percent to 10% by weight. The majority of copper in urban stormwater comes from fine copper particles abraded from brake pads. These particles are so fine that a large proportioin can be quickly dissolved by rainfall to become bioavailable, often at toxic concentrations.

Copper is used in luxury roof cladding, spouting and downpipes, fungicides and moss killers. Architectural copper could become a significant copper source if usage increases.

8.2.4. Polycyclic aromatic hydrocarbons

PAHs are created when products like coal, oil, gas, and garbage undergo an incomplete burning process. PAHs are a concern because they do not break down readily and can stay in the environment for a long of time. PAHs may also come from coal tar sealants, diesel or industrial combustion. A number of old streets were surfaced with coal tar, although they have been resurfaced with bitumen, which does not contain PAHs. Edge frittering and surface deterioration can still release coal tar particles. There can be high PAH concentrations in nearby stream and river sediments.

8.2.5. Pathogens

E. coli are sampled routinely as an indicator of the potential presence of other faecal-sourced pathogens. *E. coli* sources include faecal material from water fowl, dogs, ruminant animals, birds and humans. *E. coli* are assessed in conformity with national microbiological water quality guidelines as an indicator of human health risk.

Although there is persistent concern that wastewater overflows introduce pathogens into rivers, recent studies show there are other and potentially more significant sources such as water fowl.

Since wastewater overflows occur infrequently, and only during heavy rain when dilution and flushing also occur, they can be considered an infrequent and minor source of pathogens. Canine sourced faecal material is also less likely to be found in rivers, because of compliance with the Dog Control Bylaw 2016 (part 5; owners disposing of dog faeces), and because dog faeces enter rivers only indirectly when washed in during rainfall.

Environmental Science and Research Limited (ESR) was engaged to investigate *E. coli* sources. Moriarty & Gilpin, (2015):commented[2] that water fowl are the major cause of pathogen numbers exceeding recreation guidelines. Contact recreation can be made safer principally by reduction in the numbers of water fowl. It is recommended that the Council, through education and communication, seeks a mandate from the community to reduce water fowl numbers.

8.2.6. Nutrients

Nitrogen (nitrate, Nitrate-Nitirite-Nitrogen and Dissovled Inorganic Nitrogen) concentrations decrease downstream. This trend has been observed for many years in Christchurch rivers and has been attributed to nitrogen-rich spring input in the upper catchment deriving from rural land uses (such as fertilisers and animal waste). Recent research by the CCC within the Avon River catchment has confirmed that springs contribute high levels of nitrogen and phosphorus into waterways, accounting for this downstream trend in nitrogen concentrations (Munro, 2015). Spring flows entering the upper river are thought to arise from shallow groundwater that is more influenced by agricultural inputs. Deeper groundwater containing more seepage from the Waimakariri River enters downstream parts of the river. This water contains less nitrogen and progressively dilutes in-river nutrients.

Nitrogen very seldom exceeds LWRP toxicity guidelines with respect to ammonia (this guideline varies depending on pH) and nitrate (3.8 mg/L), but frequently exceeds a non-LWRP guideline (ANZECC, 444 µg/L) set to avoid excessive instream plant growth. The recent PDP instream springs study (PDP, 2016) also showed substantial nitrogen inflows to Ōtākaro/Avon tributaries via spring flows, suggestive of non-urban sources (i.e. agricultural catchments).

Phosphorus can exceed guidelines in Christchurch during wet weather. Higher phosphorus levels are found in Haytons and Paparua Streams, indicating that the sources are industrial. A weak-to-moderate positive correlation was recorded between suspended solids and phosphorus in the 2015 CCC surface water monitoring report (Margetts & Marshall, 2016) indicating that this increase may be related to cumulative sediment inputs downstream. Leaf decomposition can be a major source of phosphorus. Phosphorus inputs can also come from fertilisers and faecal matter.

Phosphorus concentrations increase downstream in the Ōpawāho/Heathcote River, indicating that Port Hills sediment may be an important phosphorus source. A recent study (PDP, 2016) shows substantial phosphorus inflows to Ōtākaro/Avon tributaries via spring flows, suggestive of non-urban sources (i.e. agricultural catchments).

8.2.7. Emerging contaminants

Unknown contaminants or contaminants that are not sampled for may have consequences for stream ecology that will only be discovered over time. Potential new contaminants include microplastics, hormones, herbicides and cleaning products (e.g. moss killers). The Council's approach to this subject will be to remain up-to-date with national and international research.

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[2] Additional commentary at Appendix E

Table 5: Contaminant sources

Contaminant	Source	Contribution	Possible Mitigation Methods
Sediment	Port Hills	Very high	Valley retirement & planting
	Construction sites	High	Sediment & erosion controls
	Road works	High	Sediment controls
	Road surface abrasion	Medium	Treat road runoff
	Atmospheric deposition	Low	None
	Plants (leaves, etc)	Medium (seasonal)	Street sweeping
	Vehicle emissions	Low	Treat road runoff
	Residential activity (car washing, gardening)	Medium	Behaviour change
Zinc	Bare galvanised roofs	Very high	Replace with: Non-metal roofs or Pre-coated Zn-A[3]l Paint with: Low zinc paint
	Old painted roofs	Very high	Replace with: Non-metal roofs or Pre-coated Zn-Al Paint with: Low zinc paint
	Bare Zn-Al[4] roofs	High	Replace with: Non-metal roofs or Pre-coated Zn-Al Paint with: Low zinc paint
	Vehicle tyres	High	Treat runoff from: Busiest roads Car parks Manoeuvering areas
:	Industrial discharges (inferred from monitoring)	Medium	Controls on industrial sites
Copper	Brake pads	High	Legislation bans copper in brake pads
	Roofs, cladding, spouting, downpipes	Low but increasing	Ban on copper cladding
Human sourced bacteria	Sewage overflows	Infrequent but culturally offensive	Improve waste-water system capacity

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[3] Pre-painted zinc-aluminium coated steel. Brands include ColorCote®, ColorSteel®.

[4] Zinc-aluminium coated steel. Has commonly replaced galvanised iron since 1994.

Contaminant	Source	Contribution	Possible Mitigation Methods
Waterfowl sourced bacteria	Ducks, geese	Major bacteria source	Reduce exotic waterfowl numbers
Industrial discharges	Deliberate spills or poorly controlled sites	Medium	Regulation, monitoring and enforcement
Polycyclic aromatic hydrocarbons	(1) (Old) coal tar street surfaces. (2) Combustion	(1) High but isolated. (2) Low	(1) Encapsulation or removal. (2) Monitor
Nitrogen (nutrient)	(1) Groundwater (2) Fertiliser (3) Faeces (human, dogs, farm animals and waterfowl)	(1) High (2) Believed low (3) Believed moderate	(1) Beyond CCC control (2) Education (3) Reduce wastewater over-flows and exotic waterfowl numbers. Owners collect dog droppings. Fence waterways.
Phosphorus (nutrient)	(1) Industrial sources (2) Fertiliser (3) Faeces (human and waterfowl) (4) Groundwater	(1) Moderate (2) Believed to be a minor source (3) Believed moderate (4) Moderate	(1) Education, enforcement (2) Education (3) Reduce wastewater overflows and exotic waterfowl numbers (4) Beyond CCC control

9. Flood Hazards

9.1. History

Stormwater drainage in Christchurch was under the control of the Christchurch Drainage Board from 1875 until 1989. The Board principally constructed sewage works for its first 90 years, with some open drain construction and stream widening. The Ōpawāho/Heathcote River was widened and deepened (by approximately 1 metre) in the 1950s.

Some decades of relatively dry weather came to an end in December 1963 when rainstorms caused serious flooding, especially near the Port Hills and in Waltham. After the Wahine storm (1968) the Board resolved to change the emphasis of its works programme and spend at least the same amounts of loan money on stormwater as on sewer works. This led to several major works in the 1970s and 1980s.

Investigations into a flood control scheme for the Ōpawāho/Heathcote River commenced in the 1970s. The Woolston Cut, considered essential to solve flooding in the Lower Ōpāwaho/Heathcote River, proceeded in 1985 and bypassed the 2.75 kilometre Woolston Loop. Subsequent saline intrusion killed many river-side trees and destabilised river banks. The Woolston Barrage, built in 1993 by the Christchurch City Council, allowed normal river flows to re-establish and opens only at times of heavy rain. The adverse environmental impacts of the Woolston Cut gave rise to a determination by both community and Council, to seek 'non-structural' approaches to flood mitigation. The joint Ecan/CCC *Heathcote River Floodplain Management Strategy* (1998) emphasised reducing flood damage rather than flood levels by planning measures rather than physical works. Within the upper catchment large natural ponding areas, particularly in Hendersons Basin were protected and flood detention capacity has increased over time.

The new millennium was relatively quiescent until early 2014. During March and April 2014 Christchurch experienced the heaviest sequence of rainfall since the 1970s. Flooding in many locations was exacerbated by ground level changes that occurred during the 2010 and 2011 earthquakes. Thirteen houses along the Ōpawāho/Heathcote River have experienced flood inundation above floor level two or more times since the earthquakes. A Mayoral Flood Taskforce was formed to find solutions for those residents most vulnerable to regular flooding across the city. Subsequently, a capital works programme called the Land Drainage Recovery Programme has provided a number of solutions to flooding as described in the Appendix B History of Flood Control. Flooding in July 2017 resulted in the fast-tracking of an $80 million programme of floodplain management, with work beginning on these in early 2018, with completion of expected in 2022.

9.2. 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. 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 minimum floor levels are set 400mm above the 200 year annual recurrence interval flood level. FMAs are zones in the District Plan which would be covered 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" (HFHMA) 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.
- Hendersons Basin is one of the city’s Flood Ponding Management Areas (FPMA) in the District Plan where filling is restricted so as to preserve the flood storage capacity of the basin and thus moderate the flood flows in the river.
- Otherwise a 50 year average recurrence interval event is used to set minimum floor levels as required by the Building Act.

9.3. Floodplain Management Strategy

The Christchurch City Council and Environment Canterbury jointly adopted a floodplan management strategy for the Ōpawāho/Heathcote River in 1998. The purpose of the strategy is to outline recommended planning and structural measures that the Council will follow to ensure that the risk of flooding on the Ōpawāho/Heathcote River floodplain does not increase. This general strategy remains in place with some refinements over time.

