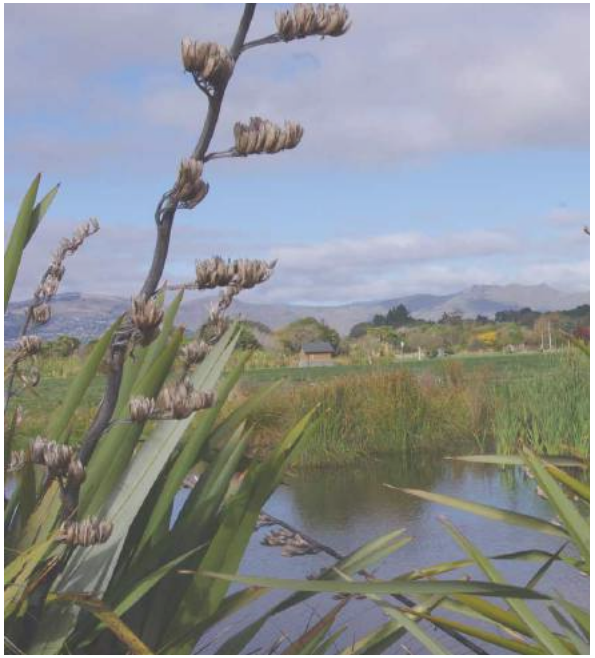
ŌTĀKARO /AVON RIVER CATCHMENT

TAUĀKĪ WAI PĀTAUA / VISION AND VALUES



Date: 26 September 2016

Christchurch City Council

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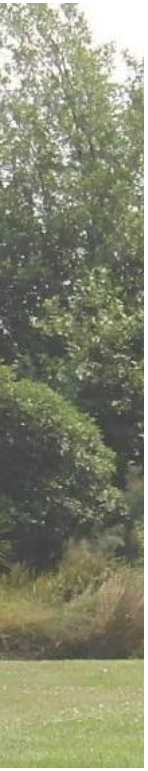

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PART 2 SUMMARY OF TECHNICAL REPORTS TO INFORM STORMWATER MANAGEMENT/ PŪRONGO HANGARAU

Executive Summary / Whakarāpopototanga

The Ōtākaro / Avon River Catchment covers an area of approximately 89 square kilometres, extending for 26 kilometres from its spring-fed source in Avonhead to the mouth at Te Ihutai / The Estuary of the Avon-Heathcote Rivers. The catchment has traditionally been a significant source of mahinga kai, and an iconic focus of natural, cultural and heritage values since earliest settlement over 600 years ago. Ongoing development and extensive settlement within the catchment over the last two centuries, combined with the more recent earthquakes of 2010/2011 has seen a degradation of catchment values including, reduced water quality due to pollution and siltation, reduced hydraulic capacity, loss of terrestrial vegetative cover and decreased in-stream habitat for fish and invertebrates.

For over 20 years, the Christchurch City Council (Council) has focussed on a multi-value and multi-party approach to the management of its waterways. By identifying six core values – ecology, drainage, culture, heritage, landscape and recreation – as the drivers for improved surface water management, the Council has begun to translate legislative requirements and community aspirations into tangible reflections of a more sustainable approach to asset management.

Vision:

The surface water resources of Christchurch support the social, cultural, economic and environmental well-being of residents, and are managed wisely for future generations.

Toitū te marae a Tangaroa, Toitū te marae a Tāne, Toitū te iwi.

This document communicates how this vision is being realised and planned for the Ōtākaro / Avon River Catchment.

Part One of the document, Realising the vision, outlines:

- Current state of the six values within the Ōtākaro / Avon River Catchment in line with the Councils' six values approach to waterway asset management.
- Surface water management - vision and approaches. Identifying eleven approaches, with exemplars, to demonstrate how future protection, enhancement and management of our waterways and surface water can achieve high level outcomes across all six values

Part Two of this document summarises a number of key technical documents that have been used to inform the development of stormwater management approaches, they detail the necessary infrastructure required for improving water quality and quantity discharges into the river.

Waikākāriki / Horseshoe Lake

Picton Reserve, Riccarton

Waikākāriki / Horseshoe Lake Reserve

Watermark, Ōtākaro / Avon River

PART 1 REALISING THE VISION / Te Pae Tawhiti

Introduction / Kupu Whakataki

Purpose of this document

- To identify and summarise the current status of, and key issues within, the Ōtākaro / Avon River Catchment relative to the Council's six values of waterway asset management: ecology, drainage, culture, heritage, landscape and recreation.
- To communicate and facilitate community discussions on how the surface water management approaches, or options available, might be implemented to enhance the six values and realise the vision for the Ōtākaro / Avon River Catchment.
- To highlight, from over 20 years of waterway enhancement experience, city-wide projects that have achieved high level outcomes across all six values and can be used as exemplars for future work in the Ōtākaro / Avon River Catchment.

The Catchment

The Ōtākaro / Avon River extends for approximately 26 kilometres from its spring-fed source in Avonhead to its mouth at Te Ihutai / the Estuary of the Avon and Heathcote Rivers in Ferrymead and covers approximately 89 square kilometres.

The Ōtākaro / Avon River originates from several spring-fed streams in the upper catchment, including the, Wairārapa, Waimairi and Ōrakipaoa), that combine at Mona Vale to create the main stem of the Ōtākaro / Avon River. The main downstream tributaries (St Albans Creek, Dudley Creek, Shirley Stream and Waikākāriki / Horseshoe Lake) contribute to the Ōtākaro / Avon River in the lower reaches below Fitzgerald Avenue.

In addition to spring-fed tributaries there are 74 kilometres of stormwater drains that contribute to both the quality and quantity of water the tributaries and river receives

Sub-Catchments

Within the Ōtākaro / Avon River Catchment, thirty five sub-catchments have been identified within four geographic areas - headwater area, west area, city area, east area, plus a standalone airport zone. Each geographic area has been identified as having similarities with respect to land use, soil type, infiltration potential and groundwater depth.

Background Investigations & Technical Reports

This document is based on a range of reports, investigations and strategy documents that have been adopted by Council over the last 20 years including:

- Waterways and Wetlands Natural Asset Management Strategy (1999);
- Christchurch City Council Surface Water Strategy 2009-2039;
- Waterways and Wetlands Drainage Guide (2003);
- Infrastructure Design Standards (Part 5);
- Christchurch City Council Public Open Space Strategy 2010-2040;
- Christchurch City Council Biodiversity Strategy 2008-2035;
- State of the Takiwā - Te Ahuatanga o Te Ihutai, Cultural Health Assessment of the Avon-Heathcote Estuary and its Catchment (2007, 2012);
- Avon/Ōtākaro SMP Blueprint for Surface Water Management (2014);
- Christchurch West Melton Zone Implementation Programme (ZIP) for the Canterbury Water Management Strategy (March 2013);
- Ōtautahi/Christchurch City Landscape Study (Draft, March 2015);
- Mahaanui Iwi Management Plan (2013).

Given that Council undertakes waterway environmental monitoring reporting on an annual basis, future reports should be read in order to understand the changing environmental state of the river.

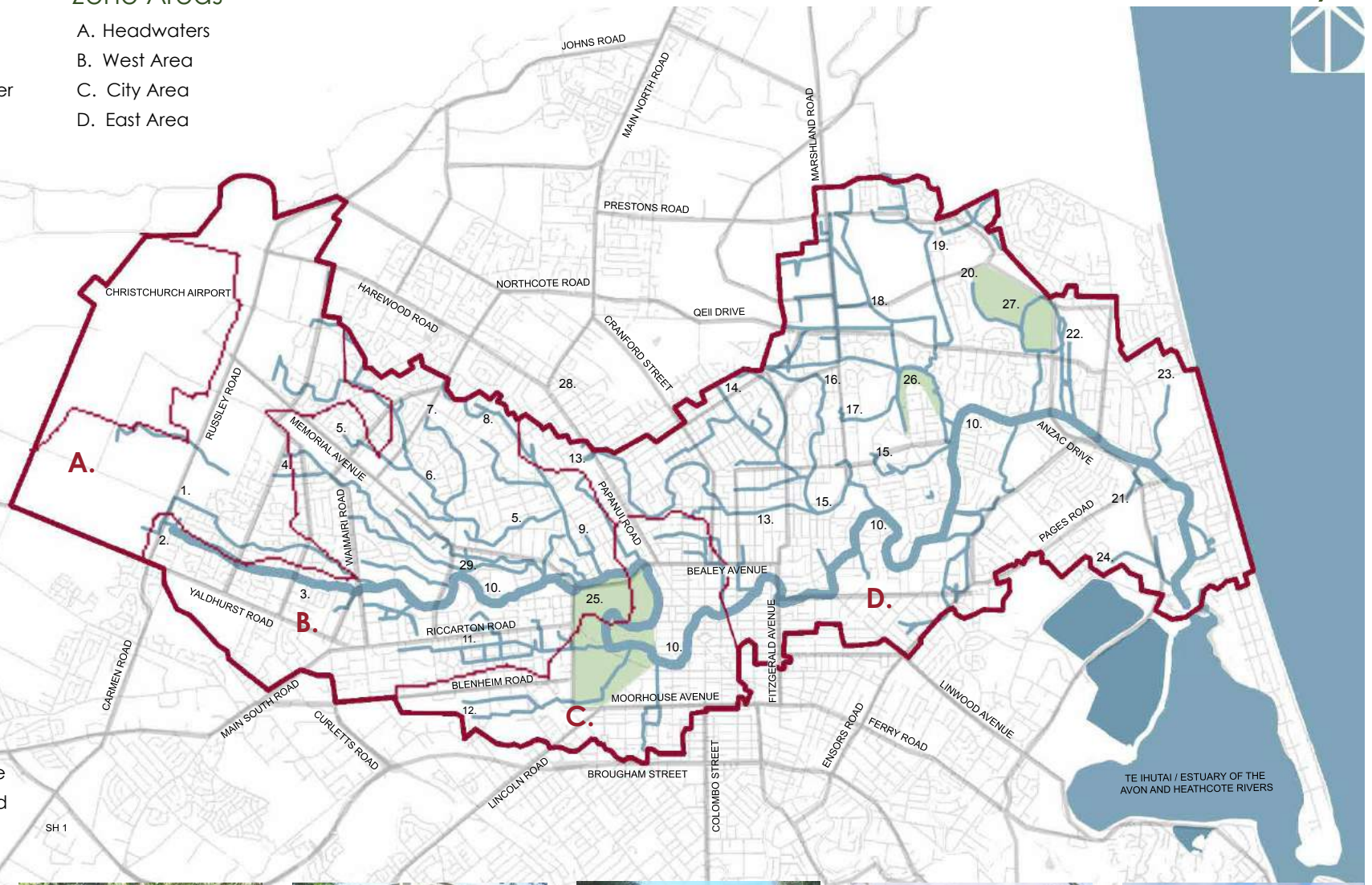
Ōtākaro / Avon River Catchment: Waterways

Legend

1. Ilam Stream
2. Austins Stream
3. Ōrakipaoa / Upper Avon River
4. Waimairi Stream
5. Hewlings Stream
6. Wairārapa Stream
7. Wai-iti Stream
8. Cross Stream
9. Old Mill Race
10. Ōtākaro / Avon River
11. Riccarton Stream
12. Addington Brook
13. St Albans Creek
14. Philpotts Road Stream
15. Dudley Creek
16. Shirley Stream
17. No 1. Drain
18. No 2. Drain
19. Snellings Drain
20. Travis Swamp Stream
21. Knights Stream
22. Preeces Stream
23. Rawhiti Domain Drain
24. Estuary Stream
25. Hagley Park
26. Waikākāriki / Horseshoe Lake
27. Ōruapaeroa / Travis Wetland
28. Papanui Drain
29. Okeover Stream

Zone Areas

A. Headwaters
B. West Area
C. City Area
D. East Area



Ilam Homestead, Okeover Stream

Riccarton Bush, Ōtākaro / Avon

Central City, Ōtākaro / Avon River

Waikākāriki / Horseshoe Lake

Ōruapaeroa / Travis Wetland

Te Ihutai / Avon-Heathcote Estuary

1.0 CURRENT STATE OF THE SIX VALUES
Te Āhuatanga o Te Wai

Ecology Drainage Culture Heritage Landscape Recreation

1.1 Ecology

The inter-relationships between organisms and their environment.

Existing conditions & values

- Generally low riparian and instream habitat values across the catchment with highest values in the north-west headwaters, mid-section of the Ōtākaro / Avon, the Okeover and Waimairi Streams, and the lowest values generally in the tributaries, such as Addington Brook and St Albans Stream.
- Generally low aquatic species diversity, with pollution-tolerant species dominating; despite this, a number of species of conservation interest are present within the Ōtākaro / Avon River Catchment, including Īnanga / Whitebait, Tuna / Longfin Eel, Koukoupara / Bluegill Bully and Kākahi / Freshwater Mussel.
- Poor water quality, due to high levels of *Escherichia coli*, nitrogen, phosphorus, sediment, copper and zinc.
- The catchment is typical of those affected by the human impacts of urban areas.

Issues

- Contaminants from stormwater, dewatering and other discharges, and waterfowl and dog faeces.
- Waste water overflows during storm events.
- Siltation from earthquakes and construction activities, and bank and channel erosion/slumping from earthquakes.
- A lack of dense native riparian vegetation, which buffers the waterways from urban development, and improves ecological habitat for aquatic species; including tall species that provide shading to the stream channel.
- Loss of the original native vegetation cover, reducing seed, fruit and nectar for native birdlife.
- Building, filling and excavating within the riparian margins of waterways.
- On-going loss of mature native and exotic tree stock due to earthquake generated changes to soils, water levels and drainage.

Desired outcomes

- Improved in-stream and riparian habitat.
- Improved habitat connectivity.
- Improved water quality through treatment prior to entering the river and tributary system.
- Improved stream side habitat values.
- Increased habitat diversity.
- Improved native plant and animal diversity.
- Reduced dissolved or suspended contaminants e.g. sediment, heavy metals and hydrocarbons.
- Maintained or enhanced fast-flowing riffle habitats.
- Contaminated sediment removed.
- Increased use of evergreen tree species along river margins to reduce leaf litter and increase shade.

Ōruapaeroa / Travis Wetland

Dudley Creek

Old Lake Outlet, Waikākāriki / Horseshoe Lake

Shirley Stream, Shirley Road

St Albans Creek, Slater Street / Hills Road

St Albans Creek, Dudley Street / Stapletons Road

Riccarton Stream, Hagley Park South

1.2 Drainage

The inter-relationships between groundwater and surface water, natural flow regimes and management of storm events.

Existing conditions and values

Geology of the Ōtākaro / Avon River Catchment is composed of complex permeable alluvial gravel fans overlain with less permeable beach, estuarine/ lagoonal dune and coastal swamp deposits of gravel, sand, silt, clay, shell and peat.

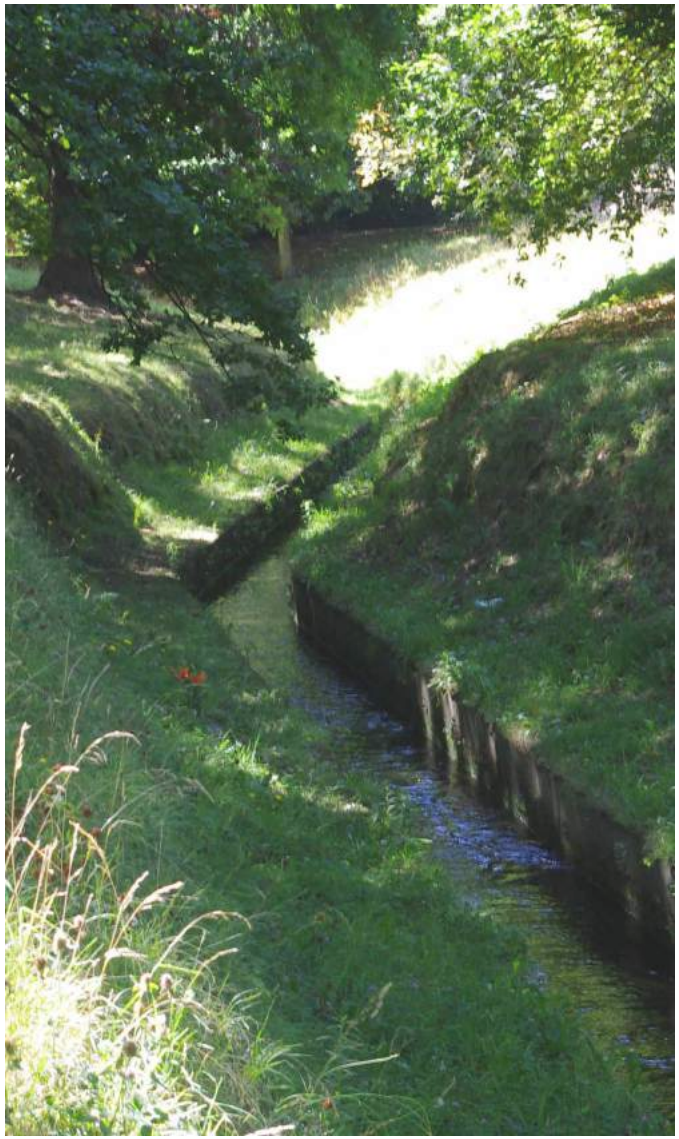
- Soils to the West of Ilam are generally well drained silt and sandy loams underlain by free draining gravels, and east of Ilam, less permeable, higher water table influenced silt loams and silty sands interspersed with swamps, peaty areas and sand deposits.
- The groundwater system in the Ōtākaro / Avon Catchment is primarily recharged by seepage losses from the Waimakariri River and rainfall infiltration.
- The surface waterways are spring-fed with the upper tributaries particularly containing significant spring discharge points. The location and discharge rates of the springs vary throughout the year in response to groundwater level fluctuations.
- The geography of the catchment can be divided into three sub-catchments: the upper reaches refer to the tributaries above Mona Vale and are essentially residential in character, the middle reaches extend downstream from Mona Vale to Kerrs Reach and are a combination of central city business and retail, and residential. The lower reaches, essentially residential in character, extend from Kerrs Reach to Te Ihutai / Estuary of the Ōtākaro / Avon and Ōpawaho / Heathcote Rivers. This area is tidally influenced (upstream from Kerrs Reach to the Fitzgerald Avenue Bridge) and saline from the estuary to Avondale Road.
- Wetlands have been significantly reduced in number and size compared to pre-settlement. Major remnant wetland areas at Riccarton Bush, Travis Wetland, Horseshoe lake, Travis Swamp and the ANZAC Drive corridor, and the estuary/salt marsh areas of the lower Avon and Avon-Heathcote Estuary.

Issues

- Water quality is generally good in the reaches north-west of the CBD, fair to poor from CBD to the east.
- Flood risk has been increased within the catchment due to combination of earthquakes and climate change/sea level rise.
- Wastewater overflows are occurring more frequently due to infrastructure damaged by the earthquakes.
- Sediment accumulations.
- Residential Red Zone (RRZ) stormwater opportunities unrealised until a long term plan for the zone is agreed.
- Earthquake damage has caused significant long term detrimental effects on the hydraulic capacity of both tributaries and Ōtākaro / Avon River due to bed heave, settlement, liquefaction and lateral spreading.
- Extensive urbanisation, discharges from vehicles and commercial/industrial areas and draining of swamps resulting in degraded water quality.

Desired outcomes

- Flood risk reduced or, at least, returned to pre-earthquake levels.
- Improved water quality.
- Reduced sedimentation in tributaries and rivers.
- Minimised waste-water overflows.
- Minimised direct flow of stormwater into tributaries and rivers.
- Slow release of stormwater into receiving catchment.
- Protection and enhancement of springs and wetlands.
- Minimised threats to ground water and surface waterways from development.
- Construction of underground structures or services which minimise disruption of spring discharge features.



Riccarton Stream, Hagley Park South

Weed removal, Ōtākaro / Avon River

March 2014 Flooding, Ōtākaro / Avon River

March 2014 High flows, Ōtākaro / Avon River

No.1 Drain, Waikākāriki / Horseshoe Lake

St Albans Creek, Stapletons Road

Stormwater outlet, Cambridge Terrace Ōtākaro / Avon River

1.3 Culture

The communities perception of a resource and its values, indicated by community involvement in the management, celebration of past events and planning for the future.

Existing conditions & values

- The Ōtākaro is a highly significant river to manawhenua, being a key site of settlement and mahinga kai for over 600 years. It was an important part of the interconnected network of trails through the former wetlands of Christchurch and linking to the key settlement of Kaiapoi in the north.
- Numerous specific sites of significance were found along its margin and include: Hereora (at the head of the Avon, near the airport); Wairārapa (along the northern tributary); Ōhikahuruhuru (near a previous swamp in upper Fendalton); Pūtarikamotu (Riccarton Bush); Waipapa (Little Hagley Park); Ōtautahi; Puari Pā (Victoria/Market Square); Te Warokuri (within an old gully in Papanui); Motu-iti (near Bryndwr); Ō-Rakipāoa (along Southern tributary); Waikākāriki (Horseshoe Lake); Ōruapaeroa (Travis Wetland) and Te Ihutai (Estuary).
- The cultural significance of the Ōtākaro has been recognised within the dual place name provisions of the Ngai Tahu Claims Settlement Act 1998 as well as within numerous planning documents.
- In particular the Christchurch Central Recovery Plan includes the following objectives for the river:
    - *Ngā Wai Whakatipu: recognition of the historical significance of the river as a resource, and a link between past, present and future generations;*
    - *Whakaorangi Wai Ōtautahi* – supporting and enhancing the cultural health of the river, water quality and native bird habitat through supplementing existing exotic plantings with riparian and embankment native plantings; and
    - *Tūtohu Tangata Whenua* – acknowledging the place of Ngāi Tahu in the city through native planting, areas of mahinga kai and provision of enriched habitat for native birds.
- Te Whakatau Kaupapa (1990) includes policies that are aimed at reducing contamination of waterways and improving health to support mahinga kai. The policies specifically support the use of wetlands to store and treat excess water as well as investment in technology to improve discharges and water use efficiency.
- The Mahaanui Iwi Management Plan contains a number of polices in relation to the Ōtākaro that advocate for the protection of waipuna (springs), improved stormwater and wastewater management and infrastructure, and designing the urban environment in a way that respects the wāhi taonga status of the Ōtākaro.
- Cultural health assessments undertaken in 2007 and 2012 identified the catchment of the Te Ihutai / Estuary of the Ōtākaro / Avon and Ōpawaho / Heathcote Rivers "to be in a state of poor to very poor cultural health" and made a number of recommendations to improve the cultural health of the Ōtākaro, particularly around stormwater management, and spring, wetland and riparian protection and enhancement.

Issues

- Varying degrees of attention to the protection, restoration and enhancement of the natural asset, and recognition of natural and cultural values.
- Lack of consistent progress on identification and revitalisation of mahinga kai and natural spring sites throughout the catchment.

- Continuing direct stormwater and drainage inputs into the Ōtākaro / Avon River and tributaries without pre-treatment through swales or wetlands.
- The need to recognise the importance of Ngāi Tahu values and tikanga within all future catchment management and development initiatives.

Desired outcomes

- Provide opportunities for Ngāi Tahu Papatipu Rūnanga to exercise rangatiratanga and kaitiakitanga of the natural environment and its resources through meaningful involvement in planning and decision making.
- Recognition of the wāhi taonga status of the Ōtākaro / Avon River to Ngāi Tūāhuriri/Ngāi Tahu.
- Recognise and protect sites of cultural significance including, where appropriate, the marking of these through restoration, interpretation and/or events.
- Identification, protection and enhancement of mahinga kai and natural spring and wetland sites and the improved ability to harvest mahinga kai for cultural purposes.
- Recognition of the Ngāi Tahu natural resource management framework - 'Ki Uta Ki Tai-From the mountains to the sea' - that highlights the connections between all resources and that they must be managed in a sustainable way for the generations to come.
- Protect and accentuate the stories of the land, its natural drainage and vegetation patterns, cultural features and landmarks. Work with private landowners while recognising private property rights and the need to use a range of protection methods to achieve desired outcomes as a win-win situation.

