A FRAMEWORK FOR

A

CULTURAL HEALTH ASSESSMENT

OF

URBAN STREAMS

AUGUST 2012

Cover page photos

Left: Ross Creek (in the headwaters of the Leith). Right: the Leith in its Lower Reaches.

Table of Contents

Chapter 1

1.0 BACKGROUND

This research examines cultural dimensions of urban water management for the purpose of developing an assessment tool for use by tangata whenua. The results of Tangata whenua assessments have implications for water policy making and planning. Urban hydrology is particularly challenging because water management is so closely intertwined with the needs and concerns of Tangata whenua which are to be balanced alongside those of diverse stakeholders such as residential populations, businesses, and environmental groups (Niemcyznowicz 1999). In many cities in New Zealand obtaining sufficient high-quality water resources for a growing urban population poses a major challenge. Decision makers, planners and hydrologists are aware of these challenges but ultimately the range of acceptable policy and management options available for implementation are shaped by public opinion. Given the strong human component in urban hydrology, decision makers must be aware of and responsive to urban residents' knowledge, i.e., beliefs and perceptions, of water quality and water management because this affects political opinion (Niemcyznowicz 1999). Simultaneously, research suggests that ecological understanding among urbanites is often relatively poor (Cox 2005, Gober 2006, Barthel 2008), but few studies have focused on water specifically. Further, in a New Zealand context, we need to consider how urban water management influences or is influenced by this understanding and whether it conflicts with the values, beliefs practices and perceptions held by Tangata whenua (given section 6(e) requires their interests to be recognised and provided for). To help examine these influences we investigate locally situated, cultural knowledge of two urban streams in the city of Dunedin.

An urban population and all key activities associated with modern cities (for example transportation, electricity supply, water supply, waste disposal, heating, supply of services, manufacturing, etc.) dramatically alter landscapes including waters, sediment, chemicals, and microorganisms. These changes then impact urban ecosystems, including urban waters and their aquatic ecosystems they sustain, and result in their degradation. As a result the provision of water services to urban populations is highly challenging.

Within this complex setting, this report focuses on the management of urban waterways, recognising that effective management of urban waters should reflect an understanding of a cultural interpretation of the anthropogenic impacts, and the means of assessing and mitigating such impacts. Urbanisation impacts vary broadly in time and space, and need to be understood within context of the local climate, urban development, engineering and environmental practices, cultural practices, and other socio-economic factors. Tangata whenua can identify cultural impacts.

In the report the connection between urban development and cultural impacts is discussed, and principles for reducing the impact of developments and restoring existing areas that have been promoted by Tangata whenua will be highlighted. Some of the intermediate steps/results in the study include:

(a) identification of the components of urban water cycle and the effects of urbanisation on water resources,

(b) quantification of the imprint of human activities on the urban hydrological cycle and an assessment of the cultural impact

(c) development of an assessment tool and process for application by Tangata whenua; and,

(d) identification of the preventive and mitigation measures available for dealing with the cultural perceptions of urban water problems.

1.1 RESEARCH OBJECTIVES

The purpose of this research as agreed with NIWA was to

Develop methods for evaluating the impacts of urban development on the way in which Maori value water bodies. This will involve

- Testing and developing the Cultural Health Index (CHI) for use in urban settings[1].
- Collecting water quality, Macro-invertebrate Community Index (MCI) and fisheries data at these sites and examining relationships between these data and CHI scores[2].
- Investigating the issues that impact on the ability of the results of Index studies to inform planning, and recommending ways to address these issues[3].

1.2 REPORT STRUCTURE

This report has been divided into a number of sections:

Chapter 1 Sets out the background and the aims of this study.

Chapter 2 Describes the methodology that was used and provides some information on Te Runanga o Otakou and their takiwa.

Chapter 3 Outlines cultural conceptualisations within which the research is situated.

Chapter 4 Describes in greater detail the urban water cycle, the urban water infrastructure, impacts of urban water management, and the subsequent impacts on the beliefs, values and practices of Tangata whenua. It concludes by proposing an assessment framework for assessing urban stream health from a cultural perspective.

[1] See Chapter 5.
[2] Results discussed in Chapter 7.
[3] See the discussion in Chapters 6, 7 and 8.

Chapter 5 Introduces the Cultural Health Index for Streams and explains how it responds to the themes from the interviews and why it forms the basis for the assessment of urban streams.

Chapter 6 Discusses the association of tangata whenua with two streams within the Dunedin urban area before examining the cultural impacts experienced as a result of the modification to these streams. It concludes by presenting the qualitative and quantitative research results to illustrate the cultural effects of concern to Tangata whenua.

Chapter 7 Then moves away from presenting the results of a specific case to provide a broader interpretation of the potential impacts of urban water management being experienced by Tangata whenua. It reflects and pulls together the qualitative and quantitative research results in the context of the recommended assessment framework that can be used by Tangata whenua;

Chapter 8 Considers the planning context within which Tangata whenua will likely engage to achieve the outcomes they seek and concludes by discussing how the assessment framework can be applied by Tangata whenua.

Chapter 2: Methods

2.0 INTRODUCTION

There is growing recognition of the significance of aquatic habitats and the resources found within them that sustain indigenous communities. Yet this recognition has not been accompanied by investigations to increase understanding of their specific contribution to the health and wellbeing of communities depending on these resources. This Chapter of the report describes the methods that were used to investigate the importance of urban streams to whanau and hapu.

Drawing on the earlier work of Bebbington (1999), importance to whanau was examined according to:

- the instrumental role – the significance of rivers, lakes and coastal environments as a source of physical health (drinking water, sanitation, nutrition) and
- the hermeneutic role - the ways in which urban streams give meaning to the lives of whanau and hapu.

This Chapter of the report outlines the methodology employed, but starts with a description of the Maori community studied.

2.1 STUDY AREA

As previously stated, this report details the results of one case study: Dunedin City. Tangata whenua participants, the majority of whom were manawhenua living in Dunedin were recruited from Te Runanga o Otakou members. Availability to take part in the research was the only exclusion criteria, although the preference was for key informants to be familiar with urban streams within Dunedin.

2.2 METHODOLOGY

The research team utilised two research methodologies to contrast the instrumental and hermeneutic role of urban streams and the aquatic resources they sustain. The first incorporated participatory research techniques via a literature review, focus group and a series of qualitative interviews.

The second was a series of quantitative assessments.

Before commencing the collection of primary data, a literature review was undertaken which focussed on five themes

1. to provide a more comprehensive understanding of historical resource use and patterns of activity by Tangata whenua in Dunedin City;

2. to gain an appreciation of the changes to the aquatic habitats in the two case study catchments over time;

3. to identify the changes over successive generations that have impacted on Tangata whenua use of urban streams;

4. to understand the aspirations of Te Runanga o Otakou to address issues of concern with respect to urban waterbodies; and

5. finally, to ascertain if and how agencies have and could respond to such aspirations.

Qualitative data were collected from published and unpublished documents, from libraries, newspapers, the Waitangi Tribunal (evidence to the Tribunal and reports from the Tribunal), statutory and iwi plans, and tribal archives. Internet searches also yielded further material. The work of Potiki (2012) proved invaluable in developing a greater in depth appreciation of the association of Tangata whenua with Dunedin City from which the importance of aquatic ecosystems to Tangata whenua could be deduced.

In addition to the literature review, thirteen interviews were conducted. The purpose of these interviews was to explore the diversity and complexity of relationships and gain a comprehensive understanding of the changes to aquatic environments and the emergent issues seen as potentially impacting health and wellbeing as perceived by different individuals. It must be noted that the formal methods were augmented by many instances of informal discussion, as is the case in most qualitative research.

The quantitative assessments followed once the interviews were complete. This was to ensure that the sites and species about which data was sought were identified by the hapu, and not predetermined by researchers. Firstly, a team representing Tangata whenua undertook Cultural Health Index assessments at selected sites in both catchments. Finally, the quantitative assessments included:

- Toxicology testing;
- E-coli tests;
- MCI tests; and
- Electric fishing.

2.3 QUALITATIVE DATA ANALYSIS

In summary, informants were interviewed and interacted with in different forums, and their written documents (both historic and contemporary) and submissions provided further context for interpreting their values, practices, activities and concerns. Accessing multiple sources of data was one of the methodological tools employed to ensure the validity of data collected. Transcripts were coded and key themes distilled.

2.4 QUANTITATIVE DATA ANALYSIS

- Toxicology testing – samples were collected by Dr Terry Broad (who is Ngai Tahu and affiliated to Te Runanga o Otakou). The samples were sent to Hills Laboratories for assessment.
- E-coli tests were completed by Citilabs (Dunedin).
- Dr Broad completed the MCI tests and the electric fishing.
- Cultural Health Index scores were calculated by Tipa and Associates Ltd.

The results of the different quantitative tests, and the CHI assessments are analysed alongside the qualitative data in Chapter 6.

2.5 SUMMARY OF METHODS APPLIED

The methods applied to enable us to understand kai gathering behaviours over different time periods are set out in Table 1.

Table 1: Methods used in this research.

PRE- EUROPEAN SETTLEMENT	20TH CENTURY UP TO 1970S – 1980S	PRESENT DAY
Manuscripts	Interviews	Interviews of members of Ngai Tahu whanui and Maori resident in Dunedin
Evidence to the Waitangi Tribunal	Evidence to the Waitangi Tribunal	Review of literature
Historical texts	Photographic archives	E-Coli tests
Dunedin City Thematic Assessment (Potiki, 2012)		Toxicology testing
		MCI tests
		Electric fishing
		CHI

2.6 TE RUNANGA O OTAKOU

The legal identity of Te Runanga o Ngai Tahu is established in the Te Runanga o Ngai Tahu Act 1996. It is the tribal representative body of Ngai Tahu whanui. It is a body corporate, established on 24th April 1996 under Chapter 16 of the Te Runanga o Ngai Tahu Act 1996. Pursuant to Chapter 3 of that Act, "*the Act binds the Crown and every person (including any body politic or corporate) whose rights are affected by any provision of this Act*".

The wharenui at Otakou Marae

The members of Te Runanga o Ngai Tahu are the 18 papatipu runanga, each of which is defined in the Act, as is the takiwa for each. This establishes who holds manawhenua rights over specific lands and waters within the rohe of Ngai Tahu. Te Runanga o Otakou is one such runanga. Te Runanga o Otakou has its offices at the marae at Otakou. As one of the 18 papatipu runanga, the takiwa of Te Runanga o Otakou, as defined in the Te Runanga o Ngai Tahu Act 1996. The takiwa of Te Runanga o Otakou centres on Otakou and extends from Purehurehu to Te Matau and inland, sharing an interest in the lakes and mountains to the western coast with Runanga to the North and to the South. Dunedin City lies solely within the takiwa of Te Runanga o Otakou.

2.7 THE USE OF QUOTATIONS

In this report we have endeavoured to incorporate as many quotes as possible from our informants. To highlight and distinguish their quotes from those sourced from written material

- the quotes from other sources appear in the text.

- *The quotes from informants appear in italised font.*

Chapter 3: Cultural Conceptualisations

3.1 BACKGROUND

In this chapter we discuss (albeit briefly) how Maori see water, how they interact with water and how key cultural concepts relate to urban water management. Although Maori communities across New Zealand are diverse, common themes and foundations exist amongst them in terms of beliefs and values. The following paragraphs describe components of a Maori worldview. However, it is necessary to caution that for many of the concepts here described they are best understood in the context of the language and the culture they derive from. To reinterpret these meanings into the English language by its very nature loses significant context and meaning (KTKO Ltd, 2005). Maori conceptualise water as an undivided entity and as part of a system of lakes, rivers, lagoon's, swamps, their associated beds, and adjoining lands (Durette 2009). Tangata whenua contend that an integrated and holistic approach to water management is necessary to give effect to the principle of water being an undivided entity. Engagement of Maori with waters (e.g. river catchments) is experiential: Maori living with a catchment experience a range of aquatic conditions. Monitoring and assessment of environmental condition is sensory, perceptual and is shaped by Matauranga Maori (Crengle, 1997, 2002). Maori interpret signs in the environment to understand ecological conditions and/or change. The assessment approach proposed in Chapter 5 is sensitive to the multi-dimensional and experiential relationship of Maori with catchments (Durette 2009). The relationship between cultural concepts and water are discussed in the paragraphs that follow: Throughout the chapter we have included quotes from our informants.

Te Ao Maori - Holism in the context of freshwater ecosystems requires a consideration of the catchment. Each river has its own catchment area with tributaries that in turn have lesser tributaries and these again yet smaller ones. A catchment constitutes soils, water, flora, fauna and the relationships between them. Many physical, chemical and biological processes affect water character and movement. Each waterway contains elements, minerals, and salts that are specific to a place and catchment.

Whakapapa – Maori adhere to some basic principles regarding their relationship with plants, animals, people, lands, waters, and other aspects of creation (Te Runanga o Ngai Tahu, 2001). The core of these relationships reflects the fundamental belief that all things are linked by *whakapapa* (genealogy). Maori see themselves as being part of the environment. *Whakapapa is embodied with legendary stories, traditions, waiata, customs and values that is rich in its depth and spirit* (KTKO Ltd, 2005). In the Maori worldview water has its own whakapapa. Maori relationships with water are part of this indivisible whakapapa linkage.

Implications for an assessment process	Whakapapa describes bonds, relationships, and connections. Water flowing through a catchment makes connections. Rivers connect the entire landscape – ki uta ki tai – from the mountains to the sea. • Understanding how manipulating flows, diverting waters, channeling river reaches, and unnatural discharges of contaminated water, break connections resulting in cultural impacts – even cultural loss – is important • A catchment wide approach to assessment is important.

Atua - It is from the Atua, through procreation, that all life in the universe came into being. It is also this conduit that links the spiritual world to the physical. The respective atua possess dominion over specific areas, for example *Tangaroa* has authority for saltwater and freshwater which includes all living things supported by these media.

A Cultural Perspective on the Separation of Waste (extracted from Smith 2011)

The Maori concept that every entity has its own realm and that when realms connect it should be done when it benefits both realms. When the mixing of two entities degrades one entity, the mixing should be avoided. An example is that a towel used for cleaning the floor should not be used for drying dishes even when the towel used for cleaning floors is washed, it should stay with cleaning floors. An environmental example is when two rivers meet, the mauri of two entities comes together and enhances each other creating a waitapu place that has two mauri. In the treatment of effluent, keeping the effluent in its own space so it does not pollute other spaces like the river or aquifers or springs or even the land is important. Also removing the opportunity for the treated effluent to go through the groundwater and then being a non-point discharge into a waterway is important too so pollution does not infect other environments. Given this imperative the best form of irrigation that keeps the treated effluent separate is deficit irrigation. When to mix the treated effluent back into the environment is important because the reintroduction needs to be done safely.

Implications for an assessment process	Managers need to make explicit • unnatural mixing of the waters used to supply the urban area; • contaminants entering the waterway; and • the extent of “separation” that is provided for within the system.

Mauri – Mauri is a central component of the Maori perspective on the environment. It can be defined as the life principle, life supporting capacity, or life force present in all things. Mauri binds the spiritual and the physical elements of resources together, enabling their existence within the bounds of their own creation. When something dies, the mauri is no longer able to bind the physical and spiritual elements together and thereby give life (KTKO Ltd, 2005). In the context of a river, mauri is about life in and around a river. A healthy mauri is reflected in high water quality of sufficient quantities sustaining a range of aquatic and riparian habitats supporting diverse kaiora. Mauri also refers to the “working ability of a river” (Tau 1993), specifically its role in building floodplains, reshaping channels, building river mouths, and sustaining biodiversity etc.