Table 6**:** Ōpāwaho/Heathcote River Floodplain Management Strategy 1998

Floodplain Area	**Issue**	**Management Measures**
Whole catchment	General	▪ Develop and implement information and education programmes ▪ Emergency warning procedures ▪ Finanial contributions from developers toward flood mitigation ▪ Encourage minimisation of hard surface areas
Lower catchment	Tidal flood damage	▪ Maintain existing floodplain management measures ▪ Localised stopbanks protect individual properties in and around Woolston Loop ▪ Minimum floor levels

	Increase in potential tidal flood damage due to sea level rise and new development	▪ Restrict development on un-developed part of the tidal floodplain ▪ Localised stopbanks protect individual properties in and around Woolston Loop ▪ Minimum floor levels
Middle catchment	Potential flood damage as a result of significant rainfall events	▪ Maintain existing floodplain management measures ▪ Minimum floor levels
	Increase in potential flood damage as a result of new development and re-development in the middle Ōpawāho/Heathcote River catchment	▪ Maintain existing floodplain management measures ▪ Enhancement of the Cashmere/Worsleys Valley ponding area ▪ Maintain river setbacks ▪ Minimum floor levels
	Increase in potential flood damage as a result of new development in the upper part of the Ōpawāho/Heathcote River catchment in areas of relatively pervious soils	▪ Maintain existing floodplain management measures ▪ Community soakage ▪ Swale systems ▪ Roof water directly to soakage ▪ Storm detention (subsequent addition to the Strategy)
	Increase in potential flood damage as a result of new development in the Cashmere Stream sub catchment in areas of relatively impervious soils	▪ Maintain existing floodplain management measures ▪ Community retention through green corridors ▪ Swale systems
Upper	Potential flood damage as a result of inappropriate development in the Waimakariri River overflow channels	▪ Avoid high risk/high damage development (e.g. industry and hospitals) in Waimakariri River overflow channels.

9.4. Flood Modelling

The first modern hydrodynamic computer model to predict design flood levels on the Ōpāwaho/Heathcote River was described in the ‘Ōpāwaho/Heathcote River Flood Study’ (Oliver and Peters, 1993) and updated in ‘Ōpawāho/Heathcote River floodplain study updated analysis and assessment of mitigation measures’ (Oliver, 1998). Hydrographs for 22 sub-catchments were generated using the MOUSE software package and routed down the river channel using the MIKE 11 hydraulic software package.

The current model is a fully coupled 1D/2D flexible mesh MIKE FLOOD model which includes 80 existing flood storage basins in the Ōpawāho/Heathcote catchment and resolution of the stormwater pipe network down to 300 mm dia. It uses rain-on-grid as an input in flat areas, and RORB for generating runoff in the hillside areas. The new model has been used to verify the performance of the network of flood storage basins constructed since 1991.

The existing development scenario (ED) is the 2020 network with all storage basins included. This includes all the infrastructure added to mitigate the increased flood risk from the changes caused by the earthquakes. The maximum probable development scenario (MPD) is based on growth projections to 2068 to match the liquid waste planning horizon.

9.5. Pre-earthquake Situation

Flood mitigation planning has included the Ōpāwaho/Heathcote Scheme Stage 1, the Ōpawāho/Heathcote Floodplain Management Strategy, and mitigation measures under the South-West Area ICMP. Past interventions included the Woolston Cut, a 90% subsidy to raise 29 flood-prone houses in the middle reaches of the river, planning controls on building and filling in Hendersons Basin, construction of the Wigram East Detention Basin, diversion of the Halswell Junction industrial area to the Halswell River, and construction of storm detention basins.

Planning measures were in place to ensure that new buildings were above anticipated flood levels.

9.6. Flood Hazards

This section is still to be completed - Identification of areas subject to known flood hazards.

9.7. Land Drainage Recovery Plan

The new millennium had been a relatively free of flooding and flood damage until early 2014. During March and April 2014 Christchurch experienced the heaviest sequence of rainfall since the 1970s. There was flooding in many parts of the city, exacerbated by ground level changes that occurred during the 2010 and 2011 earthquakes. The Ōpāwaho/Heathcote River catchment again experienced severe flooding in July 2017. Seventy seven houses in the Heathcote River corridor experienced flood inundation above floor level two or more times since the earthquakes. In addition an estimated 427 houses experienced flooding beneath the floor on two or more occasions.

The Land Drainge Recovery Programme (LDRP) was developed to provide mitgation for increased flood risk resulting from earthquake changes along the Heathcote River, Dudley Creek and in other areas. In the Heathcote catchment this involved implementing some of the structural measures identified in the 1998 Floodplain Management Strategy, as well as introuding new measures.

In December 2017 Council agreed to a package for flood mitigation measures for the Ōpāwaho/Heathcote River which included:

- Bank stabilisation – to repair the worst areas of bank slumping and to add gains in channel capacity where possible
- Lower Heathcote Dredging - removing liquefaction sediment for capacity improvement
- Flood intervention policy – the Council made 24 offers to purchase properties with severely flood prone houses and 20 offers were accepted
- Upper Heathcote Storage – four storage basins in the Upper Heathcote to reduce the frequency and extent of flooding along the upper- and mid-Ōpāwaho/Heathcote River

The combined benefits of these works are presented in **Figure 14**, which shows the increase in flood risk as a result of earthquake changes, and the subsequent reduction with the LDRP works.

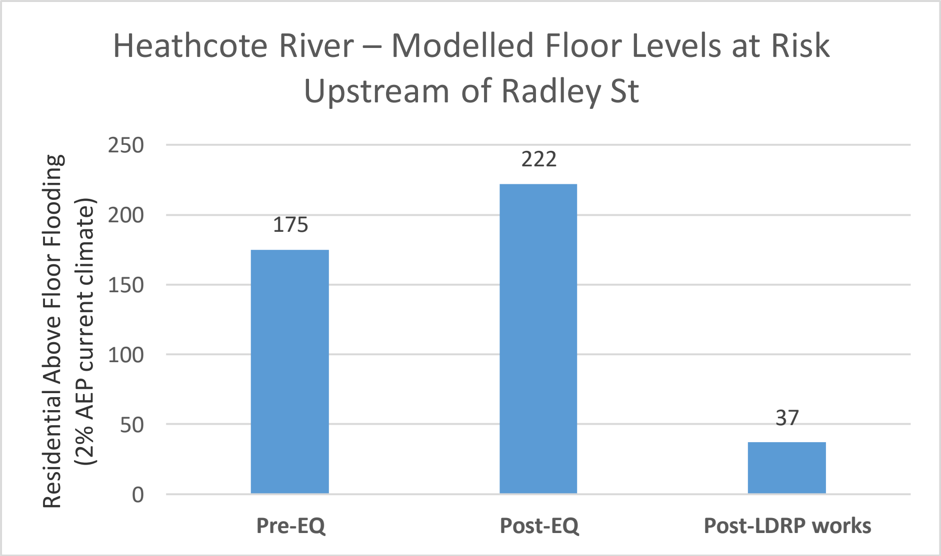


Figure 14 Modelled reduction in flood risk upstream of Radley Street as a result of LDRP works

Other significant post-earthquake projects in the catchment included:

- A city-wide hydraulic model that updates the previous Ōpāwaho/Heathcote model to include all the network down to 300mm dia
- Multi-hazard analysis - particularly for tidally influenced areas, looking at effects of non-flood hazards
- LDRP 501 - Bells Creek flood mitigation basins and pump station - works completed in 2018
- Curletts/Haytons Streams - EQ effects on flooding investigation once the City Wide model is completed
- LDRP 502 - Matuku Waterway diversion in Ōpāwaho /Heathcote Valley

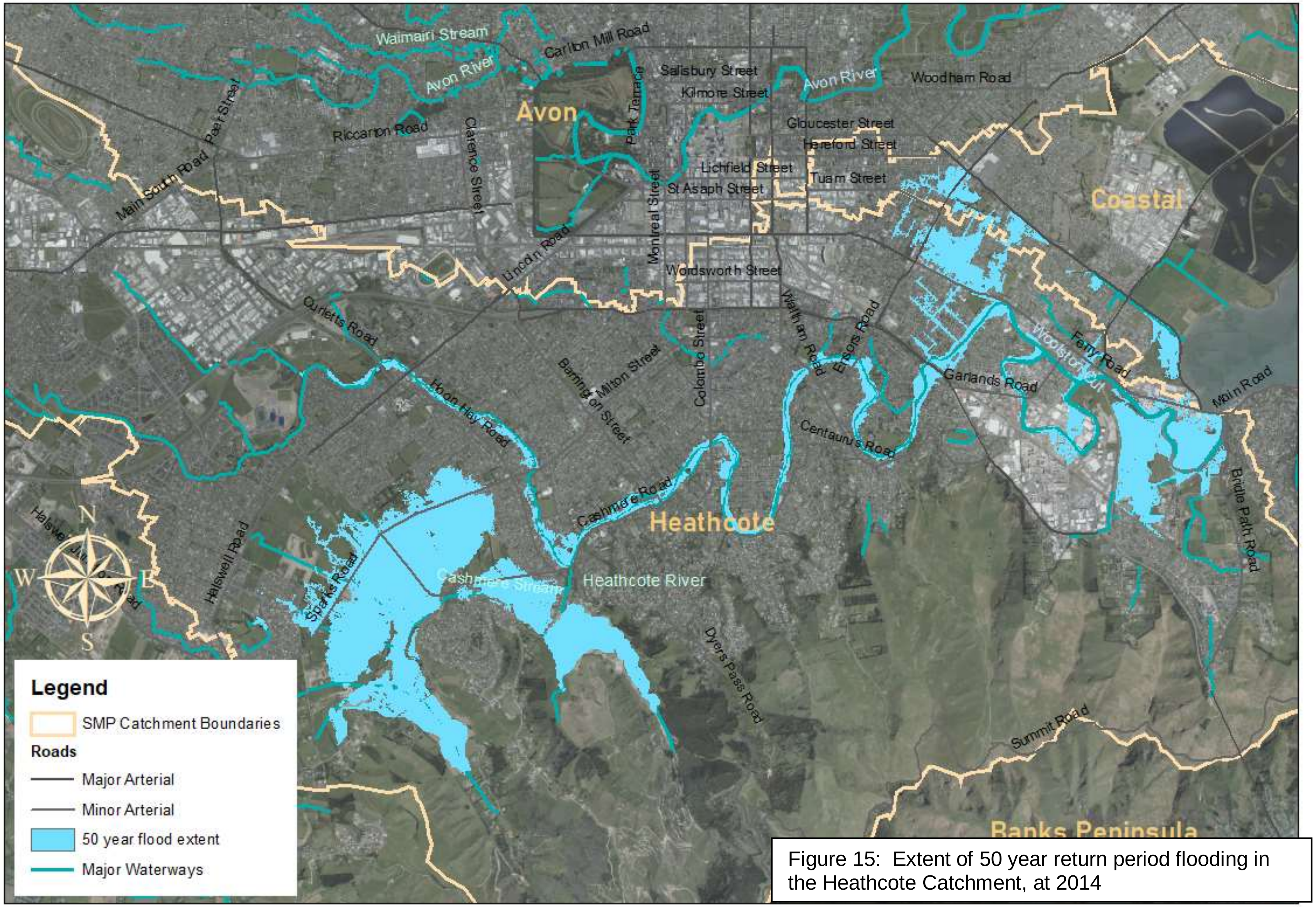


Figure 15: Extent of 50 year return period flooding in the Heathcote Catchment, at 2014

9.8. Comparison to 1991 Flood Levels at Ferniehurst Street

Schedule 10 of the Consent requires a comparison of Ōpāwaho/Heathcote River levels at the Ferniehurst monitoring site between 1991 and the present day. The requirement is that that flood levels for the 2 percent annual exceedance probability (AEP) critical duration event, measured at Ferniehurst, should not increase more than 30 millimetres *above* the comparable 1991 flood event.