Pou at Cambridge Green / Ōtāutahi

Te Ihutai / Avon-Heathcote Estuary

Victoria Street Bridge, Ōtākaro / Avon River

Oruapaeroa / Travis Wetland

Waikākāriki / Horseshoe Lake

1.4 Heritage

Includes built and natural sites, features and activities of historical, social, cultural, spiritual, architectural, aesthetic, technological, craftsmanship, archaeological, scientific and contextual value.

Existing conditions & values

- The Ōtākaro / Avon River and tributaries were one of the key connectors for both Māori and early European, as it provided strategically important linkages throughout the city area, a focus for food and resource gathering (mahinga kai), with both temporary and permanent settlement sites.
- Significant natural landscape and ecological remnants include: Pūtarikamotu / Riccarton Bush; Waikākāriki / Horseshoe Lake; Ōruapaeroa / Travis Wetland; Cockayne Reserve; Te Ihutai / the Estuary of the Ōtākaro / Avon River and Ōpāwaho / Heathcote Rivers; and natural spring sites throughout the catchment.
- Key Māori heritage sites, features and settings associated with the Ōtākaro include Puāri pā and urupā, Tautahi pā and urupā as well as Pūtarikamotu, Waikākāriki, Ōruapaeroa and Te Kai a Te Karoro.
- The European aesthetic, strongly influenced by the Christchurch Beautifying Association, has resulted in grassy banks, with a mix of exotic and native trees and plantings. The informal simplicity of the river has to a large extent stayed the same for over 100 years and plays a large part in the identity and visual character of the built city, making it distinct from other NZ cities.
- Significant European heritage sites, features and settings include: Mona Vale; Ilam Homestead; Riccarton House; Hagley Park; Antigua Boatsheds; Bridge of Remembrance; Rhododendron and Mill Islands; the Provincial and Municipal Chambers; Victorian and Edwardian bridges; Victoria Square; Edmonds Band Rotunda Area/Clock tower and settings; Poplar Ave, Barker Planting; The Bricks; Barbadoes Street Cemetery; pump stations on Oxford Terrace and River Road.

Issues

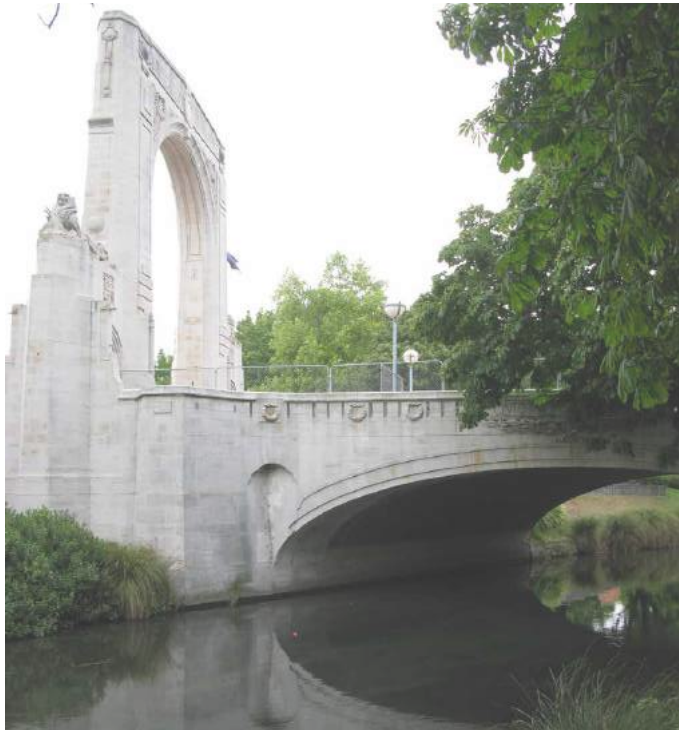
- Some features and places of heritage value may not be identified and documented, or may not be appropriate for heritage listing in the District Plan.
- The lack of recognition of, and provision for, multiple values along the river in terms of interpretation and development.
- The need to balance natural and heritage values when in conflict with each other.
- Maintaining the pre-quake heritage values and visual character of the river as a familiar reference point/landmark/cultural anchor, and key component of the city's identity.
- Management issues associated with the lack of funding for the maintenance, conservation, preservation and/or protection of significant heritage sites and/or features.
- Lack of understanding of heritage values leading to changes and possible loss of heritage sites and fabric.
- Barriers and disincentives to enable use, adaptive re-use and continued use of built heritage.
- The retention of the continuity of the character and treatment of the river as a key link through the central city, and its relationship to the city grid.
- The alteration or disappearance of the traditional network of Ngāi Tūāhuriri/Ngāi Tahu settlement and mahinga kai sites associated with landscape features such as wetlands and river channels.

Desired outcomes

- Improved understanding, protection and/or enhancement of heritage values, built and natural heritage sites and settings, in line with best practice heritage conservation.

- Improved identification, documentation and readily accessible interpretation of heritage values
- The use of built heritage is further encouraged and adaptive re-use is enabled.
- Improved representation of heritage patterns and elements as part of local distinctiveness, with referencing to the range of layers that have influenced our city, the character and treatment of the river as a key link through the central city and its relationship to the city grid.
- Recognition, protection and/or enhancement of the traditional network of Ngāi Tūāhuriri/Ngāi Tahu settlement and mahinga kai sites.

Pou at Victoria Square, Ōtākaro / Avon River



Bridge of Remembrance, Ōtākaro / Avon River

Antigua Boatshed, Ōtākaro / Avon River

Horse watering ramp, Ōtākaro / Avon River

1.5 Landscape

The special character of sites and places, their aesthetic qualities and their meaning to the community.

Existing conditions & values

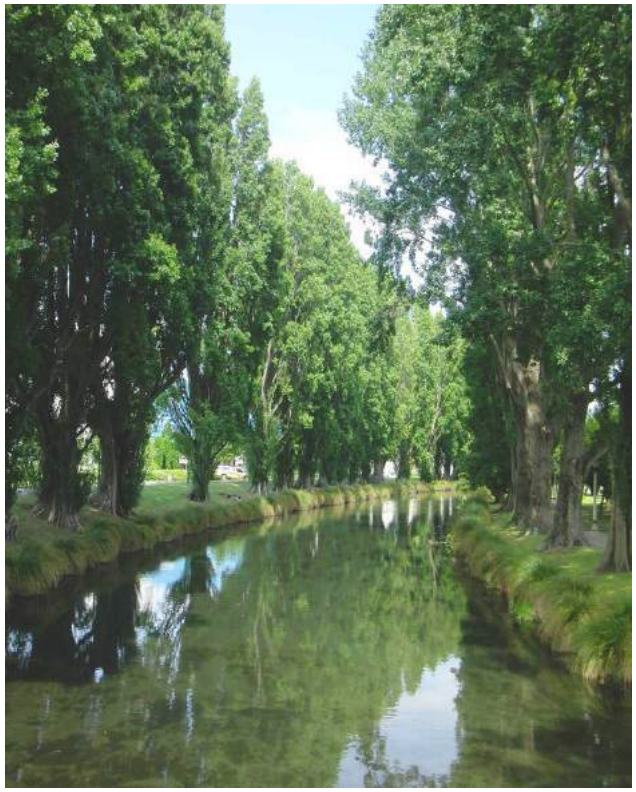
- The Ōtākaro / Avon River and its tributaries contribute significantly to the urban city's natural, cultural history and overall identity.
- The highly engineered drains, tributaries and long lengths of the Ōtākaro / Avon River with their vertical retaining walls in timber or stone (particularly within the inner city) have reduced the river's natural landscape values.
- Modifications to the natural catchment through the construction of roads, bridges, buildings, and changes to the natural land cover in the form of highly maintained lawns and plantings of exotic trees, have further reduced the river's natural landscape values but increased some associative values such as heritage and culture.
- Increased urbanisation and intensification has modified and reduced diversity of natural features and values throughout the catchment.
- Post-earthquakes, natural and cultural 'survivor' landscapes and settings have become more significant in value. They include: Mona Vale, Pūtarikamotu / Riccarton Bush, Hagley Park, Municipal and Provincial Chambers, Waikākāriki / Horseshoe Lake, Cockayne Reserve, Ōruapaeroa / Travis Wetland, Te Ihutai / Estuary, and many springs in the upper tributaries.
- Changes to the Council waterway asset management strategy over the last 20 years has seen improved accessibility by the community, which has resulted in better understanding and appreciation of waterways, wetlands, and natural landscape processes.

Issues

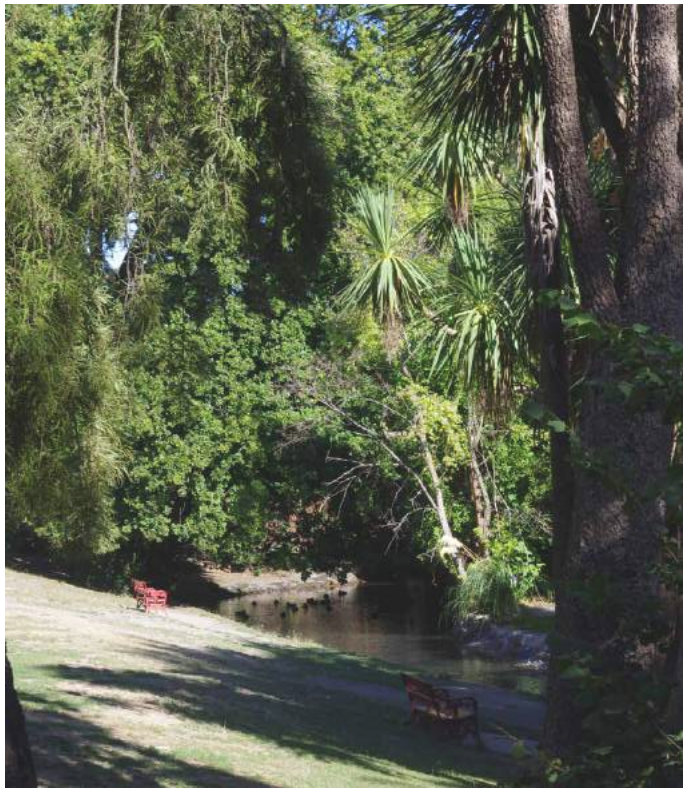
- Urbanisation and intensification causing increased runoff of contaminants that have detrimental impacts on water quality.
- Changes in land use and land cover impacting negatively on landscape values and features.
- Vegetation loss through urbanisation and earthquake damage.
- Important natural and cultural landscape values lost through earthquake damage and red zoning of large tracts of residential land.
- An inconsistent approach to visibility and legibility of natural springs, waterways and natural processes throughout the catchment, causing varying degrees of understanding of the cause and effect of processes within the landscape.

Desired outcomes

- Protection and enhancement of existing important landscape features and settings.
- Minimised negative impacts from urbanisation and intensification.
- Increased visibility and awareness of natural processes.
- Sensitive modification of natural landscapes to protect/enhance values.
- Slow release of stormwater into the receiving catchment



Poplar Ave, Ōtākaro / Avon River



Riccarton Bush, Ōtākaro / Avon River

Firefighters Reserve, Ōtākaro / Avon River

Ōruapaeroa / Travis Wetland

1.6 Recreation

Includes sport (formal, organised, competitive activities) and recreation (informal, unstructured leisure activities) on and beside the river and the structures that support these activities. Recreation opportunities are a combination of a setting and an activity that result in an experience. The setting in particular is dependent on the other five values, and correspondingly can generate an appreciation of those values.

Existing conditions and values

Existing recreational facilities include tracks and paths, lighting, seats and picnic tables, artwork, plaques, buildings, vehicle and footbridges, jetties, boat ramps, boardwalks, signage, toilets, green assets (trees, gardens, grass), playground, car parks, and sports club facilities, e.g. rowing, kayaking, waka ama.

- There is almost continuous pedestrian access along both sides of the Ōtākaro / Avon River from Fendalton Road to the Estuary at Bridge St.
- Upstream of Fendalton Road, public access is sporadic as the river winds its way through private property. Public access along the tributaries is also limited and fragmented.
- The Ōtākaro / Avon River provides a green link from the central city to the estuary. Several other parks adjacent to or linked to the Ōtākaro / Avon River, e.g. Beverley Park, Avon Park, Bickerton Reserve, City Mall, Barbadoes Cemetery, Avebury Park, Abberley Park, Halberg Reserve, Horseshoe Lake Reserve, Brooker Reserve, Donnell Sports Parks, Travis Wetland, Anzac Drive Reserve, QEII Park, Bexley Park and Hagley Park add diversity and value to the River experience.
- The river provides the ideal setting for three of the most popular recreation activities nationally: walking, cycling and jogging.

Issues

- The impact of recreational requirements, particularly those with higher impacts can conflict with the other five values.
- Attempting to achieve all six values throughout the Ōtākaro / Avon River can result in unsatisfactory compromises for recreational activities.
- The future of the large tracts of former residential land that have been red-zoned is still unknown, but could potentially attract large number of recreational users. Numerous and conflicting ideas have been proposed for redevelopment, from native forests to major sport facilities such as a rowing lake. Maintenance and sustainability of such large area of land may be challenging.
- Recreation needs and preferences are changing and there is demand for increased quantity and quality of recreational facilities.
- Diversity within the river network is required to meet the widest range of preferences.

Desired outcomes

- The greater the variety of settings, the greater the opportunities to The greater the variety of settings, the greater the opportunities to achieve different recreation experiences and outcomes, thereby meeting the widest range of recreation preferences.
- Different recreation zones along the river as a framework for a establishing a network of outcome (or value) focussed management areas.
- Group compatible sport and recreation activities. Separate conflicting interests into different zones.
- Recreation planning coordinated with planning for other values.

Fly fishing for trout, Ōtākaro / Avon River

Kayaking, Ōtākaro / Avon River

Rowing, Kerrs Reach, Ōtākaro / Avon River

Punt landing, Ōtākaro / Avon River

Interpretation shelter, Waikākāriki / Horseshoe Lake

Cyclist, Ōtākaro / Avon River

Waka, Ōtākaro / Avon River

Shared walkway, Waikākāriki / Horseshoe Lake

Shared walkway, Hagley Park, Ōtākaro / Avon River

2.0 SURFACE WATER MANAGEMENT APPROACHES
Ngā Mātāpono

Partnerships - Protection & Purchase - Suburban centres - Schools
Street Renewals - Linkages, Networks & Corridors - Residential Red Zone
Subdivisions - Wetlands - Waterway Restoration - Suburban Greenspace

Vision:

The surface water resources of Christchurch support the social, cultural, economic and environmental well-being of residents, and are managed wisely for future generations.

Toitū te marae a Tangaroa, Toitū te marae a Tāne, Toitū te iwi

2.1 Introduction

The Ōtākaro / Avon River, including its wider catchment and tributaries, has been of significant importance to Tangata Whenua 'for over 600 years prior to European settlement'. The catchment was a major source of mahinga kai (customary food or resources from plant material to fish, shellfish and birds) as well as a place of settlement and occupation. Since European settlement, the ongoing development of the city's urban environment has seen the catchment under-go a significant degree of degradation through altering natural drainage patterns, pollution, siltation and the removal of native vegetation cover. These issues since the 2010/2011 earthquakes have been exacerbated to varying degrees throughout the catchment. Ōtākaro / Avon River is an iconic symbol of our city and retains high ecological, drainage, cultural, heritage, landscape and recreation values throughout the catchment. The vision statement is both a call and a reminder that the decision making for the protection, enhancement and management of the catchment of the Ōtākaro / Avon River is not for the benefit of the current generation alone, but must reflect a longer term multi-value and multi-generational approach.

In the early 1990's, the Council was the first amongst local authorities in New Zealand to adopt a multi-value approach to the management of the city's land drainage system; at the time a revolutionary replacement of the previous Christchurch Drainage Board's single-value focus on land drainage only. The Council has subsequently developed a strong and successful history of waterway protection, remediation and enhancement, and in working with others to achieve this.

In response to new legislative responsibilities and expectations of the Resource Management Act 1991, the newly amalgamated Christchurch City Council prepared a new City Plan which set in place provisions for the sustainable management of the City's natural and physical resources.

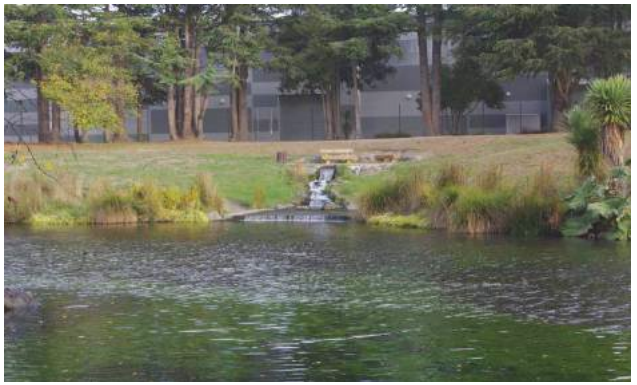
By identifying six core values – ecology, drainage, culture, heritage, landscape and recreation– as the key drivers for surface water management, the Council has been able to translate legislative requirements and a broad philosophy of sustainability into both, a natural asset management strategy, and tangible values, outcomes, and assets, reflective of the broader community's desire for a more qualitative approach to management outcomes.

Over the last 20 years the Council has developed a range of approaches to promote the six values of waterways and stormwater management including: improving drainage capacity; enhancing landscape character; improving the quality and relevance of recreational opportunities; enhancing the diversity of ecological values; and improving cultural and heritage values.

The following approaches provide a show-case of successful city-wide project exemplars implemented by the Council, their strategic partners, developers and key interest and community groups. These approaches provide an insight into the range of solutions available to help Council to work towards improving surface water quality, surface water flows, aquatic ecosystems and waterways for contact recreation, water sports and cultural values, in order to realise the long term vision for the Ōtākaro / Avon River Catchment that maximises the six values attributes within it.

Dudley Creek

Mona Vale, Ōtākaro / Avon River



Jellie Park, Ilam

Paeroa Reserve, Riccarton

2.2 Partnerships

Partnerships provide opportunities for the Council to work with Government departments and agencies, statutory parties, private developers, and communities of interest to implement cohesive and integrated approaches that are reflective of the six values approach to sustainable land-use and surface water management. Key partnerships include:

Papatipu Rūnanga and Te Rūnanga o Ngāi Tahu

- Council is working with Ngā Papatipu Rūnanga and Mahaanui Kurataiao Ltd to develop a partnership aimed at improved involvement and collaboration over the management of waterways and water infrastructure, including stormwater, across the district.
- Te Rūnanga Ngāi Tahu and Papatipu Rūnanga are also key partners with Council and Regenerate Christchurch Ltd in the rebuild of Christchurch post the 2010/2011 earthquakes, and for the Ōtākaro, ensuring core principles and objectives of Ngāi Tūāhuriri for the city and river are realised.
- Key objectives for manawhenua associated with urban development and stormwater management include: elimination of the direct discharge of wastewater and stormwater into waterways; commitment to low impact design principles; sustainability, creativity and innovation; improving water quality in rivers and streams; restoring riparian margins; and protecting and restoring springs, wetlands and mahinga kai.
- Current subdivisions developed by Ngāi Tahu offer examples of collaboration with local authorities to achieve best practise outcomes for stormwater include: Te Whāriki (Lincoln); Prestons (Burwood); and Wigram Skies

Environment Canterbury (ECan)

- Joint Council/ECan Planning and Consents Protocol for Surface Water Management (2009) - Legislative support and promotion of managing surface water in a more integrated and effective way that also promotes a six values approach to waterway protection and enhancement and a catchment-wide approach to improving surface water quality.

Christchurch-West Melton Zone Committee

- A Canterbury Water Management Strategy committee comprising representatives of the community, Ngā Rūnanga, ECan, Council and Selwyn District Council.
- Tasked with making non-statutory recommendation associated with water management and issues such as: groundwater quality and flow; improving surface water quality and flow; enhancing degraded ecosystems, indigenous biodiversity; enhancing and managing waterways for recreation and amenity; efficient use of water, and managing demand.
- Foster educational approaches to drive behaviour change/proactive pollution prevention/community buy-in.
- Working with community stream care groups.

NZ Transport Agency (NZTA)

- Via key policy and guideline documents NZTA engages with the Council on the consideration and incorporation of catchment and stormwater management best practise on any roading project within the city limits.
- Recently completed projects of best practise stormwater management include ANZAC Drive (a co-operative approach between Council / NZTA / ECan and a private developer), and future opportunities include the Christchurch Northern Arterial road.

Ministry of Education

- By working with the Ministry of Education, opportunities within new schools (e.g.: the co-location and redevelopment of Shirley Boys High School and Avonside Girls High School), or redeveloped existing schools, (eg: Aranui Community Campus), will exist to promote and implement the six values approach to surface water treatment.
- Opportunities will also exist within vacant school sites, eg: Shirley BHS and Avonside GHS, to use part or all of these sites to implement neighbourhood focussed six values surface water management plans.

Wetland planting along ANZAC Drive, Avondale

Subdivision partnership - Spring-fed watercourse

Subdivision partnership - Wetland and swale planting

BEFORE - CERA, Watermark, Ōtākaro / Avon River

AFTER - CERA, Watermark, Ōtākaro / Avon River

BEFORE motorway upgrade

AFTER - Cycleway, swale and native embankment planting along motorway

2.3 Protection + Purchase + Aquisition

Council has initiated a number of statutory protective mechanisms that protect land from intensification/ urbanisation and provide opportunities for application of a six values approach to future stormwater management and enhancement.

The City Plan, for example, prescribes a range of waterway setback requirements, ranging from five metres to thirty metres, based on the five waterway classifications. For example, Bings Drain, an 'Open Utility Waterway' requires a five metre set back, while the Ōtākaro / Avon River, a 'Downstream River', requires a thirty metre setback.

Setbacks are designed to provide a buffer between development and the waterway where open space or riparian planting can provide a public amenity with opportunity for maintaining and enhancing water quality through filtering non-point discharges, and for the protection of aquatic habitat.

In addition to protective mechanisms, since 1995 Council has purchased land as part of a long term strategy to meet its stormwater management obligations. Land purchase secures Council opportunities to implement six values aligned to enhancement and management programs as funding becomes available and project or community demand requires. Council land purchases that have since been developed as exemplars of six values design, implementation and management include:

- Grants Road, Papanui, St Albans Creek;
- Madras Street, St Albans Creek;
- Old Lake outlet, Waikākāriki / Horseshoe Lake;
- Snellings Drain.

Swale setback along Grants Road, Papanui, St Albans Creek

Residential setback from stream with native boundary planting and public open space

BEFORE - Madras Street, St Albans Creek

BEFORE - Old Lake outlet, Waikākāriki / Horseshoe Lake

AFTER- Madras Street, St Albans Creek

AFTER- Old Lake outlet, Waikākāriki / Horseshoe Lake

2.4 Suburban Centres

New suburban centres, and/or the redevelopment of existing centres, provide a multitude of opportunities to improve all six values at a local sub-catchment level through the use of sustainable and enhanced surface water treatment devices such as:

- Stormwater tree pits;
- Swales;
- Rain gardens;
- Permeable pavement;
- Storm filters;
- Green roofs.

Project examples include:

- Hills Road Shopping Centre and surrounding neighbourhood, Dudley Creek: a project that incorporated commercial, residential and community centre/education land; Council purchase of private property; the removal of box drains, boundary fences and large areas of hard surface adjacent to the creek; major recontouring of the banks to increase waterway capacity; improved accessibility to the waters edge, improved connectivity along the creek; and significant native planting.
- Under the Suburban Centres Programme, master plans have been prepared for Edgeware, New Brighton and Selwyn Street Shopping Centre that outline opportunities for a more sustainable approach to surface water management in urban areas.
- While opportunities may be limited due to spatial or budgetary constraints there are measurable, positive, values-based reasons to incorporate enhanced stormwater treatment devices as a part of any suburban centre retrofit.