> *The mauri is the life force that ensures that within a physical entity ... that all species that it accommodates will have continual life ... The mauri is defenceless against components that are not part of the natural environment* (Massey University, 1990).

Protecting the mauri of a resource is therefore a fundamental management principle for Maori (Barlow 1991). Maori treasure the mauri of freshwater and may experience cultural offence and distress when that mauri is degraded. Mauri was historically protected through application of a complex system of specific cultural and spiritual practices, customs and rules that were developed to manage and control the interactions of people and the natural world.

In relation to contemporary assessment of waterways, Maori conceive that each waterway carries its own mauri. Activities which degrade the mauri of the waters, may also offend the mana of those who hold traditional rights and responsibilities with respect to the affected waterways.

A cultural perspective on waste management (extracted from Smith, 2011)

Mauri Ora or Mauri Mate

Tamati Krugers see components of mauri being characterized in physical terms, emotional terms, spiritual terms and conceptual terms. …Aspects that promote life in these contexts is known as mauri ora. The degradation of life in all or any of these aspects is mauri mate.

A measure of when treatment has met a Maori worldview standard is when the water has moved from a mauri mate state in raw sewage that still exists in treated effluent until the treatment produces fluid that is a source of life. The normal mauri response around sewage is a physical aspect of life and can be measured this way, but the Maori response with mauri at its core can include wider ideas.

Implications for an assessment process	If mauri is viewed in the context of life, energy and vitality, it is easier to understand how resource use and development can change and degrade the mauri of rivers by altering the food or energy sources, the water quality, the habitat, the energy of the flow regime, and the biotic interactions of the river ecosystem. Tangata whenua need to be provided with: • a description of the footprint of the system to identify all waterways where the health could be impaired. • the opportunity to assess the health of systems impact of these changes.

Wairua - Like mauri, Maori also believe that all things possess a spiritual essence, a wairua, as well as physical form (Barlow 1991).

Mahinga kai **-** The term mahinga kai literally means *'food works'* and encompasses the ability to access the resource, the site where gathering occurs, the act of gathering and using the resource, and the good health of the resource gathered. For many Maori survival was and is dependent upon knowledge of mahinga kai and their ability to gather resources from the land, waterbodies, and the sea. The state of freshwater is thus important to Maori as a medium for sustaining and accessing mahinga kai. Ideally waterbodies will sustain healthy, abundant and diverse kaiora.

Implications for an assessment process	Mahinga kai is considered by one iwi (Ngai Tahu) to be, in today's language, the principal 'environmental indicator' in natural systems. If mahinga kai is not present, or is unsafe to harvest, then that natural system is under stress and requires remedial action (Crengle 2002, Goodall, 2003). Tangata whenua need to be afforded the opportunity to : • identify the kai and mahinga kai species sourced within the footprint of the urban infrastructure. • assess any issues arising from the changing health of the waterbodies.

Tino Rangatiratanga - is having the right to make decisions for your own people concerning the resources within your area.

Implications for an assessment process	In relation to urban water management it means Tangata whenua determining what, from a cultural perspective, represents satisfactory participation in urban water management.

Kaitiakitanga - governs the way humans interact with ecosystems. The notions of reciprocity and maintaining balance within nature underpin cultural practices (Crengle 2002). Balance requires respect to be shown when interacting with the environment; and access to use (within limits) the resources afforded by healthy ecosystems. Maori continue to have a duty, as Tangata Tiaki, to protect the natural world they are part of.

Implications for an assessment process	As Tangata Tiaki of waterways, Maori could not agree to actions that continue to degrade the state of the waterway. Tangata whenua need to have sufficient information to assess the health of the system, and may require detailed investigations into specific areas.

Tikanga Maori[4] also brings into play a range of other cultural concepts. In Land Air Water Association & Ors v Waikato RC (A110/01), the Environment Court, stated:

> *In a general way section 8 requires the Court to take account of tikanga Maori whereas sections 6(e) and 7(a) refer to specific philosophical concepts that form part of tikanga Maori . Examples are "waahi tapu", "other taonga" in section 6(e) and "kaitiakitanga" in section 7(a). Further the need to have regard to "tikanga Maori " by virtue of section 8 means that the Court may be required to have regard to a wide range of concepts such as "tangata whenua", "manawhenua", "whānaungatanga", "mana", "tapu". "utu" and "mauri" to mention just a few. [paragraph 391]*

Manaakitanga - plays an important role in Maori society. Manaakitanga is an expected standard of behaviour (Mead, 2003). The origins of this word derive from the word "mana" which according to Pere (1982) encompasses numerous meanings such as power, control and influence. Manaakitanga also refers to the fostering and nurturing of relationships between a host and a visitor. The well-being of the visitor is paramount to the development of this relationship. If the host fails to manaaki (support) their visitor this could result in the loss of mana within the Maori community as the host has shown they are incapable of attending to the needs of others.

Implications for an assessment process	Providing safe waters for manuhiri and adequate sanitation services is part of the duty to manaaki visitors. However, providing other services afforded by waterways, e.g. fishing, swimming, are also part of the duty.

[4] This is found in section 6(e)

Whanaungatanga - is concerned with kinship, connectedness, and inter-dependence between all things within the natural world including people. in other words, sustainable management should seek to sustain the health, wealth and well-being of the natural environment while sustaining communities dependent upon it (Crengle 2002). In Ngāti Hokopu v Whakatane DC (C168/02), the Environment Court stated that:

> *Of all the values of tikanga Maori , whānaungatanga is the most pervasive. It denotes the fact that in the traditional Maori thinking relationships are everything – between people; between people and the physical world; and between people and the atua (spiritual entities).* Maori Custom and Values in New Zealand Law NZ Law Commission, paragraph 130 citing an unpublished paper written for the Commission by Joseph Williams ("He Aha Te Tikanga Maori ".

Similarly, in Ngāti Rangi Trust v Manawatu-Wanganui Regional Council (A067/04), the Court observed:

> *This genealogical relationship is one of the foundations upon which the Maori culture is based. It is known as "whānaungatanga". Whānaungatanga in its broadest context could be defined as the interrelationship of Maori with their ancestors, their whānau, hapū and iwi as well as the natural resources within their [tribal] boundaries e.g., mountains, rivers, streams, forests, etc. [paragraph 104]*

Implications for an assessment process	Having assessment processes that recognise and provide for interrelationships is fundamental to Maori.

Without doubt freshwater formed a fundamental component of traditional lifeways, and remains important to contemporary Maori. The following section explores in greater detail some of the values ascribed to freshwater by Maori, the techniques Maori utilised to afford protection, and examines the knowledge of river dynamics that underpins the beliefs, values and techniques.

3.2 DEMONSTRATING AN UNDERSTANDING OF CATCHMENTS

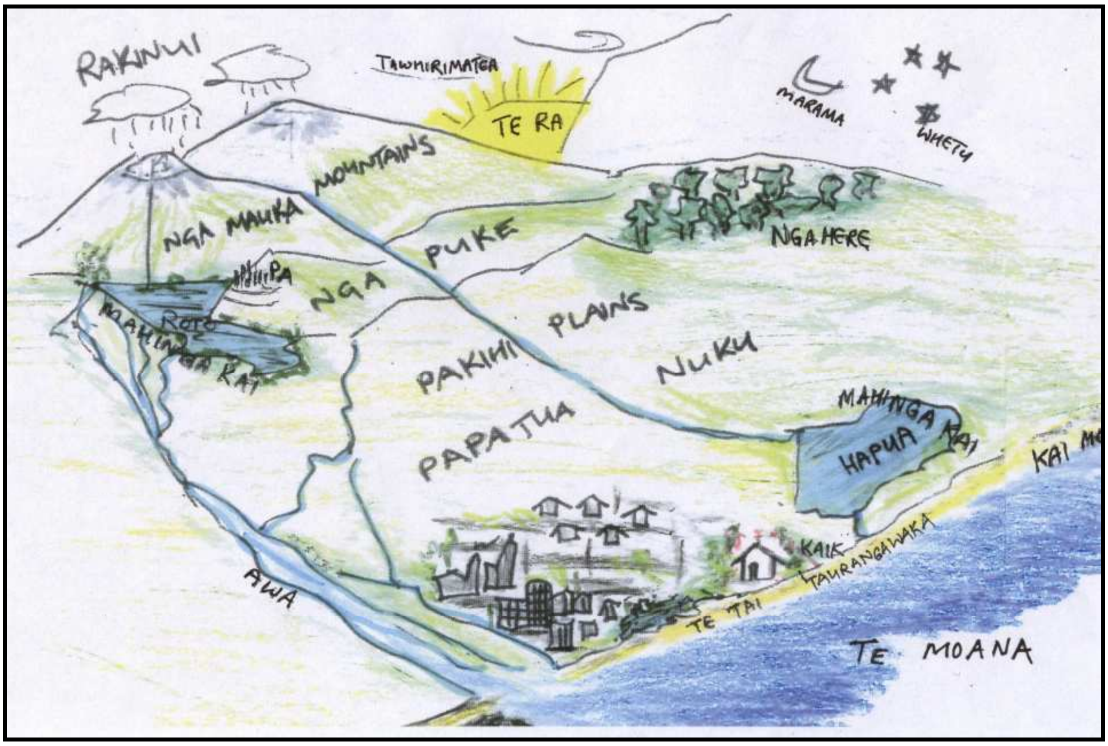
To recap water everywhere is an active entity recognised by Maori as the foundation of life. Stream and surrounding terrain always belong together united in a living totality.

The knowledge held by Maori has resulted from intergenerational interaction with the environment, through the implementation of complex food gathering systems, through the burying of generations of ancestors on tribal lands, and through the establishment of settlements linked by water and land based trails (Goodall 2003). This knowledge has been maintained through oral traditions and through the application of place names to the landscape (Tipa 1999, 2002, Goodall 2003, KTKO 2005). This knowledge, if ways are found to enable it to complement existing knowledge bases, represents a potential resource for water managers. This section seeks to further illustrate the knowledge held within whanau and hapu.

Catchment perspectives

While integrated management has become prominent in the last three decades, Maori, for generations have emphasised the necessity of considering a catchment in its entirety: from its source, the passage of it waters through a network of tributaries, onto lower floodplains, to its interface with saltwater along the coast. Holistic conceptualizations that emphasise integration, interdependencies and interrelationships are common to indigenous peoples rather than fragmenting and compartmentalizing the environment (Posey, 1999). One tribe – Ngai Tahu (from the South Island of New Zealand) - has articulated their perspective entitled "Ki Uta Ki Tai", which they describe as "a comprehensive, culturally based 'mountains to the sea' natural resource management framework developed by and for Ngäi Tahu" (Te Runanga o Ngai Tahu, 2003). Figure 1 illustrates the Ki Uta Ki Tai management philosophy.

Figure 1: A map conceptualising the philosophy of ki uta ki tai – Mountains to the Sea (from Te Runanga o Ngai Tahu, 2003).



This conceptualisation of a catchment confirms a deeper understanding that a catchment constitutes soil, water, flora, fauna and the relationships between them. It acknowledges that rivers connect the entire landscapes from the mountains to the sea, and conversely that rivers are linked to their catchments.

Ki Uta Ki Tai recognises that it is not possible to assess the mauri of the river by looking solely at the water, rather, the catchment through which the river flows must be examined. An intact mauri depends on the status of all components of the catchment. In other words Maori are explicitly acknowledging that instream river conditions are determined by processes occurring within the catchment and cannot be isolated or manipulated out of this context.

Implications for an assessment process	This confirms that any assessment process that we develop needs to take a catchment wide approach.

Hydrology

Maori can provide a historical background and describe cosmologies, mythologies, local everyday practices, and contextual regulations regarding cultural resource management. They can also describe local understandings of climate changes: temperatures, evaporation, humidity and rainfall, along with local explanations of flows in the mainstream and its tributaries, local justification of floods and droughts, and local interpretations of catchment geography. This will complement the existing knowledge of scientific river hydrology and transition to a more holistic understanding of the dynamics of the river system. Maori are able to describe changes observed over time. For example they are usually able to identify how river management regimes have impacted:

- fishing sites and the species harvested from each;
- vegetation – the species and the location of these;
- swimming holes – that were safe for different age groups;
- dynamics of a river system -
    - floods, including the functioning of flood plains and any disconnections that have resulted from river engineering (e.g., stopbanks, floodgates etc.);
    - dewatering of river reaches;
    - river mouth characteristics; and
    - flow regime components – e.g. seasonality of low flows, droughts and freshes.

River processes and functions

Tau (1993) explains mauri as the working ability of a river which means maintaining the functions and processes essential to a "working river". Consistent with the philosophy of ki uta ki tai the river ecosystem is seen as all components of the landscape that are directly linked to that river, including the source area, the channel from source to sea, riparian areas, the physical and chemical nature of water in the channel, associated groundwater, wetlands, floodplains, the estuary, and the near-shore marine ecosystem (King et al. 1999).

Figure 2: Interactions among riverine resources and processes (Stamp, Olsen, Allred 2008).

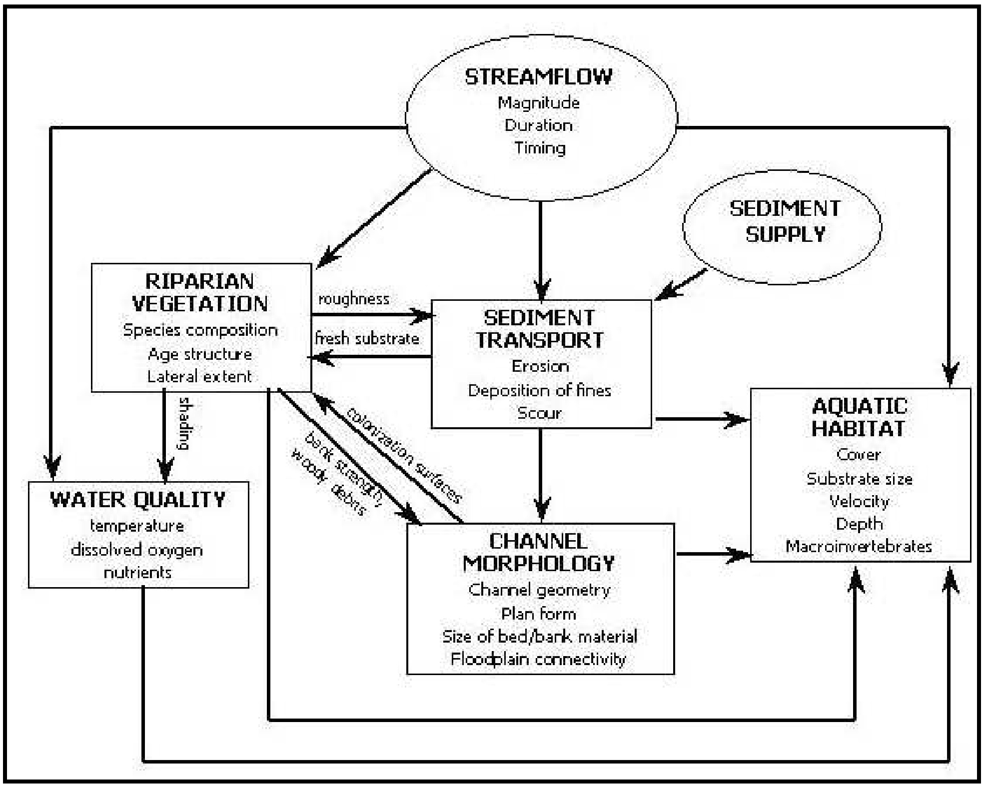


Table 2 provides a summary of how tangata whenua are dependent on function and processes within a healthy river.