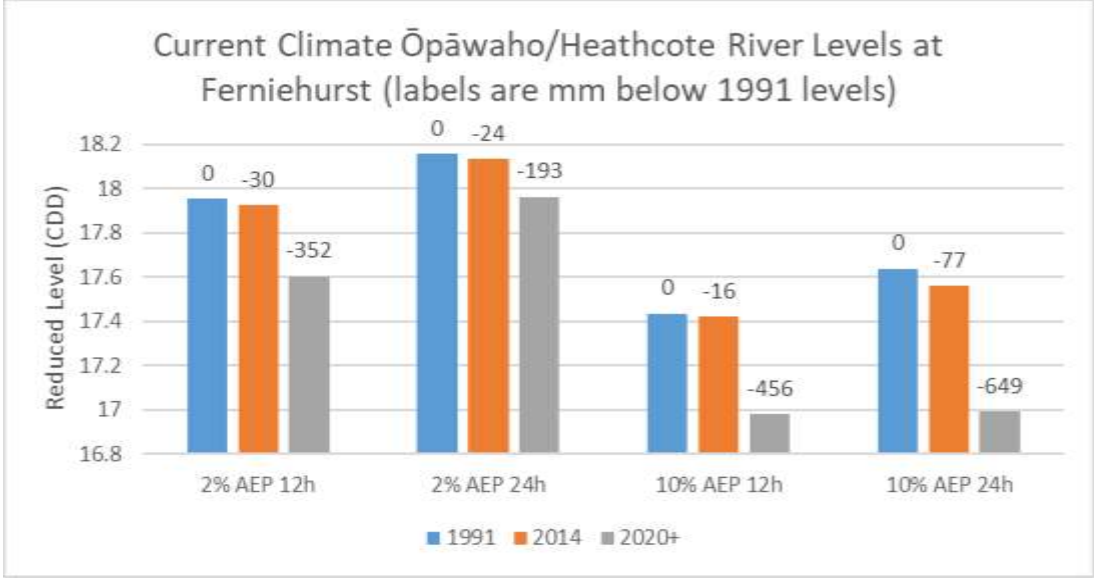
Using the new model, the critical duration at Ferniehurst Street has been determined to be 24 hours in the 2% AEP event. To meet the criteria defined by the CSNDC, Schedule 10[5], a 1991 model has been developed to allow a comparison of levels. While only the 2% AEP 24-hour event is required to be modelled, additional modelling was performed to determine the levels over a range of events and for two different 'present day' scenarios. The two present day scenarios are:

1. 2014 model – this does not include any infrastructure updates since March 2014, which is the baseline date for this model
2. 2020+ model - is the 2014 model with the addition of all basins currently in construction, but without some of the other infrastructure upgrades such as Bells Creek pump station

The Council is working towards a fully up to date model, which is not yet available. The current day result will be between the 2014 and 2020+ model, due to storage basins being partially complete.

The results of the modelling are shown in

Figure 16.



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[5] From Schedule 10 of CRC214226: 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 [30mm] when compared to the same modelled AEP for the baseline year [1991] 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.

Figure 16 Comparison of flood levels at Ferniehurst Street

As can be seen in the figure, both the 2014 and 2020+ models estimate lower flood levels at Ferniehurst Street in both the 10% and 2% AEP 12- and 24-hour duration events. There is a significant drop with the completion of the storage basins upstream. In the key 2% AEP 24-hour event, in the 2014 scenario the water level is modelled as 54 mm below the limit in Schedule 10, and 223 mm below in the 2020+ scenario.

Based on this analysis it is considered that the receiving environment attribute target level for water quantity has been met for the Heathcote catchment.

9.9. 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.

9.10. Effects of Sea Level Rise on Land

The greatest potential impacts of sea level rise include:

- increased risk of storm inundation associated with extreme tidal events
- progressive retreat of the shoreline in low lying areas.

Currently the Lower Ōpāwaho/Heathcote River is expected to experience increased frequency of inundation over time with about 1,171 ha potentially flooded by a 1% annual exceedance probability storm tide if it is accompanied by 1.0 metre sea level rise. (Tonkin & Taylor, 2014). Additional land around Ihūtai / Avon-Heathcote Estuary would be inundated by such an event.

9.11. Effects of Sea Level Rise on the Stormwater Network

Rising sea levels are expected to reduce the effectiveness of stormwater drainage. Effects can be quantified most accurately with the assistance of computer modelling, and have been included within the scope of a city-wide stormwater network model which nearing completion . Sea level rise will be perceived in increased tidal flooding of streets and rising groundwater levels. It will affect the land drainage network by

- Increasing the requirement for tidal backflow prevention
- Increasing the demand for stormwater pumping stations
- Leading in the long term to a need for pumping to lower groundwater levels,

Natural hazard planning processes are under way and will consider a range of options including engineering solutions, planning solutions and retreat – as has been done with the Council purchase of 20 properties in the lower Heathcote – however future retreat may be managed differently according to the circumstances at the time.

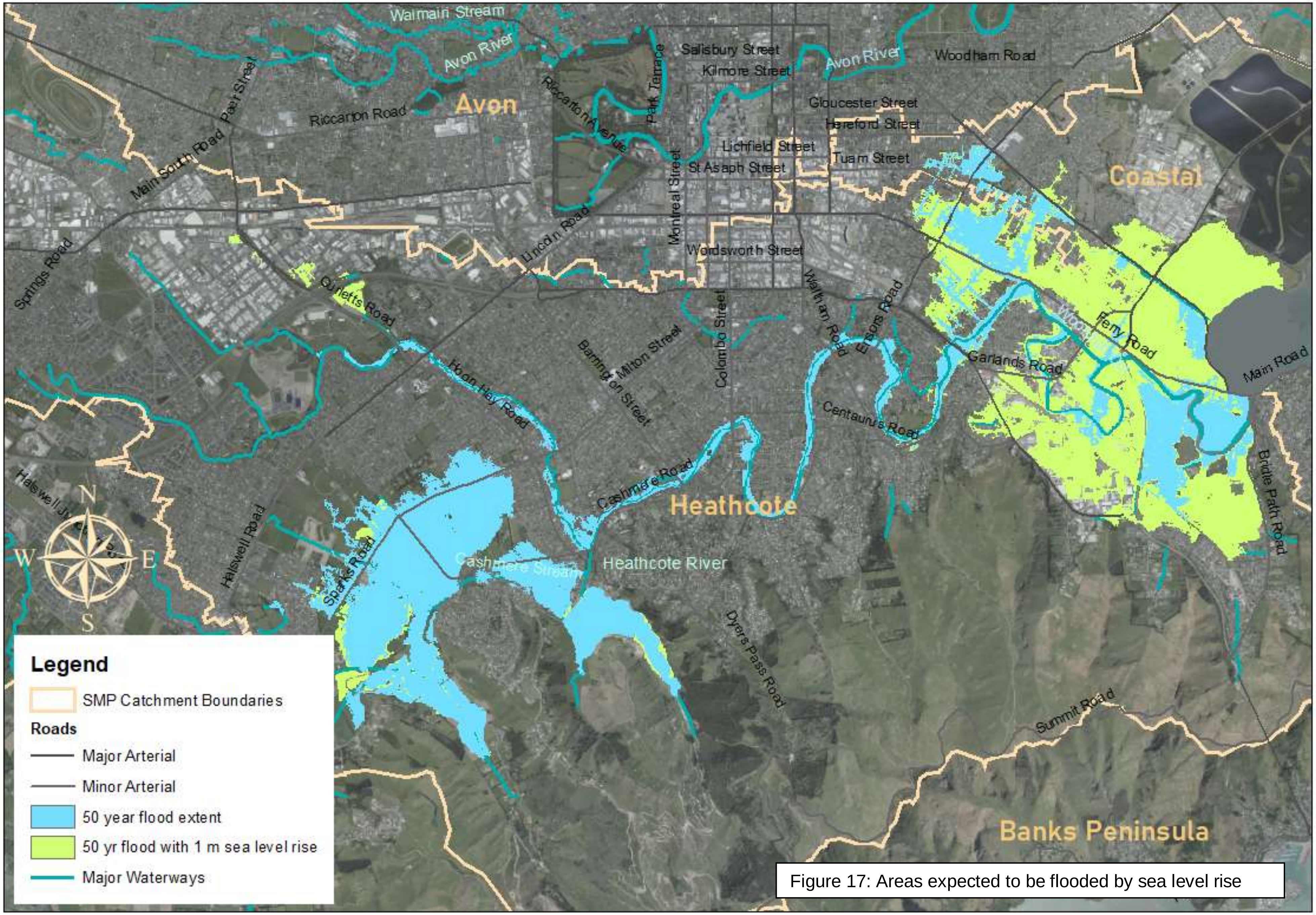

Figure 17: Areas expected to be flooded by sea level rise

Section Three

Objectives and Principles

10. Receiving Environment Targets

10.1. Numerical Consent Standards

Two CSNDC Conditions create contaminant reduction targets.

Condition 19 numerical targets: The Council is to specify target contaminant load reductions to be achieved by proposed facilities and devices.

Target reductions in Table 7 are those estimated by the C-CLM[6] be effected by a combination of future facilities and anticipated changes in contaminant sources (e.g. roof renewal with less contaminating materials). Table 7 targets contribute toward city-wide targets in CRC214226 Table 2.

Table 7: Target reductions in stormwater contaminant load.

Reductions result from treatment in new facilities and anticipated changes in contaminant sources.

Contaminant	Target reductions in stormwater contaminant load (tonnes/year) Resulting from construction of new stormwater mitigation facilities Compared to the consent application base year 2018		
	5 years from 2018 (year 2023)	10 years from 2018 (year 2028)	25 years from 2018 (year 2043)
TSS	17.9%	18.5%	19.1%
Total Zinc	10.6%	12.7%	23.8%
Total Copper	17.8%	17.9%	18.5%

Table 7 targets are the proportion of the Condition 19 Table 2 standard attributable to the Ōpāwaho/Heathcote Catchment

10.2. Non-numerical Consent Targets

Condition 23: “The (Council is to) use best practicable options to mitigate the effects of the discharge of stormwater on:

(a) Surface water quality, instream sediment quality, aquatic ecology health and mana whenua values. The extent of mitigation effects shall be measured by Receiving Environment Attribute Target Levels monitoring described in Schedules 7 and 8.

(b) Groundwater and spring water quality. The extent of mitigation effects shall be measured by Receiving Environment Attribute Target Levels monitoring described in Schedule 9.

(c) Water quantity. The extent of mitigation effects shall be measured by Receiving Environment Attribute Target Levels monitoring described in Schedule 10.”

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[6] Christchurch Contaminant Load Model

CRC214226 Schedule 7, 8, 9 and 10 targets are copied in Appendix D.