Waterway enhancement in suburban centre, Hills Road, Dudley Creek

Waterway enhancement to carpark in suburban centre, Hills Road, Dudley Creek

Native planting in retention basin, Pak 'n' Save, Wainoni Road

Integrated street art expressing a spring, Peverel Street

Native planting, Hills Road, Dudley Creek

2.5 Schools

In addition to partnerships with the Ministry of Education at a higher level, Council has developed working relationships with a number of individual schools adjacent to waterways. The aim of establishing these relationships is two-fold, to improve the six values within the school grounds and local neighbourhood/ catchment, and to promote a greater understanding by the local and school community of the relationship between water and a healthy ecosystem.

Examples of partnerships with existing schools include:

- Beckenham Primary, a strengthened relationship with the adjacent Ōpawaho / Heathcote River and the Beckenham Ponds through a Council supported native planting program along the schools river boundary.
- Christ's College. Council assisted with the funding of stage one of a 300 lineal metre river bank enhancement project that included improved access along the river bank, jetty access to the river, retaining walls to reduce eroding banks, river toe stabilisation and the planting of 2000 native tree, shrubs and grasses.
- Schools within the Ōtākaro / Avon River Catchment identified as having opportunities for stormwater treatment devices, e.g.: wetland and dry swales, rain gardens and wetlands, within their grounds include:
    - Avonhead School;
    - Burnside High School;
    - Christchurch Girls High School;
    - Cobham Intermediate;
    - Kendal Primary School.

Spring-fed ponds beside Beckenham Primary School

Native planting revegetation project, Beckenham Primary School

Native planting along dry stream bed, Hewlings Stream, Burnside High School

BEFORE - Christ's College, , Ōtākaro / Avon River

AFTER - Christ's College, Ōtākaro / Avon River

AFTER- Native bank and river edge planting, pedestrian access and seating, Christ's College, Ōtākaro / Avon River

2.6 Street Renewals

Street renewals provide opportunities to include a range of best practise stormwater management methods including: daylighting of streams; springs and drains; stormwater tree pits; rain gardens; wetland swales; dry swales; and permeable pavement. As such, street renewals have the potential to reduce the quantity of contaminants entering the Ōtākaro / Avon River and its' tributaries. They improve the quality of the water entering the system, thus providing additional six value opportunities through enhanced ecological, cultural, landscape and recreational values, and enriched interpretation and/or protection of heritage elements.

Street renewal projects that have enhanced six values and can be used as exemplars in future street renewal projects include:

- Peveril Street, Riccarton: a road narrowing project that included exposing a spring that was then interpreted further through design elements including fountains, art and native planting;
- Picton Avenue/Dilworth Street: in conjunction with the construction of a new pump station and localised road narrowing, the existing spring-fed waterway was drain timber-lined and enhancement works including planting, walkways, observation decks, and a playground were created to provide a multi-value asset to the local community and provide downstream benefits; and
- Paparoa Street/Papanui Stream: a Council streets renewal project in Papanui that was integrated with the naturalisation of Papanui Stream. The project is an exemplar of rain gardens, swales, narrowing of carriageways and the removal of a timber-lined utility drain reconstructed as an open, natural-sided, meandering stream with diverse aquatic habitat values.

Spring-fed Riccarton Stream enhanced as part of Picton Avenue renewal, Picton Reserve

Walkway and enhanced waterway, Papanui Stream, Grants Road

BEFORE - Old bridge abutment

Enhanced walkways, road narrowing, swale and native planting along Papanui Stream, Proctor Street

AFTER - Enhanced walkway and access to water edge

2.7 Linkages, Networks & Corridors

Linking public open space using existing and/or proposed pedestrian and cycle networks provides opportunities to enhance all six values including the creation of habitat-rich, terrestrial and aquatic, ecological corridors. Examples of stormwater management projects that have recognised the opportunity for linkages, corridors and networks, and provided strengthened ecological, cultural, landscape, heritage and recreational values include:

- Paeroa Reserve is a local park nested among back sections of a Riccarton neighbourhood. Riccarton Stream runs through a section of the reserve with an enhanced riparian edge and small wetlands area. Pedestrian/cycle linkages connect both north/south and east/west through the reserve.
- Papanui Stream, as part of a wider Papanui Street renewal project (see Street Renewals above), Council purchased property to naturalise the waterway. In co-ordination with a retirement village development, Council was able to provide significant pedestrian/cycle linkages along the waterway and between streets in the neighbourhood.

Examples in other Catchments:

- Halswell on the Park, Milns Road area – as part of the Halswell on the Park residential development a comprehensive network of swales, small wetland basins, and spring-fed waterways were enhanced with native plantings alongside walkways and sport and recreation areas.
- Regents Park Reserve is part of the wider Styx Mill Reserve that extends into a residential neighbourhood of Casebrook.
- Future opportunities identified as being able to incorporate the six values approach as part of the post-earthquake recovery program include: Te Papa Ōtākaro / Avon River Precinct; the Accessible City Programme; the Residential Red Zone from Barbadoes Street downstream to Te Ihutai / the Estuary; and Council's city-wide cycleways program.

Recreation linkage along a waterway through a subdivision

Native swale planting and pedestrian linkage through a subdivision

Pedestrian and cycle corridor through Jellie Park

Riccarton Stream, Picton Reserve

Pedestrian and cycle link through a wetland

BEFORE - Dudley Creek

DURING CONSTRUCTION - Dudley Creek

AFTER - Dudley Creek, Pedestrian and cycle link along enhanced waterway

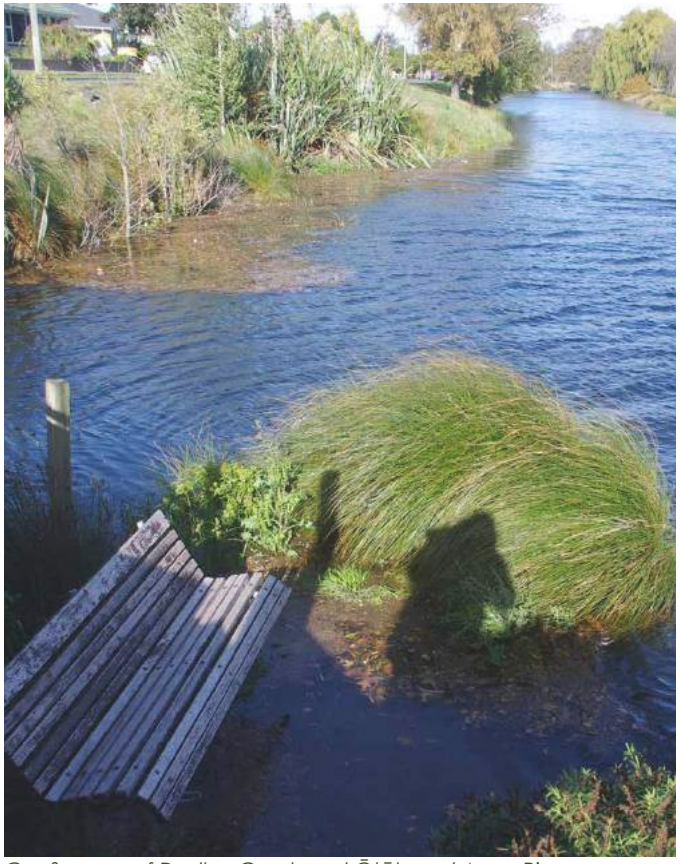
2.8 Residential Red Zone

Within the Ōtākaro / Avon River Catchment the Residential Red Zone (RRZ) extends from the Barbadoes Street/Avon Loop area downstream to approximately Te Ihutai / the Estuary of the Avon and Heathcote Rivers and covers an area of approximately 445 hectares of varying drainage, landscape, ecological, heritage, cultural and recreational values.

- While the final outcome for the RRZ has yet to be determined by Regenerate Christchurch, the Council, Ngāi Tūāhuriri, Te Rūnanga o Ngāi Tahu and a number of other Government agencies and key interest groups eg. Ōtākaro / Avon network, Avon Loop Planning Association Inc, Avon-Heathcote Ihutai Trust, NZ Landscape Trust, Royal Forest and Bird Protection Society of NZ, and the Christchurch Civic Trust, have expressed strong interest in, and a variety of views on, how the RRZ should be managed. These views cover a range of opportunities highlighting the enormous potential for design, implementation and management responses, including:
    - A strong commitment to enhanced aquatic and terrestrial ecological values with opportunities to strengthen cycle and pedestrian links to other ecologically-rich and mahinga kai areas such as Waikākāriki / Horseshoe Lake and Ōruapaeroa / Travis Wetland.
    - Recognition and protection of the range of landscape types within the RRZ from the upper, former residential, intensely developed reaches, where the river is relatively narrow and the banks steep, to the lower, wider tide- influenced reaches of the river at Kerrs Reach and Te Ihutai / the Estuary.
    - Promoting a greater recreational use of the area.
    - Directing stormwater from pipelines crossing the RRZ and discharging it into basins and wetlands to provide stormwater treatment.
    - Interpreting, protecting and enhancing sites and activities of historical and natural significance e.g.: former school sites; former residential areas; natural areas of significance such as Waikākāriki / Horseshoe Lake; Cockayne Reserve; Ōruapaeroa / Travis Wetland.
    - Recognising and enriching the cultural values within the RRZ with specific reference to Ngāi Tūāhuriri values and objectives, and the broader community values established post- European settlement.
    - Ensuring drainage opportunities, associated with groundwater, surface water, natural flow regimes and the management of these and storm events, are maximised to the benefit of both upstream and local communities, and integrated with the other five values.

Avonside Drive, Ōtākaro / Avon River

Reaby Street, Burwood



Confluence of Dudley Creek and Ōtākaro / Avon River

Bangor Street / Oxford Terrace, Ōtākaro / Avon River

Cockayne Reserve, New Brighton

2.9 Subdivisions

The 2010/2011 earthquakes have hastened both the development of new subdivisions and the expansion of existing ones. There are numerous recent examples where a combination of legislative and market demands have produced sub-divisional outcomes with strong representation across all six values. Some examples of waterway enhancements from other catchments that could be integrated into future developments within the Ōtākaro / Avon Catchment are:

- Prestons Subdivision, Burwood (Styx / Avon Catchment);
- Waitikiri, Burwood (Styx / Avon Catchment);
- Wigram Skies (Ōpawaho / Heathcote Catchment);
- Halswell on the Park and Milns Estate (Ōpawaho / Heathcote Catchment);
- Regents Park (Puharakekenui / Styx Catchment);
- Delamain, Yaldhurst (Ōpawaho / Heathcote Catchment).

Waterways, wetlands and native planting define character of new a subdivision, Waitikiri

Spring-fed waterway as feature of new a subdivision

Native planting and swale through a subdivision

Native planting in swale in a new subdivision

Planted stream edges connecting residential development

Integrated subdivision and wetlands incorporating significant native planting

2.10 Wetlands

Over the last 20 years Council has secured the long term protection of a number of wetlands within the Ōtākaro / Avon River Catchment. Opportunities to enlarge and enhance these existing wetlands to incorporate all six values have been identified. In addition to increasing the number and quality of physical linkages between wetlands, enhancement and appropriate management within them will allow their important roles in the drainage, storage, and cleaning of surface water inputs to increase.

Existing wetlands providing enhanced six values include:

- Ōruapaeroa / Travis Wetland – a 116 hectare lowland freshwater wetland located in the midst of an urban environment. Previously farmed and drained, the wetland is the last of its type in Christchurch, and is now managed as a Nature Heritage Park. While extremely valuable as a scientific research and education asset, the Wetland has regionally significant drainage, ecological, landscape, recreation, heritage and cultural values. Other organisations with various types of jurisdiction over the Wetland, including the Department of Conservation, Te Rūnanga o Ngāi Tahu, Ngāi Tūāhuriri, and ECan, further reinforce the importance of partnerships in determining managing six values outcomes.

- Cockayne Reserve – a 3.3 hectare narrow strip of wetland bordered by the lower reaches of the Ōtākaro / Avon River and New Brighton Road 2.5 kilometres upstream from Te Ihutai Estuary. The reserve, protects one of the few remaining examples of native lowland fresh and brackish wetlands remaining in Christchurch and is an example of a pre European settlement wetland type that was common along the coastal margins of the Canterbury Plains. While relatively small, and effected by the earthquakes, the reserve is still an important local contributor of all six values to the immediate community.

- Waikākāriki / Horseshoe Lake – a 31 hectare wetland reserve balancing a range of significant recreation, cultural, heritage, landscape and ecological values with a critical drainage and stormwater role for the north-east of the city. The earthquakes have had a significant impact locally, and, with the red zoning of the adjacent residential area, opportunities exist to extend the wetland and further enrich all six values beyond the current boundaries of the reserve.

Opportunities for new, enlarged or linked wetlands that could have strong six values outcomes include:

- The Residential Red Zone;
- The Avon Loop;
- Bexley Wetland;
- Existing areas of open space with strong recreation values, that may be able to incorporate new wetland systems.

Corsers Stream, Donnell Sports Park, Burwood

ANZAC Drive, Avondale

Waikākāriki / Horseshoe Lake

Ōruapaeroa / Travis Wetland

Cockayne Reserve, New Brighton

2.11 Waterway Restoration

Over the last 20 years the Council has developed a range of 'tools', or design solutions, enhancement and management to promote the six values approach to waterways restoration including: improving drainage capacity; enhancing landscape character; improving the quality and diversity of recreational opportunities; enhancing terrestrial and aquatic ecological values; and improving cultural and heritage values.

Significant waterway restoration projects that strongly reflect these six values and can be used as exemplars for new projects in the future include:

- Corsers Stream and ANZAC Drive;
- Dudley Creek;
- No. 2 Drain, Shirley Golf Course;
- St Albans Creek, Bishop Street;
- Te Papa Ōtākaro / Avon River Precinct (ARP) – the first blueprint project to be undertaken by CERA as part of the Christchurch Central Recovery Plan.

Integrated art interprets enhanced waterway values

Enhanced native planting and in-stream ecological values, Corsers Stream, Burwoood

BEFORE - CERA, Watermark, Ōtākaro / Avon

AFTER - Enhanced in-stream values, improved access, enhanced landscape character and improved recreational opportunities, Watermark, Ōtākaro / Avon River

BEFORE - No.2 Drain, Shirley Golf Course

DURING - No.2 Drain, Shirley Golf Course

AFTER - Enhancement of all six values, No.2 Drain, Shirley Golf Course

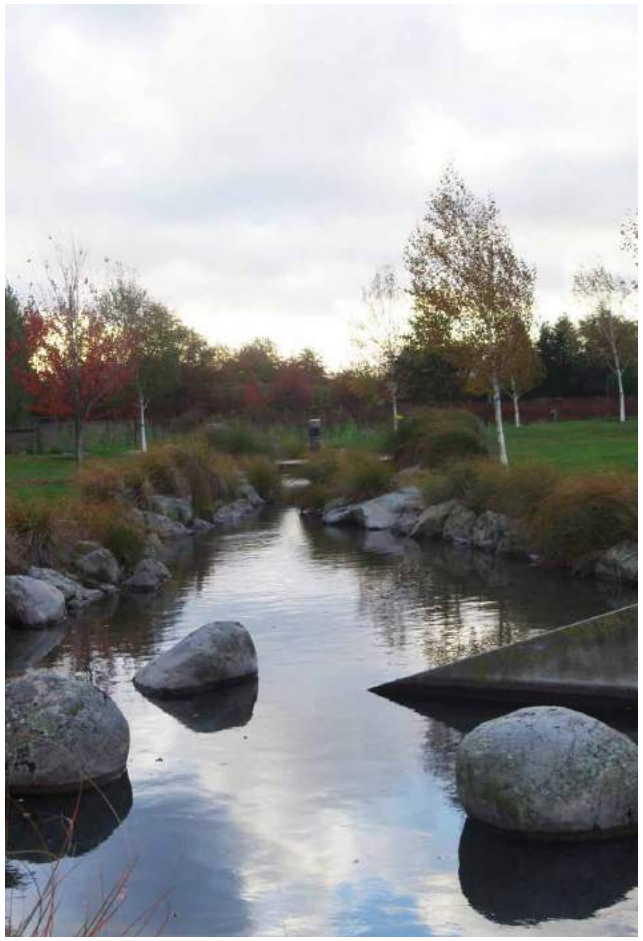
2.12 Suburban Greenspace

Areas of existing greenspace within suburban areas can be enhanced to incorporate positive responses to all six values and mitigate the impacts of urbanisation and increased surface water runoff.

City-wide suburban greenspace projects that exemplify enhanced six values include:

- Shirley Golf Course - the enhancement of the No. 2 Drain as it passes through the Golf Course into Waikākāriki / Horseshoe Lake;
- Waikākāriki / Horseshoe Lake – a 31 hectare wetland reserve balancing a range of significant ecological, cultural, heritage, landscape and recreational values with a critical drainage and stormwater role for the north-east of the city. The earthquakes have had a significant impact locally, and with the red zoning of the adjacent residential area opportunities exist to extend all beyond the current boundaries of the reserve;
- Opportunities for six value treatments of suburban green space within the Ōtākaro / Avon River Catchment that have been identified by Council but not yet realised include:
    - Burnside Park;
    - Clare Park extension;
    - St Albans Creek through English Park;
    - Jellie Park;
    - Macfarlane Park;
    - Ray Blank Park;
    - Addington Brook;
    - Riccarton Stream.

Artist interpretation of signage and shelter, Waikākāriki / Horseshoe Lake



Spring-fed waterway as focus of a new subdivision

Native stream-side planting in neighbourhood park

Te Ihutai/ Ōtākaro / Avon River Heathcote Estuary

Crosbie Park, Avonhead

BEFORE

AFTER - Native revegetation of eroding creek bed

2.13 Ōtākaro / Avon River Catchment: Exemplar Sites

(8) Burnside High School

(14) Jellie Park, Ilam

(5) Madras Street, St Alban's Creek

(19) Waitikiri Subdivision

(24) Ōruapaeroa / Travis Wetland

(30) Crosbie Park, Avonhead

(22) Corser's Stream, Donnell Park

(4) Old Lake Outlet, Waikākāriki / Horseshoe Lake

(15) Riccarton Bush, Riccarton

(11) Picton Reserve, Riccarton

16) Oxford Terrace, Avon Loop

(25) Te Ihutai/ Ōtākaro / Avon River Heathcote Estuary

Partnerships

1. ANZAC Drive
2. Watermark, Ōtākaro / Avon River
3. CHCH Southern Motorway

Protection & Purchase

4. Old Lake Outlet Waikākāriki/ Horseshoe Lake
5. Madras Street, St Alban's Creek

Suburban centres

6. Hills Road shopping centre
7. Pak 'n' Save, Wainoni Road

Schools

8. Burnside High School
9. Christ's College
10. Christchurch Girls High School

Street renewals

11. Picton Reserve
12. St Alban's Creek

Linkages, Networks & Corridors

13. Dudley Creek
14. Jellie Park
15. Riccarton Bush, Ōtākaro / Avon River

Residential red zone

16. Oxford Terrace, Avonloop
17. Avonside Drive, Ōtākaro/ Avon River
18. Cockayne Reserve

Subdivisions

19. Waitikiri
20. Prestons

Wetlands

21. ANZAC Drive
22. Corser's Stream, Donnell Park
23. Cockayne Reserve
24. Ōruapaeroa / Travis Wetland
25. Te Ihutai/ Ōtākaro / Avon River Heathcote Estuary

Waterway restoration

26. Corsers Stream
27. No.2 Drain Shirley Golf course
28. Watermark, Ōtākaro / Avon River

Suburban greenspace

29. Crosbie Park
30. Waikākāriki/ Horseshoe Lake
31. Avonhead Park

2.14 Ōtākaro / Avon River Catchment overlying the 1856 Black Maps

Waikākāriki / Horseshoe Lake

Old Lake Outlet, Waikākāriki / Horseshoe Lake

Ōruapaeroa / Travis Wetland

Burnside High School

ANZAC Drive, Avondale

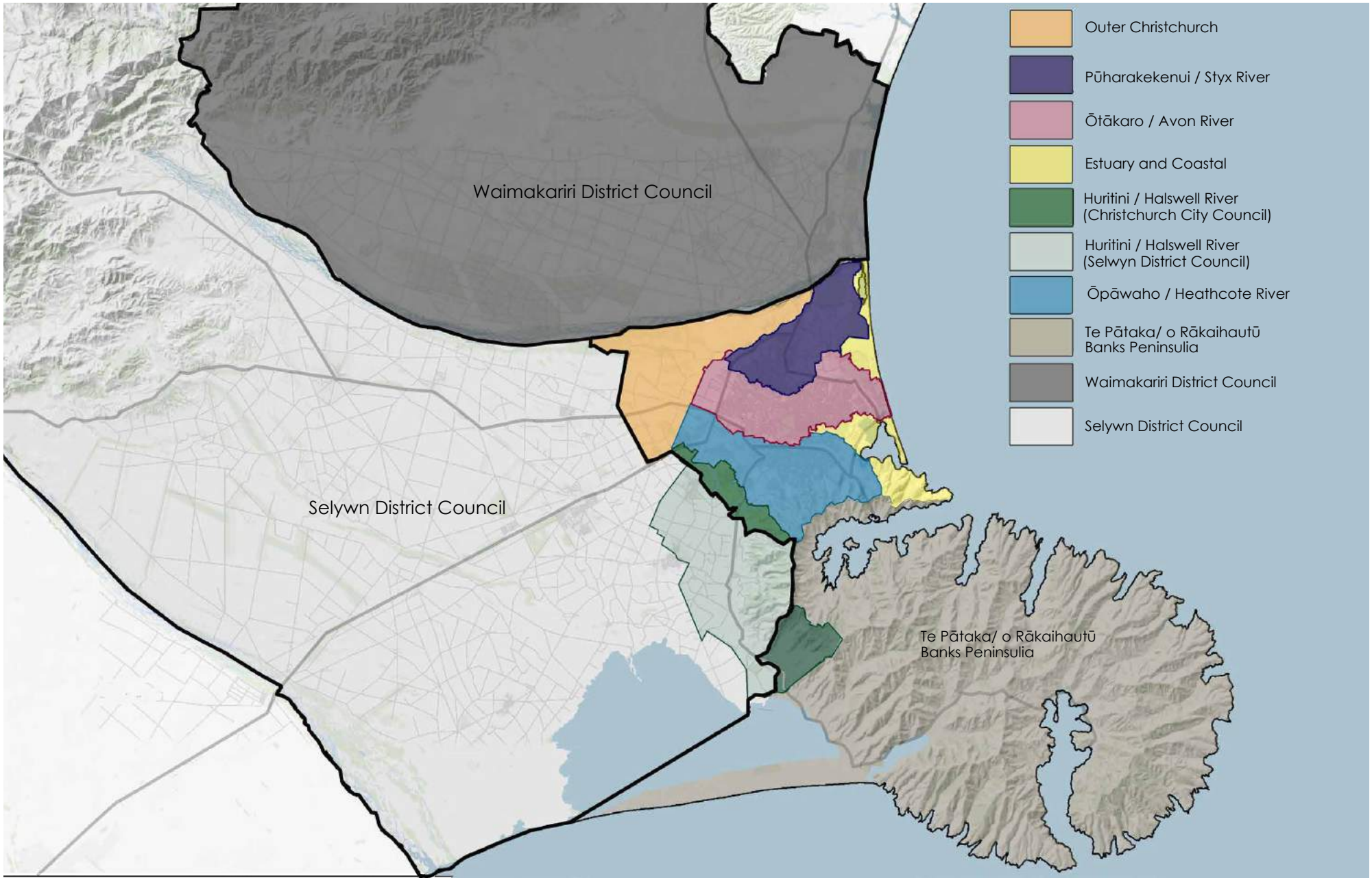
Cockayne Reserve, New Brighton

Riccarton Bush, Riccarton

Te Ihutai/ Ōtākaro / Avon River Heathcote Estuary

The 1856 Black Map is a survey plan (J Thomas & T Cass Chief Surveyors) that shows the original land formation, vegetation, waterways and wetlands of Christchurch at the time of European settlement. It is still relevant today as an indicator of natural drainage and vegetation types.