Table 2: The relationship between river functions and processes & tangata whenua values.

River function and processes	How this relates to cultural values
Navigation	Navigation is important for boating, waka ama, waka taua, mokihi. Maori are able to advise where navigation is problematic, describe the nature of the problem and the flows required to provide for navigation requirements.
Riverbank occupation	Historically settlements (pa, kainga, nohoanga) were found alongside or on islands in rivers and on adjacent plains. Many whānau still live alongside rivers. These sites can be impacted by both hydrological and morphological processes. It goes without saying that this greatly affects whānau and hapū in their communities.
River fisheries	Synexe (2009) describe the value of fishers ecological knowledge which they believe is a akin to Mātauranga Maori and propose tools for collecting data from tangata whenua. An issue for Maori may be that the key species investigated in AEEs may not align with the taonga species as defined and prioritised by tangata whenua.
Coastline stabilisation & river mouth dynamics	Coastal environments remain of fundamental importance to Maori . Maori can identify sites along coastlines and rivers and historic patterns of erosion, accretion, and changes they attribute to changing flows.
High flows	Land use intensification (especially conversion to dairying) is a major concern, so Maori will be seeking certainty with respect to the impacts of harvesting on long-term river health.
Coastal fisheries	These sites are also highly valued by tangata whenua.

River function and processes	How this relates to cultural values
Estuarine and lagoon integrity	Estuaries and lagoons are highly valued by tangata whenua for a number of values – fisheries, wāhi tapu, whakapapa etc.
Ecosystem integrity	Maori have a holistic appreciation of ecosystem health and use other terms such as mauri, wairua, whakapapa, te ao Maori to describe this concept.
Miscellaneous cultural materials	Resources from rivers and other waterways are collected by Maori for customary / commercial uses.
Water quality	Maori believe that the source of contamination is an issue to be managed directly and many whanau and hapu do not support the strategy of using "dilution as the solution".
Flood mitigation	In many forums tangata whenua identify the need for floods and freshes to "flush clean the river system". River regimes which reflect flow variability are more likely to be seen to respect the mauri of the river.
Health	The long-term interaction of Maori with catchments enables them to identify health concerns.
Wellbeing	River ecosystems continue to serve various functions for Maori living alongside and interacting with rivers, e.g., for drinking, washing, bathing, but also for fish and the collection of other food, of cultural materials, or for recreation. Changes in the aquatic ecosystems could have an impact on the lives of Maori .
Hydrological cycle	Maori can identify what they believe are recharge zones, important wetlands, springs etc. and describe the interconnections. They can also advise of the impacts observed that they believe will result from modified regimes.
Salinity and salt water intrusion	Maori have identified changes in lower reaches of rivers, e.g., the Taieri, brackish waters are being experienced further upstream, species composition is changing e.g., tidal mudflats & crabs replacing vegetated riverbanks & eels, and salt intolerant plants are dying.
Sediment and suspended matter	River regimes which reflect flow variability and take into account replicating the natural movement of sediment and suspended matter through the whole river system are more likely to reflect the whole catchment approach recognised in Te Ao Maori .

Implications for an assessment process	Managers need to be able to develop a spatial understanding of • the dependency of Tangata whenua on these functions, processes and services. • the changes to functioning of waterbodies that impact the beliefs, values and practices of Tangata whenua.

Life cycle of species

The life cycle of many species is timed to take advantage of flows of varying magnitudes. Tangata whenua interacting with rivers are able to describe the flows that provide cues for certain life cycle events. Synexe & Nexus Associates (2009) refer to fishers' ecological knowledge (FEK) which is the knowledge held by local fishers and is likely to include not only information of species presence and abundance but also differences in the species behaviour that could be linked to hydrological variables e.g., inter-annual, seasonal, lunar, diet and food-related variations, and movements of fish.

Implications for an assessment process	FEK represents some of the earliest "scientific programmes" and provides a valuable longitudinal perspective (gathered over generations) that can inform the current state of fish and waterways (Lydon & Langley 2003). As Durette (2008) note, however, the main challenge is to convert this knowledge into technical data so that it can inform resource management. Resource managers need to: • to identify the data that Tangata whenua can bring can to the management process. • to build up a historic profile of changes to waterways.

Distinguishing between different waterbodies

Maori understand the subtle differences between streams and rivers within a catchment, as evidenced by two examples; the first being the *ki uta ki tai* conceptualization where a level of degradation is anticipated as water moves from its source to the sea. The second is a traditional water classification system. The classifications as presented by Douglas (1984, 1) are summarized in Table 3.

Table 3: An Example of a Traditional Water Classification (adapted from Rochford 2003, Williams 2004, Tau et al 1992)

Classifications by *Ki uta ki tai*	Classifications by spiritual description	Classification by physical description	Classification by special uses
Waimaori freshwater	*Waimaori* • becomes waimaori when it comes into unprotected contact with humans. . • has a mauri (which is generally benevolent) and which can be controlled by ritual.	*Waimaori* • is the term used to describe water that is running freely or unrestrained, or to describe water which is clear or lucid	*Waimaori* • is normal, usual and ordinary
	Waiora • Pure water is termed Te Waiora a Tane, and to the Maori it contains the source of life and wellbeing. • is the spiritual and physical expression of Rakinui the sky father, shedding tears at the loss of Papatuanuku, the earth. The rain is waiora	*Waiora* The purest form of water	*Waiora* • is used to purify and heal. • can remain pure, as waiora, only if its contact with humans is protected by appropriate ritual prayers. • has the potential to give life, to sustain wellbeing, and to counteract evil
	Wai whakaheke tupapaku Classed as wai tapu		*Wai whakaheke tupapaku* • are water burial sites
	Wai tohi Classed as wai tapu		*Wai tohi* • used by a tohunga during initiation and baptism ceremonies.
	Waikino • is water, which has been polluted or debased, spoilt or corrupted. In waikino, the mauri has been altered so that the supernatural forces are non-selective and can cause harm to anyone	*Waikino* • describes water, which is rushing rapidly through a gorge, or water where there are large boulders or submerged snags which give the potential to cause harm to humans.	
	Waimate • has lost its mauri or life force • has the potential to cause ill fortune, contamination or distress to the mauri of other living things, including people, their kai moana or their agriculture. The subtle differences between waikino and waimate seem to be based on the continued existence of a mauri (albeit damaged) in the former, and its total loss in the latter	*Waimate* • is dead, damaged or polluted water which has lost its power to rejuvenate either itself or other living things. • has a geographical meaning; to denote sluggish water, a backwater to a main stream or tide, but in this sense the waimate retains its mauri.	
Waimataitai • brackish water of estuarine areas • the interface of freshwater and seawater.			.
Waitai • the sea, the surf or the tide, sea water	*Waitai* • has returned to Tangaroa in the natural process of generation, degradation and rejuvenation.	Waitai • Rough, angry or boisterous like the surf, or the surge of the tide.	

Rochford (2003, 45) explains the relationships between the different categorizations in Table 3.

> *Each body of water has its own mauri. The mauri of any particular water then becomes diminished as the water travels through the world to the sea. These steps see this diminishment of mauri not only in a quantitative fashion but also once reaching a certain threshold changes in a qualitative manner.*

Contemporary water management has the potential to impact traditional classifications.

Implications for an assessment process	It is important to determine any waters of special significance to Tangata whenua that are within the footprint of the urban water infrastructure.

Environmental Indicators

Crengle (1997, 2002) explains that Maori utilise ecological indicators which are the manifestations of a robust mauri life force, including: aesthetic qualities e.g. clarity and wild character; capacity to provide for amenity and cultural use; abundance, depth, and velocity of flow supporting the character of the river; spiritual and physical character and presence; diversity of being (i.e. a range of moods and manifestations of the river including braids, pools, eddies, and shallows etc); and productive capacity. A project managed by Harmsworth (1999) resulted in the identification of indicators to be used by Maori to assess the cultural health of wetlands.

- No. of ***taonga*** species (flora and fauna) within wetland
- % area of ***taonga*** plants within total wetland.
- % area of exotic (introduced, foreign) plants covering total wetland.
- No. of cultural sites within or adjacent to wetland.
- Assessment of ***te Mauri*** (scale).

A project initiated by one tribe (Ngai Tahu) in 1997 led to the identification of indicators that tribal members utilise to assess stream health (Tipa 1999, Teirney and Tipa 2003). The indicators represented a mix of physical attributes of waterways and other values that Maori ascribe to freshwater. The indicators confirm that Maori are concerned with health throughout a catchment, *ki uta ki tai – from the mountains to the sea*, and as a set of indicators reinforce the significance of holism. All of the indicators identified represent the factors that Ngai Tahu believe are conducive to a healthy river, with a strong vibrant mauri[5]

Implications for an assessment process	It is essential that the assessment framework uses indicators that Tangata whenua can relate to.

Placenames, Myths and Taniwha

As previously stated, a Mäori worldview does not separate spiritual and intangible aspects from the non-spiritual practices of resource management. Arguably, it is the intangible values ascribed to freshwater by Maori that are difficult for resource managers and scientists to accommodate within existing management regimes. The importance of placenames examined below. The significance and intergenerational relationship between Maori and cultural landscapes within a catchment is perhaps best reflected in the placenames assigned to waters within a traditional territory. Placenames were the medium by which Maori described and passed on both the nature of the resource and an assessment of its status (Tipa 1999, Crengle 2002, KTKO 2005). Specific to waterways, placenames may describe the source of the waterway, its character, or discrete features within the catchment. Table 4 lists examples of traditional placenames within New Zealand and explains the characteristics of the waterbody that the name encapsulates[6].

Table 4: Placenames and the waterbody characteristics they describe.

Placename	Waterbody	Meaning of the placename
Whakapapa Ariki	A stream found in the Lower Waitaki River	A sacred site because of its association with ancestors
Waiareka	A stream in North Otago, south of Oamaru	Sweet water
Waikoura	A tributary of the Waitaki River	Stream of fresh water crayfish
Waikakahi	A stream in South Canterbury	Stream of fresh water mussels
Haka Pupu	Pleasant River	Shellfish harbour
Wai a Riki	A stream entering Lake Wanaka	Small water
Waihola or Waihora	A lake just outside Dunedin	Spreading waters
Te Awa-makarara	Lee Stream	The stream that makes a noise' or 'a stream with a noisy tributary'.
Te Waihoaka	A stream running from Kaitangata Range.	'Grindstone River' – because stone found for grinding greenstone
Te Awa Kokomuka	Trotters Creek in North Otago	A stream where a particular plant is to be found.
Te Awa Kauru	Hog Burn	A stream where kauru (a sweetener) was extracted from Ti kouka trees.
Wai pouri	The Waipori River in Otago	Dark waters
Wairere	The junction of the Clutha and Manuherekia Rivers	The junction where the river narrows
Paru Paru Awa	Muddy Gully (mouth of the Taieri River)	A site from which dyes were sourced.

[5] Twenty tribal members were interviewed in 1997 as part of Stage 1 of the Taieri Project with a further eighteen interviewed in 2000 as part of Stage 2.

[6] It must be acknowledged that on occasion there may be more than one interpretation for a placename. The descriptions contained in Table 4 represent one interpretation that has been authenticated by the tribal authority.

Implications for an assessment process	Resource managers need to be cognizant of • placenames that can be used as indicators • opportunities to promote the use of traditional placenames.

3.3 PROTECTING WÄHI TAPU/TAONGA

Tangata whenua are likely to engage in urban water management to achieve specific outcomes. Protecting waahi tapu and waahi taonga is likely to be one the outcomes specified. Since 1999 Ngai Tahu has identified a range of wahi tapu / wahi taonga. It is necessary to refer to the respective iwi plans to see how they are identified, and the policy frameworks in place to ensure their protection.

1. Ara tawhito (ancient trails)
2. Käika Nohoanga (occupation, settlement sites)
3. Mahika Kai (places where resources including food were/are procured)
4. Mauka (important Mountains)
5. Pä Tawhito (ancient pä sites)
6. Tauranga Waka (canoe moorings)
7. Tüähu (sites of importance to identity)
8. Tuhituhi Neherä (Rock drawing sites)
9. Urupä (human burial sites)
10. Umu (earth ovens)
11. Ikoa Tawhito (place names)
12. Wähi kaitiaki (resource indicators from the environment)
13. Wähi kohätu (rock formations)
14. Wähi mahi kohätu (quarry sites)
15. Wähi pakanga (battle sites)
16. Wähi paripari (cliff areas)
17. Wähi Pounamu (greenstone/jade areas)
18. Wähi raranga (sources of weaving material)
19. Wähi räkau (areas of importance)
20. Wähi rua (food storage areas)
21. Wähi taoka (treasured areas)
22. Wähi tapu (sacred places)
23. Wähi täpuke (buried taoka)
24. Wähi tohu (locators and their names within the landscape)
25. Repo Raupö (wetlands)
26. Wai Mäori (important freshwater areas)

Implications for an assessment process	Managers need to be able to develop a spatial understanding of wahi taonga and wahi tapu

3.5 INTERGENERATIONAL CONTINUITY

Contemporary discussions of cultural interests and the knowledge held by tangata whenua may make reference to broad generalised value statements derived from oral histories. Internationally it is recognized that histories, stories, and myths which are often highlighted as examples of ecological knowledge are in fact the cultural framework within which knowledge of the environment is transmitted. Such histories provide a clear cultural framework for indigenous ecological knowledge, but they are not however ecological knowledge in and of themselves. Ecological knowledge, or in the case of Maori, Matauranga Maori, emerges through direct active use of the landscape. To understand Matauranga Maori one must interact with local environments. For example, in a river context, such interactions could include:

- fishing, gathering and processing of kai and other materials;
- bathing, healing, ceremonial purposes; and / or
- Waka ama, waka taua, swimming, relaxing, walking.

These interactions enable Tangata whenua to identify how their beliefs, values, uses and practices are dependent of freshwater resources and more specifically are dependent on aquatic ecosystems.

Implications for an assessment process	Although the dependency of the relationship may have changed over time, and some knowledge within Maori communities has been eroded, Maori are still active within catchments (but often not to the extent that they want to be). The health of catchments should not be such that it inhibits or prohibits use of waterbodies by Tangata whenua. Resource managers need to develop an understanding of how urban catchments are used by Tangata whenua, along with an appreciation of the cultural impact of non-use.

3.6 CONCLUSION

This chapter has introduced cultural values and the knowledge held within whanau, hapu and iwi. While this knowledge has the potential to benefit contemporary freshwater management, the nature of this collaboration, in particular the type of participation by Tangata whenua and the mechanisms by which their knowledge is to be recorded and used in urban water management still needs to be determined. An integrative assessment process is therefore proposed in Chapter 4.6 and 7.1. Firstly, however, the next chapter examines how the material presented in this chapter relates to urban water management.

Chapter 4: Urban Water Cycle

4.0 BACKGROUND

I think an urban stream, is probably what was originally a natural stream that has now been modified, probably channelised, and you've got run off and discharges occurring that in a natural environment wouldn't happen. So you are getting pressure on it in terms of contaminants, nutrients, pollutants, and habitat compromise

I'd define an urban stream as one where a greater proportion of the surrounding land catchment feeding into that part of, that stream draws from as being urban. And urban would be land buildings, asphalted or tarmac roads, concrete, so it could be industrial, it could be residential, could be retail, so on….most of it will end up on roofs or roads, and gutters, pipes and then end up in the river….That changes the river flow quite significantly….it would have landscaped banks. Being an urban stream it's going to suffer from high flows quickly, spikes in the flow regime….In other words, when it rains, it rises really quickly and drops really quickly, and it'll rise to a greater level than a rural stream and then drop back down to its normal flow or low flow very quickly. So, therefore, it's going to still have to have some sort of flood control system, otherwise all that water's gonna spill out onto the roads ….And it would have access along the banks, footpaths, places for people to walk, picnic, sit in the sun, ride their bikes, walk their dogs, all those sorts of things.