The Council is committed to actions in response to consent conditions that will lead to contaminant load reductions. At the present time the following actions are best practicable options for the Council to implement through the SMP:

- Treatment of stormwater from new development, Section 12.1 Goals 1.1 & 1.2
- Erosion and sediment control on development and construction sites, Section 12.1 Goals 1.3 – 1.5
- Investigating the feasibility and legality of zinc control measures for building cladding, Section 12.1 Goal 2.2
- Auditing high-risk industrial sites and working with occupiers to remediate contaminated stormwater discharges, Section 12.1 Goal 4.2
- Working with community groups and the public to educate the community about the effects of and mitigation of stormwater contaminants, Section 12.1 Goal 5.1
- Managing flooding by ensuring that stormwater from all new development sites or re-development sites will be attenuated to a minimum standard, Section 12.1 Goal 6.1

Further work will be required to identify best practicable options (BPOs) for mitigating copper and zinc discharges from buildings, copper discharges from vehicles and sediment discharges from sources other than development sites. Implementation of such BPOs is more likely to be implemented through the Surface Water Strategic Plan referred to in section 2.1.

10.3. Role of Monitoring and Tangata Whenua Values in Setting Targets

10.3.1. Environmental Drivers

Although the state-of-the-environment sampling programme provides a limited basis from which to draw conclusions about water quality effects from stormwater flows, it is clear from ecological monitoring that waterways in the catchment are in poor condition overall. It is generally inferred that that this is a result of altered flow regimes and contaminant discharges associated with urban development. Targets have been set with a view to obtaining significant reductions of TSS, copper and zinc over the long term.

10.3.2. Maahanui Iwi Management Plan Objectives

This Plan recognises and is intended to help support the policies and objectives for water and the environment in the Ihūtai Catchment, from the Mahaanui Iwi Management Plan 2013.

Table 8: Response to the Maahanui Iwi Management Plan

Iwi Management Plan	Ōpāwaho/Heathcote SMP response
Policy IH3.1 To improve water quality in the Ihutai catchment by consistently and effectively advocating for a change in perceptions of waterways: from public utility to wāhi taonga.	A *Community Water Partnership* programme is being prepared and will carry out an education and advocacy role once it is funded and implemented.

Iwi Management Plan	Ōpāwaho/Heathcote SMP response
Policy IH3.2 To require that waterways and waterbodies (including Te Ihūtai) are managed to achieve and maintain a water quality standard consistent with food gathering.	The SMP can contribute toward this to the extent indicated by the Goals in section 12.1.
Policy IH3.3 To require that local authorities eliminate sources of contaminants to waterways in the Ihutai catchment, primarily:	
(a) Sewage overflows in the Ōpāwaho and Ōtakaro rivers;	8 significant overflow sites eliminated since the earthquakes. Somerfield WW pumping station due $7.7M upgrade 2022-24; Eastern Tce WW main $1M upgrade 2022 will further reduce overflows. (Wastewater overflows are consented separately under CRC182203.)
(b) Stormwater discharges into all waterways, including small headwater and ephemeral streams, and drains;	The SMP is a management tool for reducing contaminant discharges into waterways. The CCC does not see an alternative to stormwater discharge into waterways in the near term.
(c) Run-off and discharges into waipuna;	The CCC cannot currently prohibit discharges into a waterway that flows past/over waipuna. Improving stormwater quality generally is the only approach that seems to be open to the CCC in the foreseeable future.
Policy IH3.4 To advocate for the following methods for improving water quality in the catchment:	
(a) Avoiding the infiltration of stormwater into the sewage systems, which results in overflow discharges to the rivers and estuary;	(measures are being implemented to reduce wastewater overflows)
(b) Protect and retain margins and set back areas along waterways, and ensure that these are of appropriate width and planted with indigenous species;	Waterway margins are generally protected by the District Plan
(c) Restoration of degraded springs and wetlands; and	
(d) Requiring on site and closed stormwater treatment and disposal techniques (that do not discharge to water) for urban developments, public lands and parks	High groundwater and impermeable soils seem to make this unfeasible in many parts of the city. Treatment is required for new development, (although the CCC is aware that even best practice treatment is not fully effective.) The volume of stormwater seems to make closed systems not practicable: however the Council is working to remove contaminants of stormwater in the long term
Policy IH5.1 To require that the waipuna in the catchment are recognised and managed as	The SMP may not be the right way to control discharges to waipuna and restoration of waipuna.

Iwi Management Plan	Ōpāwaho/Heathcote SMP response
wāhi taonga, as per general policy on wetlands, waipuna and riparian margins (Section 5.3, Issue WM13), with particular attention to: (a) Ensuring that waipuna are protected from the discharge of contaminants; (b) Ensuring that there are appropriate and effective setbacks from waipuna, to protect from urban development or re-development; (c) Restoring degraded waipuna; and (d) Enabling flow to return to waterways in naturalised channels.	The CCC will try to prevent direct discharges into waipuna through the District Plan: however such discharges are not prohibited by the consent conditions. Management of waipuna is a District Plan and possibly a Bylaw matter. Asset Planning – Stormwater and Land Drainage staff will advocate for this form of protection in District Plan reviews
IH6.2 To require that any physical works on waterways in the urban environment occurs in a manner that does not reduce the width of margins or riparian plantings, and is consistent with the re-naturalisation of the waterway.	Controls re applied through District Plan waterway setbacks and the Stormwater Bylaw, rather than through the SMP. However RMA provisions do not always permit full control.

11. Developing a Water Quality Approach

11.1. Introduction

An approach to mitigation has been considered for contaminants that regularly exceed water quality targets and are believed to be the major causes of poor stream health. Contaminant sources include industrial waste releases which cause pollution, although they are not readily monitored. Commonly detected contaminants that can be mitigated through the SMP are:

- Sediment (consent conditions require control by specified means)
- Industrial discharges containing oils, cleaning compounds, nitrates/nitrites, chemicals, etc (section 11.4)

Common contaminants requiring further investigation to establish best practicable mitigation options are:

- Port Hills sediment (section 7.3)
- Zinc (section 11.2)
- Copper (section 11.2.1)
- *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 Strategic Plan).

Other less significant contaminants that 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 include:

- Polycyclic aromatic hydrocarbons (PAHs): no consent targets. Do not exceed LWRP guidelines
- Nitrate and nitrite: no direct consent targets. Non-stormwater sources
- Phosphorus: no direct consent target. Non-stormwater sources
- Ammonia: no consent target. Does not exceed LWRP guidelines.

11.2. Modelling and options selection

A number of options were considered during development of the SMP. Option evaluation was informed by the Christchurch Contaminant Load Model (C-CLM) and two zinc contaminant models developed for this catchment.

Modelling indicates that significant gains could be made from reducing roof-sourced zinc. Other forms of treatment such as filters and rain gardens treating road runoff can also perform a useful role in treating zinc and other major contaminants. Stormwater treatment facilities, many already in place, are also beneficial, although they are most effective in capturing particulate contaminants including sediment and particulate metals.

Potential mitigation options are summarised in Table 9. However there is insufficient information to select a best practicable option (BPO) to control dissolved zinc. Considerably more information, such as the long term costs and benefits of maintaining roof coatings or of substituting roof materials, would be required before the Council could consult on and select a BPO.

The Council is researching the effectiveness of contaminant reduction options and the toxicity of short duration bursts of dissolved metals in waterways during stormwater runoff. Answers to these questions may be available within 2 – 3 years.

11.3. Potential Mitigation Options

Table 9 summarises potential at-source mitigations for contaminants. A more detailed list is in Appendix A – Action Plan

Table 9: Potential at-source mitigations for contaminants
TSS = total suspended solids BPO = best practicable option

Contaminant	Source	Potential Control Option	Comment	How the controls could be implemented
TSS, copper, zinc	New subdivisions (large sites)	Facilities in new developments to limit increases in flow rate and capture TSS	Partial mitigation, mostly for new growth (greenfields)	As conditions on subdivision, resource or building consents
TSS, copper, zinc	New development (small sites)	On-site (private) devices	Partial mitigation for new development (typically brownfields)	Included in Table 7 Minimum Standards for Development
TSS (mostly sediment)	Construction & excavation sites	CCC implements and monitors on-site erosion and sediment control	Can be difficult to do and is often poorly managed on site	Effected through conditions on individual resource or building consents
TSS (mostly sediment)	Road works	CCC implements and monitors on-site erosion and sediment control	Many contractors do this already	Required as a condition of Road Opening (road works) Permits
TSS	Vehicle traffic	Rain gardens, tree pits, and filters to treat runoff from busy roads. Road sweeping	Can also remove some zinc and copper. 7% of the city's roads generate an estimated 50% of metallic contaminants.	Install treatment devices over time to treat stormwater from contaminated catchments.
Port Hills sediment	Slips,under-runners, bank erosion	Fence and vegetate unstable valleys, slips, water courses	A small programme is ongoing. (Would offset erosion that results from urban activity e.g. bike tracks, road cuttings)	CCC leads by example on its own land; CCC educates and incentivises private land owners.
Port Hills sediment	Unprotected road cuttings	Shield from rain and runoff	Council leading by example	Further action may result from trials that are under way

Contaminant	Source	Potential Control Option	Comment	How the controls could be implemented
Copper	Vehicle brake pads	Educate residents about the value of low/no copper brake pads. Advocate with Government for legislation change	Legislation has occurred in USA. Some low-Cu pads available in NZ	Copper-free brake pads becoming available by market forces. CCC educates local auto industry and residents..
Copper	Architectural copper (roofs, spouting, downpipes)	Transparent sealer applied to copper surfaces	May not be fully effective e.g. inside downpipes. Sealer must be maintained in good condition or copper will continue to discharge.	This is a current control effected through building consents.
Copper	Architectural copper (roofs, spouting, downpipes)	Investigate the feasibility of a District Plan rule to discourage the use of copper claddings.		By seeking legal advice about the practicability of such a Rule. Under way.
Copper, zinc	Roads, roofs	Divert first flush to the wastewater network	Limited capacity available in WW network	This option is one of a number of Schedule 4 (CSNDC Condition 40) investigations.
Zinc	Bare steel roofs (mostly industrial)	1. Educate and encourage use of pre-painted roofing 2. Potential District Plan rule to require roof runoff treatment on site. 3. Potential District Plan rule to discourage the use of bare zinc roofing.		1. Educate and encourage use of pre-painted roofing 2. Investigate the feasibility of a District Plan rule to require roof runoff treatment on site. 3. Investigate the feasibility of a District Plan rule to discourage the use of bare zinc roofing.
Zinc	Poorly maintained painted roofs	Education programme re roof maintenance. Possible incentives.	Old paint coatings expose zinc primer and zinc substrate. Can be half as bad as bare roof. Roof re-painting could cost 20-30% of the cost of re-roofing.	CCC to investigate the costs & benefits of painting v renewal v civic scale stormwater treatment. Under way.
Zinc	Vehicle tyre wear	Treat runoff from major roads	Treatment is partially effective. Overseas research may	Install road runoff treatment devices. The CCC will continue to engage

Contaminant	Source	Potential Control Option	Comment	How the controls could be implemented
			discover a less toxic alternative to zinc. No current alternative.	with the government through MfE
Industrial waste and spills	Poorly controlled industrial sites	Surveillance, education, on-site improvements, enforcement		CCC Pollution Prevention Team to visit, educate and enforce starting with high risk sites.
Pathogens (bacteria, etc)	Water fowl, dogs, wastewater overflows	Reduce water fowl numbers, dog controls, wastewater overflow controls	Some dog and wastewater overflow controls in place.	CCC introduces controls on water fowl to restrict numbers to an agreed limit. Wastewater overflows are progressively being reduced.
Phosphorus	Multiple potential sources	Investigate sources. Education and enforcement used to control private/industrial sources.		Education and investigations could be funded through the Community Waterways Partnership
Nitrogen	Multiple potential sources	Investigate sources. Use education and enforcement to control private/industrial sources.		Education and investigations could be funded through the Community Waterways Partnership

11.4. High Risk Sites and Industries

The Council will manage industrial sites through a revised Stormwater Bylaw. The Bylaw (in preparation) will require the control of industrial contaminants to meet best practice. 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 (to be set up).
- Enforcement will occur as Pollution Prevention Officers identify and visit high-risk industrial sites and work with industries to improve site management.