2.15 Context Plan: Catchment Boundaries within Christchurch



Part 2.0 SUMMARY OF TECHNICAL REPORTS TO INFORM STORMWATER MANAGEMENT Pūrongo Hangarau

3.0 Physical Context / Te Horopaki

3.1 Geology

The Canterbury Plains are a complex of coalescing fans deposited by eastward-flowing rivers emerging from the foothills of the Southern Alps. During glacial periods valley glaciers reached almost to the foothills, and meltwater rivers built alluvial fans.

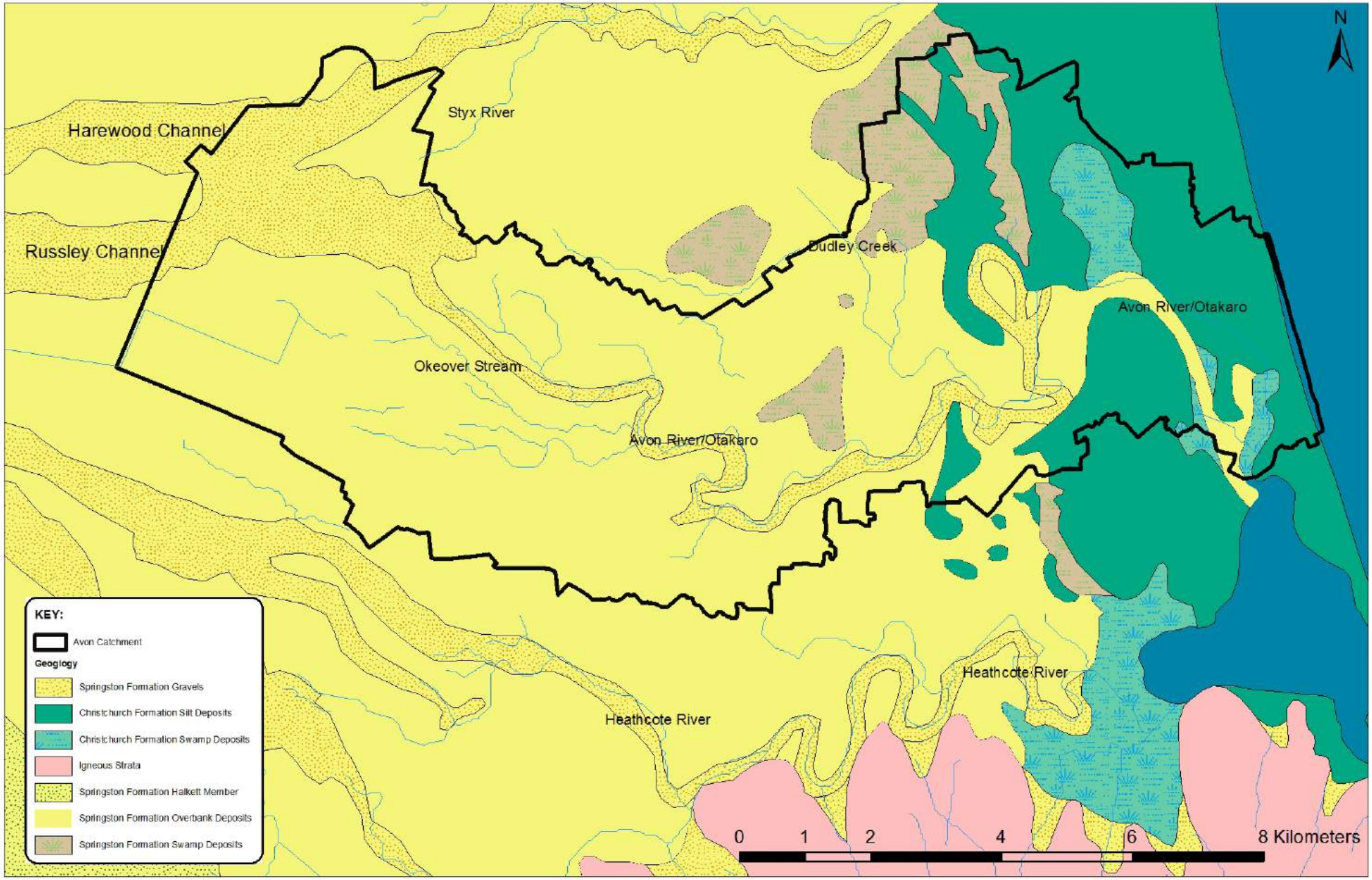
The Canterbury Plains are formed on more than 500 m of gravel deposited during the late Tertiary and Quaternary periods (the last 5 million years). At the coast the gravel is shallower, being underlain at 240 m by clay, sand, silt, peat and interbedded gravel deposited in an ancient coastal environment. Basement rock is generally at a depth of 1.5 to 2 km, although rock occurs at shallower levels near the Banks Peninsula hills.

Accumulating progressively downstream, the alluvial fans extended to a coast which was several kilometres east of the present shoreline. Successive glaciations deposited gravel layers that are generally 10 – 20 m, but up to 40 m thick. During interglacial periods the rising sea created deposition areas for blue, brown and yellow sand, silt and clay with inter-bedded shell, peat and wood layers in the vicinity of the present day city. Successive climate cycles have laid down six or more gravel layers separated by significantly less permeable fine sediment. Layers can be identified in some of the 10,711 well logs in the area. Inland from Christchurch, the impermeable layers dwindle and disappear.

Groundwater beneath the plains is fed by percolating rainfall and seepage from the Waimakariri River. It flows toward the coast, entering each of the gravel layers which form separate aquifers, from which water exits by upward leakage or by abstraction. Deeper aquifers are fed from further up-gradient and are under artesian pressure.

The Ōtākaro / Avon River extends for approximately 26 km from its spring-fed source in Avonhead to its mouth at Te Ihutai / the Estuary of the Avon and Heathcote Rivers in Ferrymead and covers approximately 89 km².

Surface Geology of the Ōtākaro / Avon Catchment



3.2 Soils

Christchurch soils are rather clearly divided between those based on outwash gravels and over-bank flows of the Waimakariri River to the west, and near-coastal deposits typical of swamps, dune areas, floodplains and estuaries nearer the coast. Soils range from well drained to very poorly drained (facing page).

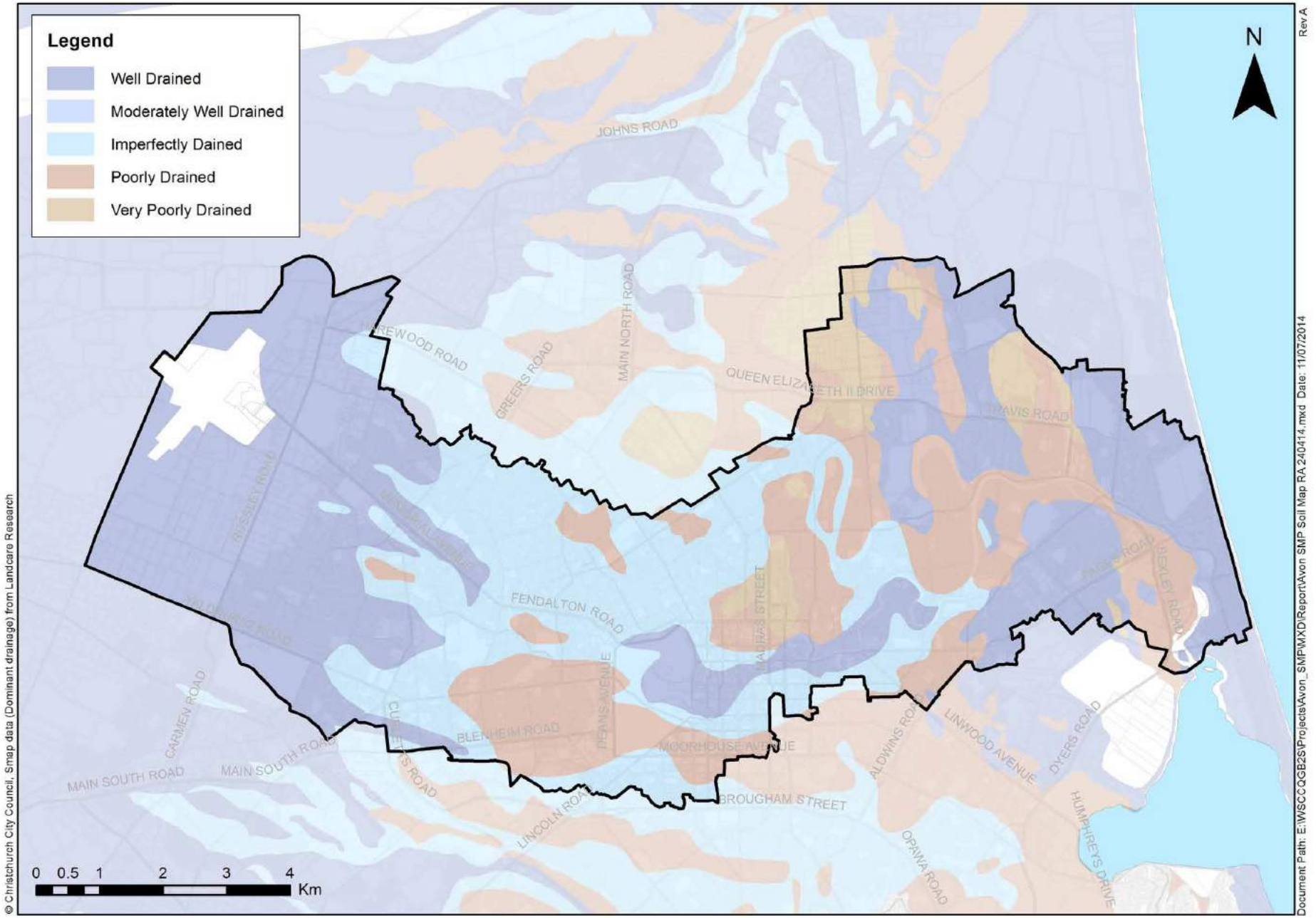
West of a line through Bishopdale – Ilam – Sockburn – Hornby are the Waimakariri and Selwyn sandy loams. Waimakariri soils were deposited by ancient spillages of the Waimakariri River through the Islington Channel (a shallow, mostly concealed, old channel of the Waimakariri River that runs from West Melton via Islington to Westlake), and are found south of Avonhead. North of Avonhead and around the airport are Selwyn silt and sandy loams deposited by river floods spilling from the present-day river channel of the Waimakariri. These soils are well drained, and whether shallow or deep are underlain by free draining gravels.

East of Ilam, approximately, the surface materials have been influenced by landward incursions of the sea over the last 8000 years, and by coastal processes: the highest post-glacial sea level rise 6500 years ago shifted the shore to the vicinity of Riccarton Bush. Soft sediments have therefore accumulated over a wide coastal zone in over-bank and estuarine deposits interspersed with swamps, peaty areas and sand deposits. These form the Kaiapoi silt loams and Tai Tapu silt loams. Drainage is impeded by fine sediments and a high water table. The high water table reflects the proximity of the coast, but also imperfect drainage and upward leakage from the Riccarton aquifer beneath.

East of Marshland – Linwood – Dallington is a general predominance of the sandy Waikuku complex, (and near Travis Wetland the Aranui complex) soils. Silty sandy soil over-lies various mixtures of sand, and may be well drained or wet depending on elevation. On the coastal margin including Aranui and Wainoni is Kairaki complex soil built on an extension of coastal soil formations ranging from sand hills and seaside scrublands adjoining the local beaches.

In general the Waimakariri and Selwyn soils are very well drained, allowing the stormwater network to be more sparse toward the west. At and west of Russley and Avonhead ground infiltration is a predominant means of drainage and new developments in that area are expected to discharge stormwater to ground, after treatment. Sandy New Brighton soils are free draining but are less adapted to ground soakage due to a high water table. Between these areas, from Fendalton to Linwood, with exceptions, a combination of tight soils and high groundwater impedes drainage and makes ground soakage difficult to achieve.

Christchurch soils from S-map online (http://smap.landcareresearch.co.nz)



3.3 Groundwater

The near surface geology of the Ōtākaro / Avon catchment is comprised of unconsolidated gravel, sand, silt and clay sized particles, deposited in two different environments. Coarser grained gravel and sand deposits are derived from alluvial fans, which have spread out from the Southern Alps in the west, across the Canterbury plains including the Christchurch City area and the Ōtākaro / Avon catchment. These river processes have formed zones of permeable water bearing aquifers which occur extensively around the western edge of the Ōtākaro / Avon catchment and in more discrete, deeper, layers towards the central and eastern catchment. The gravels are interspersed with zones of alluvial sand and silt associated with alluvial depositional processes and finer grained overbank flood deposits. The formation of 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 in the eastern areas of the Ōtākaro / Avon catchment.

Groundwater occurs within pore spaces between the gravel and finer grained particles. Where the gravels and coarse sands extend to the ground surface, in the west of the catchment, the strata is classified as an unconfined aquifer and surface water can infiltrate relatively unimpeded into the gravel strata. In the east of the catchment, where finer grained estuarine and marine strata occur at the ground surface, they provide a cap over the gravels, thereby creating a confined aquifer system. Consequently, at depth below the central and eastern parts of the catchment the gravels form a layered sequence of discrete aquifers, separated by low permeability fine grained marine and estuarine deposits.

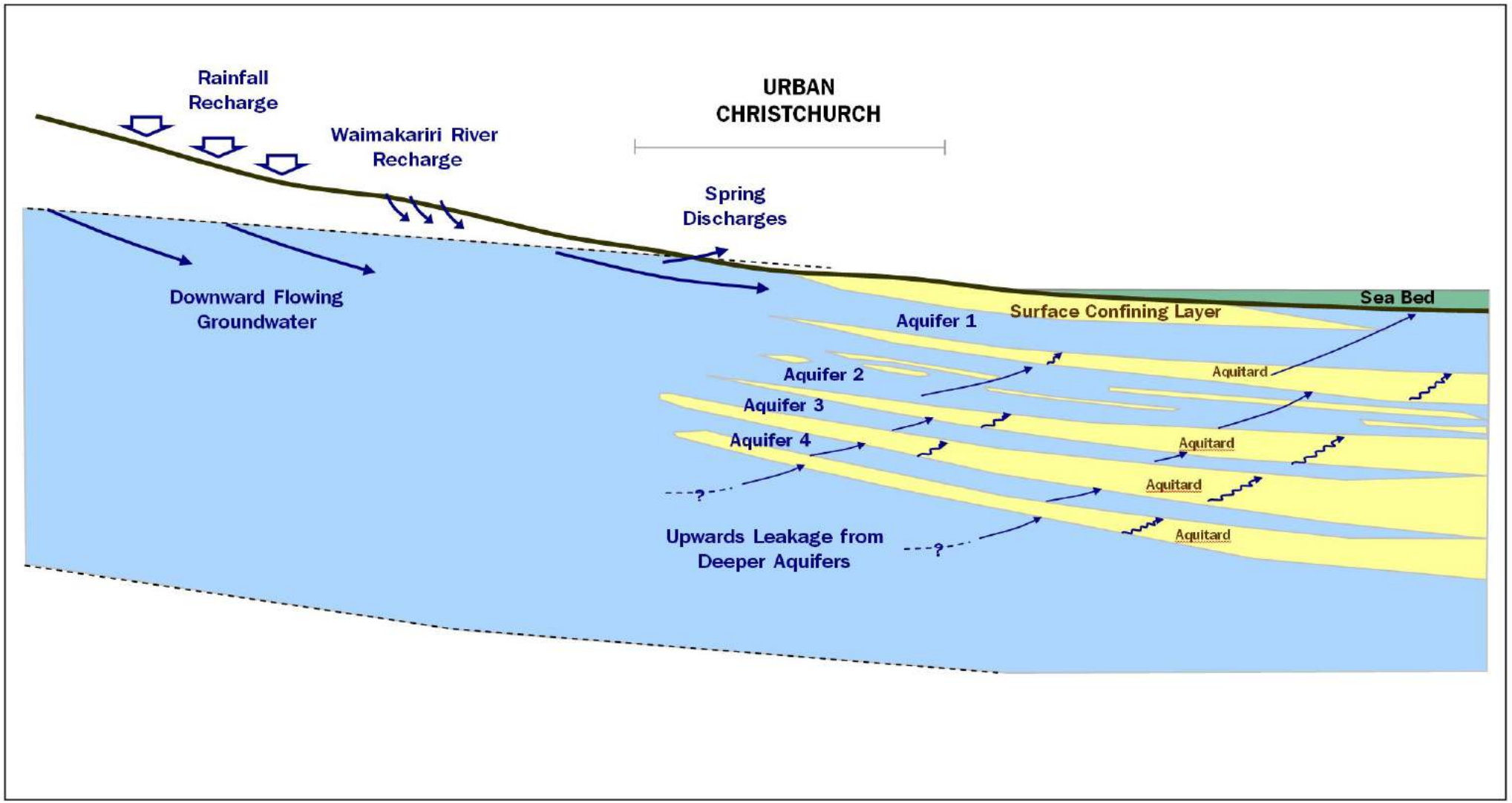
The groundwater system in the Ōtākaro / Avon catchment is primarily recharged by seepage losses from the Waimakariri River as it flows across the gravelly plains and rainfall infiltration that occurs on the gravel and coarse sand strata in the western catchment and further west across the inland plains. Leakage from the stockwater races that cross the plains also contributes some groundwater recharge water. Groundwater levels are influenced by the rate of recharge entering the groundwater system and the permeability of the strata through which the groundwater moves. The levels are deepest at the western end of the catchment (typically around 6 m deep) and become shallower toward the east, approaching ground level in the vicinity of the springs that feed the Ōtākaro / Avon catchment waterways. Groundwater moves in a general easterly direction across the Christchurch City area, in response to the hydraulic gradient resulting from the groundwater levels. The major discharge from the groundwater system occurs into these springfed waterways and that loss of groundwater corresponds to a flattening of the hydraulic gradient in the groundwater system. Further east, the groundwater within the gravel aquifers develops artesian pressures and an upward hydraulic gradient within the eastern area of confined aquifers.

The groundwater inflow into the surface waterways of the Ōtākaro / Avon catchment occurs either as general seepage into the stream bed, or through discrete permeable gravel seams that discharge at high inflow vents within the streambed strata.

The permeable aquifers are used extensively for water abstraction via a network of bores to supply the Christchurch reticulated water supply (45% of maximum consented daily abstractions), in addition to 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 the Ōtākaro / Avon River and its tributaries.

Groundwater Cross Section Through Canterbury



3.4 Springs and Wetlands

The surface waterways of the Ōtākaro / Avon catchment are springfed and support a number of wetland areas. These are highly valued for their cultural and ecological significance, in addition to their contribution to the general river environment that is enjoyed by the wider Christchurch community.

Baseflow into the surface waterways of the Ōtākaro / Avon catchment is maintained by the perennial inflow of groundwater which occurs via general seepage through the streambed, along with more concentrated higher inflow rates occurring at discrete spring locations. The Ōtākaro / Avon, Wairarapa, Waimairi, Okeover Streams and their tributaries all contain significant spring discharge points and drain the Ilam-Fendalton North area, contributing a significant component to the total baseflow in the Ōtākaro / Avon catchment. The springs are most easily identifiable in the western parts of the city where the groundwater transitions from the western unconfined aquifers through the gradually thickening lower permeability surface confining strata that is predominant in the eastern parts of the catchment. These primarily occur to the west of Hagley Park and have measured individual flows ranging from 3 – 50 L/s.

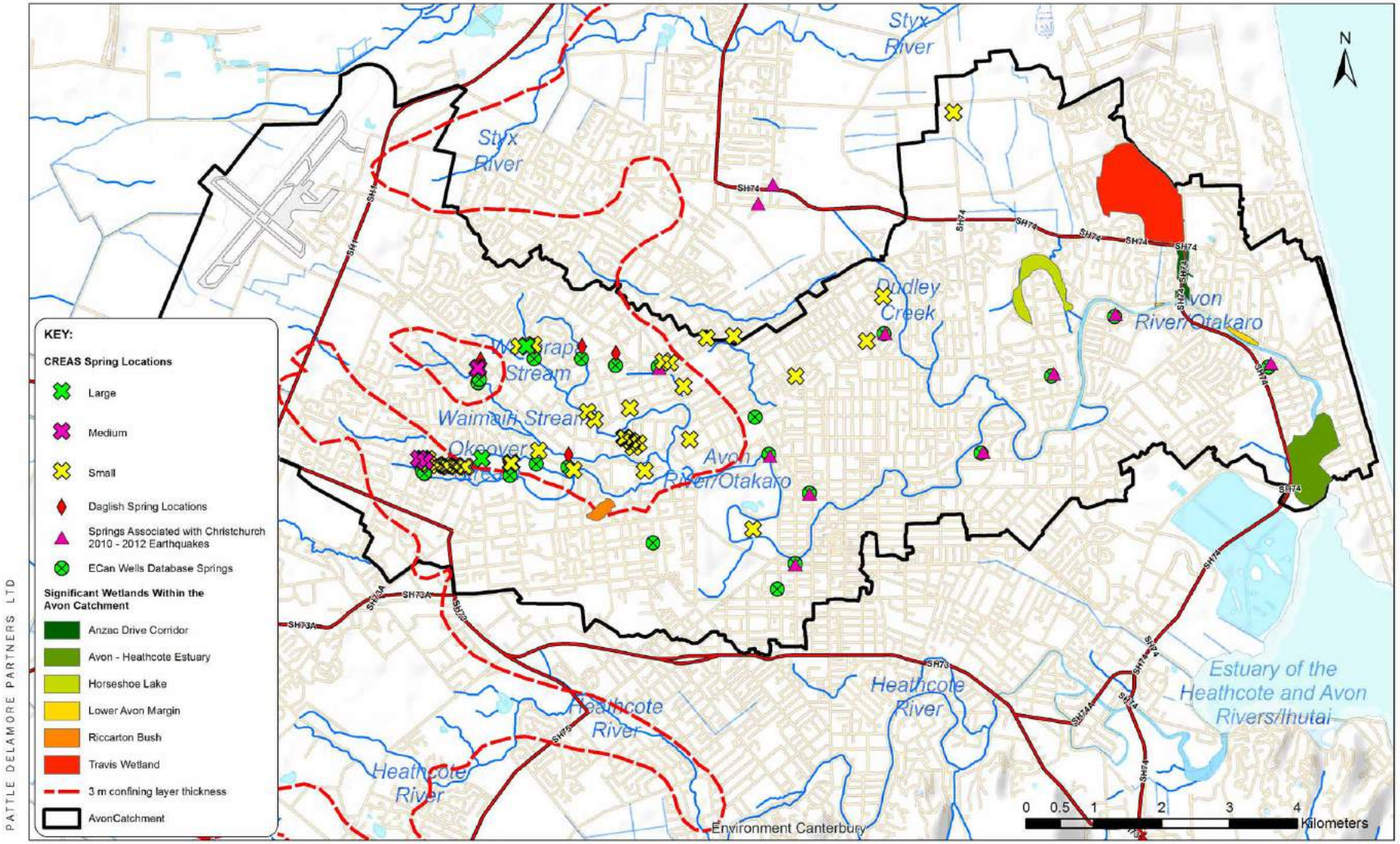
The location and discharge rates of springs will vary throughout the year in response to groundwater level fluctuations. The greatest variation is expected to occur for springs in the western headwaters of the surface waterways, with the springs in the uppermost headwaters drying up at times of low groundwater levels.

The Canterbury earthquakes in September 2010 and February 2011 resulted in the occurrence of a number of new springs in the Avon catchment, which result from a variety of causes, including damage to the casing of old previously sealed bores, reactivation of old springs due to higher water levels and/or discontinuities developing in the confining layer related to liquefaction effects. The majority of earthquake related springs generally occur in the eastern areas of the Ōtākaro / Avon catchment.