Consistent with the need for the present research to be examined in a context of international literature and academic thought, this Chapter seeks to position the research design and data analyses within contemporary writings from three related areas:

- urban water cycle;
- urban water infrastructure and its management; and
- effects of urbanisation of the urban water cycle.

When discussing the findings from the literature review we highlight possible implications of tangata whenua engaging in urban water management. We conclude the discussion by weaving together the implications into an initial assessment framework. Although the information in this Chapter was largely sourced from literature and is intended to provide a generic overview, wherever possible we have inserted comments from informants.

4.1 THE URBAN WATER CYCLE

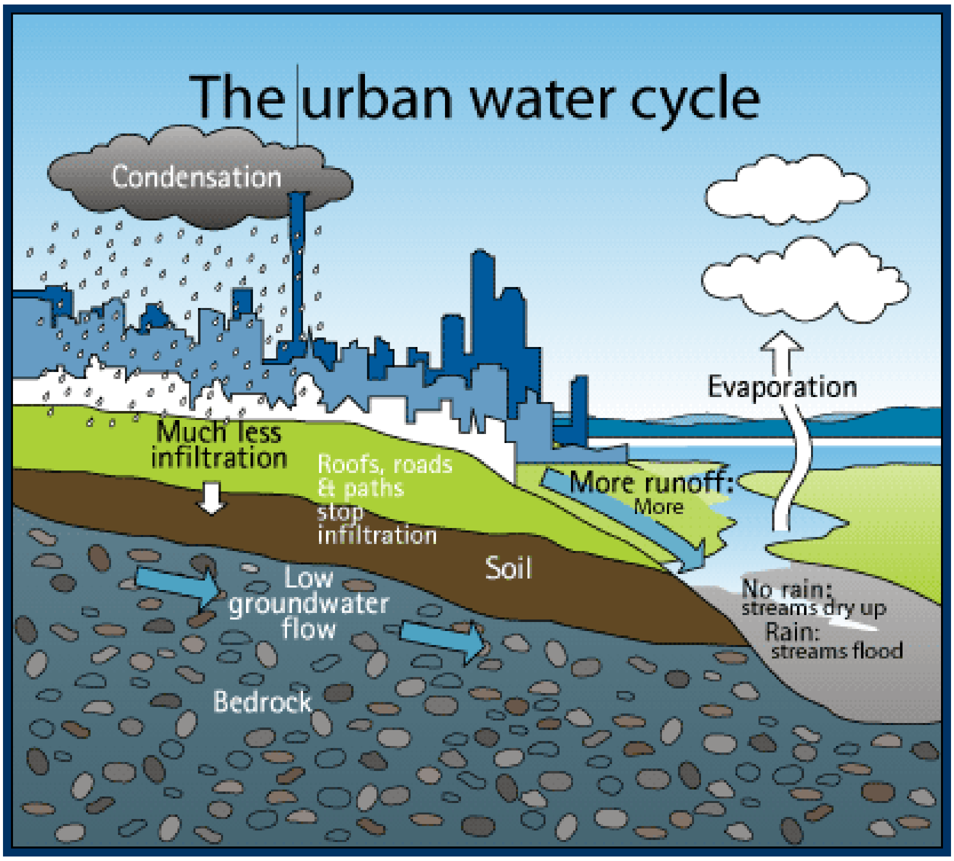
One of the most fundamental concepts in hydrology and water resource management is the hydrologic cycle (also referred to as the water cycle) which is generally described as the continuous journey water takes on, above and below the surface of the Earth as it circulates from the land to the sky and back again. Water can be stored in the atmosphere, oceans, lakes, rivers, streams, soils, glaciers, snowfields, and groundwater aquifers. Circulation of water is caused by processes such as evapotranspiration, condensation, precipitation, infiltration, percolation, snowmelt and runoff.

The combined effects of urbanisation, industrialisation, and population growth affect landscapes and the hydrology of catchments. The hydrologic cycle is greatly modified by the need to provide water services to the urban population, including water supply, drainage, and wastewater collection – the result being what is referred to as the "urban" water cycle (UWC) which is shown in Figure 3 and Figure 4.

The urban water cycle provides a good basis for studying streams in urban areas, if the intent is to mitigate the anthropogenic pressures and impacts. Drawing from Figure 1, in the paragraphs that follow we discuss briefly:

- precipitation;
- runoff;
- groundwater;
- interception;
- evaporation and evapotranspiration; and
- soils

Figure 3: An Overview of the Urban Water Cycle



Precipitation - An important source of water is precipitation, which occurs in greatly varying quantities depending on local climate.

Evaporation and evapotranspiration - Evaporation is the process occurring along the water-air or soil-air interface where water transforms into water vapour and escapes into the atmosphere. Land use changes in urban areas lead to a reduced extent of green areas in cities and thereby can contribute to reduced total transpiration from trees and vegetation.

Soil moisture - Large parts of urban areas are covered by impervious surfaces (and reduced vegetated areas), resulting in reduced infiltration and evapotranspiration. Another factor contributing to changes in soil moisture in urban areas is a partial removal of topsoil during the urban development and construction, and changes in soil structure resulting from the use of heavy machinery. After development, less topsoil may be returned and lower soil layers may have been compacted.

Interception - Interception is water that wets and stays above ground until it evaporates and returns to the atmosphere (Viessman et al., 1989).

Infiltration - Infiltration is the process of water movement into the soil. Through this process, shallow aquifers are recharged and, by discharging to surface waters, contribute to streamflow during dry periods. Compared to natural areas, infiltration rates decrease in urban areas because of:

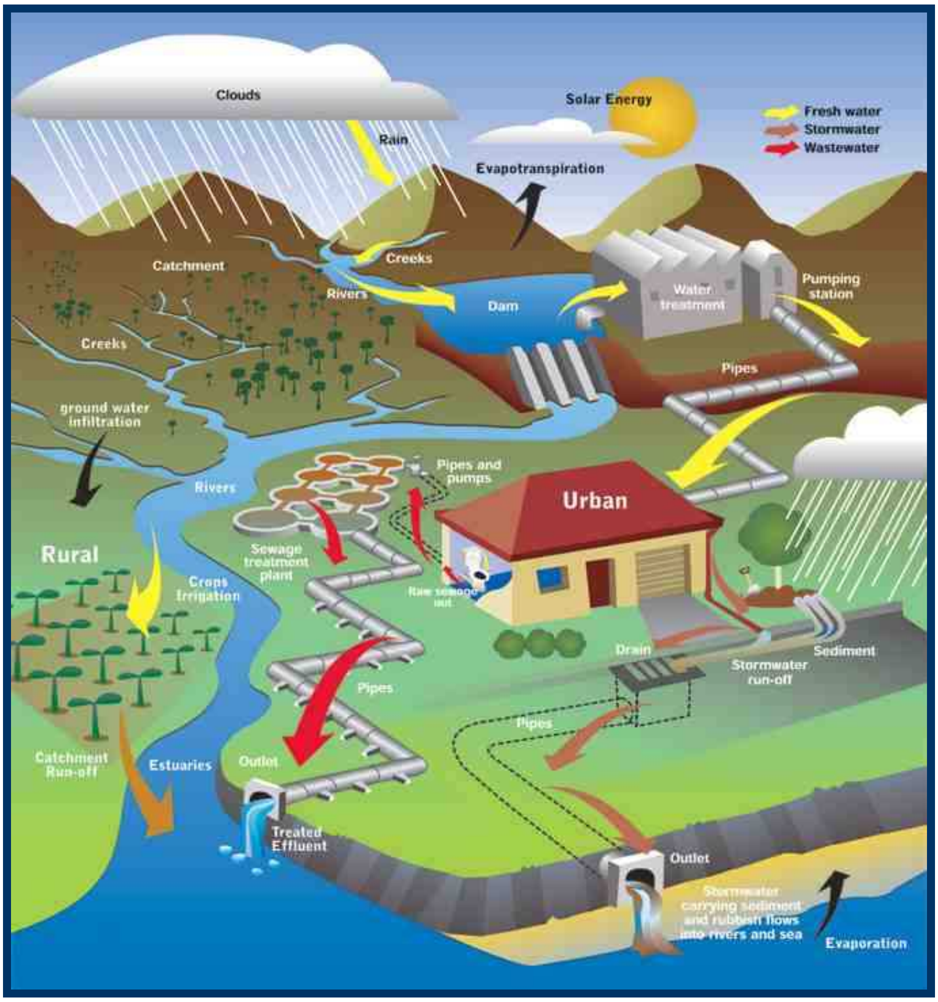
- increased imperviousness (through pavements, rooftops, parking lots, etc.),
- compaction of soils, and
- presence of a man-made drainage system providing for quick removal of ponded water, without allowing water enough time to infiltrate into the ground.

The most visible consequence of urbanization, particularly noticeable in downtown areas, is the increase in the extent of the impervious ground cover which increases runoff volumes. This effect is often cited when explaining urban floods. Another significant consequence of increasing ground imperviousness is the lack of recharge of groundwater aquifers (Leopold, 1968). This phenomenon can be accentuated when water is withdrawn from the same aquifer for urban water supply.

Runoff - As the urbanising area develops, there are profound changes in runoff conveyance, by replacing natural channels and streambeds with man-made channels and sewers. In general, these changes increase the hydraulic efficiency of runoff conveyance by increasing the speed of runoff. This process starts with overland flow in headwaters of the catchment and progresses to the receiving streams and rivers, which are canalised to increase their hydraulic capacity and protect their beds against erosion. Finally, the general drainage pattern of the catchment is also affected by transportation corridors required in urban areas. The most important component of the cycle is stormwater runoff. As noted above, rainwater infiltration in urban areas is reduced by high imperviousness of urban areas and this contributes to increased surface runoff (Leopold, 1968). Furthermore, urban runoff may become polluted which can cause adverse water quality impacts on the receiving waters (Marsalek, 2003). Therefore, during the last 30 years, stormwater management has sought to reduce anthropogenic impacts, and the mobilisation and transport of sediments and pollutants in particular.

Urban groundwater - Urbanisation affects not only surface waters, but also groundwater, with respect to both its quantity and quality.

Figure 4: A more detailed description of the urban water cycle showing common urban infrastructure



Drawing from Figure 4, in the paragraphs that follow we discuss the following components of the urban infrastructure:

- Water sources for town water supply;
- Water distribution systems;
- Urban drainage; and
- Wastewater and sanitation.

4.2 URBAN WATER CYCLE INFRASTRCUTURE

Urban areas require various resources including water, food, energy and raw materials, and produce wastes, which need to be safely disposed of. The hydrological regime in urban areas has been historically managed by building an urban infrastructure, starting with water supply pipelines, followed by stormwater and sewage collection, and eventually sewage treatment plants. Recently, the depletion and degradation of urban water resources has led to the advocacy of a sustainable urban water system, characterised by lower water consumption, preservation of natural drainage, reduced generation of wastewater through water reuse and recycling, advanced water pollution control, and preservation and/or enhancement of the receiving water ecosystem. Specifically, sustainable urban water systems should fulfil the following basic goals:

- supply of safe and good-tasting drinking water to the inhabitants at all times;
- collection and treatment of wastewater in order to protect the inhabitants from diseases and the environment from harmful impacts;
- control, collection, transport and quality enhancement of stormwater in order to protect the environment and urban areas from flooding and pollution; and
- reclamation, reuse and recycling of water and nutrients for use in agriculture or households in case of water scarcity.

Three urban infrastructure sub-systems are considered in the discussion that follows: water supply, drainage, and wastewater management and sanitation.

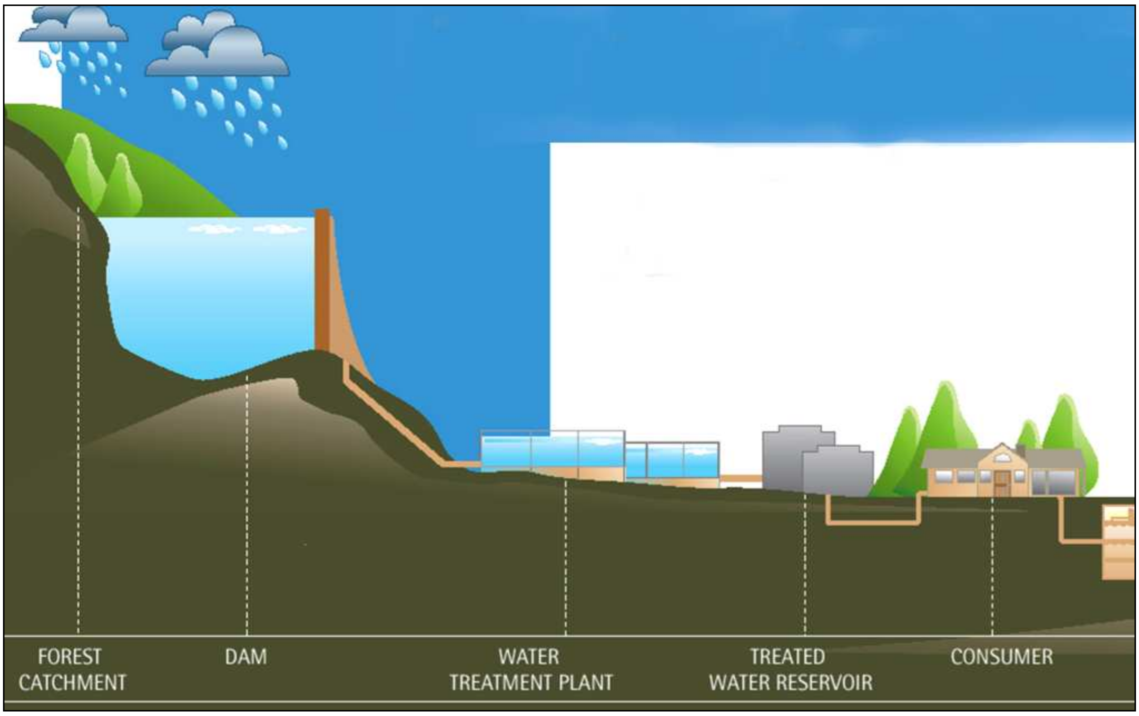
4.2.1 Water supply, including water sources

I think they are too flippant with our drinking water. I don't think people really appreciate the water that they actually have in an urban environment, and I don't think we appreciate where it's sourced from or the limitations that drinking water actually has, … for me living in a city, we take for granted that we can turn on a tap and there will be a water supply there that is potable, that it doesn't have any bugs in it, it's not gonna make us sick. And I think we take for granted that that water will always be there and should, in my opinion, be free. I don't think we should be paying for water.

In most cities the citizens benefit from a water supply service that meets their needs in terms of water quantity and quality. Water is normally treated in a water treatment plant and distributed by a pipe system to households. Town water is often imported from outside of the urban area (or even outside the catchment in which the urban area is located).

It should be an accessible resource to everyone.

Figure 5: From the Sky to the Sea



Source: (The Auckland Water Management Plan)[7]

By definition, urbanisation results in a population increase. The provision of adequate water supply and sanitation to a growing urban population is a problem for government authorities throughout the world. Locating new sources or expanding and upgrading existing sources is becoming more difficult and costly, and is often physically and economically infeasible. The ability to manage existing water resources and plan for developing new water resources is tied directly to the ability to assess both the current and future water demand. Water use can be classified into two basic categories: consumptive (which removes water from the immediate water source) and non-consumptive uses (where water is either not diverted from the water source, or it is diverted and returned).