Contamination risks are controlled 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.

The Christchurch City Council’s objective is that the water quality of stormwater discharges into the CCC’s network from industrial sites should be equivalent to the discharge from residential areas. For direct discharges from industrial sites to receiving waters the required water quality is likely to be to an even higher standard. On-site pre-treatment will 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.

Future needs include:

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

11.5. New Development

The SMP assumes that the city will extend through new development into the residential and commercial zones indicated in Figure 12. The rate of development can only be estimated: information available at this time is in section 7.1.

Contaminants, particularly sediments, generated by development are controlled by:

- rules in the District Plan,
- the Stormwater Bylaw 2021,
- the Erosion and Sediment Control Toolbox for Canterbury
- requirements of this SMP.

11.5.1. 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 both earthworks and building. The Stormwater Bylaw 2021 (in preparation at this time – March 2021) will specify standards for activities not controlled by consents.

Standards for sediment discharges are set by the (draft at March 2021) Sediment Discharge Management Plan 2020 (SDMP). The sediment discharge management process is intended to 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 onsite and monitored.

11.5.2. Constructed stormwater treatment systems

District Plan rules require new developments to incorporate stormwater quantity and quality mitigation. Treatment systems may comprise detention basins, infiltration basins, rain gardens, swales and filters. The majority of development in the Huritini/Halswell catchment is expected to be mitigated, multi-lot development. Both stormwater quantity and quality mitigation will be required:

i. Stormwater from development will be detained in storage so that post-development peak flows do not exceed pre-development peaks up to the 2% AEP critical duration event for the catchment.

ii. Stormwater contaminants are to be treated by the best practicable option as measured by Receiving Environment Attribute Target Levels in CRC214226 Schedule 7.

The minimum standards for stormwater detention and treatment associated with new development follow in Table 10.

Table 10: Minimum standards for stormwater detention and treatment

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	Erosion and Sediment Control Plan is required	Erosion and Sediment Control Plan is required
From new / re-development **residential** roof and hardstand areas	No discharge onto or into land where average site slope exceeds 5 degrees Sumps collecting runoff from new hardstand areas shall be fitted with submerged or trapped outlets wherever practicable 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) On-site rain water storage is required for new and redevelopment sites on the hills	No discharge onto or into land where average site slope exceeds 5 degrees First flush treatment is required for stormwater runoff from new hardstand areas in excess of 150m^2 and buildings with copper or uncoated galvanised metal roofs or guttering/spouting (1) 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) On-site rain water storage is required for new and redevelopment sites on the hills
From new / re-development **non-residential** roof and hardstand areas	No discharge onto or into land where average site slope exceeds 5 degrees First flush treatment is required for stormwater runoff from new hardstand areas in excess of 150m^2, buildings with copper or uncoated galvanised roofs or guttering/spouting and high-use sites An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required (2) Site management and spill procedures required for sites that engage in hazardous activities	No discharge onto or into land where average site slope exceeds 5 degrees First flush treatment is required for stormwater runoff from new hardstand areas in excess of 150m^2, buildings with copper or uncoated galvanised roofs or guttering/spouting and high-use sites An assessment of water quantity effects and provision of on-site stormwater storage or network upgrade may be required (2) Site management and spill procedures required for sites that engage in hazardous activities
Any land use with Canterbury Land and Water Regional Plan Schedule 3 activities.	An application for approval under the CCC Stormwater Bylaw must be made to authorise connection and discharge into the CCC network.	An application for approval under the CCC Stormwater Bylaw must be made to authorise connection and discharge into the CCC network.

Explanatory notes to Table 10:

(1) CCC has discretion to waive the requirement for first flush treatment of hardstand areas on large residential sites where the amount of pollution-generating hardstand being added is considered to have less than minor effect. “Uncoated” means without a painted or enamelled coating.

(2) 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 CCC considers an increase (including cumulative increases) has a more than minor effect, onsite 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.

(3) 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

11.6. Treatment Facilities

11.6.1. Existing facilities

Facilities serve both new developments, funded by developers, and established areas, funded by the Council. Many of the existing facilities follow from the South-West Integrated Catchment Management Plan 2008 (ICMP), either accompanying development (e.g. in Wigram Skies Subdivision) or were retrofitted to treat previously unmitigated developments (e.g. Awatea Basin). Some detention facilities (e.g. Curletts Basin & Wetland, 2019) were built to mitigate post-earthquake flooding, and also have a treatment function.

Stormwater treatment facilities, both existing and under construction, are mapped in Figure 17. Most facilities are detention basins, which treat stormwater and release a reduced flow rate into watercourses. Infiltration basins treat stormwater by filtration through the soil liner. All stormwater from infiltration basins up to (typically) a 50 year return period event goes into the ground.

All facilities in the South-West Area ICMP are already in some stage of construction.

11.6.2. Future facilities

Facilities will be built in future to service new development, which in this catchment will mostly be in the north-west. In order to comply with section 8.4.7.3.c in the Christchurch District Plan, stormwater must:

a. be detained and released at a rate not exceeding the pre-development peak flow rate up to the 50 year ARI critical duration event for that sub-catchment;
b. be treated by means of the best practicable option to remove contaminants in the stormwater;
c. be discharged into the ground by infiltration where practicable.

Stormwater should be discharged into the ground after treatment where discharge to ground is possible. Figure 19 [PLACEHOLDER] will be updated to show zones where discharge to ground is practicable.

11.6.3. 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 7. Developments should also comply with "*Onsite Stormwater Mitigation Guide'* (CCC 2021) which gives guidance about onsite storage and treatment for small to medium sites.

11.6.4. Designing Basins to Minimise Bird Strike on Aircraft

New stormwater facilities within a defined zone extending 3 km from airport runway thresholds (see District Plan Appendix 6.11.7.5) must meet activity standards in section 6.7.4.3 of the Christchurch District Plan. These activity standards are applied at the time of subdivision and provide a standard of bird strike protection approved through the District Plan Hearings process.

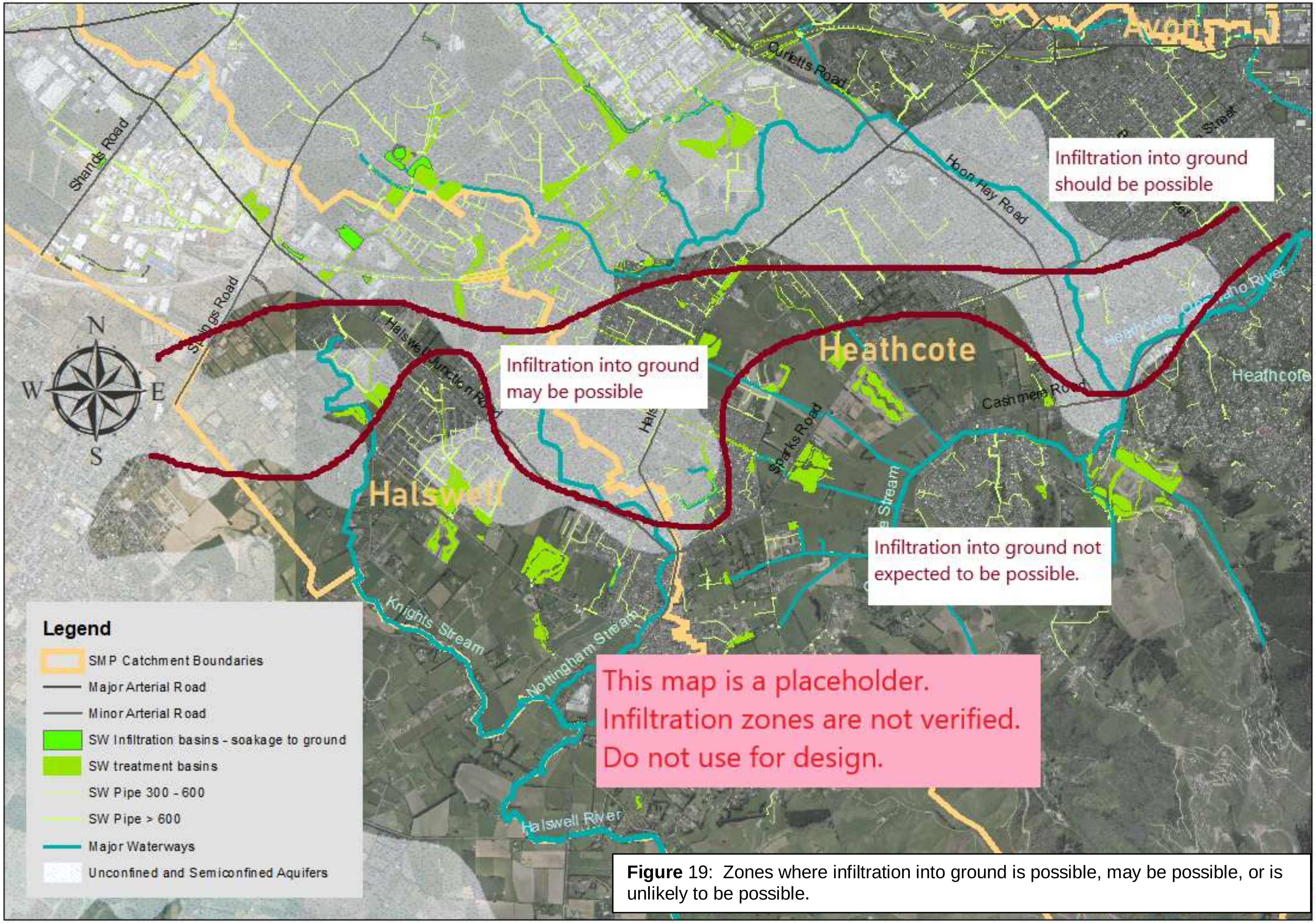
11.6.5. Avoiding Groundwater Mounding Beneath Infiltration Basins

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. Groundwater depth is not expected to be limiting for most future basins, which will be situated on gravelly plains in the north-west of the catchment; refer to Figure 17. Mounding is less likely where permeable gravels underlie a basin.

Groundwater Quantity and Quality Assessment for the Heathcote Catchment (PDP, 2016) indicates, based on modelling, that "…the extent of mounding (beneath basins) is expected to be limited. Under a worst case scenario infiltration could cause groundwater levels to rise by up to 3 m during a 50 year storm event."

Where groundwater may rise either to ground level or the basin floor level the designer must make provision, as appropriate, to discharge at a slower rate, and/or store stormwater until infiltration is no longer impeded, or acquire adjacent land that may be subject to water logging.