Springs and wetlands are significant to manawhenua and regarded as taonga (treasures). Springs or Waipuna provide a source of freshwater as well as being used for ceremonial and healing purposes. Wetlands are places of mahinga kai (food gathering), providing a rich habitat for valued plant, bird and fish species. Springs also maintain the base flow to sustain the recreational and aesthetic attraction of the waterways which are enjoyed by many people.

Wetlands are significantly reduced in number and size compared to the Christchurch environment prior to urban development. The major remnant natural wetland areas are the freshwater basins at Riccarton Bush, Travis Wetland, Horseshoe Lake and the Anzac Drive corridor and the estuary/ salt marsh areas along the lower Ōtākaro / Avon River margins and the upper Avon- Heathcote estuary. There are also some constructed wetlands, primarily related to stormwater management.

All wetlands contain a certain cultural and spiritual significance for Māori. They are regarded as taonga (treasures). Wetlands often are the places of mahinga kai (food gathering) sites, they also provide habitat for plants for rongoa (medicinal use) and for weaving.


KEY:
CREAS Spring Locations
Large
Medium
Small
Daglish Spring Locations
Springs Associated with Christchurch 2010 - 2012 Earthquakes
ECan Wells Database Springs
Significant Wetlands Within the Avon Catchment
Anzac Drive Corridor
Avon - Heathcote Estuary
Horseshoe Lake
Lower Avon Margin
Riccarton Bush
Travis Wetland
3 m confining layer thickness
AvonCatchment
Styx River
Dudley Creek
Avon River/Otakaro
Waimairi Stream
Okeover Stream
Heathcote River
Estuary of the Heathcote and Avon Rivers/Ihutai
Environment Canterbury
0 0.5 1 2 3 4 Kilometers
N
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3.5 Surface Water Network

Waterways Description

The Ōtākaro / Avon River surface water network comprises many spring-fed streams with high amenity value and generally good water quality in the west. East of the CBD, stream amenity values waterways is often low and water quality is fair to poor. The Avon and its tributaries are the receiving waters for stormwater discharges from the very extensive piped drainage network.

The past 150 years have seen extensive modification of the Ōtākaro / Avon River and its catchment. Draining of swamps (the 'lungs' of any river), extensive urbanisation, and discharges from vehicles and commercial / industrial areas has seen water quality degrade significantly.

The Ōtākaro / Avon Stormwater Management Plan (SMP) study area measures 8918 ha and includes a small area of Pūharakekenui/Styx River Catchment headwaters north-east of the airport. The catchment is already largely urban with few opportunities for growth, apart from urban intensification. As a consequence of the activities and land uses in the catchment, the existing water quality in the river and streams is fair to poor.

The Ōtākaro / Avon River has spring-fed dry weather flows which multiply many times during rainfall. Stream channels were formed in over-bank deposits of the Waimakariri River by the larger spring flows that occurred in pre-European times when groundwater levels were higher. Upper tributaries such as Waimairi and Wairarapa Streams are of steeper gradient and retain underlying gravel beds (although the river bed is now often blanketed with fine sediment of urban origin). Eastern tributaries like Dudley Creek are more likely to be flowing through silt, sand and peat strata.

Upper tributaries, west of Mona Vale, are natural looking meandering streams flowing between grassed or planted margins through well-kept residential areas. Trees provide frequent shade. Channels in many places retain a wide, shallow trapezoidal profile. Banks have frequently been stabilised with walls of timber or other materials and it is not uncommon for filling to encroach into much of the original channel. The landscape of the riparian land is often integrated into the adjacent backyard and used as outdoor living space. The streams have been modified in various ways over time by the owners to enhance their visual, landscape and recreational value. These modifications generally narrow stream channels so that over time in places the flood capacity has gradually diminished.

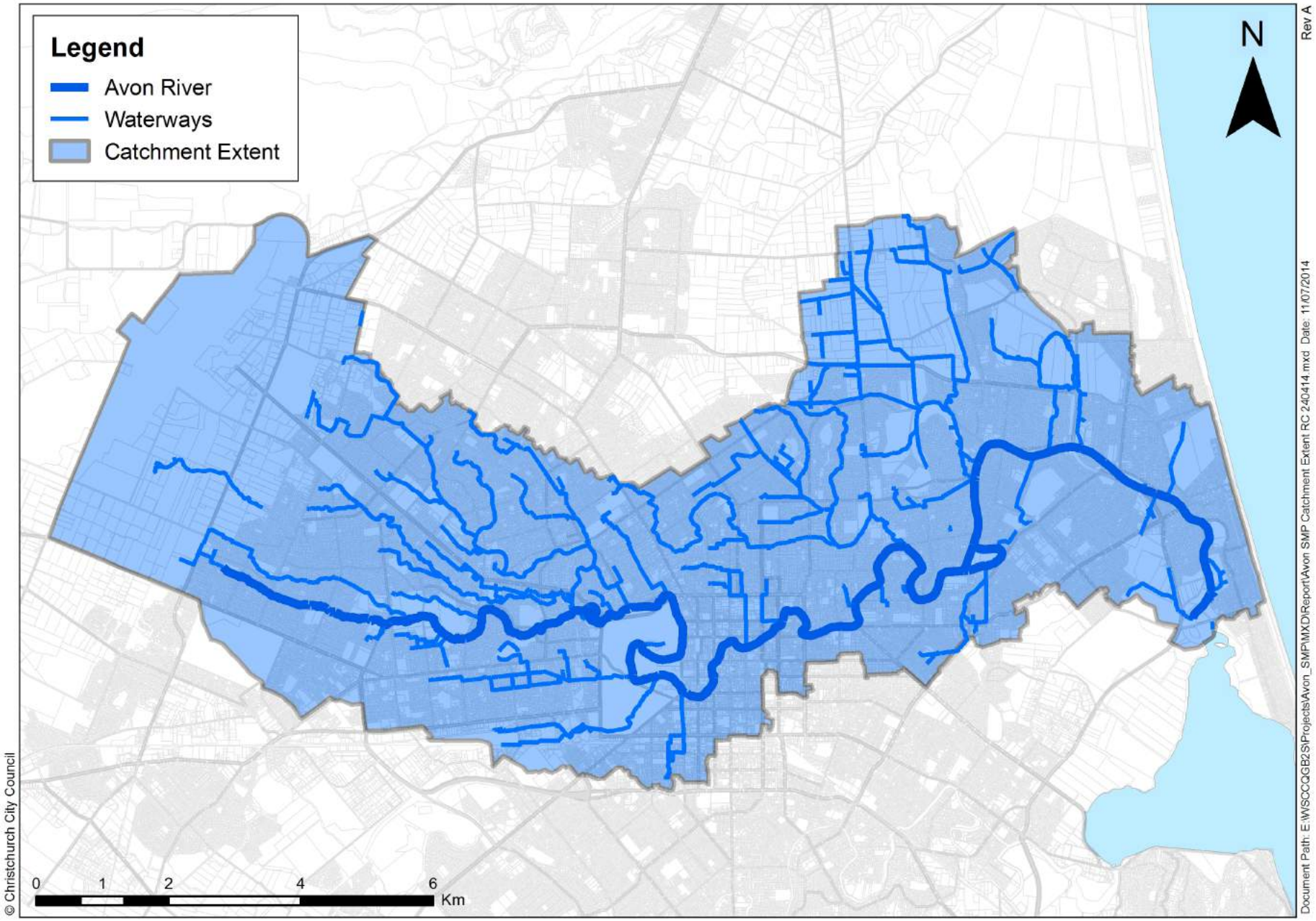
Middle catchment tributaries such as Dudley and St Albans Creeks and Shirley Stream were formed as coastal backswamps when the sea level was higher than today. Consequently the middle catchments are flatter in gradient and more poorly drained. These waterways flow through more densely populated neighbourhoods nearer the city centre and are more affected by pressure of development. Much of their length is retained within a timber lining of approximately square cross section ('boxed drains'). Enclosure of waterways has facilitated building close to the edge of waterways which, together with low bridges and culverts, has greatly impeded flood passage. A programme of waterway enhancement commenced in 1994 to restore a natural character to lined waterways during the lining renewal cycle.

Lower catchment areas such as Burwood, Avondale and Wainoni are low-lying, flat and poorly drained suburbs with high groundwater levels. Filling for development and the demands for drainage have resulted in the piping of waterways and pumping to assist drainage. Some waterways have been piped, while others were concrete-lined to improve hydraulic efficiency. They barely provide a minimum level-of-service in the face of rising sea level and land subsidence during the 2010 and 2011 Christchurch earthquakes.

North of the Ōtākaro / Avon River, New Brighton and Parklands areas are old coastal sand dunes which were without natural surface drainage patterns, despite a high water table. The major outlet to the river from Travis Wetland, Corsers Stream, is a recent waterway excavated to permit development between the wetland and New Brighton Road.

The river and its tributaries above Mona Vale has good riparian plant cover, but this reduces downstream in the tidal reaches. Aquatic weed removal throughout the river system is a regular maintenance activity, especially in Kerrs Reach where infestations of the invasive exotic weed *Egeria densa* have occurred.

Surface Water Network of the Ōtākaro / Avon Catchment



4.0 State of the Takiwā / Te Āhuatanga o te Takiwā

4.1 Te Āhuatanga o Te Ihutai- Cultural Health Assessment of the Avon Heathcote Estuary & its Catchment (2007 & 2012)

Cultural health assessments of the Ihutai catchment were undertaken in 2007 and 2012 by members of Ngāi Tūāhuriri and Te Hapū o Ngāti Wheke using the Ngāi Tahu Takiwā assessment tool. The 2007 study was carried out for Environment Canterbury as part of a wider research project being led by the Avon-Heathcote Estuary Ihutai Trust called 'Healthy Estuary & Rivers of the City', while the 2012 study was carried out for the Christchurch City Council.

Both studies confirmed that Ihutai waterways are in a state of poor cultural health and do not meet basic standards for cultural use. In particular, the impacts of historical and ongoing drainage and untreated stormwater, the loss of native vegetation, including wetlands, grasslands and lowland forests, and the decline of water quantity within the catchment were identified as major issues influencing the assessment. The 2012 study had similar findings to the 2007 study, with some improvements at certain sites, particularly associated with improved riparian and stormwater management as well as further degradation at others, associated with earthquake damage.

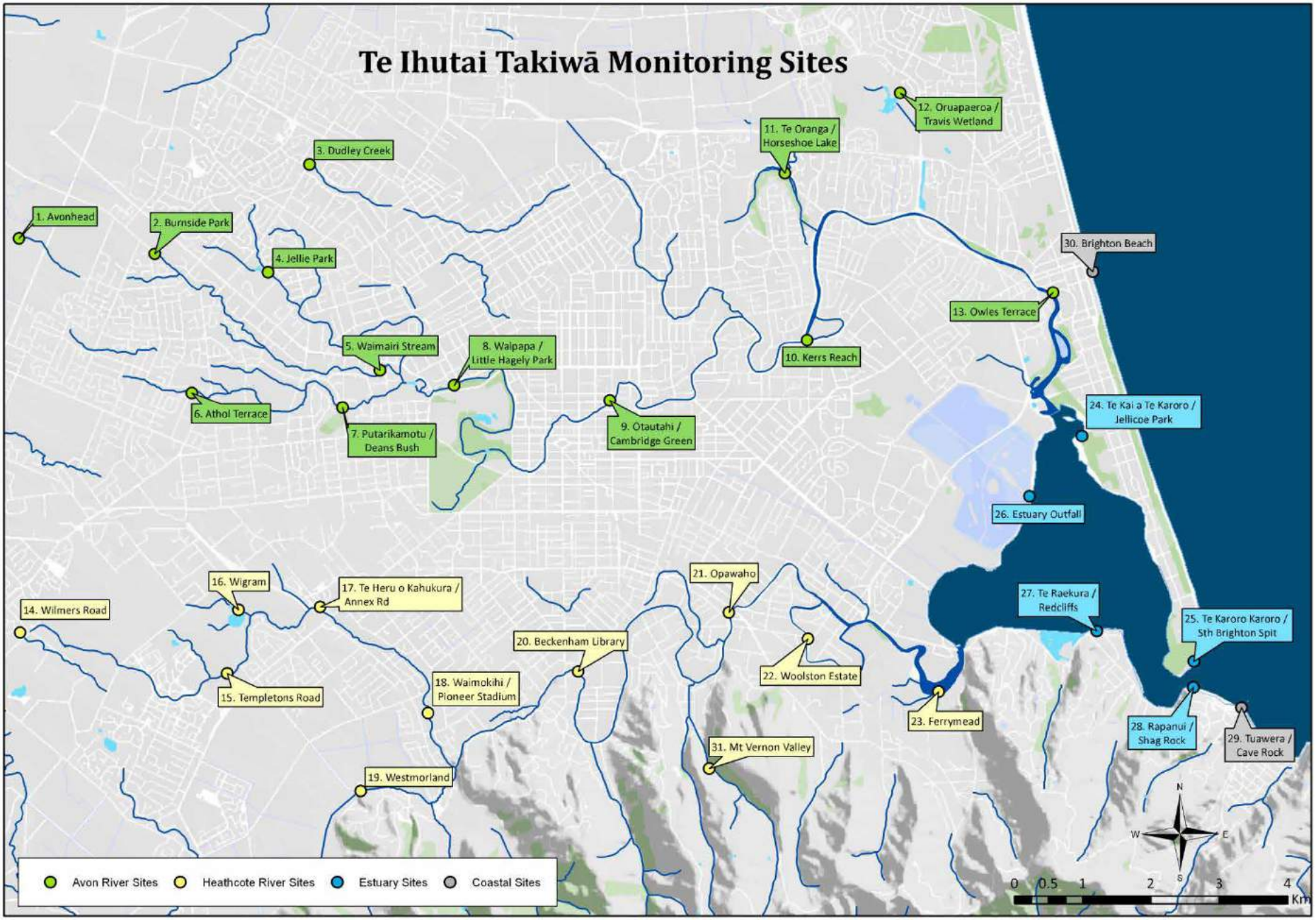
Both studies noted that stormwater inputs, wastewater discharges and the occurrence of extreme sedimentation are undermining the mauri of waterways. The 2012 study noted:

"Overall the biggest influence on poor catchment health is the historical and continuing impacts of drainage and untreated stormwater."

Both studies cited that the elimination of discharges of contaminants to water is one of the most important challenges for future management of the Ihutai catchment and that addressing this requires mechanisms to avoid new inputs (e.g. low impact urban design such as greywater recycling) and a full assessment of existing sources of contaminant discharges, particularly stormwater. The studies advocate for the elimination of wastewater and stormwater discharges from waterways through a combination of repairs, upgrades, and replacement of existing infrastructure and the use of alternative disposal technologies. Planting riparian margins along waterways and drains to restore habitat, filter run off, and reduce sediment entering waterways will further restore the mauri and cultural health waterways in the catchment were also recommended.

The 2012 study also identified Waikākāriki (Horseshoe Lake) as a priority site for water quality and stormwater issues stating:

"Water quality at Waikākāriki (Horseshoe Lake) is particularly degraded. It is a significant urban drainage sink with multiple stormwater inputs draining urban and rural land. Despite the degraded water quality, Waikākāriki scored high in a recent cultural health assessment, largely due to the presence and abundance of remnant/restored native vegetation and wetland/ spring values. Given that there is good remnant/restored native vegetation at this traditional settlement (Te Oranga) and food gathering site, and therefore a good potential to achieve full cultural health, Ngāi Tahu have identified it as a priority site with regard to addressing water quality issues."


Te Ihutai Takiwā Monitoring Sites
1. Avonhead
2. Burnside Park
3. Dudley Creek
4. Jellie Park
5. Waimairi Stream
6. Athol Terrace
7. Putarikamotu / Deans Bush
8. Waipapa / Little Hagely Park
9. Otautahi / Cambridge Green
10. Kerrs Reach
11. Te Oranga / Horseshoe Lake
12. Oruapaeroa / Travis Wetland
13. Owles Terrace
14. Wilmers Road
15. Templetons Road
16. Wigram
17. Te Heru o Kahukura / Annex Rd
18. Waimokihi / Pioneer Stadium
19. Westmorland
20. Beckenham Library
21. Opawaho
22. Woolston Estate
23. Ferrymead
24. Te Kai a Te Karoro / Jellicoe Park
25. Te Karoro Karoro / Sth Brighton Spit
26. Estuary Outfall
27. Te Raekura / Redcliffs
28. Rapanui / Shag Rock
29. Tuawera / Cave Rock
30. Brighton Beach
31. Mt Vernon Valley
Avon River Sites
Heathcote River Sites
Estuary Sites
Coastal Sites
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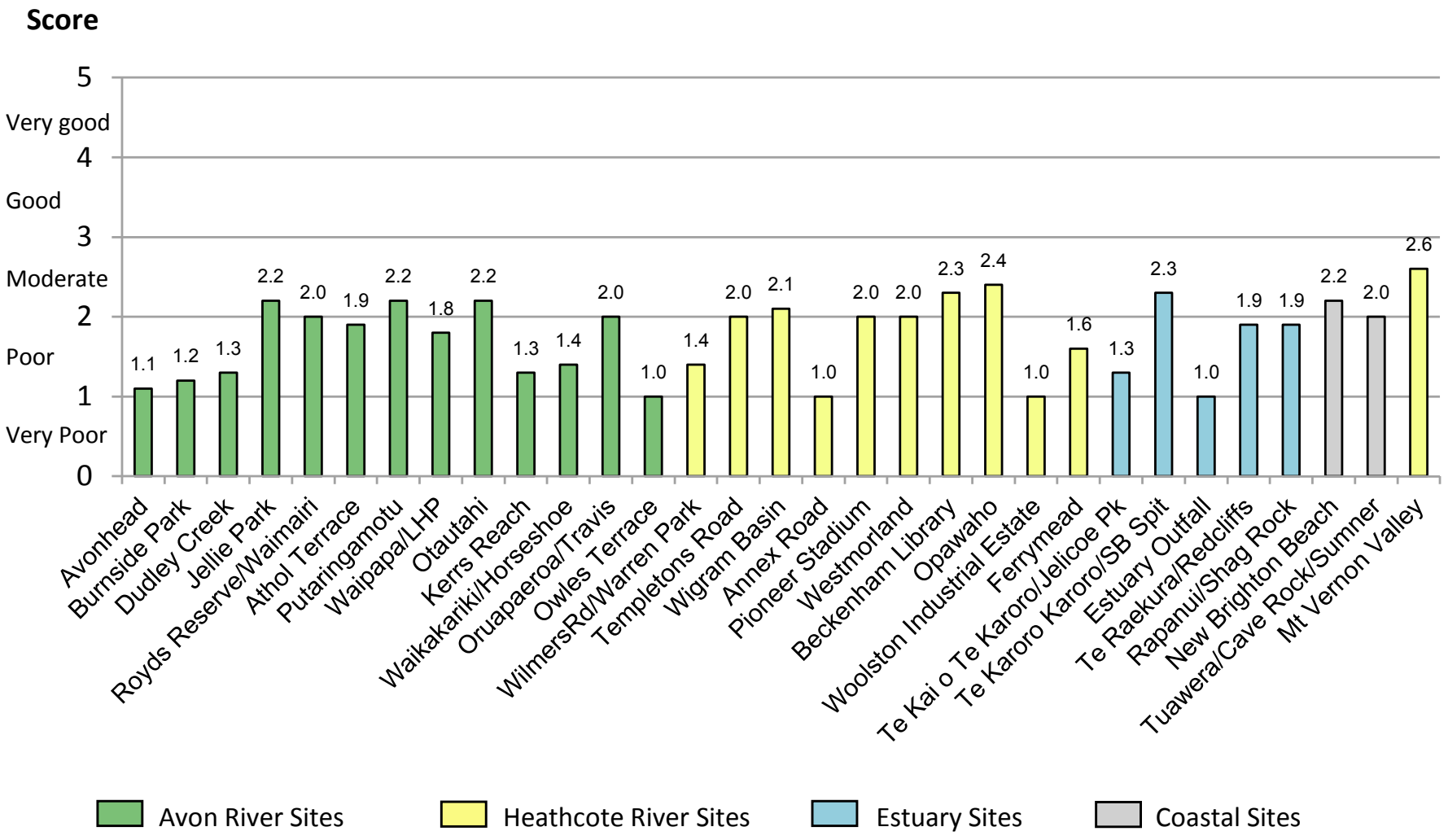
Score
5
Very good
4
Good
3
Moderate
2
Poor
1
Very Poor
0
1.1
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1.9
1.9
2.2
2.0
2.6
Avonhead
Burnside Park
Dudley Creek
Jellie Park
Royds Reserve/Waimairi
Athol Terrace
Putaringamotu
Waipapa/LHP
Otautahi
Kerrs Reach
Waikakariki/Horseshoe
Oruapaeroa/Travis
Owles Terrace
WilmersRd/Warren Park
Templetons Road
Wigram Basin
Annex Road
Pioneer Stadium
Westmorland
Beckenham Library
Opawaho
Woolston Industrial Estate
Ferrymead
Te Kai o Te Karoro/Jelicoe Pk
Te Karoro Karoro/SB Spit
Estuary Outfall
Te Raekura/Redcliffs
Rapanui/Shag Rock
New Brighton Beach
Tuawera/Cave Rock/Sumner
Mt Vernon Valley
Avon River Sites
Heathcote River Sites
Estuary Sites
Coastal Sites

4.2 Management Recommendations

Both studies made a number of recommendations, with many being relevant to stormwater management, including:

- The progressive elimination of contaminant inputs throughout the catchment, including from the wastewater network and from stormwater runoff and rural land uses;
- Restoring of water quality to a level at which mahinga kai can be safely gathered;
- Further studies to investigate the source of human, agricultural, and medical contaminants located throughout the catchment, and a move towards *Escherichia coli* (*E. coli*) monitoring by source as a standard approach to environmental monitoring;
- The protection and enhancement of all known springs in the catchment;
- A concerted effort is required to restore and protect indigenous riparian vegetation throughout the catchment, particularly on Christchurch City Council/public land;
- The development of policy in the district plan to require native riparian buffer zones and on-site stormwater treatment systems when any land adjacent to any waterway (including drains) is subdivided or developed;
- Identification and recording of all stormwater inputs in the catchment and investigation into the effects of these inputs on water quality, including native fish, birds, insects and plants.

4.3 Te Whakamutunga / Summary

Freshwater is of the utmost importance to Ngāi Tahu culture and identity and the iwi has been actively involved in protecting and advocating for improve water management through resource management processes for over 30 years. Stormwater management is a key aspect of improved water management and the Mahaanui Iwi Management Plan (IMP) contains numerous policies that provide guidance of Ngāi Tahu perspectives in relation to stormwater, including catchment specific policies.

Overall the IMP stormwater policies encourage the consideration of actions that reciprocate the use of natural resources (regardless of effect), manage the cumulative impacts and the implementation of best management practices as well as addressing adverse effects of intensive land use on cultural values. This includes the requirement for indigenous riparian planting and on-site land based treatment and disposal systems for stormwater, such as vegetated swales, constructed wetlands and retention basins that result in zero stormwater discharges. Land based treatment systems are seen to promote cultural values, reduce erosion, protect soil and reduce sedimentation and contamination of waterways. Policies for specific catchments focus on improving urban development, particularly subdivision and the impacts of stormwater runoff to protect water quality, significant sites and mahinga kai.

While the stormwater policies state an opposition to the use of global consents for stormwater discharges, there is also clear support for integrated catchment management plans as a tool to manage stormwater and the effects of land use change and development on the environment and tangata whenua values, when they are consistent with other policies.