[7] Presented at a conference - the slides can be found at http://www.thesustainabilitysociety.org.nz/conference/2004/Session4/Donnelly.ppt#291,10,The Urban Water Cycle

Town water uses typically include residential/domestic use (flats, apartments and houses), commercial (stores and small businesses), institutional (hospitals and schools), industrial, and other water uses (fire-fighting, swimming pools, park watering). These uses require withdrawal of water from surface or groundwater sources, and some parts of the withdrawn water quantity may be returned to the source, often in a different location and time, and with different quality.

Domestic water use includes water used for washing and cooking, toilet flushing, bath and shower, laundry, house cleaning, yard irrigation, private swimming pools, car washing and other personal uses (e.g., hobbies). Public services water use includes water used in public swimming pools, institutional uses by government agencies and private firm offices, educational institutions (such as schools, universities and their halls of residence), fire fighting, irrigation of parks and golf courses, health services (hospitals), public facilities (public toilets), art establishments (e.g., libraries and museums), street cleaning and sewer flushing, entertainment and sport complexes, restaurants, and hotels. Small industries include workshops, and similar establishments. Transportation water use includes water used for operation of taxis, buses, and other transportation means (stations and garages), ports and airports, and railways (stations and workshops).

Implications for an assessment process	Tangata whenua will be able to identify the institutions, such as marae or papakainga housing that require adequate water supplies.

Water supply sources - Water needed in urban areas may come from groundwater or surface water sources such as lakes, reservoirs, and rivers. It is called untreated or raw water, which is usually transported to a water treatment plant. The degree of treatment depends on the raw water quality and the purpose that this water will be used for. Water supply storage facilities range from large reservoirs created by building dams to small scale storage tanks.

In many cities, water demand has exceeded the total water resources in the catchment in which the city is located. In such cases, one of the approaches to water supply management is to develop new inter-basin water transfer schemes in order to keep ahead of the ever-increasing requirements due to the growing population and improved standards of living.

If we're constantly sourcing our drinking water from further and further away, may be we need to start looking inwards again and seeing what we're doing to our local sources of water so *we could potentially access them in a more effective way. And that could be an alternative source of water for the local council rather than importing it. Cos then we wouldn't be mixing mauri.*

Supplementary sources of water - Three supplementary sources of water are of particular importance in urban areas: rainwater harvesting, bottled water and wastewater reclamation and reuse.

Rainwater harvesting is a supplementary or even primary water source at the household or small community level, especially in places with relatively high rainfall and limited surface waters. Also, the use of roof runoff for irrigation or other uses is becoming of interest in highly developed urban areas, as one of the measures supporting environmental sustainability, by reducing water supply demands for irrigation and reducing urban runoff and its impacts. Roofs of buildings are the most common collecting surfaces. In designing rainfall harvesting systems the following issues should be considered.

- *Quantity issues*: Rainwater collection systems often suffer from insufficient storage tank volumes or collector areas.
- *Quality issues*: Physical, chemical, and biological pollution of rainwater collection systems occurs where improper construction materials have been used or where maintenance of roofs and other catchment surfaces, gutters, pipes, and tanks is lacking (Falkland, 1991).

Water and wastewater reuse - Water scarcity in many parts of the world causes stress on water supplies when the demand for water exceeds that available or when poor quality restricts the use of water. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.) (EEA, 1999). In urban areas this has emphasised the need for developing other kinds of water resources, such as desalination of seawater, collection of rainwater and reclamation of used water. The reuse of treated wastewater has been practiced in many countries over a long time, mostly for recharge of over-exploited aquifers by infiltration but is likely to cause significant issues from the perspective of Tangata whenua.

Water supply (quantity) - Adequate quantities of water for meeting basic human needs are a prerequisite for human existence, health, and development. If development is to be sustained, an adequate quantity of water must be available. Domestic consumption of water per capita is a commonly used measurement that describes the amount of water consumed per person for the purposes of ingestion, hygiene, cooking, washing of utensils and other household purposes including garden uses.

Water supply (quality) - The quality of water is assessed in terms of its characteristics and its intended uses. Water to be used for public water supplies must be potable (drinkable). In other words it should be without polluting contaminants that would degrade the water quality and constitute a hazard or impair the usefulness of the water. The quality of drinking water is prescribed by standards.

Water shortage - Urban demands on water supplies are continually increasing as a result of growing urban populations and higher standards of living. When demand exceeds the available water, water shortages result, which may create significant social, political, and economic implications.

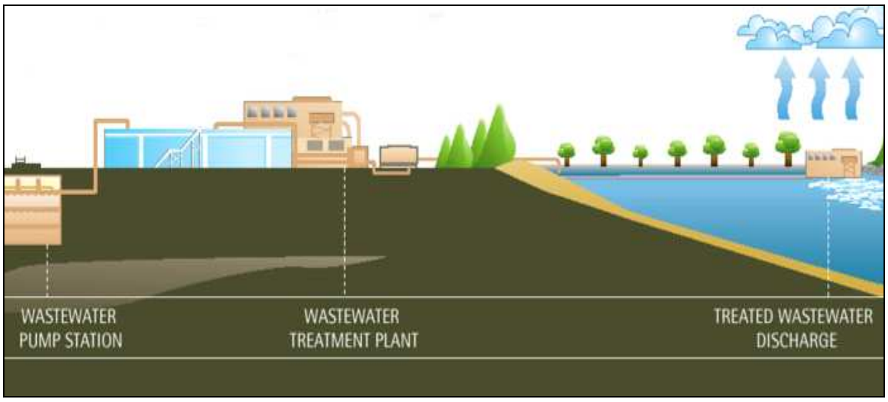
Implications for an assessment process	Resource managers are to • identify the sources of water, • any crossing mixing of waters; • and work with Tangata whenua to identify how such waters are valued.

4.2.2 Water Distribution Systems

After treatment, the water is usually distributed via a water distribution network.

Water distribution systems include the entire infrastructure from the treatment plant outlet to the tap while the collection system refers to the water from the tap being collected and conveyed to the wastewater treatment plant.

Figure 6: Waste Management - From the Sky to the Sea



(Source: The Auckland Water Management Plan)

Drinking water treatment - Water treatment is generally required to make raw water drinkable. As high quality sources of water are depleted, the concern is that water utilities are increasingly using lower quality source water which requires more treatment.

Implications for an assessment process	Resource managers are to • identify the sources of water; • any crossing mixing of waters; and • and work with Tangata whenua to identify how such waters are valued.

4.2.3 Water Collection Systems and Wastewater Treatment

And our bodily waste disappears, it's very much that hands-off, don't really know what happens to it, don't really care what happens to it. But I do know that a lot of water, potable water, is used for the washing away and transportation of our waste, and I think that, you know, the water/waste system, there's somehow an overlap between those two. We waste a lot of water, of flushing waste away.

And I think our systems of waste disposal with minimum water use is an avenue that I think we seriously need to explore

A Cultural Perspective of the types of waste (extracted from Smith, 2011)

Human Effluent - is a source of concern for Tangata whenua and needs to be set apart to prevent it infecting other things through pathogens, viruses and hormones. "Human waste will lower the spiritual and physical quality of other elements it will come into".

Trade waste - Trade waste does not contain human waste but is a pollutant that affects what it comes in contact with. It contains nutrients and metals which are problematic in contaminating natural receiving bodies.

Stormwater - Stormwater picks up metals and oils that are harder to break down than most other elements. The effects of stormwater can be lessened by decreasing the amount of stormwater and improving the quality of stormwater. The use of natural stormwater traps like significant wetlands and significant ngahere or woodlands are more permeable surfaces for stormwater that are likely to be supported by Maori.

Inflow and infiltration - The inflow and infiltration of groundwater into the sewage pipelines needs to be accounted for, because it affects the time allowed for treatment. Maori also contend that water is too important to be used inefficiently.

Wastewater and Sanitation - Urban populations require access to adequate sanitation and disposal of generated solid and liquid wastes, to ensure pollution control, public health protection, avoidance of flooding, and recycling of nutrients.

> *Pollution control* aims to protect the receiving waters, (including creeks, streams, rivers, lakes and the sea), against discharges of wastewater that may cause eutrophication, oxygen depletion, toxicity and other negative impacts that decrease the biological diversity or impair beneficial uses of the receiving waters (e.g., drinking water supply for downstream settlements). Pollution control is one of the major reasons for the construction of wastewater treatment plants.

Public health protection has historically been the major driving force behind the construction of wastewater treatment plants.

Flooding in urban areas can be exacerbated by poorly designed and functioning sewer systems. Flood damages caused by local flooding are often less severe in drainage systems using open channels, ditches or swales for flow conveyance, rather than underground sewers.

Recycling of nutrients recognises that the nutrient contents of domestic wastewater may be valuable as fertiliser in agriculture (or aquaculture). Associated problems however are the contamination of the sludge with heavy metals and certain organic substances. Additional demands on wastewater systems are that they should be affordable, and accepted by the public.

Affordable wastewater systems provide services, that are *accepted* by the consumers, regarding the service delivery, water quality and prices. The water and wastewater systems must be socially and culturally acceptable to the consumers.

Town sewage is a mixture of domestic, commercial and industrial wastewaters.

A Cultural Perspective of Treatment (extracted from Smith, 2011)

In order for effluent to be safe for reintroduction into the environment traces of human element needs to be removed. Those from a science background argue that the focus on the human element is a perception because animal effluent and decaying vegetable component contain the same elements. The perception though is powerful and is the reason for stringent standards throughout the world including a Maori worldview.

In a Maori world view everything has its place, so the act of separating different components into different places is a matter of safety. The treatment of water from the effluent that most pollutes our waterways in the perception of the many markets or perhaps in Maori terms our manuhiri is human effluent. While the simplistic answer is not to pollute our waterways with human effluent, the challenge is how to break that effluent down so the human element is transformed into a vegetative state as naturally as we can. When the treated effluent has been treated wholly in isolation then released to another environment it is not able to degrade what it comes in contact with. The initial orthodox treatment can be better and the matrix below suggests how it meets the multiple levels of Maori experiences.

Cultural Perspective of the Quality of Treated Effluent (extracted from Smith, 2011)

Human effluent - There are many concerns for Maori with human effluent being found in the treated effluent as it can compromise the spiritual value of water; can be physically dangerous to people through transmittable pathogens; can physically affect indigenous fauna negatively; and is a perception that many cultures find abhorrent.

The mechanical UV treatment of human effluent seeks to remove the human pathogens from the effluent. Testing of effluent that is treated by mechanical UV for the removal of human elements is the main standard that most public wastewater treatment plants are aiming for. The main driver for this type of treatment is meeting the public health standard measured in ecoli quantities. While this standard can be met, the nutrients broken down from human element can be perceived as human if they are not transformed further into vegetative states through irrigation.

Nutrient rich effluent - For Maori nutrients in the form of human effluent have adverse spiritual effects. The mauri of the waterway can be transformed by the disposal of nutrients from a mauri ora state, or a life giving entity, to a mauri mate state, or a life threatening state not just for people, but also for indigenous fauna. While the legal situation allows for discharge that crudely does not change the state of mauri, where a waterway might already start in a state of mauri mate this does not align with kaitiakitanga.

Algae build up - The accumulation of algae can result from conditions that encourage algae growth like increased water temperatures usually in shallow unshaded water like the conditions that might exist in ponds and in rivers. This water is not good for indigenous fauna and suggests the absence of indigenous flora that could give shade. In sewage treatment ponds the build up of algae needs to be broken up so that UV is not blocked by algae. Algae build up would for my whanau be a sign of an unhealthy river and an unhealthy pond. Discharging the algae into the river would be passing on this growth to grow in the river, a sign of mauri mate, a degraded environment and a habitat that does not encourage growth.

Suspended solids - Turbidity because of suspended solids from discharges is an indicator the end point is not delivering a high enough quality of effluent and an indicator that the treatment in the sewage ponds is being interrupted. Suspended solids can shield effluent from the breakdown by UV thus making treatment ineffective.

Implications for an assessment process	Resource managers are to identify the • level of treatment • nature of treatment • the quality of the waste discharge

4.2.4 Drainage

The final components of the urban water cycle are the receiving waters. Wastewater from various town sources, including residential, commercial, and industrial and institutional areas is collected by sewers or open drains and conveyed to treatment facilities, or discharged directly into receiving waters. Two types of receiving waters are commonly recognised, receiving surface waters and groundwater. Receiving waters are valued by Tangata whenua and by communities for example for fishing, recreation and ecological functions (e.g., aquatic habitat), or aesthetics. But, from the perspective of the urban water manager they also serve to transport/store/purify urban effluents conveying pollution. Similar conflicts are reported for groundwater, which may also be used water supply as well as (often unintentionally) for disposal of some pollutants. To protect a diversity of water values, it is necessary to manage urban effluents with respect to their quantity and quality, in order to lessen their impact on water resources.

In urban areas, what would have been a natural drainage network comprising sinuous waterways partly blocked by vegetation, is replaced with an artificial conveyance network, which is often oversized in the upstream parts and characterised by a straight layout to limit its length, and laid on significant slopes to decrease drain sizes (and thus reduce costs) and improve its self-cleansing. The same process may also take place in peri-urban areas, with respect to drainage and the canalisation of the creeks and ditches. This canalisation is generally promoted as an effective means of reducing the risk of flooding and inconvenience due to surface water ponding, alleviating hazards, and improving aesthetics of urban areas.

From the perspective of Tangata whenua floods are naturally occurring hydrological events characterised by high discharges and/or water levels leading to inundation of land adjacent to streams, rivers, lakes, or coastal areas.

Urban drainage interacts with other components of the urban water cycle, and particularly with receiving waters. Fast runoff from impervious surfaces, together with the use of street gutters, and storm drains, results in an increased incidence and magnitude of stormwater runoff. The resulting high flows affect the flow regime, sediment regime, habitat conditions and biota in receiving waters. Urban drainage also affects low flows. Reduced infiltration leads to reduced groundwater recharge, lowered groundwater tables and reduced base flows in rivers. Low flows reduce the self-cleansing capacity of rivers, limit the dilution of polluted influents and consequently are characterised by poor water quality.

Stormwater requires special mention as the literature on urban stormwater quality is very extensive. The main pollutants of concern in stormwater, include suspended solids, nutrients (particularly P), heavy metals, hydrocarbons, and faecal bacteria. Only during the last 30 years, stormwater management has sought to reduce runoff generation by allowing more rainwater to infiltrate into the ground, balance runoff flows by storage and provide some form of runoff quality enhancement.

Alternative techniques have been developed for stormwater management during the last several decades (Parkinson and Mark, 2005), including the following:

- infiltration facilities,
- ponds and wetlands,
- swales and ditches,
- oil and sediment separators

Infiltration of stormwater helps keep the groundwater table at a natural level The construction costs of drainage systems with infiltration facilities are also cheaper than those of conventional systems. Infiltration is also implemented on grass or other permeable surfaces, and in drainage swales and ditches. The use of this measure is steadily growing in many countries.

Ponds and wetlands have become a common and accepted means of attenuating drainage flows and treating stormwater by removal of suspended solids, heavy metals and, to some extent, nitrogen and phosphorus. The cost of construction and operation of such facilities is often low compared to the environmental benefits. However, ponds and wetlands should be considered as stormwater treatment facilities and not as natural water bodies as the sediments from ponds may contain high concentrations of heavy metals.

Swales and ditches are applied commonly in the upstream reaches of drainage to control runoff flows and provide runoff quality enhancement. Flow control is obtained by stormwater infiltration into the ground, quality enhancement by filtration through the turf, solids deposition in low flow areas, and possible filtration through a soil layer.