Figure 18 Stormwater Treatment Facilities



Infiltration into ground should be possible

Infiltration into ground may be possible

Infiltration into ground not expected to be possible.

This map is a placeholder.
Infiltration zones are not verified.
Do not use for design.

Figure 19: Zones where infiltration into ground is possible, may be possible, or is unlikely to be possible.

11.7. Effects of stormwater on groundwater

Impermeable surfaces created during urban development reduce stormwater infiltration into the ground. Stormwater management is likely to affect waterways rather than groundwater. However, groundwater can be affected due to changes in the location and rate of groundwater recharge.

In greenfields developments stormwater is detained in storage facilities which may be either detention or infiltration basins. The the type of basin depends on the permeability of the underlying strata and the depth to groundwater beneath the basin. Infiltration basins are typically more appropriate where strata are permeable and groundwater levels are relatively deep, and these conditions occur west of Hoon Hay and north of the Southern Motorway. Some localised groundwater mounding effects occur beneath infiltration basins. In general, these effects need not occur if infiltration basins are carefully designed.

Groundwater quality could be adversely affected by stormwater discharge from infiltration basins, which reduce but do not eliminate contaminants. This could potentially affect private drinking water supplies and could affect invertebrates (stygofauna) living in the aquifers. If infiltration basins are appropriately constructed, and located away from community drinking water supply protection zones and landfills the effects are expected to be limited. Detention (i.e. non-infiltration) basins leak minimally and are not expected to cause negative effects.

Groundwater mounding could cause adverse groundwater quality effects in the vicinity of old landfills or other contaminated sites. This issue will continue to be considered on a site by site basis.

Stormwater treatment mechanisms are expected to have minor effects on groundwater quality overall.

Because of the large amount of inflow from the Waimakariri River and the comparatively large amount of rainfall on the plains, the reduction in groundwater recharge due to urbanisation across those parts of the catchment where detention basins are suitable is not expected to be significant in the context of the overall water balance (PDP, 2016). Overall effects are expected to be small.

11.8. Changes to springs and baseflow

Existing land use in the Ōpāwaho / Heathcote catchment consists of a mix of residential, industrial, commercial and open space areas. Future development will increase the amount of impervious area and introduce new drainage patterns in new developments, which could be expected to affect the infiltration of rain into the ground and baseflow in the river. Developing areas are mostly in the west of the catchment where soils are permeable and there is a preference to infiltrate stormwater into the ground. Pattle Delamore Partners investigated the expected effects of urban development on the water balance, base flow and springs.

It was found that because stormwater runoff will be detained in treatment basins and infiltrated into the ground:

a. Anticipated development should result in a very minor increase in groundwater recharge.
b. The percentage baseflow change is estimated to be less than 1%.
c. Changes to spring flows are anticipated to be slightly positive, although almost negligible.

Section Four

Stormwater Outcomes

12. The Plan - Objectives

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

12.1. Objectives and Goals

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 section 11.5.1 being the minimum standard)*

1.2 *100% of stormwater treatment facilities contributing to consent condition 19 Table 2 are constructed and conform to WWDG standards.*

1.3 *Sediment from 95% of consented construction activities on the flat is treated to best practice by 2025*

1.4 *Sediment from 90% consented construction activities on the Port Hills is treated to best practice by 2025*

1.5 *Investigate the feasibility of techniques for remediating adverse effects of sediment discharges on receiving environments by 2022 (Schedule 3f)*

1.6 *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 CCC planning, design and procurement process.	Ongoing
1.3 & 1.4 Construction & excavation sites	On-site sediment and erosion control effected through Erosion and Sediment Control Plans	CCC enforcement powers under the Building Act 2004.	Train Building Inspectors. Implement an enforcement process. Contractor(s) on standby for cleanup when breaches occur.	ESC now part of resource consents for earthworks and building
1.5 How feasible to remove sediment	Desktop studies and field trials involving sediment removal from waterways.	Sediment removal by suction or excavation and	Desktop studies and field trials	2021-22

Action Plan for Urban Sediment				
Goal	**Action**	**Mechanism**	**Action Components**	**Timing**
from streams		sieving.		
1.6 Road runoff contains sediment	Investigate & develop methods to treat runoff from arterial roads,	Increase frequency of street sweeping, rain gardens	1. Street sweeping trials. 2. Construct rain gardens where feasible.	Commencing 2021

Recommended for consideration through the Surface Water Strategic Plan

1.7 *Plant severely eroding natural areas of the Port Hills (600 Ha identified by the Trangmar 2003 definition) from Ōpāwaho/Heathcote Valley to Hoon Hay Valley.*

1.8 *The Council works with farmers to control sediment from erosion sites on Port Hills farms by 2030, with subsidies as required to expedite controls.*

1.9 *Best practice sediment controls are implemented on Port Hills roads and tracks by 2025*

1.10 *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.)*

Objective 2. Control zinc contaminants

Our goals are

2.1 [repeats Goal 1.2] *All the facilities required to meet contaminant load reduction standards (Table 2 in the consent conditions) are constructed.*

2.2 *By 2022 the CCC 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				

Action Plan for Zinc				
Goal	**Action**	**Mechanism**	**Action Components**	**Timing**
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
2.2 & 2.3 Bare steel roofs, esp. industrial	Encourage owners to paint bare roofs. Consider subsidy to paint existing bare roofs	Education, incentives	Investigate environmental harm and costs/benefits of alternative materials. Educate via Community Water Partnership.	
2.2 & 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 is available	Research and trials	Under way 2021

Recommended for consideration through the Surface Water Strategic Plan

2.5 *By 2025 a civic-scale facility (or array of devices) will be installed in at least one urban sub-catchment to treat runoff from busy roads. By 2029 similar facilities/devices will be installed in at least three urban sub-catchments*

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

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

Objective 3. Control copper contaminants

Our goals are

3.1 *The CCC seeks to consult with the government, through the Ministry for the Environment, about legislation to limit the copper content in vehicle brake pads.*

3.2 *The CCC does not permit stormwater discharges into the network from unprotected copper cladding, spouting or downpipes.*

3.3 *The CCC 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.	NZ-wide legislation; possible District Plan rule; otherwise investigate Regional Rule	Liaise with government thru MfE. Investigate and consult.	Unknown

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 Limited information about industrial sites.	Gather data to improve database of industrial site information.	Desktop analysis, questionnaires, Chamber of Commerce	Desktop analysis, mailouts, questionnaires, industry liaison	Starting 2021
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	Starting 2021
4.2 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.	Phase in over c 5 years
4.2 Non-compliant discharges	Trace and eliminate discharges	Audit sites and follow up with education and enforcement.	Communicate the issue to industry & visit industries.	Phase in over c 5 years

Action Plan for Industrial Sites				
Goal	**Action**	**Mechanism**	**Action Components**	**Timing**
			Generate improvement plan. Engage and obtain compliance.	

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 (CCC, ECan, Ngāi Tahu, CWMS) with stream care and other community groups	Community Water Partnership programmeto be considered in 2021 LTP
5.1 Communication strategy	Develop a long term communication strategy	Strategy development	Understand community thinking about waterways. Agree message and means of communicating.	After 2021 LTP
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 CCC planning. Fund and track funding. Monitor results.	After 2021 LTP
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.	CCC to contact MfE, starting at executive level, progessing to staff level contacts	Ongoing

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 houses will continue to be achieved through full mitigation of water quantity effects during 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 basins. 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

Objective 7. Maintain stream base-flows and spring flows

Our goals are

7.1 Stormwater will be infiltrated into the ground where practicable, after treatment, in order to maintain as much as possible the pre-development water balance.

Note: Infiltration of stormwater into the ground, after acceptable treatment, is the Council's preferred means of stormwater discharge.

Action Plan for Flooding

Goal	Action	Mechanism	Action Components	Timing
7.1 Maintain base flows	Infiltrate stormwater into ground where practicable.	Stormwater networks in newdevelopment prioritise detention and infiltration.	Normal planning processes	Ongoing

12.2. Flood Management Plan

12.2.1. Recommended Flood Risk Management Option

Flood protection needs continue to be investigated by the CCC following the dis-establishment of the Land Drainage Recovery Programme to determine what flooding effects have arisen from the 2010/11 earthquakes. River channel changes that include gradient changes caused by uplift and settlement have caused many river-side houses to be more susceptible to flooding. The CCC's intention has been to return the risk of flooding to a level not exceeding what existed prior to 2010.

Modelling results have given confidence that post-earthquake river channel improvements and storage basins have reduced the risk to houses adjacent to the river channel .

Results from the whole-catchment hydraulic model (a 2-D floodplain model) when available will enable the Council to assess the vulnerability of buildings in areas remote from the river.

12.2.2. Key Flood Level Locations

Schedule 2(s), Condition 7, requires the "identification of key locations in addition to those shown in Schedule 10 where modelled assessments of water levels and/or volumes shall be made for the critical 2% AEP event and any other relevant return interval." Six key locations are proposed:

Table 11: Key flood level and volume locations.

Waterway	Key Flood Level/Volume Location	Reason for selection
Paparua and Hayton Streams	Lodestar Avenue	An indicator site for these sub-catchments
Ōpāwaho/Heathcote River	Templetons Road	An indicator site for development and mitigation in the upper catchment
Ōpāwaho/Heathcote River	Frankleigh Street	An indicator site for the river corridor between Halswell and Cashmere Roads
Ōpāwaho/Heathcote River	Ferniehurst Street	SPECIFIED INDICATOR SITE
Ōpāwaho/Heathcote River	Buxton Terrace	Existing water level monitoring site with a long record
Ōpāwaho/Heathcote River	Ōpāwa Road Bridge	Existing water level monitoring site with a long record; near to tidally affected neighbourhoods.

Key locations may be amended when the floodplain model is delivered. This may be requested as a minor change to the SMP under Condition 10.

13. 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 at source from entering stormwater
- Eliminate or reduce contaminants at source (e.g. by substituting for 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.