5.0 Freshwater Ecology / Rauropi Wai-māori

As part of the technical investigations for the Ōtākaro / Avon River Stormwater Management Plan, an ecological survey was undertaken within the Ōtākaro / Avon River and tributaries in October and November 2013 by Boffa Miskell. This survey included investigations of habitat, periphyton (algae), macrophytes (aquatic plants), macroinvertebrates (aquatic insects) and fish, from 29 sites within the catchment. These sites included the lower non-wadeable sections of the Ōtākaro / Avon River.

5.1 Overview of Ecological Health of Waterways

To assess the ecological health of each of the sites in the catchment, five macroinvertebrate indices were used as indicators. For example, the Quantitative Macroinvertebrate Community Index (QMCI) was used, which determines stream health based on the sensitivity of species present to pollution and their abundance. These five indices indicated that the majority of sites in the Ōtākaro / Avon River had poor ecological health. In addition, 48% of sites were below the proposed Land and Water Regional Plan (pLWRP) QMCI guidelines for spring-fed urban systems. However, these waterways are typical of those in moderately urbanised catchments.

5.2 Areas with High Ecological Value

Areas with the highest ecological value were those in the north-west of the catchment, specifically the headwaters and mid-section of the Ōtākaro / Avon River, as well as Okeover and Waimairi Streams. The top five sites, when ranked by macroinvertebrate indices, were all located upstream of the confluence of Riccarton Stream with the Ōtākaro / Avon River. Those sites with the highest overall health typically had the best quality in-stream and riparian habitat. A key driver of health was reliable and reasonable flow, with little dissolved or suspended pollutants. Some sites within the catchment also supported communities of threatened fish, including inanga, bluegill bullies and longfin eels.

5.3 Areas with Low Ecological Value

The five most degraded wadeable sites were within Saint Albans Creek (two sites), Addington Brook, Dudley Creek and Riccarton Stream. The non-wadeable reaches of the Ōtākaro / Avon River, from Fitzgerald Avenue Bridge to Pages Road Bridge, also recorded low ecological health. These sites were affected by poor water, sediment and habitat quality.

5.4 Management Recommendations

- There needs to be a multi-faceted approach to the management of the catchment.
- Areas with high ecological value need to be maintained through appropriate management activities.
- Areas with low values should be restored through intensive management of water quality, and riparian and in-stream habitat; particularly in areas that displayed high potential for ecological health (i.e. they had good instream and riparian habitat), but the poor condition of the water is affecting stream health (e.g. Addington Brook).
- Stormwater management should continue to focus on reducing levels of contaminants (e.g. sediment, heavy metals and hydrocarbons), particularly in the tributaries.
- The removal of contaminated sediment within waterways should be undertaken.
- Deciduous trees in riparian margins should be replaced with evergreen species, to reduce excessive amount of leaf litter input into waterways, which affects water quality.
- Riparian and in-stream habitat should be enhanced, including the use

of such things as emergent large substrates (which provide laying sites for the eggs of aquatic insects) and specialist habitat (e.g. riffles for bluegill bullies).

- Connectivity along streams should be improved by reducing the impact of in-stream structures, such as culverts and low bridges.
- Lighting systems should be used that reduce the effects of light pollution on freshwater fauna.
- All areas of the catchment, regardless of their current ecological health, contribute to the health of the Ōtākaro / Avon river and the Ihutai/ Avon-Heathcote Estuary, and therefore should all be considered.
- It is crucial to maintain the fast-flowing, riffle habitat of the Ōtākaro / Avon River, which supports diverse macroinvertebrate communities and bluegill bully populations.

6.0 Surface Water Quality / Kounga Waimāori

Environment Canterbury produced a report summarising the results of the Christchurch City Council monthly water quality monitoring at sites within the Ōtākaro / Avon River catchment from 2007 to 2012 (Bartram, in press). This has been used to inform the development of the Ōtākaro / Avon Stormwater Management Plan. The monitoring was undertaken at thirteen sites within the mainstem and tributaries of the Ōtākaro / Avon River, for a range of parameters. The results of this report are summarised below.

6.1 Overview of Surface Water Quality

Water quality in the upper catchment was characterised by low suspended solids, ammonia, phosphorus and microbial concentrations (using *E. coli* as an indicator), but high nitrogen concentrations. These higher nitrogen levels may be due to groundwater contaminated by rural land use entering waterways via springs in the headwaters. In contrast, the impact of stormwater runoff was apparent at sites further downstream, as indicated by generally higher concentrations of suspended solids, ammonia, zinc, *E. coli* and phosphorus.

The main water quality issues in the Ōtākaro / Avon catchment were related to nutrients (nitrogen and phosphorus), copper, zinc and *E. coli*. Key points from the report were:

- Trigger values for nitrogen and phosphorus were exceeded at many sites, indicating a potential risk of nutrient enrichment;
- The contact recreational guidelines for *E. coli* were exceeded frequently at the majority of sites, including in tidal reaches where recreational activities are likely to take place;
- Hotspots for *E. coli* included the Ōtākaro / Avon River at Dallington Terrace/Gayhurst Road, Ōtākaro / Avon River at Manchester Street, Dudley Creek, Horseshoe Lake, Riccarton Main Drain and Addington Brook;
- Zinc concentrations frequently exceeded the guideline and remained steady over time within Dudley Creek, Addington Brook, Riccarton Main Drain and the Ōtākaro / Avon River at Dallington Terrace/Gayhurst Road site;
- The copper guideline was also exceeded at some sites, most notably at Addington Brook;
- These concentrations of metals may pose a toxicity risk to freshwater fauna;
- Suspended solid concentrations were generally below the trigger value, with most exceedances associated with the earthquakes.

Some trends were also recorded over time, including:

- A potential increase in phosphorus concentrations at multiple sites in the catchment;
- A decease in zinc concentrations at some sites (although, this was not the case at sites that recorded the highest zinc concentrations);
- Spikes in suspended solids and turbidity associated with the earthquakes, with some high levels following the earthquakes, potentially related to rebuild activities.

6.2 Areas of Good Water Quality

In general, the north-west tributaries (Wairarapa and Waimairi Streams) recorded the best water quality relative to the other waterways. The most notable exception to this was the higher concentrations of nitrogen, which as explained previously, is likely related to groundwater input.

6.3 Areas of Poor Water Quality

The sites that recorded the worst water quality were Dudley Creek, Riccarton Main Drain, Addington Brook and Horseshoe Lake. The report concluded that input from these tributaries likely decreases water quality downstream in the Ōtākaro / Avon River mainstem. This is likely a reflection of lower flows in these smaller waterways for dilution, and high contaminant inputs from commercial and industrial activities.

6.4 Management Recommendations

The report made the following management recommendations:

- Improvement in the water quality of tributaries could create substantial benefits downstream in the mainstem;
- Given the impact of stormwater runoff, the focus of the Surface Water Plan should be stormwater treatment systems throughout the catchment, particularly for zinc;
- An investigation into the source of nitrogen in Riccarton Main Drain is advisable given the increasing trend in concentration recorded;
- Addington Brook should be a focus for stormwater treatment, given the particularly poor water quality in this waterway;
- Investigations into phosphorous inputs in the waterways, particularly Addington Brook, should be carried out to help direct management efforts;
- Management options for nitrogen in the catchment should be considered carefully due to inconsistent trends, many different inputs to the river, and the complex relationship of rainfall and groundwater on concentrations.

7.0 Instream Sediment Quality / Kounga Parakiwai

7.1 Overview of Instream Sediment Quality

A survey of the sediment quality within the waterways of the Ōtākaro / Avon River catchment was also undertaken as part of the Ōtākaro / Avon Stormwater Management Plan technical investigations in 2013.

Metal concentrations were within the range measured in urban streams elsewhere in Christchurch and around New Zealand, and results against guidelines is shown on the facing page. No clear spatial pattern in contaminants was recorded, but copper, lead, zinc and cadmium had similar levels, suggesting the same source. Lead, zinc and Polycyclic Aromatic Hydrocarbons (PAHs) all exceeded guidelines at 15 of the 35 sites, indicating they are contaminants of concern. Guideline levels were also exceeded for arsenic (two sites) and copper (one site). Cadmium, chromium and nickel did not exceed guideline levels at any of the sites.

Comparison to a prior survey in 1980 indicated that lead concentrations are lower, chromium and nickel concentrations are higher, while zinc, copper and cadmium levels are no different. Arsenic, chromium, lead and nickel are likely sourced from soil within the catchment. Lead is elevated in urban areas and is a result of historical lead additives in petrol. Impervious surfaces appear to result in higher concentrations of metals and hydrocarbons, and metals appear to be higher in commercial and industrial areas. Post-earthquake dredging seems to have removed the presence of metals within sediment, but the effects of liquefaction are unclear. Wastewater discharges do not appear to have any effects on instream sediment quality.

7.2 Areas with Good Sediment Quality

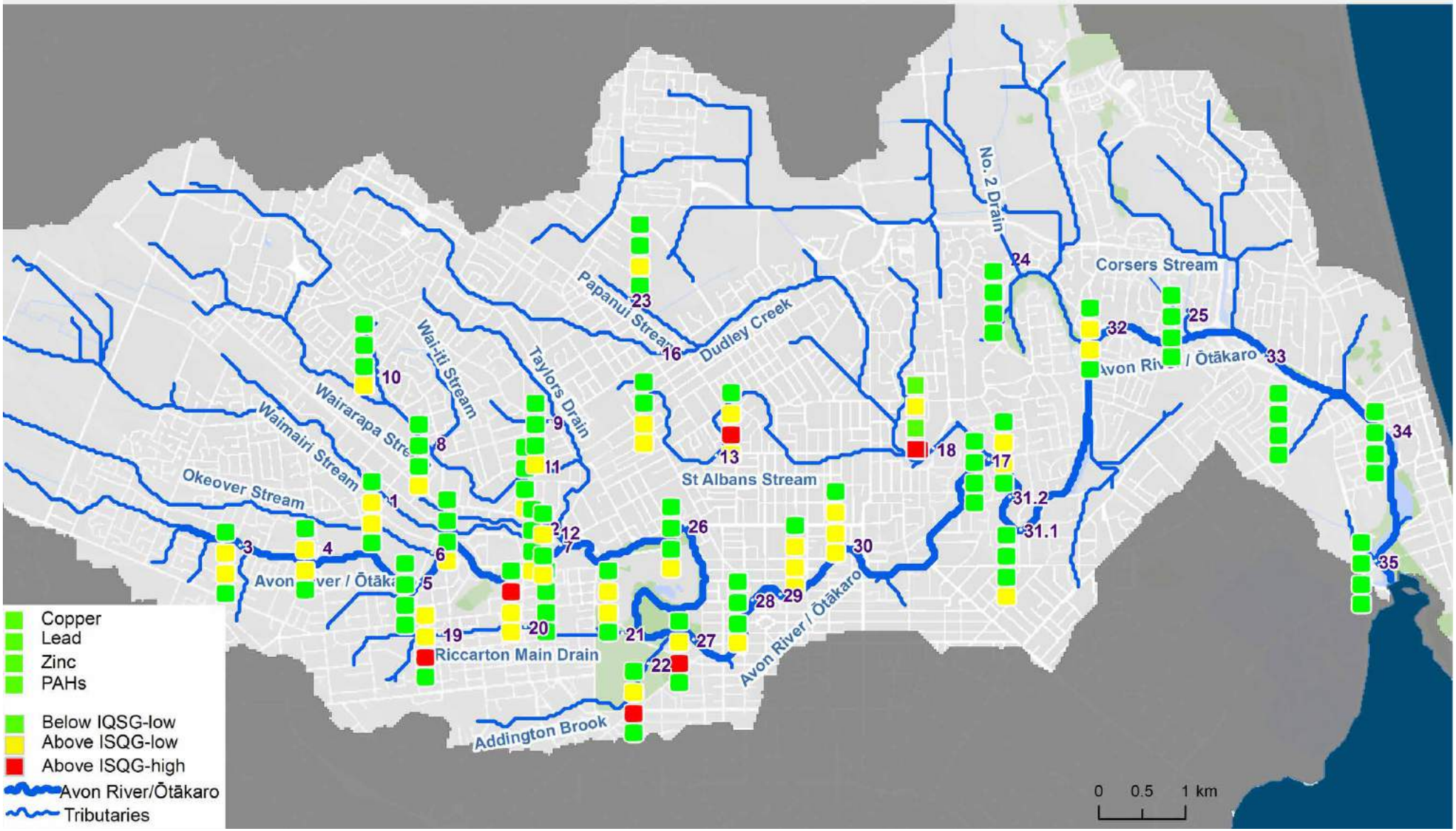
Old Number Two Drain in the Christchurch Golf Course had very low concentrations of all contaminants compared to other sites and did not exceed any guideline levels for any of the parameters. There were also other sites where no guideline levels were exceeded; these included parts of the Ōtākaro / Avon River (at Clyde Road, confluence with Wairarapa Stream, Galbraith Avenue, Wainoni Road, New Brighton Power Boat Club House and Bridge Street), Wai-iti Stream and Corsers Stream.

7.3 Areas with Poor Sediment Quality

The sites with the poorest sediment quality were Addington Brook, Riccarton Main Drain, St Albans Creek, Dudley Creek (and all its tributaries) and all sites in the mid-to-lower Ōtākaro / Avon River. High levels of arsenic in particular were recorded in Addington Brook, this originated from an old sheep dip. Lead was also recorded in high levels in Riccarton Main Drain (downstream of Westfield Riccarton). Dudley Creek was found to have a PAHs hotspot which probably originated from old coal tar residue used in roading material.

7.4 Management Recommendations

- Catchment-wide measures to control pollutants, such as source control and treatment devices.
- Control of roading material entering stormwater system and waterways in areas where coal tar was used.
- Sediment toxicity testing to elucidate effects of contaminants on freshwater fauna.
- Further studies to investigate contaminant sources in hotspot areas.
- Removal of sediment to remove contaminants in system.
- Testing of sediments at sites not sampled during this study.
- Event based testing to determine localised contaminant sources.


Copper
Lead
Zinc
PAHs
Below ISQG-low
Above ISQG-low
Above ISQG-high
Avon River/Ōtākaro
Tributaries
Papanui Stream
Dudley Creek
No. 2 Drain
Corsers Stream
Wai-iti Stream
Taylors Drain
Wairarapa Stream
Waimairi Stream
Okeover Stream
St Albans Stream
Riccarton Main Drain
Addington Brook
Avon River / Ōtākaro
0 0.5 1 km

8.0 Groundwater Quality / Kounga Puna Wai

8.1 Groundwater Protection Zones

The occurrence of the fine-grained strata which confines the gravel aquifer and the upward hydraulic gradient from the groundwater flow system protects the central and eastern groundwater from surface contamination risks. That protection does not exist in the west of the catchment where the permeable strata extends to the ground surface and any effects of land surface recharge infiltrate down into the aquifers. These differences in geology have allowed the definition of groundwater protection zones, as shown in the figure on the facing page, which Environment Canterbury define as follows:

- Zone 1 has high intrinsic hydrogeological vulnerability;
- Zone 2 displays a transition in intrinsic hydrogeological vulnerability;
- Zone 3 has low intrinsic hydrogeological vulnerability.

Despite this Figure showing an apparent vulnerability to contamination in the west of the Ōtākaro / Avon catchment, the plentiful recharge from the Waimakariri River seepage and the permeable nature of the strata means that groundwater quality is generally very good and supports many of the abstraction bores that contribute to the highly valued drinking water supply for Christchurch City.

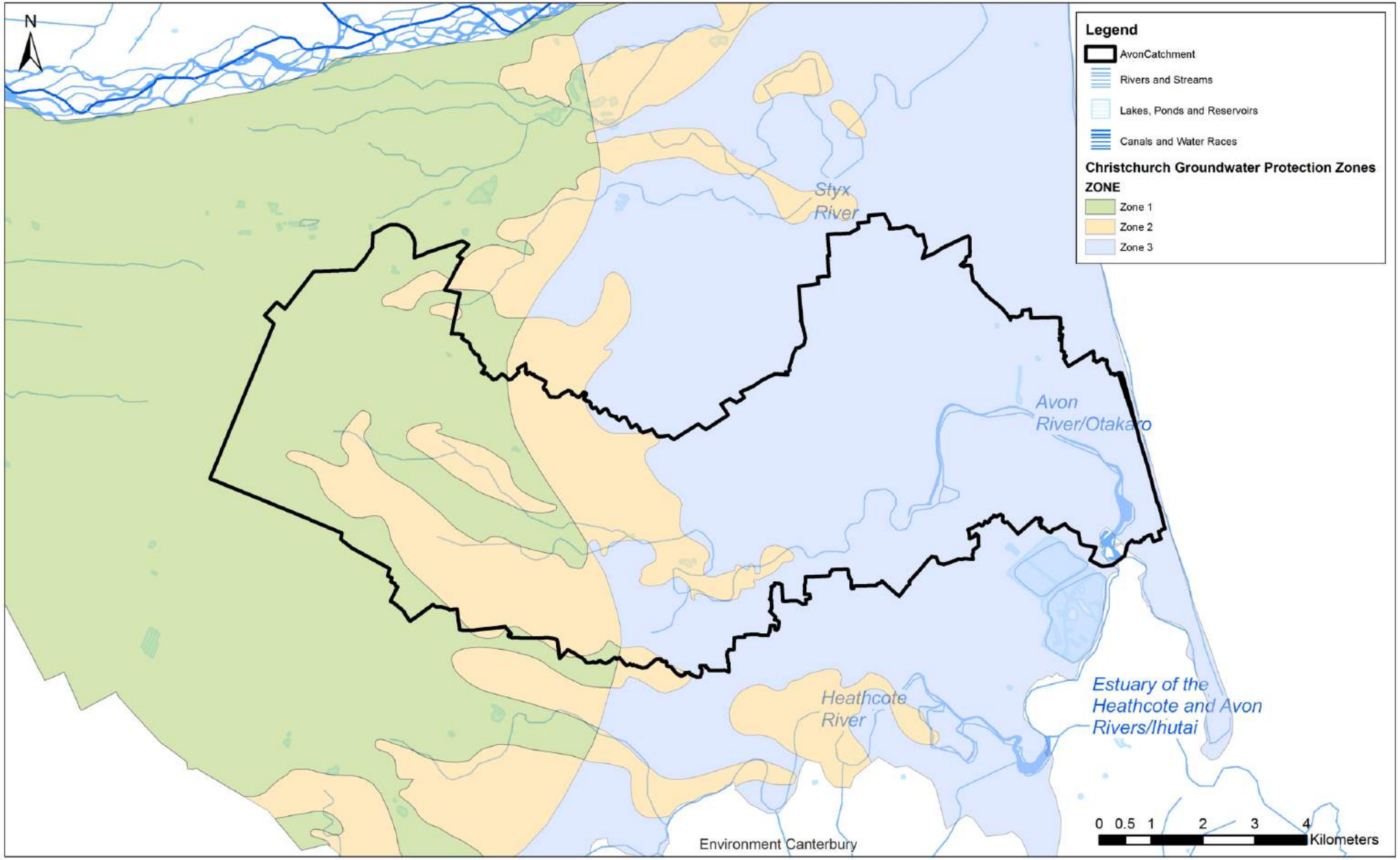
8.2 Groundwater Quality

The overall pattern of groundwater quality is indicated by measurements of electrical conductivity, which indicates the total dissolved chemical concentrations in groundwater. Concentrations of dissolved chemicals are lowest in the north-western area of the catchment where recharge from Waimakariri River seepage is dominant. Further south, higher concentrations of dissolved chemicals occur due to greater influences from land based recharge and the effects of some historical industrial activities. Most notably, waste pits from the former Islington Freezing works and other uncontrolled landfill activities are the likely source of elevated nitrate concentrations along the southern margin of the catchment. Some signs of saline water occur in the south-eastern area of the catchment, due to a reversal of the natural upward hydraulic gradient in the confined coastal aquifers caused by groundwater pumping inducing an inflow of coastal sea-water, either through the fine-grained surface confining strata and/or through abandoned bore casings. These more noteworthy changes to groundwater quality occur further to the south, outside of the Ōtākaro / Avon catchment.

Despite these variations across the Ōtākaro / Avon catchment, the groundwater quality used by bores typically complies comfortably with New Zealand drinking water standards. Groundwater quality in the western area of the Ōtākaro / Avon catchment tends to have slightly elevated concentrations of nitrate-nitrogen (around 1 - 5 g/m^3). Whilst these do not pose a threat to groundwater used as a source of drinking water supply, they do contribute nutrients into the surface water environment which will, at times, detract from the surface water quality due to the excessive growth of periphyton.

For any proposals that involve disposal of stormwater or potentially contaminated water via soakage into the ground, careful design and siting of these infiltration systems is required to minimise contamination risks by maintaining separation distances both to water supply bores and to sources of contamination such as old landfills which may be affected by changes caused by the infiltration discharge. The figure on the right has been prepared to show potential infiltration areas and the location of old landfills and community drinking water supply protection zones.

Groundwater protection zones across the Ōtākaro / Avon Catchment



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8.3 Management Recommendations

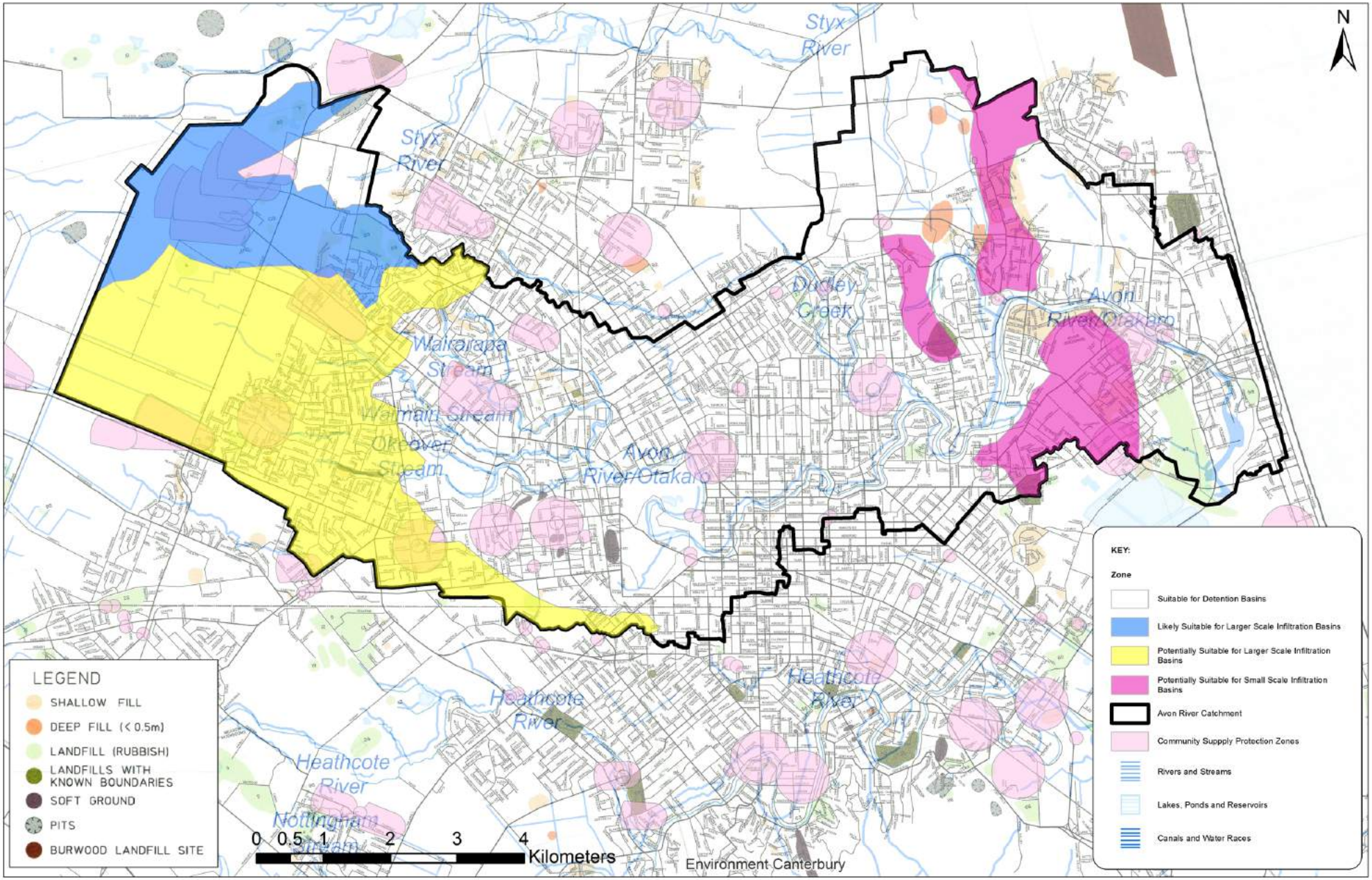
The natural strata within the catchment and the groundwater levels create a major influence on the management of urban stormwater. Where the strata are sufficiently permeable and groundwater levels are deeper (typically greater than three metres, which primarily occurs in the west of the catchment) stormwater infiltration to ground can be achieved. This helps to preserve the natural (pre-development) water balance for the catchment. Stormwater infiltration basins may cause some increase in groundwater levels, which can contribute to drainage problems in areas of shallow groundwater. The installation of drainage systems beneath, or adjacent to, stormwater infiltration basins can assist with the control of high groundwater level issues, however, the widespread occurrence of a shallow water table and/or low permeability near surface strata creates a situation where the management of stormwater via detention basins or wetlands, prior to release to surface waterways, is preferable. The figure opposite shows general areas where different types of stormwater management could be implemented.