Oil and sediment (grit) separators are used to treat heavily polluted stormwater from highways or truck service areas, or where polluted stormwater is discharged into sensitive receiving waters.

Implications for an assessment process	Resource managers are to identify the • receiving waters • the quantity and the quality of the waste discharge • how the hydrology, quality and biota of receiving waters will change • how the coastal waters may be impacted.

4.2.4 *Summary*

In conclusion, the provision of urban water services and construction of the related infrastructure changes components of the hydrological cycle in urban areas. Specifically, water supply generally involves import of large quantities of water into urban areas, sometimes from remote catchments. Some of this water finds its way into urban aquifers, via losses from the water distribution networks. Most of the remaining water is used within the urban area and turned into wastewater. Increased catchment imperviousness and hydraulically efficient urban drainage contribute to higher volumes and flow rates of runoff, and reduced recharge of groundwater. For most cities in developed countries, collected wastewater is treated at sewage treatment plants, which may discharge their effluents into receiving waters, thus contributing to the pollution of receiving waters. Thus, elements of the urban water infrastructure and their interactions with the hydrological cycle are of particular interest for Tangata whenua.

4.3 POTENTIAL ACTIVITIES OF CONCERN IN RESIDENTIAL AREAS

There are many activities associated with living in an urban area that impact waterways. Some of these are listed in Table 5.

Table 5: Key Behaviours Within Residential Source Areas that can impact Waterways

Source Area	Polluting Behavior
Sections and Lawns	Over-Fertilization
	Excessive Pesticide Application
	Over-Watering
	Extensive Turf Cover
	Tree Clearing
	Improper Yard Waste Disposal
	Soil Compaction
	Soil Erosion
	Failing Septic Systems
	Pool Discharges
Driveways, Paths, and Curbs	Car Washwater Flows
	Hosing/Leafblowing
	Application of Salts and other Deicers
	Dumping of Household Hazardous Waste
	Dumping of Oil/Antifreeze
Rooftops	Downspout Connections
	Added Impervious Cover/Exposed Soils
Common Areas	Pet Waste
	Unmaintained Storm Water Practices
	Encroachment onto riverbank areas
	Storm Drain Dumping

4.4 THE IMPACTS OF URBANISATION

The process of urbanisation changes the landscape and the hydrology of catchments. Other changes are caused by construction of urban infrastructure, increased water consumption in urban areas, and releases of wastewater effluents, which include stormwater, and town wastewaters that differ in their physical, chemical and microbiological characteristics; consequently their effects also differ. Some effects manifest themselves instantaneously; others may become apparent only after periods of many years. The Parliamentary Commissioner for the Environment (PCE) summarised the problems associated with the urban water system in New Zealand (see Table 6).

Table 6: New Zealand's Urban water system problems, underlying causes and impacts (from PCE 2000)

Issue	Problems	Underlying causes	Impacts
Social/Cultural/ Health	Perception that water is \`free\`	Historical abundance - \`fundamental right\` Societal/cultural attitudes influence water use Incomplete pricing and \`hidden\` costs through funding by property rates Consumers not paying the \`true\` costs of water services and have little understanding of the value of services – reduced incentives for change Lack of awareness and information – urban residents separated from environment	Excessive extraction and inefficient use Increased wastewater flows requiring large treatment systems Resulting environmental, economic, and social impacts Adverse effects on taonga of tangata whenua, and on the mauri of the water resource
	Lack of access to potable water/low water quality/water-borne diseases e.g. giardia, cryptosporidium, campylobacter	Inadequate investment and asset maintenance Some communities unable to fund infrastructure Inadequate catchment management (legislation) No national drinking water standards – only guidelines Inadequate monitoring of water quality – no mandatory disclosure of water quality Lack of small systems/local solutions – limited research	Potential health risks – individual and community Restricted economic development Water not always \`fit for purpose\`
	Poor recreational/bathing water quality/water-borne diseases	Inadequate investment and poor asset management e.g. sewer overflows Inadequate investment in stormwater management and lack of onsite control and reuse of stormwater Inadequate monitoring/reporting of bathing water quality (legislation)	Potential health risks – individual/community Adverse effects on taonga of tangata whenua, and on the mauri of the water resource Adverse effects on recreational values Adverse effects on economic development
	Poor information disclosure	No mandatory requirements for formal contracts and customer charters (legislation)	Customers unable to hold service provider to account for quality of service Lack of information to bring about change

Issue	Problems	Underlying cause	Impacts
Environment	Inadequate water flows	Excessive extraction and use with supply-side focus, ie large ams/pipes Incomplete pricing and cross-subsidies Fire Service supply requirements mean larger networks (legislation) Poor asset management eg broken/leaking pipes Lack of awareness and information Lack of demand management and use of old/inefficient technology Little integration of water supply, wastewater and stormwater networks	Low environmental flows – adverse effects on instream values and biodiversity Adverse effects on taonga of tangata whenua, and on the mauri of the water resource Large volumes of wastewater requiring treatment and disposal Restricted economic development
	Contamination of surface waters and ground water	Contamination at source or recharge area (which may include rural areas) due to inappropriate landuse and management Low or incomplete treatment of wastewater flows and reliance on assimilative capacity of surface waters Inadequate investment and poor asset management eg sewer overflows Some communities unable to fund required infrastructure Peak period overload for coastal/holiday centres Incomplete pricing an cross-subsidies (legislation) Inadequate management of trade waste (legislation) Limited stormwater management/lack of onsite control and recycling Inadequate monitoring and public disclosure of bathing water quality	Adverse effects on instream values and biodiversity Adverse effects on the coastal and marine environment and biodiversity Adverse effects on public health Adverse effects on taonga of tangata whenua, and on the mauri of the water resource Adverse effects on recreational values Community inability to pay for infrastructure
	Excessive flows e.g. flooding, stormwater flows	Increased flood peaks due to inappropriate landuse and catchment management: high proportion of impervious surfaces and runoff Some communities unable to fund flood control infrastructure Inadequate investment and maintenance eg failed channels and drains Inadequate investment in stormwater management Reliance on piped systems – neglect of natural waterways and wetlands Lack of `whole catchment` approaches to urban water management	Localised flooding, damage to property, potential loss of life and economic impacts Adverse effects on instream values and biodiversity Adverse effects on taonga of tangata whenua, and on the mauri of the water resource Adverse effects on recreational values

Issue	Problems	Underlying cause	Impacts
Economic	Lack of investment and incomplete pricing	History of poor asset management – now improving Incomplete pricing and charging for services (legislation) Limited valuation and pricing of ecosystem services Difficulties with establishing and obtaining financial contributions via RMA processes (legislation)	Intergenerational payment issues Estimates of $5 billion in new investment and deferred maintenance over next 20 years Community inability to pay for infrastructure
	Inefficient delivery of services	Inadequate investment and history of poor asset management – now improving Limited financial controls and `drivers` for efficiency and no requirements to disclose information on operational performance (legislation) Fragmented and unclear legislation – responsibilities of consumers and suppliers are not clearly defined in legislation (legislation) Limited research and development of alternative service provision	Excessive extraction/inefficient use Increased wastewater flows requiring large treatment systems Reduced economic efficiency and potential loss of international competitiveness Difficult for customers to evaluate the quality of service provision
	Potential risk of infrastructure failure	Inadequate investment and poor asset management Lack of community awareness and information Limited research and development of alternative delivery approaches and cost-benefit analysis of different solutions	Potential health risks – individual/community Disruption to the community Impact on commerce and economic development, exports and tourism Effects on environment and `clean blue and green image`

Table 6 confirms that urbanisation typically leads to modification of river courses, by damming, widening and training. Little streams are gradually canalised, covered and buried. Most important watercourses are enclosed between high embankments, which completely isolate them from the city. The results of this state of affairs are twofold.

- Urban rivers are gradually forgotten by the citizens who only perceive their harmful effects.
- Urban rivers are enclosed in a too narrow “corset” and thereby have lost any "natural" possibility of spilling onto natural flood plains in the case of floods.

Consequences can be serious; the city, which is appropriately protected as long as the water levels remain below the top of the embankments or dams, risks being inundated when the flow increases, or these protective structures fail.

In the paragraphs that follow we focus on the potential impacts on aquatic ecosystems.

Implications for an assessment process	Tangata whenua are able to inventory their association with waterways and from that determine how the urban water system impacts their cultural values

4.4.1 Urbanisation Effects on Surface Waters

Urbanisation strongly impacts on surface waters, particularly in the case of streams, small rivers, impoundments, lakes, estuaries and coastal waters. The effects depend on the magnitude of effluent discharges and the type and physical characteristics of the receiving waters. The effects are most serious in small urban creeks which can be severely impacted by cumulative effects of elevated discharges, and incoming discharges of chemicals, pathogens and heat. The morphology of such streams may change dramatically and these changes contribute to physical habitat destruction. The effects on lakes and reservoirs depend on the size of such water bodies. The most impacted are small impoundments in urban areas (e.g. stormwater ponds), particularly by faecal bacteria, nutrients, and contaminated sediment. Finally, potential effects on ocean waters are minimal; however, town effluents, in general, do impact on harbours, estuaries and coastal waters.

Table 7: Impacts of Urbanization on Streams

Stormwater outfalls	Stormwater outfalls are dispersed throughout urban areas. Sewage effluents, which are also called point sources of pollution, are discharged usually downstream of the urban area, or via outfalls, which may extend deep into a lake or ocean. Such arrangements are intended to reduce sewage effluent impacts on urban waters. On the other hand, pollutant transport in the receiving waters further increases the spatial extent of effluent effects.
Effects on flows	River flows are variable based on topography, climatic and catchment conditions. High catchment imperviousness (increased volume of runoff), fast runoff (increased speed of runoff) and quick catchment response to critical rainfall of reduced duration, all of which contribute to increased runoff flows. Environmental effects of increased flows include flooding, sediment and habitat washout (Borchardt and Statzner, 1990), and morphological changes (Schueler, 1987).

Erosion	Soil erosion is intensified in urbanising areas as a result of two factors: the stripping of natural protective vegetative covers from the soil surface during construction and increased runoff flows, which cause sheet erosion, scouring in unlined channels and transport of eroded material to the downstream areas (Horner et al., 1994). Excessive erosion causes ecological damages by sweeping away habitats and expanding stream channels (both width and depth) either gradually, or as a result of a single severe storm resulting in rapid downcutting, or channel incision (Booth, 1990; Urbonas and Benik, 1995).
Sediment transport	Summary of Impacts of Suspended Sediment (Schueler and Holland, 2000) • Abrades and damages fish gills, increasing risk of infection and disease • Scouring of periphyton from stream (plants attached to rocks) • Loss of sensitive or threatened fish species • Shifts in fish community toward more sediment-tolerant species • Reduces sight distance for trout, with reduction in feeding efficiency • Reduces light penetration causing reduction in plankton and aquatic plant growth • Adversely impacts aquatic insects, which are the base of the food chain • Slightly increases the stream temperature in the summer • Suspended sediments can be major carrier of nutrients and metals • Reduces anglers chances of catching fish Summary of Impacts of Deposited Sediments (Schueler and Holland, 2000) • Physical smothering of benthic aquatic insect community • Reduced survival rates for fish eggs • Destruction of fish spawning areas and eggs • Embeddedness of stream bottom reduced fish and macroinvertebrate habitat value • Loss of trout habitat when fine sediments are deposited in spawning or riffle-runs • Sensitive or threatened darters and dace may be eliminated from fish community • Increase in sediment oxygen demand can deplete dissolved oxygen in streams • Significant contributing factor in the alarming decline of freshwater mussels • Reduced channel capacity, exacerbating downstream bank erosion and flooding • Reduced flood transport capacity under bridges and through culverts • Deposits diminish scenic and recreational values of waterways
Water Quality	Urban areas affect the water quality in rivers through discharges of wastewaters, that modify temperature, suspended solids, organic matter, turbidity and faecal pollution indicators in rivers. Excess nutrients may cause eutrophication in rivers, particularly where rivers are impounded. Other effects encountered in rivers include increased salinity (total dissolved solids, TDS), acidification, and higher concentrations of trace elements and nitrates. Other reasons for increased TDS in rivers may be soil erosion and water evaporation. Where such waters are used for water supply, higher costs of treatment are encountered for removing TDS. Trace elements are discharged into rivers from various industrial operations, urban runoff, pesticide applications (copper), atmospheric deposition, and sanitary landfill leachates. Trace metals consequently accumulate in sediments. Bacteria can transform metals into volatile organometallic compounds. Thus, sediments play an important role in water pollution and decontamination. The main sources of microbial contamination of urban waters are human wastes. Faecal coliforms or *E. coli* are currently used as indicators in freshwater, and enterococci in marine waters. However, these microorganisms are not adequate indicators of the presence of viruses, protozoan and helminth ova, but only of bacteria.

Biodiversity impacts	• Loss of species and diversity • Loss of riparian cover
Channel geomorphology	• Channel enlargement, • Channel incision, • Reduced channel sinuosity, • Changes in pool/riffle structure, • Stream embeddedness • Loss of 1st and 2nd order streams through storm drain enclosure
Warmer in-stream temperatures	Changes to riparian vegetation, channel geometry, low flow regimes, and temperature of water inputs all influence stream temperature. Where riparian buffers are not protected, clearing of vegetation reduces channel shading, thereby changing temperatures. The temperature of water inputs to a stream can also change because of discharges of industrial or wastewater treatment effluents and from heating of runoff that flows over impervious surfaces. The typical result of these combined impacts of urbanization is to increase stream temperature during baseflows and some peakflows. Elevated temperature has been shown to enhance rates of biological processes resulting in cascading changes to urban stream ecosystems.
Cumulative impact	Urban wastewater effluents cause numerous biological effects through combination of five factors: (a) flow regime changes, (b) impairment of habitat structure, (c) biotic interactions, (d) changes in energy (food) sources, and (e) chemical and microbiological variables (water pollution).
Implications for an assessment process	Tangata whenua are able to provide a spatial interpretation of impacts.

4.4.2 Effects of urbanization on lakes and reservoirs

Lakes and reservoirs are characterised by long hydraulic residence times and relatively low capacity for decontamination. Lakes located near urban areas are often used for water supply, recreation yet also receive waters for urban effluents. Thus, a delicate balance among the various water uses must be achieved.

Table 8: Main water quality problems in lakes and reservoirs

Process	Cause	Effects on water quality
Acidification	Atmospheric deposition of acidity.	Decrease in pH, increased concentrations of heavy metals, loss of biota.
Increased salinity	Water balance modifications, soil leaching, industrial and municipal discharges	Increased TDS, increased treatment cost if dissolved solids exceed 1,500-2,000 mg/L.
Eutrophication	Excess of nutrients	Increased algae and plant production; consumption of the hypolimnion oxygen; release of Fe, Mn, NH_4 and metals from the hypolimnion; loss of diversity in the higher trophic levels; favourable conditions for reproduction of mosquitoes and spread of shistosomiasis.
Pathogen contamination	Sewage discharges	Spread of disease including infection by bacteria, virus, protozoa and helminth ova.
Increased toxicity	Industrial and municipal discharges	Increased concentrations of trace organic and metal toxicants; introduction of endocrine disruptors; toxic effects through bioaccumulation and biomagnifications; and, fish tumours and loss of biota.

Reservoirs behave similarly to lakes. Constructed reservoirs require some aging to develop the characteristics of natural lakes. As these reservoirs usually serve many purposes, including water supply, flood control and hydroelectric power generation, their levels greatly and frequently fluctuate.