Progressive improvement can occur through

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 Improvement Plan 2021 (referred to in section 2.1)
The Council and others making progressive environmental improvements such as restoring waterways and their corrridors to a natural state	Community Outcome (Healthy Environment)
Citizen-based awareness and advocacy for clean water and improved biodiversity.	Kaitiakatanga

Advocacy by Ngāi Tahu for the mana of water and waterways	Kaitiakatanga. Kawanatanga. Mahaanui Iwi Management Plan

14. Acknowledgements and References

14.1. Acknowledgements

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Appendix A Schedule 2 matters

Matters for inclusion in SMPs Schedule 2, Condition 7	Where addressed in 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;	10.1 and 10.2
d. 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: i. Relevant objectives, policies, standards and rules in the Christchurch District Plan; ii. Relevant bylaws; and iii. Relevant strategies, codes, standards and guidelines;	2.3 through 2.7
e. 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: i. Stormwater mitigation facilities and devices; ii. Erosion and sediment control guidelines; iii. Education and awareness initiatives on source control systems and site management programmes; iv. Support for third party initiatives on source control reduction methods; v. Prioritising stormwater treatment in catchments: that discharge in proximity to areas of high ecological or cultural value, such as habitat for threatened species or	12.1

Areas of Significant Natural Value under the Regional Coastal Environment Plan (Canterbury Regional Council, 2012); and areas with high contaminant loads;	
f. 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;	11.6
g. 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;	7.1 and 11.6.3
h. Identification of areas subject to known flood hazards;	9.6
i. A description of how environmental monitoring and assessment of tangata whenua values have been used to develop water quality mitigation methods and practices;	11.2, 11.3
j. Results from and interpretation of water quantity and quality modelling, including identification of sub-catchments with high levels of contaminants;	Section 6.
k. Mapping of existing information from Canterbury Regional Council and the Consent Holder showing locations where discrete spring vents occur;	4.5.2
l. Consideration of any effects of the diversion and discharge of stormwater on baseflow in waterways and springs and details of monitoring that will be undertaken of any waterways and springs that could be affected by stormwater management changes anticipated within the life of the SMP;	11.8
m. A cultural impact assessment;	5.4
n. A summary of outcomes resulting from any collaboration with Papatipu Rūnanga on SMP development;	5.4
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;	There is insufficient information to report on this
p. Assessment and description of any additional or new modelling, monitoring and mitigation methods being implemented by the Consent Holder;	9.4 and 11.2
q. A summary of feedback obtained in accordance with Condition 8 and if / how that feedback has been incorporated into the SMP;	To follow 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
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;	12.2.2
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;	11.6.2
u. A description of any relevant options assessments undertaken to identify the drivers behind mitigation measures selected; and	11.2
v. An assessment of the potential change to the overall water balance for the SMP area arising from the change in pervious area and the stormwater management systems proposed.	11.8

Appendix B History of flood control

Stormwater drainage in Christchurch was under the control of the Christchurch Drainage Board from 1875 until 1989. The Christchurch District Drainage Act covered area of 13,000 hectares from the Ōpawāho/Heathcote River in the south to the Styx River watershed in the north and from Upper Riccarton in the west to the sea. The new Drainage Board had relatively wide powers for the time, to maintain or modify natural watercourses and construct sewers and drains.

In April 1878 William Clark, a British drainage engineer to engaged to advise the Board presented a “Drainage Scheme for Christchurch and the Suburbs”. The key points of Clark's 1878 report to the Drainage Board were the separation of wastewater and stormwater and recommendations for drainage improvements. The Board principally constructed sewage works for the next 70 years, with some open drain construction and stream widening. The Ōpawāho/Heathcote River was widened and deepened (by approximately 1 metre) in the 1950s.

Some decades of relatively dry weather came to an end in December 1963 when rainstorms caused serious flooding, especially near the Port Hills and in Waltham. There were further floods in March and August of 1965 and in January and November of 1966. Storms in April (the Wahine storm), May and June of 1968 "highlighted the inadequacies in many sections of the drainage system and stressed the need for major relief works". The areas most severely affected were Sumner, Waltham and the suburbs adjacent to the Ōpawāho/Heathcote River.

The Board resolved, in June 1968, that it would change the emphasis of its works programme and spend at least the same amounts of loan money on stormwater as on sewer works. This led to several major works being completed in the 1970s and 1980s.

Storms in the 1970s and 1980s exposed further limitations in the city's stormwater drainage system, especially when ground water levels were high. Storms in June, August and November of 1975 overtaxed some rivers and drains, notably the Wilderness Drain, the Ōpawāho/Heathcote River and the Dudley Creek. Flooding occurred in 1976, 1977, 1978 and 1979. This last year, the Board noted, was the sixth year in succession of high rainfall. The new decade opened inauspiciously with widespread flooding in January.

Investigations into a flood control scheme for the Ōpawāho/Heathcote River commenced in the 1970s. A number of river widening proposals were considered and rejected because of the anticipated environmental effects. The Woolston Cut, considered essential to solve flooding in the Lower Ōpawāho/Heathcote River, proceeded in 1985 and bypassed 2.75 kilometre Woolston Loop. Subsequent saline intrusion killed many river-side trees and destabilised river banks. The Woolston Barrage, built in 1993 by the Christchurch City Council, allowed normal river flows to re-establish and opens only at times of heavy rain.

The Cut represented implementation of the first stage of the Ōpawāho/Heathcote River Catchment Investigation. Stage 2 (also known as Scheme VB) was overtaken by local government amalgation in 1989 and was not proceeded with. Meanwhile adverse environmental effects along the Ōpawāho/Heathcote River upstream of the Cut were beginning to give rise to new concerns. Extensive slumping of banks and the gradual death of riverside trees caused by an increase in the salinity of the river was occurring. The solution was a tidal barrage at the upsteam end of the Cut. Tidal movement was restored in the original river channel except that flood flows passed through the barrage.

The adverse environmental impacts of the Woolston Cut gave rise to a determination by both community and Council, encouraged by Environment Canterbury, to seek 'non-structural' approaches to flood mitigation. The Ōpawāho/Heathcote River Floodplain Management Strategy was subsequently produced and adopted jointly by Christchurch City Council and Environment Canterbury in 1998. The Strategy emphasised reducing flood damage rather than flood levels per se and planning measures rather than physical works. Within the upper catchment large areas of natural ponding particularly in Hendersons Basin were protected and flood detention capacity was increased where possible.

In terms of flooding and flood damage, the new millennium has proved to be a relatively quiescent period for Christchurch until early 2014. During March and April 2014 Christchurch experienced the heaviest sequence of rainfall since the 1970s. In many locations the flooding was exacerbated by ground level changes that occurred during the 2010 and 2011 earthquakes. Seventy seven houses were identified city-wide that experienced flood inundation above floor level two or more times since the earthquakes. Thirteen of these were along the Ōpawāho/Heathcote River between Sloan Terrace and Ferry Road. In addition, an estimated 427 houses experienced flooding beneath the floor on two or more occasions. One hundred and twenty seven of these were along the River. The Mayoral Flood Taskforce was formed and tasked to find immediate or short-term solutions for those residents most vulnerable to regular flooding. The Taskforce’s remit was city-wide but concentrated in the Flockton Street precinct of Dudley Creek and lower Ōpāwaho/Heathcote River.

Appendix C 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.*

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.
Adverse effects on water clarity and aquatic biota do not occur due to sediment inputs	Fine sediment (<2 mm diameter) percent cover of stream bed TSS concentrations in surface water	Upper limit fine sediment percent cover of stream bed: • Spring-fed – plains – urban waterways: 30% • Spring-fed – plains waterways: 20% • Banks Peninsula waterways: 20% Upper limit concentration of TSS in surface water: 25 mg/L No statistically significant increase in TSS concentrations in surface water	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.

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	Upper limit concentration of dissolved zinc: • Ōtākaro/ Avon River catchment: 0.0297 mg/L • Ōpāwaho/ Heathcote River catchment: 0.04526 mg/L • Cashmere Stream: 0.00724 mg/L • Huritīni / Halswell River catchment: 0.01919 mg/L • Pūharakekenui/ Styx River catchment: 0.01214 mg/L • Ōtūkaikino River catchment: 0.00868 mg/L • Linwood Canal: 0.146 mg/L • Banks Peninsula catchments: TBC-A	These metals can be toxic to aquatic organisms, negatively affecting such things as fecundity, maturation, respiration, physical structure and behavior. The CCC 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' (ANZECC, 2000) 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. These targets can be achieved primarily through reducing contaminant loads.
		Upper limit concentration of dissolved copper: • Ōtākaro/ Avon River catchment: 0.00356 mg/L • Ōpāwaho/ Heathcote River catchment: 0.00543 mg/L • Cashmere Stream: 0.00302 mg/L • Huritīni / 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	

Objective	Attribute	Attribute Target Level	Basis for Target
		Upper limit concentration of dissolved lead: • Ōtākaro/ Avon River catchment: 0.01554 mg/L • Ōpāwaho/ Heathcote River catchment: 0.02916 mg/L • Cashmere Stream: 0.00521 mg/L • Huritīni / 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 No statistically significant increase in copper, lead and zinc concentrations	
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	Upper limit total macrophyte cover of the stream bed: Spring-fed – plains – urban waterways: 60% Spring-fed – plains waterways: 50% Banks Peninsula waterways: 30% Upper limit filamentous algae cover of the stream bed:	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
		Spring-fed – plains – urban waterways: 30% Spring-fed – plains waterways: 30% Banks Peninsula waterways: 20%	
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	Upper limit concentration of total recoverable metals for all classifications: Copper = 65 mg/kg dry weight Lead = 50 mg/kg dry weight Zinc = 200 mg/kg dry weight Total PAHs = 4 10 mg/kg dry weight No statistically significant increase in copper, lead, zinc and Total PAHs	Meta Metals can bind to sediment and remain in waterways, potentially negatively affecting biota. These trigger values are based on the ANZECC guidelines (ANZECC, 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	Lower limit averaged Waterway Cultural Health Index and State of Takiwā scores for all classifications: Spring-fed – plains – urban waterways: TBC-B Spring-fed – plains waterways: TBC-B Banks Peninsula waterways: TBC-B	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.

Schedule 8: Receiving Environment Objectives and Attribute Target Levels for Coastal Waters

- *The EMP outlines the methodology for the monitoring of Attributes and how these will be compared against Attribute Target Levels.*
- *TBC-B = To Be Confirmed following consultation 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 water clarity and aquatic biota do not occur due to sediment inputs	TSS concentrations in surface water	No statistically significant increase in TSS concentrations	Elevated levels of TSS in the water column decrease the clarity of the water and can adversely affect aquatic plants, invertebrates and fish. For example, sediment can affect photosynthesis of plants and therefore primary productivity, interfere with feeding through the smothering of food supply, and can clog suitable habitat for species. There is no guideline available for this parameter, so no change in concentrations is proposed to be conservative. The target will be achieved by reducing contaminant loads (particularly using erosion and sediment control measures).
Adverse effects on aquatic biota do not occur due to copper, lead and zinc inputs in surface water	Copper, lead and zinc concentrations in surface water	Maximum dissolved metal concentrations for all classes (with the exception of the Operational Area of the Port of Lyttelton): Copper: 0.0013 mg/L Lead: 0.0044 mg/L Zinc: 0.015 mg/L No statistically significant increase in copper, lead and zinc concentrations	Metals, in particular, copper, lead and zinc, can be toxic to aquatic organisms, negatively affecting such things as fecundity, maturation, respiration, physical structure and behavior (Harding, 2005). These targets are taken from the ANZECC (2000) guidelines for the protection of 95% of species. The Operational Area of the Port of Lyttelton is affected by direct discharges from boats that will make monitoring of the effects of stormwater difficult, therefore the targets are not applicable to this area. These targets will be achieved by reducing contaminant loads.
Adverse effects on Mana Whenua values do not occur due to stormwater inputs	Marine Cultural Health Index and State of Takiwā scores	Minimum averaged Marine Cultural Heath Index and State of Takiwā scores for all classes: TBC-B	The Marine Cultural Health Index and State of Takiwā scores 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 coastal areas, so this target will be developed specifically for this consent. These targets can be achieved through reducing contaminant loads.