For all urban development situations, careful consideration needs to be given to the possible interception of permeable underground flow paths that feed the springs that sustain surface waterways. It is important that the construction of underground structures or services do not divert water away from the spring discharge features, which could cause a permanent detriment to the surface waterway. Construction measures can be implemented to minimise the risk of such unintended diversions occurring.

The occurrence of the springs coincide with areas of shallow groundwater. Similarly most wetlands are areas of shallow groundwater, often coinciding with low permeability surface strata. Consequently, urban stormwater management in these areas is most likely to involve detention systems discharging to surface waterways, or limited infiltration areas. Urban development, including stormwater management should be undertaken in a way that protects and enhances these spring and wetland areas. This includes maintaining separation distances to allow for adequate dispersion of potential stormwater discharge effects arising from raised groundwater levels and possible risks to water quality. In addition, the development of underground structures as part of urban development, needs to be done in a way that minimises disruption to underground flow paths which feed these important surface water features.

For any proposals that involve disposal of stormwater or potentially contaminated water via soakage into the ground, careful design and siting of these infiltration systems is required to minimise contamination risks by maintaining separation distances both to water supply bores and to sources of contamination such as old landfills which may be affected by changes caused by the infiltration discharge. The figure opposite shows potential infiltration areas and the location of old landfills and community drinking water supply protection zones.

Stormwater treatment zones in the Ōtākaro / Avon Catchment



9.0 Flood Risk / Mōrea Waipuke

9.1 Nature of Flooding

Flooding in the Ōtākaro / Avon River Catchment can be divided into four types:

- Surface flooding;
- Stormwater network flooding;
- River and stream flooding; and,
- Tidal flooding.

Surface Flooding

Surface flooding occurs when rainfall rates exceed the ability of the ground to absorb water. Surface water (or rainfall runoff) ponds on the surface or flows overland towards drainage channels, waterways and the coast. Rainfall runoff rates are affected by the type of land use and the nature of the rainfall events.

When surface water collects it can create a flooding hazard. Surface flooding can occur in streets, open space and private property. Surface flooding is most notable on streets and in low points where surface water has not yet entered a stormwater network.

Areas where surface flooding occurs are typically categorised by wet ground conditions, buildings constructed well above the ground or by depressions in the ground. Surface flooding could also become hazardous where overland flow paths are interrupted by filling of land or structures, such as fences or walls.

Stormwater Network Flooding

Most of the Ōtākaro / Avon catchment is fully developed. These urban areas contain older stormwater pipe networks which can only convey the 20% Annual Exceedance Probability (AEP) storm event ('5 year'). These networks have limited capacity; both at the inlets to the system and in the underground pipelines. When inflow into the network exceeds capacity then surface ponding is likely to result.

Often nuisance flooding can be attributed to the ability of the network to accept surface flooding, either due to limited inlet capacity or blockages. Council operations and maintenance teams pay attention to the condition of sumps to minimise this type of flooding, particularly in locations where surface flooding has occurred historically.

Tidal flooding can also have adverse impacts on the stormwater network.

River and Stream Flooding

River (or fluvial) flooding occurs when surface flows reaching the river, stream or waterways exceed either the open channel (and/or structures within the channel) capacity or storage capacity within the floodplain.

The type of river and stream flooding varies depending on location within the Ōtākaro / Avon catchment. Flooding above Hagley Park is driven by peak in-channel flow and channel / floodplain capacity (i.e. the shape and size of the main channel and the capacity of channel crossings, such as bridges and culverts). Obstructions in the floodplain can also significantly impact on water levels within the channels where buildings, fences, road embankments, dense vegetation and other features can impede the flow of water across the floodplain. Many of the open channels within the catchment have significant obstructions within stream boundaries. One significant obstruction on Wairarapa and Waimairi Streams and the Ōtākaro / Avon River is the South Island Main Trunk line railway line between Mona Vale and Wairakei Road.

The mid catchment from Hagley Park to Fitzgerald Avenue is flatter than

the upper catchment and is influenced by both river capacity and available floodplain storage. The river is much wider and overtopping of the main channel is likely in significant rainfall events at a number of locations. Flood levels are influenced by the large number of bridges crossing the river (as shown in the photo).

There are a number of waterways within the catchment that pose significant flood risk to dwellings and roads. Dudley Creek, Mairehau Drain, Bings Drain, Shirley Stream, Wairarapa Stream, Wai-iti Stream, Ōtākaro / Avon River above Hagley Park, Taylors Stream and Brittans Drain are the most significant. Some of the urban areas adjacent to these waterways (e.g. Flockton Street area) have experienced regular flooding since the earthquakes.

The Land Drainage Recovery Programme (LDRP) has already carried out investigations on some of these waterways, with the remainder to follow over time. The LDRP will investigate the changes in flood risk resulting from the earthquakes and, if appropriate, develop options or adaptive management strategies to remedy these effects.

Tidal Flooding

The lower Ōtākaro / Avon catchment is low-lying, flat and at risk of flooding caused by extreme high tides. Progressively over time adjoining land has been protected from high tides by the construction of stopbanks along river banks and the installation of flap valves on the stormwater network outfalls.

Below Fitzgerald Avenue flooding is influenced by the tide and the volume of flood water. Flooding downstream of Kerrs Reach is dominated by extreme tide levels rather than channel capacity. There are temporary stopbanks along the top of both banks of the river for much of this length of the river. These temporary stopbanks constructed at a crest level ranging between RL 11.0 m and RL 11.2 m prevent extreme tides inundating the adjacent land.

Ōtākaro / Avon River Flooding at Gloucester Bridge 5th March 2014

The local stormwater network draining to this reach of the river typically has backflow prevention devices, such as flap gates, to prevent the tide from flowing beneath the stopbank and flooding properties behind the stopbank. The gates close when flood levels in the main channel exceed the local stormwater network levels. Regular inspection and maintenance is undertaken to ensure the network is operating effectively during tidal events.

There are a number of stormwater pumping stations installed to drain the stormwater network during periods of elevated water levels in the river to prevent network and surface flooding.

10.0 Stormwater Contaminants / Paitini Wai Āwhā

10.1 Background

The National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health Regulations (NES) (pursuant to Section 43 of the RMA 1991) came into effect in 2011. The Regulations cover activities such as sampling, removing fuel storage tanks, excavation, and changing land use on sites where hazardous activities have been undertaken. A resource consent and remedial action may be required.

ECan maintains the Listed Land Use Register (LLUR), a database of contaminated and potentially contaminated sites where Hazardous Activities and Industries List (HAIL) activities are, or have been carried out. A concerted effort has been made over the last few years to identify sites in Christchurch where HAIL activities have been carried out, to provide information about the potential risk from rebuild activities. However this database is not a complete list and is continually being updated as more information becomes available. Approximately 25.7% of the area of the Avon catchment is currently listed on the LLUR, with more than half of the sites relating to pesticide storage or application (generally market garden areas or parks) or storage tanks for fuel, chemicals or liquid waste (such as a diesel tank site).

The network discharge consents held by Council, such as the Interim Global Stormwater Consent (IGSC - to be replaced by the Comprehensive Stormwater Network Discharge Consent), contain specific conditions which apply to LLUR sites. Under the IGSC any activities or industries listed under Schedule WQL9 (formerly WQL3 in the proposed regional plan) are excluded from this consent. The LLUR process assigns categories to each site. Sites that have been registered by ECan on its LLUR as "verified" (has been verified as having a HAIL activity undertaken at some time), "contaminated for….." (sites which exceed guideline values for a particular land-use), "significant adverse environmental effects" (the site has contamination which is likely to have significant adverse effects on the environment), or "managed for….." (sites with contamination that are managed so they are appropriate for a particular land-use) are also excluded from the IGSC, as well as those located on, or bounded by land that has been used in the past as a landfill.

Under the Comprehensive Stormwater Network Discharge Consent (CSNDC), any area or facility that has been identified as being contaminated (or in South-West Christchurch has a high risk of being contaminated), or is on ECan's LLUR is excluded unless otherwise considered to be low risk by both ECan and Council. Sites that have been analysed for appropriate contaminants and shown to be "at or below background concentrations" or "below guideline values for residential" can be included. Any industrial site discharge that bypasses the Council stormwater network is excluded.

In practice, exclusion of all verified HAIL sites from the IGSC proved to be unnecessarily conservative and the decision was made to develop a strategy for assessing the risk of individual sites listed on the LLUR in order to allow inclusion of residential sites considered to be low risk.

10.2 Low Risk Sites

A Memorandum of Understanding (MoU) was agreed between Council and ECan in July 2014 to allow stormwater discharges from low risk residential rebuild sites listed on the LLUR and/or identified as having had HAIL activities to be processed by Council rather than ECan. It is anticipated that as confidence grows over time in the operation of the MoU, the list of "low risk" situations that Council can process will be extended. The list of low risk situations that can be processed by Council without input from ECan as at March 2015 is as follows:

- Sites not on the LLUR (unless a HAIL activity has been identified as having been undertaken on the site);
- 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;

- Sites categorised as "at or below background concentrations" or "below guideline values" for the proposed site use.

A large proportion of the Ōtākaro / Avon catchment is listed on the LLUR because of its previous use for horticulture and market gardening with associated persistent pesticides and herbicides. The number of sites listed under these activities is 339 which collectively cover approximately 1509 ha. These sites generally pose a low risk to stormwater because of the nature and age of the chemical use.

10.3 High Risk Sites

Some types of activities are considered to pose a higher risk of contaminating stormwater than others. This is due to the types of contaminants likely to be present on the site, the likely concentrations of these contaminants and the characteristics of those contaminants. For example, some types of contaminants are more soluble and more likely to be mobilised into water than others.

Some of the types of sites considered to be relatively high risk are:

- Petroleum/petrochemical industries or storage;
- Petrol stations;
- Wood treatment/preservation, bulk storage of treated timber;
- Landfill sites;
- Skin or wool processing;
- Livestock dip or spray races;
- Chemical manufacture or bulk storage;
- Paint manufacture or formulation;
- Dry cleaning plants;
- Gasworks;
- Vehicle workshops;
- Scrap yards.

The cumulative area of high risk sites is 948 ha and represents approximately 10% of the total catchment.

10.4 Management Recommendations

Facility Location

Discharging stormwater through contaminated soil can mobilise contaminants into the stormwater. Stormwater treatment facilities must not be located on a contaminated part of a site unless an investigation has shown that the likelihood of contaminants leaching from the soil is low, or alternatively the stormwater is isolated from contaminated soil. For example, a retention basin may be able to be located on contaminated soil if it were lined to completely isolate stormwater from the contaminated soil. If investigation shows that the HAIL activity has not resulted in contamination on some parts of the site, the facility could be located on those areas. This approach ensures that stormwater discharges on contaminated sites pose a low risk to human and ecosystem health.

Risk to Surface Water

Contaminated sites pose a risk to surface water quality, particularly during construction phase when soils are being disturbed and can be mobilised into surface water. A good management plan for construction phase is important to ensure that mobilisation of contaminants is minimised.

Many contaminants are bound to sediments and can be transported attached to the soil particles. These contaminants can be managed by using good sediment control, and taking care with where soil is disposed of off-site. Other contaminants are more mobile and will not be controlled by typical sediment control practises, and for these sites more specific measures, including on-site treatment, may be needed.

11.0 Contaminant Load Model / Wāhi Paitini

11.1 Background

Stormwater contaminants in urban catchments such as the Ōtākaro / Avon River derive from a number of sources including road surfaces, building roofs and walls, industrial sites and other impervious surfaces including pavements, driveways and parking areas as well as atmospheric deposition. Contaminant composition and quantity varies according to activities and land use. Contaminant loads are typically greater in urban sub-catchments where residential, commercial and industrial land uses predominate and in sub-catchments with roads carrying high vehicle numbers compared with rural sub catchments.

Priorities for stormwater quality treatment identified in the Ōtākaro / Avon Stormwater Management Plan (SMP) were heavy metals (zinc and copper), nutrients (nitrogen and phosphorus), hydrocarbons and bacterial contamination.

Contaminant loads in the receiving waters of the Ōtākaro / Avon SMP area were modelled for some of these contaminants using the Auckland City contaminant load model. Total Suspended Solids (TSS), Zinc, Copper and Total Petroleum Hydrocarbons (TPH) are the contaminants included in the Auckland City model because they are considered the contaminants characteristic of urban stormwater runoff. The Golder report presents an assessment of the contaminant loads for base case development (i.e., the existing scenario pre-earthquake), the maximum probable development (MPD) scenario (i.e. for development up to 2050) and four possible stormwater treatment scenarios. The following discussion of contaminant sources is based on results from the MPD scenario only.

11.2 Contaminant Load Model

The contaminated load model (CLM) used in this study is based on Auckland's Microsoft Excel model which assesses the annual contaminant load of the four key contaminants for each of the sub-catchments and reporting nodes identified throughout the Ōtākaro / Avon SMP Area.

The CLM comprises a series of source areas with different activities and land uses which are assigned annual contaminant yields. The source area categories used in the model are: urban and rural grasslands, roofs, roads and other paved urban areas. Each of the source areas are sub-categorised into type of material or use. For example, the sub-category for roofs includes different roof materials and the sub-category for roads includes a roading hierarchy ranging from Major Arterial to Local Roads based on numbers of vehicles per day.

Significant contaminant yields (g/m²/year) are summarised below.

Source Areas		**Sediment**	**Zinc**	**Copper**	**TPH[1]**
Roads	Major Arterial	95	0.47	0.16	3.6
	Minor Arterial	58	0.26	0.086	1.9
	Collector				0.84
Roofs	Galvanised (unpainted)		2.24		
	Galvanised (poor paint)		1.34		
	Zinc Alume (uncoated)		0.20		
	Colorsteel		0.02		
Paved	Insdustrial		0.59	0.11	
Grassland	Urban	27			
Construction		1500			

[1]TPH is a measure of hydrocarbons.

Roads are a significant source area for yields of all four contaminants. Unpainted and poorly painted galvanised steel roofs are a significant source area for zinc. (Note that the contaminant yield from Colorsteel is over one hundred times less than that from unpainted galvanised steel.) Construction areas have a high sediment yield, although the contaminant load is relatively small because the area under construction at any one time is small. Nevertheless, the high yield emphasises the importance of good site erosion and sediment control during the construction phase.

The CLM is evaluated to produce sub-catchment and catchment wide annual contaminant loads (i.e., tonnes/year or kg/year). The CLM is also evaluated to produce an area weighted catchment yield (i.e., kg/ha/year or g/ha/year).

The model assessment presented in this report provides a means of evaluating the effects of urban development and land use change, as well as the effectiveness of proposed mitigation measures.

The CLM model was run for both the base case (i.e. pre-earthquakes) and the MPD scenario. The MPD provides an indication of the expected increase in contaminant loading resulting from urban intensification and new developments over the next 35 years to 2050, but because this increase is small, the MPD scenario represents a small increase in contaminant loading overall only.

11.3 CLM Results

The contaminant load results presented in the report were derived by multiplying source areas (ha) by contaminant yields. Some of the most significant contaminant load results for the Ōtākaro / Avon study area were:

- Urban grassland accounted for 39% of sediment;
- Unpainted and poorly painted roofs accounted for 52% of zinc;
- Major and minor arterial roads accounted for 73% of hydrocarbons and 31% of copper;
- Paved industrial areas also made a significant contribution to contaminant loads.

The CLM indicates that busy roads are a major source of stormwater contamination for all four contaminants modelled. The busier the road, the greater the contaminant yield. Paved industrial areas also contribute significantly to sediment, zinc and copper contaminant loads (and no doubt to the hydrocarbon load as well, although this wasn't tested in the model).

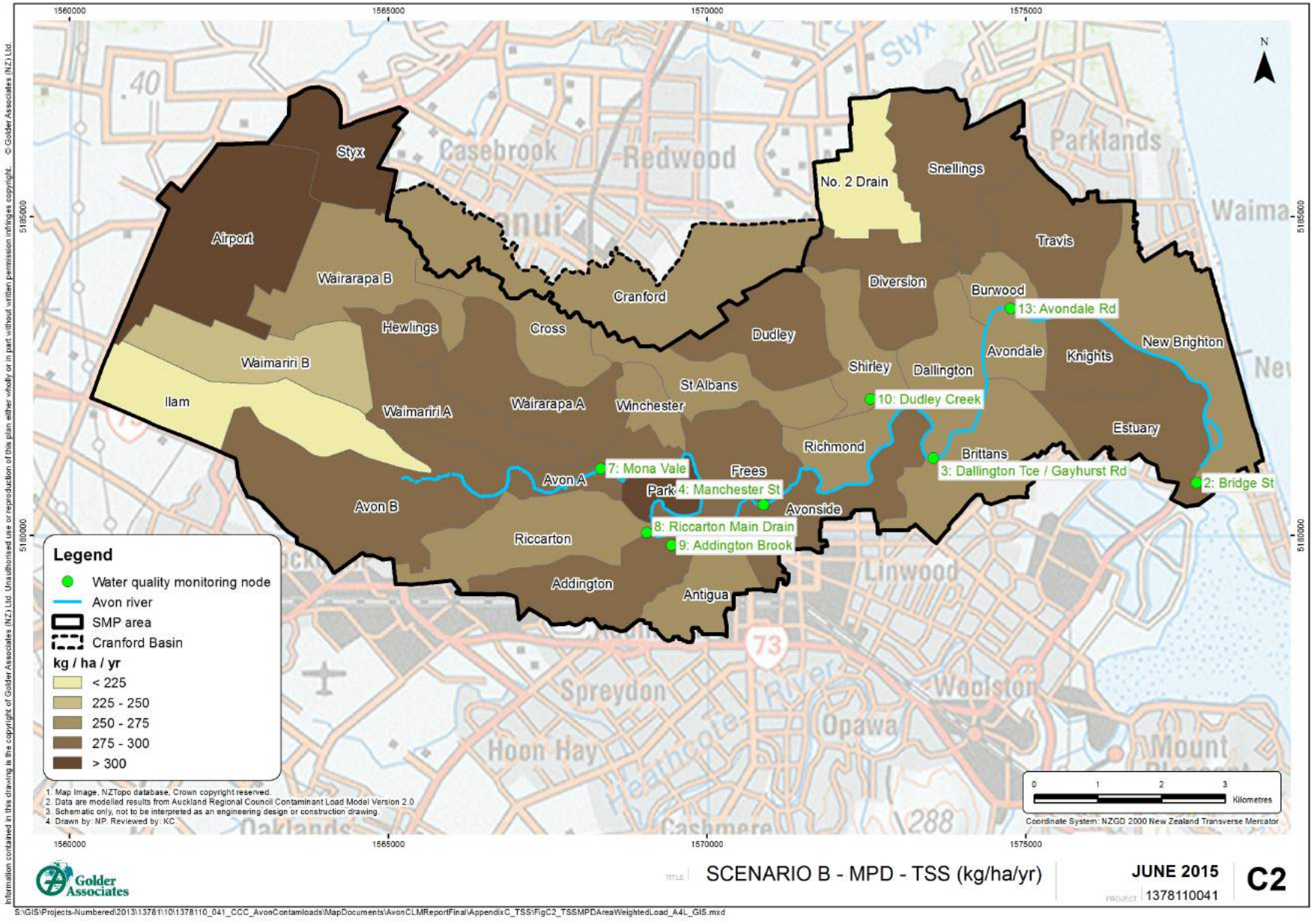
Urban grassland is a major contributor of sediment. Unpainted and poorly painted galvanised steel roofs are the major source of zinc, closely followed by busy roads.

These results are represented geographically in Figures C2 to F2 where sub-catchment contaminant yields without mitigation for the MPD scenario for the four contaminants are mapped ('Scenario B' in the figures).

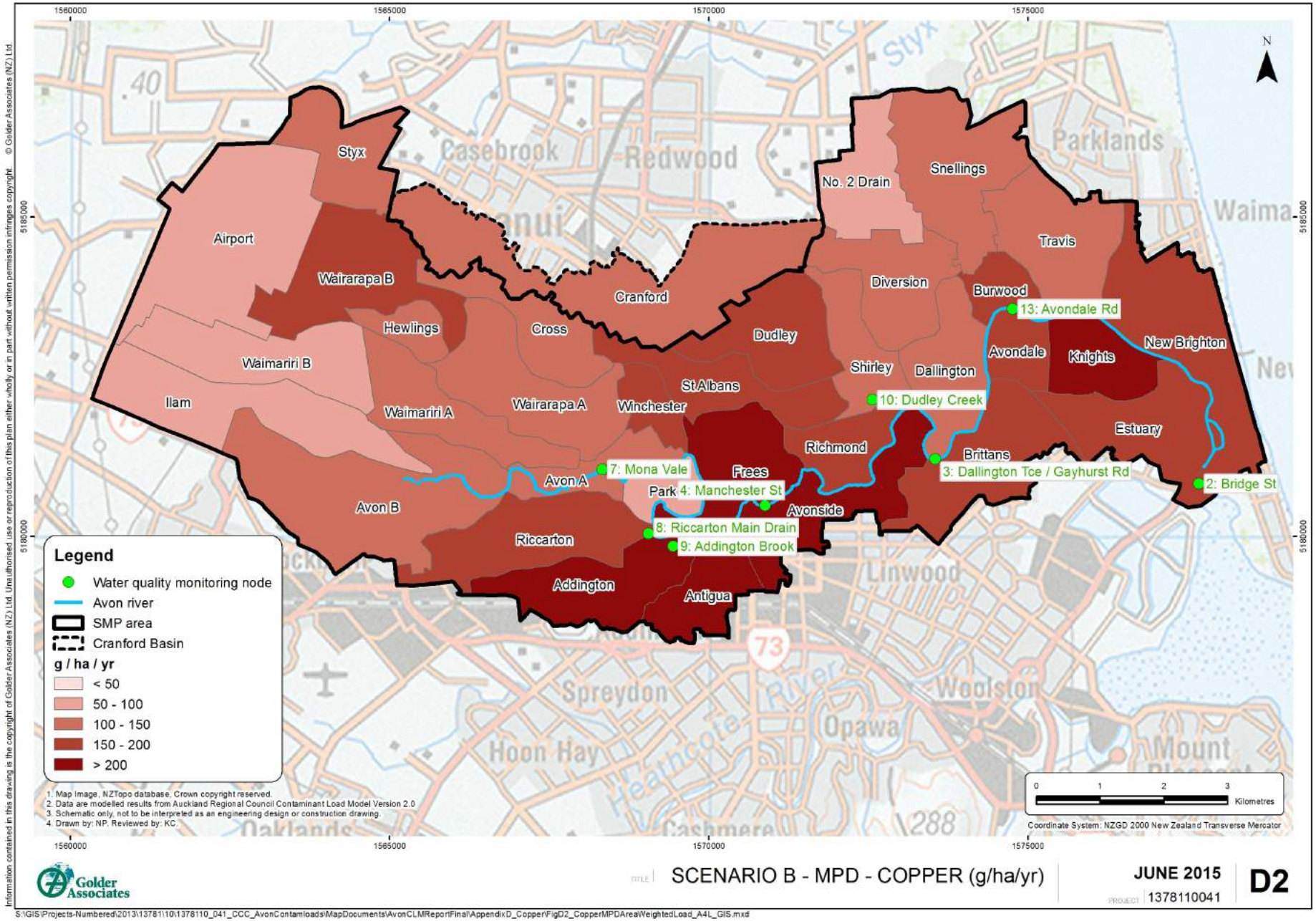
The highest sediment yields are from the Hagley Park, Airport and Styx catchments which have the highest urban grassland coverage (Figure C2). The highest copper yields are from Addington, Antigua, Frees, Avonside and Knights catchments which have a high percentage of impervious surfaces zoned industrial and commercial with busy roads (Figure D2). Addington, Antigua, Frees and Avonside catchments also have high zinc yields partly due to the large area of unpainted galvanised steel roofs found in old industrial and commercial zones (Figure E2). The high zinc yield in the Cranford catchment is due primarily to the high percentage of unpainted and poorly painted galvanised steel roofs in old residential neighbourhoods. Catchments with high hydrocarbon yields are spread more uniformly throughout the Ōtākaro / Avon study area wherever busy roads predominate (Figure F2).