4.4.3 Effects Of Urbanisation on Wetlands

Wetland ecosystems represent the transition between terrestrial and aquatic systems and are inundated, or characterised by high water tables (at or near the land surface) during much of the year. Plants and animals that inhabit wetlands are uniquely adapted to live under conditions of intermittent flooding, and changing conditions. These characteristics make wetlands suitable for treating wastewater; constructed wetlands have been used for enhancing stormwater quality, and treating wastewater. Constructed wetlands are designed to mimic the characteristics of natural wetlands, but are typically strongly affected by accumulation of solids and chemicals resulting from the treatment of urban effluents. Such wetlands, with either surface or subsurface flow, are recommended for stormwater quality enhancement, with good guidance available for their design (Tanner, 2010).

In order for wetlands to operate effectively as treatment systems implementation of pre-treatment and good maintenance are essential. Maintenance operations include removal and disposal of deposited sediment with associated contaminants, occasional harvesting of vegetation, clearing of drainage channels and similar measures.

4.4.4 Effects of Urbanisation on Groundwater

Bedient et al. (1994) listed 30 potential sources of aquifer pollutants divided into six categories. Among these, the most frequent pollution source in cities were storage tanks, septic tanks, leaks from sewerage systems, hazardous and town landfills, and polluted soils used to store materials. These potential sources are described in Table 9
Based on a literature review, van Eyck et al. (2001) established that potentially harmful contaminants of groundwater include metals, pharmaceuticals, estrogens (natural and synthetic), surfactants, and solvents.

Table 9: Sources of Contaminants to Urban Aquifers

Source	Issue
Landfill	Any landfill, controlled or not, can be a source of aquifer contamination. Most of such contamination comes from old landfills or garbage dumps, which were built without adequate guidelines and before hazardous waste segregation was introduced.
Hazardous materials	From confinement sites of hazardous wastes, as various trace metals and organics may leak and enter aquifers.
Septic tanks	Wastewater may leak from septic tanks, sewers, wells or be directly discharged into soils (Lewis et al., 1986) and contribute to aquifer recharge and pollution.
Sewage leakage	Pollutants include biodegradable organic matter, nitrogen compounds, phosphorus, microorganisms suspended solids and trace organic compounds. Among them, nitrates are the most mobile and persistent, which is why they are normally detected in polluted aquifers.
Small industries and service operations	These include mechanical factories, dry cleaning services, etc which handle toxic substances like chlorinated solvents, aromatic hydrocarbons, pesticides, etc. It is important to control their wastes (liquid and solids), since by recycling or disposal at appropriate confinement sites rather than discharging to soils.

4.4.5 Urban Impacts on Biota – Loss of Biodiversity

Many urban areas have developed on shores of lakes and rivers and have affected the biota. Each water body sustains its own set of organisms, plants and animals living in balance, within a specific ecosystem described by physical and chemical characteristics of the environment. Aquatic ecosystems are physically made up of three zones: water body including its bottom (aquatic zone), the transition zone between water and earth (riparian zone), and the terrestrial zone. Each zone is characterised by specific conditions that determine the structure of biological communities.

Eels are highly prized by Tangata whenua

Table 10: Sources of Contaminants to Urban Aquifers

Steam Change	Effects on Organisms
Increased flow volumes/Channel forming storms	Alterations in habitat complexity Changes in availability of food organisms, related to timing of emergence and recovery after disturbance Reduced prey diversity Scour-related mortality Long-term depletion of large woody debris (LWD) Accelerated streambank erosion
Decreased base flows	Crowding and increased competition for foraging sites Increased vulnerability to predation Increased fine sediment deposition
Increase in sediment transport	Reduced survival of eggs and alevins, loss of habitat due to deposition Siltation of pool areas, reduced macroinvertebrate reproduction
Loss of pools and riffles	Shift in the balance of species due to habitat change Loss of deep water cover and feeding areas
Changes in substrate composition	Reduced survival of eggs Loss of inter-gravel fry refugial spaces Reduced aquatic insect production
Loss of LWD	Loss of cover from predators and high flows Reduced sediment and organic matter storage Reduced pool formation and organic substrate for aquatic insects
Increase in temperature	Changes in migration patterns Increased metabolic activity, increased disease and parasite susceptibility Increased mortality of sensitive fish
Creation of fish blockages	Loss of spawning habitat for adults Inability to reach overwintering sites Loss of summer rearing habitat Increased vulnerability to predation
Loss of vegetative rooting systems	Decreased channel stability Loss of undercut banks Reduced streambank integrity
Channel straightening or hardening	Increased stream scour Loss of habitat complexity
Reduction in water quality	Reduced survival of eggs and alevins Acute and chronic toxicity to juveniles and adult fish Increased physiological stress
Increase in turbidity	Reduced survival of eggs Reduced plant productivity Physiological stress on aquatic organisms
Algae blooms	Oxygen depletion due to algal blooms, increased eutrophication rate of standing waters

Implications for an assessment process

If mauri is about life, energy, and vitality it is important that these adverse effects are avoided or at the least minimized.

4.5 INTEGRATING VALUES & IMPACTS

In Table 11 we have collated the potential impacts described in this Chapter and summarised how they impact the cultural values of Tangata whenua as described in Chapter 3.

Table 11: Summary of different types of impacts on cultural interests

Principle	Description of concern[8]	Purpose[9]	Potential impact				
			Surface waters	Wetlands	Soil	Groundwater	Biota
Manaakitanga (Hospitality and Security)	Unable to afford the level of hospitality given to visitors, and security of community, as desired	To embrace and welcome all peoples, especially visitors, and to provide a safe and secure community environment	Health risks Pollution of streams and lakes limiting use Faecal pollution of beaches or drinking water sources giving cultural offence Impairment of uses including drinking, swimming, gathering	Health risks Pollution Changes in bacterial ecology	Soil pollution Changes in bacterial ecology Landfills	Health risks Contamination Polluted drinking water Degraded aquifers	Toxic effects, loss of biodiversity Risk of biotic impacts (diseases, losses)
Whanaungatanga (Participation and Membership)	Participation but limited ability to achieve outcomes in community and social settings	To encourage community participation and pride through building and emphasizing community identity	Increased surface runoff and flooding, higher water temperature Pollution of streams and lakes limiting use Connections broken - waterways no longer focal point for activities, waterways disconnected from catchment.	Changes in water balance Changes in bacterial ecology Loss of biodiversity, impacts on biota		Lower or higher water table Contamination	Loss of abundance, loss of biodiversity
Kaitiakitanga (Guardianship and Stewardship)	Ability to protect significant landscape features important to the local community compromised.	To support the protection of important environmental and cultural features through community ownership and collective responsibility	Loss of biodiversity, impairment of beneficial uses Modified character of waterbodies Degraded water quality Larger volumes of wastewater requiring treatment and disposal Loss of habitats	Loss of biodiversity, impacts on biota	Increased erosion changes in physical structure Soil pollution Changes in bacterial ecology Landfills	Contamination Degraded aquifers	Loss of habitat, benthic organism burial Toxic effects, loss of biodiversity Loss of abundance, loss of biodiversity

[8] Taken from Landcare,2008
[9] Taken from Landcare,2008

Mauri Essence/Life-force	Life-force or essence of a natural environment compromised.	To identify and promote the maintenance or restoration of mauri	Modification of quality and quantity of waters Increased surface runoff and flooding, higher water temperature Pollution of streams and lakes Larger volumes of wastewater requiring treatment and disposal Faecal pollution of beaches or drinking water sources Loss of biodiversity, impairment of beneficial uses	Changes in water balance Pollution Changes in bacterial ecology Loss of biodiversity, impacts on biota	Increased erosion changes in physical structure Soil pollution Changes in bacterial ecology due to sludge application Landfills	Lower or higher water table Contamination Polluted drinking water Degraded aquifers	Loss of habitat, benthic organism burial Toxic effects, loss of biodiversity Risk of biotic impacts (diseases) Loss of abundance, loss of biodiversity
Mātauranga **Knowledge and Understanding**	Understanding of community history, identities, character limited	To encourage community understanding and pride through shared knowledge	Ability to use is impaired. Connections are broken. Over time uses, knowledge associated with uses, Te Reo & tikanga associated with use are lost.				

Internationally there is growing recognition of the importance of the social conditions and need to recognise links between the socio-economic system and aquatic environments (Lundqvist et al., 2001). Further it is recognised that sustainable solutions to water related problems must reflect the cultural dimensions of people's interactions with water. Culture is a powerful aspect of water resources management. Therefore the next chapter focuses on how cultural conceptualisations can help us construct a cultural health assessment framework.

4.6 A SUMMARY OF A POSSIBLE ASSESSMENT FRAMEWORK FOR ASSESSING THE CULTURAL HEALTH OF URBAN STREAMS

In the previous tow chapters we have highlighted the key popints in a shaded box at the end of each section. In Table 12 we draw together all the key points and present them as part of an assessment process for use by Tangata whenua.

Table 12: Preliminary Cultural Health Assessment Framework for Urban Streams

Principle	Relevance to Urban Water Cycle

1. Manaakitanga - (Hospitality and Security)	**Part A. In order to complete an assessment some base information will be required by Tangata whenua including**
	• a description of the footprint of the urban water infrastructure to identify all waterways where the cultural health could be impaired.
	• identifying all the sources of water,
	• identifying any crossing mixing of waters;
	• identifying all receiving waters
	• defining the quantity and the quality of the waste discharged after use
	• identifying how the hydrology, quality and biota of receiving waters has changed and is expected to change in the future as a result of urban activities
	• identifying how the coastal waters may be impacted.
	
	Part B. Substantive assessment – To structure their assessment
	• Tangata whenua will identify how the waters are valued, which will include developing an understanding of how urban catchments are used by Tangata whenua. This will mean inventorying their association with waterways
	    o identify the institutions, such as marae or papakainga housing that require adequate water supplies and sanitation.
	    o identify the kai and cultural materials sourced within the footprint of the urban infrastructure.
	    o develop a spatial understanding of wahi taonga and wahi tapu.
	    o identify how whanau use urban environs especially aquatic ecosystems
	    o identify how whanau aspire to use urban environs especially aquatic ecosystems

2. Kaitiakitanga - (Guardianship and Stewardship)	**Part C. Process -** Tangata whenua will determine what, from a cultural perspective, represents satisfactory participation in urban water management. During the assessment itself • A catchment wide approach to assessment is important. • Tangata whenua will have the opportunity, as kaitiaki to undertake the assessments • The assessment will not solely be an assessment of present condition. The assessment will include assessing the impact of changes over time. • Tangata whenua may identify areas that require in-depth investigation. **In order to complete an assessment some base information will be required by Tangata whenua including** • See 1A above. **Part D: Substantive assessment – To structure their assessment** • Tangata whenua will also, in part, undertake an impact assessment process • Tangata whenua will assess the current state using indicators related to their cultural values

Principle	Relevance to Urban Water Cycle
3. Whanaungatanga - (Participation and Membership)	**Process -** Tangata whenua will determine what, from a cultural perspective, represents satisfactory participation in urban water management. **Substantive assessment – To structure their assessment** • See 2B and 2C above.
4. Mauri - Essence/Life-force	**In order to complete an assessment some base information will be required by Tangata whenua** • See 1A above. **Substantive assessment – Drawing on the points raised above, to structure their assessment** • Tangata whenua will identify how the waters are valued, which will include developing an understanding of how urban catchments are used by Tangata whenua. This will mean inventorying their association with waterways o identify the institutions, such as marae or papakainga housing that require adequate water supplies. o identify the kai and mahinga kai species sourced within the footprint of the urban infrastructure. o determine any waters of special significance to Tangata whenua that are within the footprint of the urban water infrastructure. o develop a spatial understanding of wahi taonga and wahi tapu o the dependency of Tangata whenua (and wahi taonga and wahi tapu) on the functions, processes and services afforded by healthy waterbodies. o identify how whanau use urban environs especially aquatic ecosystems o identify how whanau aspire to use urban environs especially aquatic ecosystems • Tangata whenua will also, in part, undertake an impact assessment process by o the changes to functioning of waterbodies that impact the beliefs, values and practices of Tangata whenua. o assess any issues arising from the changing health of the waterbodies. o Identify unnatural mixing of the waters used to supply the urban area; o identify contaminants entering the waterway; and o The extent of "separation" that is provided for within the system. o determine how the functions, processes and services afforded by healthy waterbodies are impaired by the effects of urbanisation o Identify how manipulating flows, diverting waters, channeling river reaches, and unnatural discharges of contaminated water, break connections results in cultural impacts – even cultural loss. • Tangata whenua will assess the current state using indicators related to their cultural values
Mātauranga - Knowledge and Understanding	**Process** See 2A above. Tangata whenua will assess the current state using indicators related to their cultural values. Wherever appropriate existing cultural tools will be used.

Before applying this framework in our two case study catchments, we analyse the relevance of the existing CHI for assessing stream health in urban areas.

Chapter 5: The Cultural Health Index for Streams

The Cultural Health Index (CHI) for rivers and streams is an existing tool that involves tangata whenua in resource management processes. Funded by the Ministry for Environment as part of its Environmental Performance Indicator (EPI) Programme, this work arose in an attempt to recognise and incorporate Maori values in river management. The existing CHI is introduced in section 5.1. The current CHI provides a diagnostic tool which identifies issues of concern to tangata whenua. Remedial actions can then be prioritized using data gathered from field assessments. Monitoring aspects of the freshwater resource can also be undertaken. Section 5.2 considers how the issues raised in this report may be accommodated.

5.1 OVERALL STRUCTURE OF THE CULTURAL HEALTH INDEX (CHI)

The Cultural Health Index that was previously developed is made up of three components:

1. site status, specifically the significance of the site to Maori ;
2. a mahinga kai measure; and
3. a stream health measure.

Component 1 - Site status - This component of the CHI explores the significance of the site to Maori and distinguishes between traditional and contemporary sites. There are two questions to establish this component:

The first question requires a site to be classified as either:

A - indicates a *traditional* site of significance to Maori ; or

B - indicating the site is not traditional but has been included because of other aspects (e.g. the site may be one monitored by the regional council).

The second question asks whether Maori would return to the site in the future. If the runanga would return, the site is awarded a 1 and, if not, a 0. When the answers to the two questions are collated there are four possible combinations:

A-1	A-0	B-1	B-0
This is a traditional site, that Maori would return to and use as they did in the past.	This is a traditional site that Maori would not return to.	This is a site that is not of traditional significance to Maori . However they would go to the site in the future.	This is a site that is not of traditional significance to Maori . Further they would not go to the site.

Component 2 - Mahinga kai measure **-** The second component of the CHI addresses the mahinga kai values of a site. This component, in addition to encapsulating the many intangible qualities associated with the mauri of a waterway, is tangibly represented by some of the physical characteristics of a freshwater resource, including: indigenous flora and fauna; water clarity, water quantity, and the mahinga kai it yields (Ministry for Environment, 1997). There are four parts to the "mahinga kai measure" of the Cultural Health Index.

1. The first part (a) **identifies mahinga kai species present** at the site. A list of plant, bird and fish species is prepared. A score (1 – 5) is then assigned, depending on the number of species present.
2. The second part (b) **compares the species present today and the traditional mahinga kai** sourced from the site. This was deliberately factored into the design of the Cultural Health Index to recognise that maintaining cultural practices, such as the gathering of mahinga kai, is an important means of ensuring the transference of cultural values through the generations. Cultural continuity means that greater value is likely to be assigned to sites of traditional significance that continue to support the mahinga kai species sourced in the past. A single score (1 – 5) is assigned, based on the number of species of traditional significance that are still present:
   - non-traditional site scores 1
   - none of the species sourced in the past is present at the site scores 1
   - at least 50% of the species sourced in the past are still present at the site scores 3
   - all species sourced in the past are still present at the site scores 5.