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	Concentration to not exceed: Dissolved Copper: 0.5 mg/L Dissolved Lead: 0.0025 mg/L Dissolved Zinc:0.375 mg/L No statistically significant increase in the concentration of *Escherichia coli* at drinking water supply wells	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.
Avoid widespread adverse effects on shallow groundwater quality	Electrical conductivity in groundwater	No statistically significant increase in electrical conductivity	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 CCC stormwater management activities. Electrical conductivity is to be used as an indicator for identifying any general changes in groundwater quality related to recharge.

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 level(s) 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	Annual Exceedance Probability	Maximum Increase (mm)
Ōtākaro/ Avon River	Gloucester Street Bridge	2014	2%	50
Pūharakekenui/ Styx River	Harbour Road Bridge	2012	2%	100
Ōpāwaho/ Heathcote River	Ferniehurst Street	1991	2%	30
Huritīni/ Halswell River	Minsons Drain confluence*	2016	2%	0

NON-MODELLED CATCHMENTS

Receiving Environment	Attribute Target Level	Basis for Target	Notes
Ōtūkaikino River	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 an Baseline Year can be set during review of the SMP	See Note 1 below.

CCC has just begun monitoring the Ōtūkaikino at Dickeys Road Bridge. Council does not currently model flooding in the Ōtūkaikino 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 Maximum Increase can be set during review of the SMP.

Appendix D Contaminant Modelling

14.2.1. Scope of modelling

The evaluation of options has been informed by the Christchurch Contaminant Load Model (C-CLM) and two zinc contaminant models developed for this catchment. Copper was not modelled because means of mitigating copper discharges are adequately understood. Sediment concentrations from significant urban sources (e.g. construction sites) are not sufficiently quantified for a concentration model to be developed for TSS. However, the major interventions needed to control sediment discharges are adequately understood. Port Hills sediment discharges, although known to be significant, are also not well quantified.

Contaminants in careless discharges, leakage and spills from industrial plants and processes cannot be quantified and are not modelled.

The concentration models are:

- An event mean concentration (EMC) model for dissolved zinc (PDP 2018). Zinc concentration is expressed as EMC at the sub-catchment outlet, after attenuation where relevant.
- MEDUSA[7], a contaminant load model developed by the University of Canterbury Department of Civil and Natural Resources Engineering (O'Sullivan et al, 2016).

14.2.2. Zinc Concentration Model

The spreadsheet-based concentration model estimates average dissolved zinc concentrations from each of 20 common surface types (e.g. "unpainted zincalume roof", "minor arterial road", "commercial car park" – see Appendix I) combined in proportion to the estimated rate of runoff. Input zinc concentrations are derived from a mixture of sources including stormwater sampling in Christchurch (Charters) and New Zealand and international research. Only dissolved zinc is quantified because (a) it is the bioavailable (i.e. most immediately harmful) zinc fraction, (b) sampling indicates that most zinc is in the dissolved fraction, (c) the dissolved metal fraction is reported to ECan in monthly monitoring results.

A number of simplified scenarios were modelled to help explore potential city-wide approaches to zinc contaminant reduction. The scenarios were:

- (s1) 2016, with existing treatment facilities, (mostly in Wigram area) in place
- (s2) Anticipated future development in 2100 with no additional treatment facilities.
- (s3a) Future development (2100); present-day roof types and material percentages, treatment for collector and arterial roads and motorways.
- (s3b) Future development (2100); all roofs Pre-painted steel; no other mitigation.
- (s3c) Future development (2100); all roofs non-steel; no other mitigation.
- (s4) Future development (2100); all industrial roofs zinc/aluminium coated steel; all other roofs Pre-painted steel; treatment for collector and arterial roads and motorways

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[7] Modelled Estimates of Discharges for Urban Stormwater Assessment

- (s5) Future development (2100); all roofs Pre-painted steel; treatment for collector and arterial roads and motorways
- (s6) Future development (2100); mix of residential & industrial roof types; treatment for collector and arterial roads and motorways.
- (s7) Future development (2100); all roofs Pre-painted steel; treatment for collector and arterial roads and motorways; anticipated maximum probable treatment facilities in all sub-catchments.
- (s8) Future development (2100); all roofs non-steel; treatment for collector and arterial roads and motorways; anticipated maximum probable treatment facilities in all sub-catchments.

“Present day” model results are in good agreement with wet weather sampling, in which receiving water zinc concentrations are five to six times the water quality Attribute Target Level (which is 39.6 µg/litre in the Ōpāwaho / Heathcote River).

Scenario 3a (treatment of major roads only) gives an estimated 5% reduction in dissolved zinc EMC.

Adopting ColourSteel(G) roofs everywhere (scenario 3b) should reduce zinc concentrations in receiving water by approximately 38%. (Roads and older ColourSteel(G) roofs with deteriorated paint coatings would continue to be zinc sources.)

Scenarios 4 to 8 (roof-sourced zinc emissions progressively reduced, treatment of major roads via filters, and some full subcatchment treatment options) indicates that the greatest potential gains could be made from reducing roof-sourced zinc, however other forms of treatment (e.g. filters and rain gardens) can have significant effects.

It is interesting that catchments where urban land uses are similar, no matter what the proportion of rural land, will discharge similar zinc concentrations in small storms, which are the frequent storms. This is because impervious urban surfaces contribute all or most of the stormwater in small rain events and many catchments have broadly similar impervious surfaces.

14.2.3. MEDUSA Model

MEDUSA, a contaminant load model[8], has been developed by the University of Canterbury Department of Civil and Natural Resources Engineering.

“MEDUSA applies measured first flush and steady state contaminant concentrations representing the surface types "roof", "road", "car park", "paved", etc to an event hydrograph and predicts the amount of total suspended solids, dissolved and particulate copper and zinc that are discharged in the event. Results from a project in the Addington Brook catchment have shown good agreement with loads derived from observed instream concentrations.” (F Charters 2016).

In this study, stormwater runoff quality was monitored from eight different impermeable surfaces in the Heathcote catchment over 9 rainfall events from July to November 2016. These sites represented typical surfaces in the catchment: a new Coloursteel® roof, an older

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[8] Modelled Estimates of Discharges for Urban Stormwater Assessment

Coloursteel® roof, a concrete roof, a galvanized painted roof, three roads (local, collector, minor arterial) and a commercial/light industrial carpark.

Despite the relatively low proportion (7 %) of roofs within the Heathcote Catchment that are defined as poorly painted or unpainted galvanised, it is indicated by the sampling that they contribute 31-38 % of the total zinc load from roofs in each year. Zincalume® roofs, are estimated to comprise 6 % of the Heathcote catchment roof areas, and contribute an average of 8-11 % of the total zinc load. Some concrete roofs contributed elevated zinc loads thought to originate from galvanised guttering. Concrete roofs (48 % of the roof area within the catchment) would contribute an average of 21 % of the total zinc load based on high range runoff concentrations (with galvanised guttering) or 2 % of the total zinc load based on low range sampling from roofs with plastic guttering etc.

Individual sub-catchment modelling highlights that the proportion of specific roof types (e.g. unpainted galvanized) is better determinant of how much total zinc can be expected in roof runoff rather than an assumption based on zone type alone. Furthermore, the condition of the roof material is important, with higher zinc loads expected in runoff from older roofs and roofs in poor condition.

Appendix E E Coli

Environmental Science and Research Limited (ESR) investigated *E. coli* sources in the Avon and Heathcote Rivers; reported in Moriarty & Gilpin, (2015). Their comments in summary are:

"*E. coli* levels in the water samples were typically elevated, exceeding recreational water guideline values on a number of occasions during base flow, and after rainfall almost all samples exceeded recreational water guideline values.

Campylobacter were found in all but one of the river water samples taken, and at concentrations of up to 240 MPN (most probable number) per 100 ml during base flow and up to 460 MPN per 100 ml following rainfall. Speciation and genotyping of *Campylobacter* isolates suggested that base flow isolates were consistent with a wildfowl source. Following rainfall, wildfowl genotypes were still present, but supplemented by isolates more likely to come from ruminant or poultry sources. As *Campylobacter* isolates from ruminant and poultry sources are frequently found among human clinical cases, based just on *Campylobacter* genotyping, these isolates could also be from human sewage.

Additional faecal source tracking analysis was undertaken using molecular markers and faecal sterols. These supported wildfowl as (being) the dominant faecal source during base flow with the highest levels observed at the Antigua boatsheds. At Kerrs Reach and Catherine Street, human sources were detected on occasion during base flow conditions.
Following rainfall, human sources were detected at much higher frequency, with the strongest human signals in the Waltham and Antigua sites after rainfall. Canine sources are also primarily detected following rainfall events. Ruminant sources were detected in the Heathcote River samples following rainfall, with both sheep and cow markers identified.

Comparison of the faecal source tracking results with previous studies suggests that in the Avon River, the situation has now returned to a similar situation to that prior to the earthquakes with wildfowl the dominant source during base flow, and the input of canine and some sources during rainfall events."

Appendix F Street Sweeping

(From *Street sweeping: an effective non-structural Best Management Practice for improving stormwater quality in Nelson?* C Depree 2011)

Street or road runoff is generally regarded as an important source of pollutants in catchment runoff, including reticulated stormwater. Typical mass loadings of street particulate material range between 100 and 250 kg per kilometre of kerb (kerb-km). Three major factors influencing the quantity of street particulates are:
1) local meteorology (i.e. frequency and intensity of storms and wind conditions,
2) use of streets and adjacent areas (i.e. land use, traffic type and volume); and
3) street surface condition; the type and age of pavement, gutters and kerbs.

Despite claimed pick up efficiencies of > 90% by manufacturers (from testing carried out under optimised conditions), the reported efficiency of sweepers is typically in the 20-30% range under real world conditions. Under favourable conditions it seems realistic to expect a 10-30% reduction in runoff contaminant loads. This may still represent an environmental benefit, given that on a catchment scale the contaminant reductions from street sweeping would combine with other management actions such as source control and structural stormwater BMPs like retention ponds and filtration devices.

The most important parameter determining the effectiveness of sweeping to reduce stormwater contaminant loads is the time interval between sweepings relative to the time interval between storms. This is because street pollutant loads accumulate until the street is cleaned by sweeping or rainfall wash-off – hence substantial rainfall events between each sweeping will result in the majority of the street pollutant mass being entrained in stormwater rather than being removed via sweeping operations. Accordingly the sweeping interval should be the maximum of two times the interval between storms, which means street sweeping has greater potential as a BMP in areas where the climate consists of long dry spells.

Timperley (2005) estimated that vehicular zinc emissions are 0.413 mg per vehicle kilometre, which gives a basis for estimating on-road zinc loads. However Timperley presents an estimate of 1.29 mg/vehicle km zinc losses from tyre wear (Table 8 below) which implies that up to ⅔ of metals emitted from vehicles do not land on the road. TDC Environmental (2015) suggests that a proportion of airborne tyre particles are transported by air to land near but not on the road. Some of this zinc will be immobilised on grass and soil surfaces and some will land on roofs and paved areas from where it can enter stormwater, perhaps in addition to the suggested 0.413 mg/vehicle km.

Ōpāwaho
Heathcote River

Draft Stormwater Management Plan 2021

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