The CLM results have been used to develop the management approaches and priorities outlined in the Ōtākaro / Avon SMP.

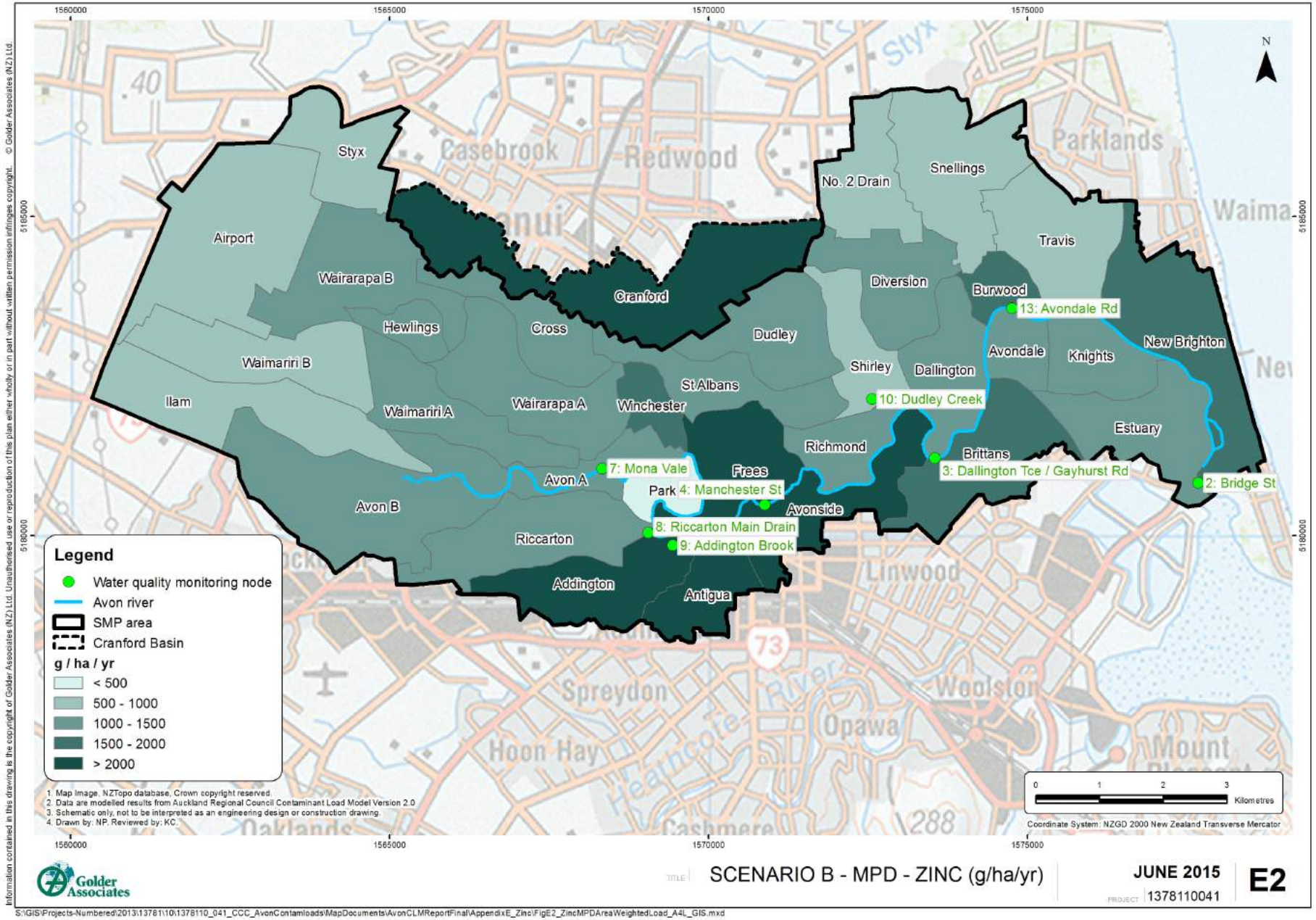
Total Suspended Solid (TSS) Contaminant Generation (kg/ha/yr) - MPD Scenario Without Mitigation



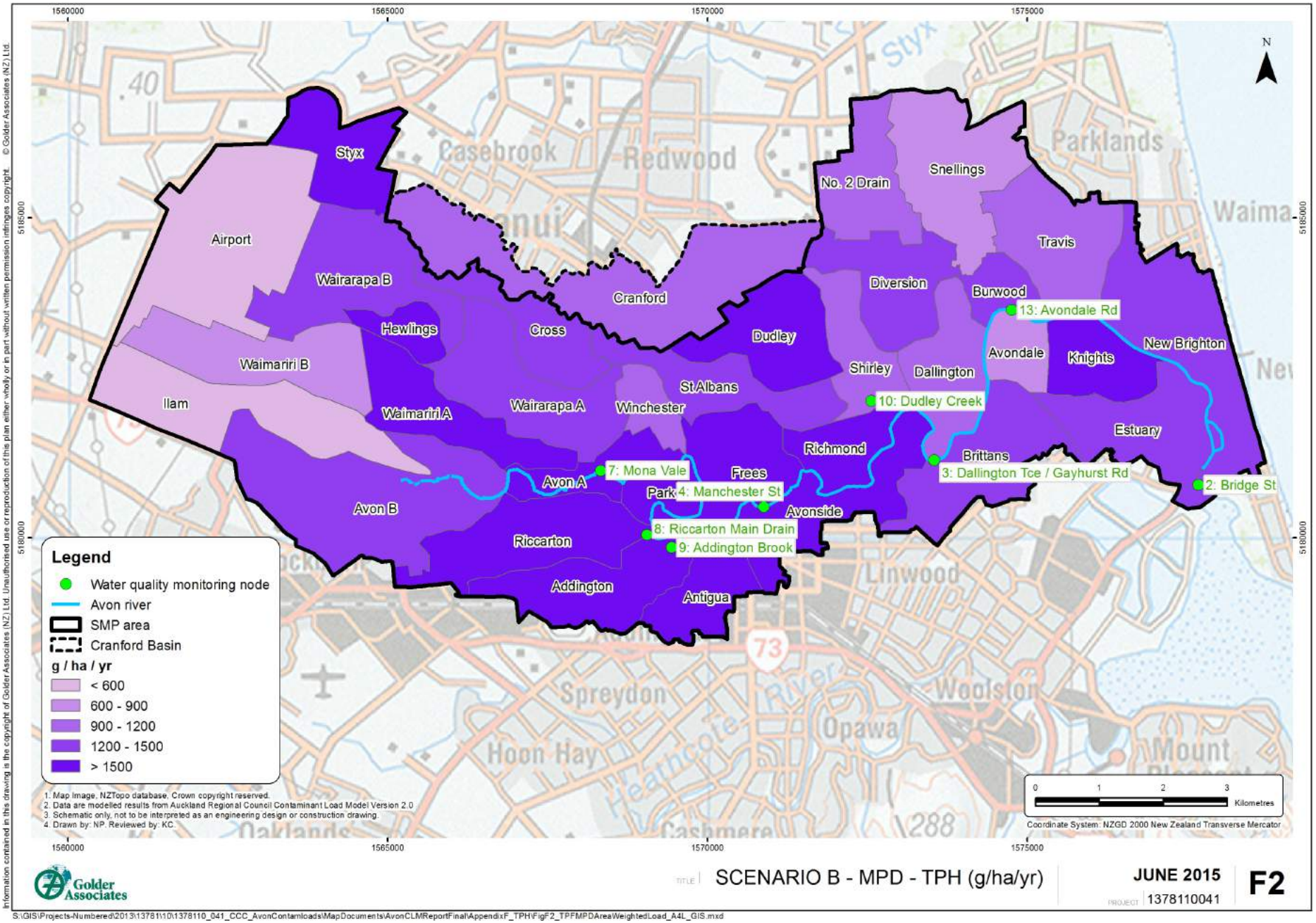
Copper Contaminant Generation (g/ha/yr) - MPD Scenario Without Mitigation



Zinc Contaminant Generation (g/ha/yr) - MPD Scenario Without Mitigation



Total Petroleum Hydrocarbon (TPH) Contaminant Generation (g/ha/yr) - MPD Scenario Without Mitigation



12.0 Stormwater Management Plan (SMP) Mahere Wai āwhā

In order to meet stormwater discharge consent requirements set by ECan, the Council has developed the Ōtākaro / Avon SMP (separate to this document) to maintain and where appropriate improve existing water quality in the receiving waters.

12.1 Background

A toolbox of stormwater management measures has been developed to suit the largely developed Avon catchment where space is at a premium.

Council is committed to a 'multi-value' approach to management of surface water through its *Surface Water Strategy 2009 – 2039*. The six values supported include landscape, ecology, recreation, culture and heritage as well as drainage. Culture stands for Tangata Whenua values predominantly, but not exclusively.

Treatment facilities and other engineering measures that support a range of values are sometimes called 'water-sensitive' as in Water Sensitive Urban Design (WSUD), or 'low-impact' as in Low Impact Urban Design (LID). Non-engineering methods such as education, enforcement, and planning controls are known as 'non-structural' methods. Non-structural approaches to stormwater management are an important means of managing stormwater and improving surface water values and need to be part of any comprehensive SMP programme. Each of these is discussed in the following sections.

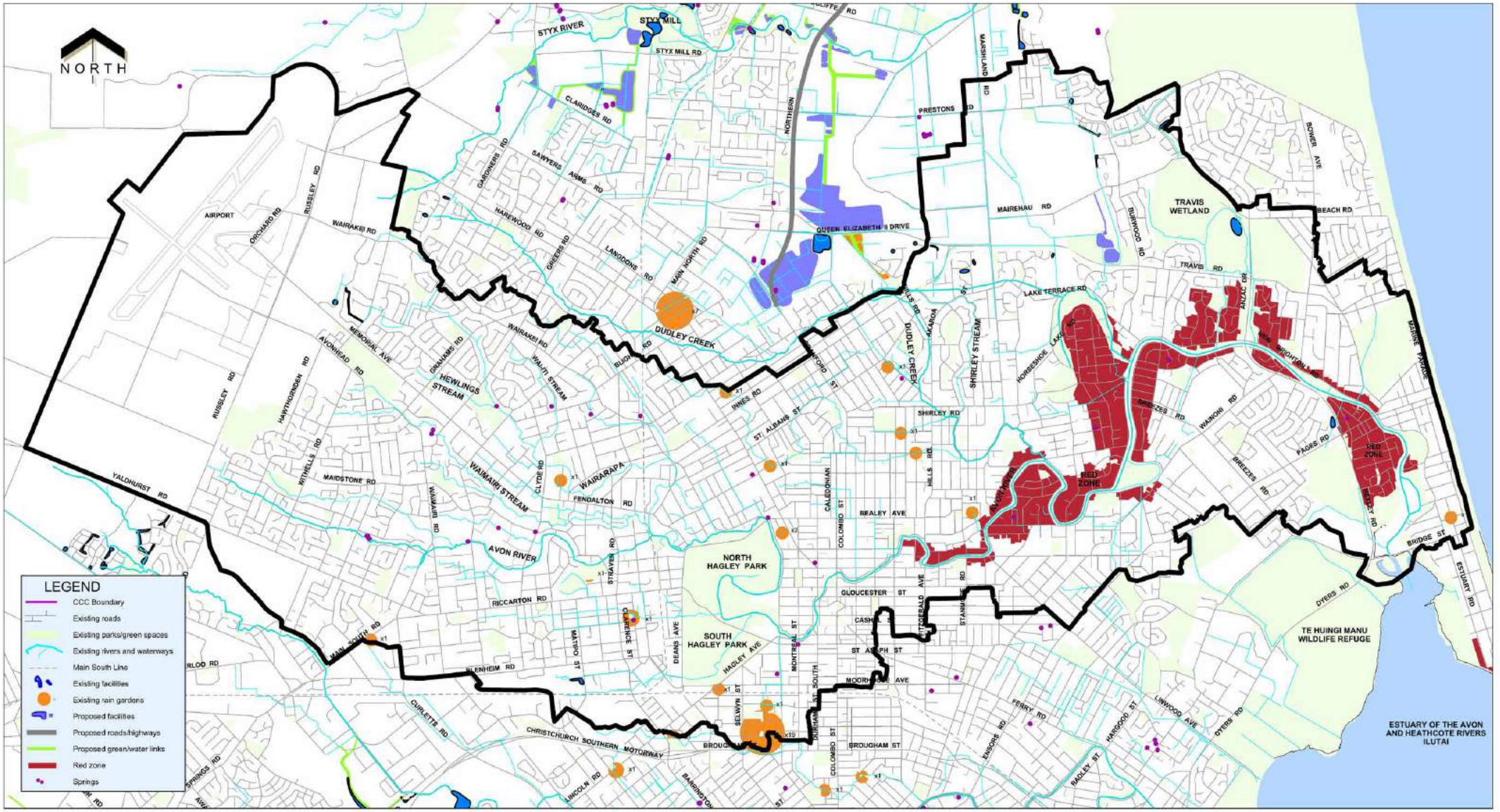
12.2 Facilities and Devices

Since the year 2000 new subdivisions have required stormwater quality treatment facilities in place prior to discharge to downstream receiving waters. The table on the opposite page lists the 16 existing surface facilities in the Ōtākaro / Avon catchment that treat stormwater runoff to current or near current standards and the Airport area which also has its own disposal to soakage treatment system.

Most of the facilities also have a flood attenuation function. The total treated catchment area of 793.3 ha represents approximately 9% of the Ōtākaro / Avon Surface Water Plan area.

The Chateau Drive silt trap and Ellington detention basin are not included above because they were not designed to provide significant stormwater quality treatment. Most of the facilities also have a flood attenuation function.

Facility Name	Catchment Area (ha)	Suburb	Facility Type
Becmead Basin	9.1	Bishopdale	Extended sedimentation
Applecross Basin	9.0	Bishopdale	Extended sedimentation
Stableford Basin	1.6	Burnside	Soakage basin
Pickerings Swale	11.0	Burnside	Dry swale
Kiwirail Facility	35.0	Addington	Wetland/wet pond
Roseneath Basin	3.6	Mairehau	Sedimentation basin
Haughey Pond	1.2	Mairehau	Wet pond
Queenswood Basin	4.4	Mairehau	Extended sedimentaion
Clearbrook Pond	10.1	Mairehau	Wet pond
Sanctuary Basin	4.0	Mairehau	Wetland
Birkdale Pond	6.8	Shirley	Wet pond
Waitikiri Pond	19.8	Waitikiri	Wet pond
Cameo Grove Basin	2.6	Marshland	Sedimentation basin
Titirangi Reserve Basin	56.4	Queenspark	Extended wetland
Preeces Pond	17.5	Parklands	Wet pond
Knights Pond	1.2	Bexley	Wetland
Airport	600.0	Airport	Rapid soakage
TOTAL	793.3		


NORTH
LEGEND
CCC Boundary
Existing roads
Existing parks/green spaces
Existing rivers and waterways
Main South Line
Existing facilities
Existing rain gardens
Proposed facilities
Proposed roads/highways
Proposed green/water links
Red zone
Springs
STYX RIVER
STYX MILL
STYX MILL RD
CLARIDGES RD
GARDINERS RD
SAWYERS ARMS RD
HAREWOOD RD
GREERS RD
LANGDONS RD
MAIN NORTH RD
NORTHERN
PRESTONS RD
MARSHLAND RD
QUEEN ELIZABETH II DRIVE
MAIREHAU RD
BOWER AVE
BEACH RD
TRAVIS WETLAND
TRAVIS RD
BURWOOD RD
LAKE TERRACE RD
ANZAC DR
BRIGHTON
BRIGHTON MALL
BRIGHTON PARADE
AIRPORT
ORCHARD RD
RUSSLEY RD
WAIRAKEI RD
MEMORIAL AVE
AVONHEAD RD
GRAMMS RD
HEWLINGS STREAM
WAITI STREAM
RUGHY RD
DUDLEY CREEK
INNES RD
ST ALBANS ST
WHITFORD ST
SHIRLEY STREAM
HEATHCOTE
HORSESHOE LAKE
SHIRLEY RD
HILLS RD
BREEZES RD
WAIRONI RD
FAGES RD
RED ZONE
BEALEY RD
HAWTHORNDEN RD
WITHELLS RD
MAIDSTONE RD
YALDHURST RD
WAIMAIRI STREAM
CLYDE RD
WAIRARAPA
FENDALTON RD
CALEDONIAN
COLOMBO ST
BEALEY AVE
AVON RIVER
NORTH HAGLEY PARK
STRAVEN RD
GLOUCESTER ST
FITZGERALD AVE
STANMORE RD
BRIDGE ST
ESTUARY RD
RICCARTON RD
MAIN SOUTH RD
CASHEL ST
SOUTH HAGLEY PARK
HAGLEY AVE
DEANS AVE
CLARENCE ST
MONTREAL ST
ST ASAPH ST
MOORHOUSE AVE
TE HUINGI MANU WILDLIFE REFUGE
DYERS RD
BLENHEIM RD
CURLETTS RD
SELWYN ST
CHRISTCHURCH SOUTHERN MOTORWAY
BROUGHAM ST
COLOMBO ST
FERRY RD
EMORS RD
HARGOOD ST
LINWOOD AVE
BADLEY ST
ESTUARY OF THE AVON AND HEATHCOTE RIVERS ILUTAI
LINCOLN RD
BARRINGTON

12.3 New and Retrofitted Devices

Stormwater treatment methods and devices have been arranged from multi-value at the top to single value at the bottom of the Toolbox Treatment Hierarchy (opposite). For any particular site, appropriate methods near the top of the table (multi-value) are preferred to single value methods lower down the table. The toolbox table lists only the 'structural' or engineering methods considered in this SMP. Other engineering methods such as green roofs, for example, have been used elsewhere. However, 'green roofs' have not been included in the Toolbox because they have not been assessed in the SMP technical studies for potential coverage and subsequent benefit.

Method	Constraints	Suitable Location	Catchment Size	Number of values supported
Waterway restoration	Habitat limiting waterways	Public land beside streams		6
Wetland	Space required. Proximity to houses	New growth area.	Large	6
Sedimentation basin	Space required. GWL*>1m	New growth area. Confined aquifer.	Large	4
Soil adsorption basin	Space required. GWL>2.5m	New growth area. Unconfined aquifer.	Large	5
Stormwater tree pit	Clogging after 20 years. GWL> 1m	Central City avenues	Small	4
Rain garden	GWL>0.6m	Streets retrofit	Medium	4
Wetland swale	Width required	High GWL, low gradient sites	Small/medium	3
Dry swale	Width required. GWL>1m	Wide roads. Industrial sites.	Small/medium	2
Permeable pavement	Light traffic. Clog-ging.	Street parking bays. On-site parking.	Small	1
Waterway sediment removal	Site access. Sediment disposal.	In-line weirs and ponds	Large	2
Propietary filtration devices	Minimum head loss	Busy roads. Industrial sites.	Small/large	1
Vacuum street sweeper	Low interception. Not available in NZ.	Busy intersections		1
Street sump cleaning	Low interception	Busy intersections		1
Stormwater tank	Flow attenuation rather than treatment	Residential intensification	Small	1

*GWL = groundwater level

12.4 Non-Structural Approaches to Stormwater Management

Preventing or minimising stormwater contamination at source is generally the most effective and efficient way of avoiding adverse effects on the receiving environment. 'End-of-pipe' measures alone will not deliver the improvements desired in receiving water quality and consideration needs to be given to contamination generating activities and to non-structural controls.

Non-structural controls include source controls, monitoring and enforcement, the 2014 Water Supply, Wastewater and Stormwater Bylaw, education and working with industry. Contamination activities and potential non-structural controls are listed in the table on the opposite page. Non-structural controls benefit all six values by minimising adverse effects on waterways.

Activity	Contaminants	Present Controls	Potential Controls	Control Mechanisms
Roofs	Zinc, copper	Preference for colorsteel™ (residential). Move toward zincalume™ (industrial).	Treatment of runoff from zinc and copper surfaces.[1]	1. SMP consent condition. 2. Revised Stormwater Bylaw 2014.
On-road construction	Sediment	Erosion and Sediment Control Plans (ESCPs)	Treatment de-vices for all significant road reconstruction.	1. Interim Global Stormwater Consent conditions. 2. Construction Std. Spec. Pt 1 s. 18 & CCC std. spec re ESCP.
Building sites	Sediment	ESCP required but difficult to enforce	More site inspections	1. Building Consent. 2. SMP condition for building sites.
Subdivisions and major earthworks	Sediment	ESCP required	More site inspections	Subdivision consent
Commercial discharges onto street	Detergent, cleaners, chemicals, food and drink	Monitoring by Trade Waste team and re-porting to ECan.	1. Washdown water captured by sewer. 2. On-street treatment devices in high risk areas	Automatic valve switching between stormwater and sewer.
Vehicles	Copper and zinc	1. Occasional sump cleaning. 2. Street sweeping.	1. More sump cleaning & vac-uum sweeping. 2. Copper free brake linings.[2]	1. CCC operations contracts. 2. National initiative needed via Ministry of Transport.
Spills	Various	ECan/CCC procedures	Review procedures	
Air discharges	Various	ECan consents		pLWRP rules
Industrial	Chemicals, hydrocarbons, litter, particles, dust	Trade Waste Bylaw	More treatment on site.	Trade Waste Bylaw
Litter	Visual, ingestable solids trapped by wrappings, BOD	Sump grates & street sweeping	1. More street sweeping. 2. Education pro-gramme.	On-going education programme
Residential waste products	Oil, paint, car washdown, herbicide	Water Related Services Bylaw	1. Revised Stormwater Bylaw 2014. 2. Education programme.	On-going education programme
Animals and waterfowl	Nutrients, bacteriological	Limited control of Canada Geese	Maintain control of exotic water fowl numbers	River bank and riparian vegetation design
Wastewater discharges	Nutrients, bacteriological	Overflow reduction programme to meet Ecan consent conditions	Maintain overflow reduction programme	1. Ecan consent. 2. Wastewater Recovery Programme.

[1] The Avon contaminant load model estimates that approximately half of zinc comes from roofs.

[2] Up to 75% of copper in Auckland stormwater comes from vehicles

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