3. Mahinga kai gathering assumes Maori have physical and legal access to the resources that they want to gather. The third part of the mahinga kai measure (c) assesses each site based on **access to the site.** (A score of 1 equalling no access and 5 equalling unimpeded legal and physical access.)
4. The fourth part in the mahinga kai measure (d) assesses whether Maori would **return to the site** in the future and use it: No scores 1, Yes scores 5.

The four mahinga kai elements are then averaged to produce a single score (1-5).

Component 3 - Cultural Stream Health Measure - The third and final component of the CHI is the Cultural Stream Health Measure (CSHM). Indicators of stream health identified in Part 1 of the study were tested and refined by different tangata whenua assessment teams in the four rivers studied as part of the development of the CHI in 2003. This has resulted in a set of indicators that best reflects iwi participants' assessment of overall stream health and that can be defined objectively. Each of these eight indicators receives a score (1 – 5) from each runanga member involved in the assessment. The scores for each indicator are then averaged. The average of all indicator scores is calculated as the CSHM (1-5).

5.2 THE EVOLUTION OF COMPONENT 1 OF THE CHI: SITE STATUS

Oral records from runanga members reinforced the relevance and usefulness of the overall structure of the CHI (components 1-3). During further application of the CHI there was no call for addition or deletion of any component, however, refinements of a generally minor nature were made as the research progressed.

For some sites, members of the assessment team were not unanimous about whether they would return to the site. However the assessment of the majority was always clear and able to be used as the final determinant of the score for that dimension. For some catchments and sub-catchments where the CHI has been applied, whanau have decided to list all sites as "Traditional".

5.3 THE EVOLUTION OF COMPONENT 2 OF THE CHI: MAHINGA KAI

This component of the Index recognizes that mauri is tangibly represented, in part, by some of the physical characteristics of a freshwater resource including the mahinga kai it yields (Ministry for Environment, 1997). In the Taieri/Kakaunui study, Component 2 focused entirely on mahinga kai values. However, runanga members on the Hakatere study identified the need to recognize cultural uses other than mahinga kai, and this was confirmed in subsequent studies where it was observed that while mahinga kai is important for many sites, Component 2 needs to recognize sites that maintain other cultural uses. Thus, of the four parts making up Component 2 the only refinement was to the fourth part, changing the focus from whether Maori would return and gather mahinga kai in the future to whether Maori would return and use the site in future.

In relation to assigned scores for the number of species present, concerns were raised at each stage about expressing the 1-5 score in relation to the maximum number of species at any site on the river in question. The problem was threefold. First, it may be inappropriate for a degraded site to score highly simply because it was the "best of the worst". Second, unlike other measures, this scoring system does not allow for comparisons between catchments. Third, such an approach to deriving a catchment-specific score may involve complex calculations. Despite these concerns, it was not considered appropriate to apply a generic 1 – 5 rating for a set number of species[10]. Thus, to assign a score for the number of species present at a site, the steps are:

[10] Developing a generic scoring system for mahinga kai species was beyond the scope of the original CHI project and a generic set would have failed to recognise that what constitutes a species gathered for kai or cultural use varies

- Collate the list of plant, fish and bird species present.
- For all sites assessed, determine the maximum number present.
- Based on the maximum number of species present at any one site to assign a score of 1 – 5 based on how many species there are compared to this maximum figure.

5.4 EVOLUTION OF COMPONENT 3 OF THE CHI: CULTURAL STREAM HEALTH MEASURE (CHSM)

The CSHM is calculated by averaging scores for a number of separate cultural indicators of stream health. As part of the original development of the CHI, the original 30 indicators were reduced to 19 after further interviews with kaumatua and others from within the Ngai Tahu rohe. Some indicators were considered to be too subjective or unable to be clearly defined or readily measurable. Thus, only a subset was used. At the conclusion of the four river studied in development of the original CHI, a set of eight indicators was chosen for inclusion in the
Component 3:

1. Catchment land use;
2. Vegetation – banks & margins - (100m either side);
3. Use of the river banks + margins (100m either side);
4. Riverbed condition;
5. Changes to river channel;
6. Water quality;
7. Water clarity; and
8. A variety of habitats

5.5 COMPONENTS OF THE URBAN CHI

From the interviews conducted as part of the present research we know that the three components remain valid. From our analysis of the key themes from informants we also concluded that the indicators which are currently included in each of the components are still appropriate. Quotes supporting the current structure of the CHI are included in the following figures.

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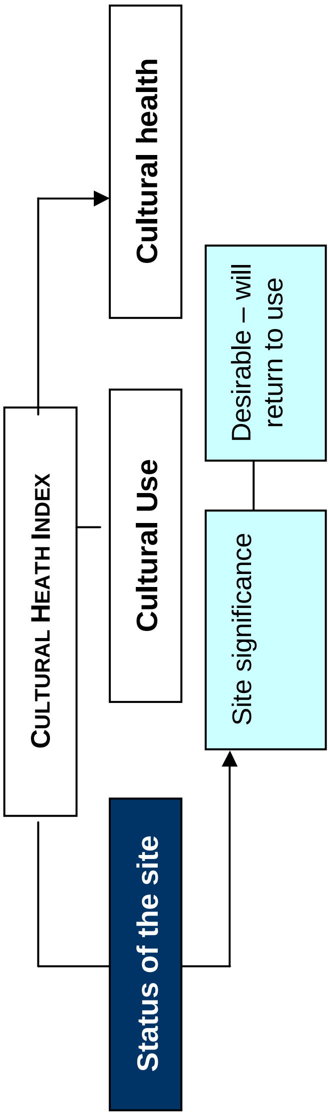
between hapu. The present system lets whanau identify species of importance. Further the range of species of only 1 of 4 indicators that determine the mahinga kai score.



Component 1: In the words of whanau

For my own whakapapa. I grew up playing in that river so my kids should have a bit of that too. You know, I have only good memories about the Kaikorai Stream….So for me it's part of my whakapapa, part of my history, part of who I am

I mean a healthy river for me, I would know its whakapapa, I would know it's name?

Make places available where you can enter and exit and play around with safely… so they would be shallow and open banks in some parts.

Improvements to the stream shouldn't just be thought of in terms of engineering and design physical landscape things. They should also be thought of in terms of our relationship and understanding on a variety of levels …people sharing understandings, feelings, relationships, histories and stories with demonstrations of relationship to those waterways.

The "urban stream" should be understood, 'cos all streams are different, they all have different catchments and characteristics and we should therefore have different relationships with them. So there has to be a level of understanding about the stream itself

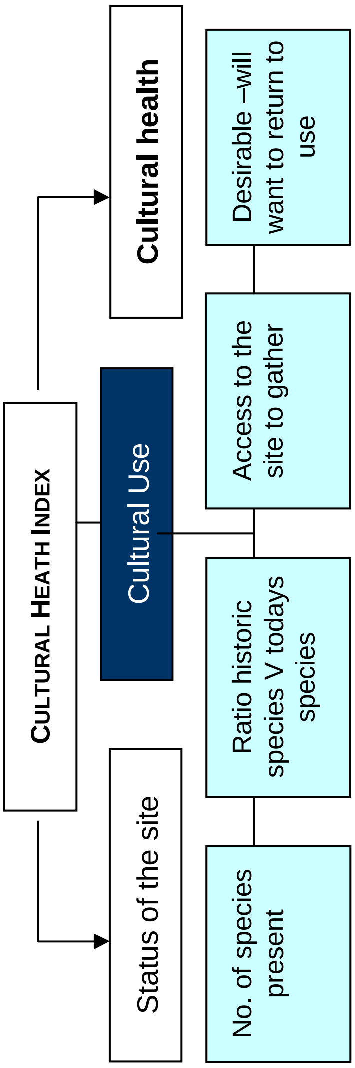
The stories of the river. How the river's changed. What's happening to it now

I could safely take my whanau back there, and knowing from our Maori community that it was safe.

Improving the banks and sides and so on of the Leith, in some ways will give more benefit to people than the actual to fisheries or wildlife benefits. It will certainly fix things up for eels, crayfish, trout and bullies, and the water fowl. But the big advance would actually be for people. There would be so many more nice places along that river to enjoy.

There'd probably be increased activity actually in the water.

Having a stream, an urban stream, good quality, running right through your city on your back doorstep has gotta be of really high importance in getting kids environmentally aware.



Component 2: In the words of whanau

You need to get access to it

You'd eat the kai out of them and fish safely and not going to be eating Mercury when you eat the fish, etc.

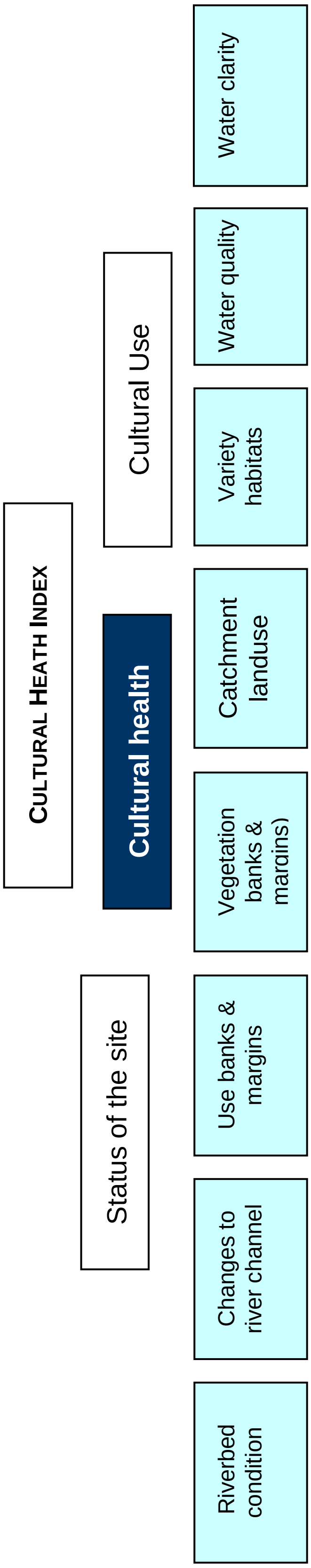
I could take my kids to play in that water safely, that I could safely drink out of it if needed. So that I could engage with it in a recreational way,and that I knew there were no run-offs running into that stream. That it was safe.

Most people have to go out of the city to collect watercress. But that's an indicator for me.

If our rivers could ever have the capacity of providing watercress again and that they weren't in hydroponics, that would be an indicator and I'd use those rivers again.

On a hot summer's day seeing people play in the river. That would be an indication that it was safe again.

Component 3: In the words of whanau



Riparian

- *The riparian plantings are really good and important*
- *Require people to manage their riparian margins so that they're minimising impacts,*

Water quality and clarity

- *The water would be pristine.*
- *You know you're not going to go near a waterway that stinks and smells stagnant. I mean seeing shopping trolleys and other bits and pieces floating down at times, you know it's not that healthy – and rubbish bags.*

Catchment landuse

- *There's commercial forestry in parts of those catchments…and there's the tussock grasslands and the higher alpine parts. I don't know in terms of percentages but we should know.*
- *In terms of the amount of coverage of the catchment with good vegetation*

Use of banks and margins

- *There needs to be buffer zones*
- *All these hard surfaces of concrete and roofs, and it just runs off into the stream. Picks up all the crap on the roads, and that gets onto the roads and then it gets washed into our waterways as well.*
- *The bank conditions in most parts are very steep and in many parts they're in concrete channels and/or very steep banks, which aren't very accessible, parts of it it's relatively normal and natural.*

Habitats

- *Urban stream should have systems that support diverse plants and fish and insects and birds*
- *It would have its wee pools and eddies and the riparian – the banks would be in natural state. There'd be birds, plenty of water fowl, you'd see sign of fish – you'd see people catching, fishing*

Vegetation of banks and margins

- *Ideal healthy streams would have cover. They'd be a bit more meandering, wandering.*
- *Surrounded by tree, rocks in the water and clear water, you can see to the bottom when its still. I could jump in it and drink it at the same time.*

Channel, sediment and riverbed condition

- *Usually when you think about an urban stream you probably think concrete sides, concrete bottom, things like that. Quite controlled in where it goes and how it goes, more than a natural flowing stream that might've flooded its banks every now and then. They're much more controlled obviously because there's infrastructure at risk if they flood.*
- *An urban stream is much more likely to be channelled in an artificial channel, and I think that brings certain problems with it.*
- *I'd like it to be allowed to follow it's own channel. I'd like it to be running over rocks and stones and shingle*
- *At the subdivision that they were doing and they had just basically ripped all the cover off the land, so it was just dirt and it had rained, and you could see the water was absolutely dirty, as it just ran through the mud, the dirt and bringing it all into the stream.*
- *Lots of sediments*

Our analyses, however, highlighted a need for greater in-depth investigations to accompany the cultural assessments by whanau. These additional investigations are summarised in Table 12:

Table 13: Recommended Responses to the Concerns of Whanau

In the words of whanau	How addressed in the present research	Recommendation
I guess the more natural they are the more healthy they are, But they're not, cos it's backed onto industrial where historically there was a lot of illegal and legal discharges …it's probably not that healthy.	Gathered data using a range of bio-physical and chemical parameters in addition to the cultural assessment to assess the "unseen"..	Include • Bio-physical testing, • Chemical parameters to assess water quality
I also understand that a lot of stormwater that runs into streams carries heavy metals in particular	Trialled a form to identify stormwater inlets along a reach of river.	• Inclusion of forms for identifying potential sources in the field. • Recommended process includes toxicology testing,
The stories of the river. How the river's changed. What's happening to it now. ...	Sourced material on Kai Tahu history in and around Dunedin[11]	Recommended process includes a Cultural Values Report.
• *You've got these mono cultural signs, that are about the European industries … Easy enough to, get new boards and put some 'new' combined information.* • *The information boards are sort of rotting and broken.*		Recommend more appropriate signage.
I have caught flounder and mullet, so the wildlife is certainly there, I don't know whether they were suffering from the pollution or not. …. I wouldn't think they were particularly clean at the time	Undertook toxicology tests based on the species that whanau said they gathered.	
It needs a focus on the industry that's discharging and must still be discharging through various ways.	Trialled a form to identify stormwater inlets along a reach of river.	Inclusion of forms for identifying potential sources of contaminants in the field e.g. outfalls..
• *Finding out where the discharges are getting into the stream, and it might be that well, it's getting in via stormwater, so why bother trying to solve where all the illicit stormwater connections are,* • *But there needs to be some means of better control of stormwater. Because that will inevitably reduce the amount of pollution going in, and if there's pollution going in*	Trialled a form to identify stormwater outfalls along a reach of river.	Inclusion of forms for identifying potential sources in the field.
Somebody reports a fish kill but how many go unreported?		Recommend a local hotline be advised to whanau
There's so much vested interest … I think you could spend a lot of money and not achieve a hell of a lot.		Recommend collaborative processes be employed.

[11] We were fortunate in having access to the Thematic Study completed by Potiki (2011).

5.5 RELEVANCE OF PROPOSED INDICATORS TO OTHER URBAN FRAMEWORKS

In Tables 14, 15 and 16 we identify the extent to which the indicators in the CHI and the additional tools that we propose relate to indicators utilised in other assessment processes. We have shaded those indicators that are incorporated in our proposed assessment process.

Table 14 Examples of Upland and Stream Corridor Metrics Used[12]

Upland Metrics	Stream Corridor Metrics
1. Current impervious cover	14. Subcatchment stream density
2. Current forest / bush cover	15. Stream corridor cover
3. Storm water pond density	16. Available area in stream corridor
4. Subcatchment development potential	17. Road crossings
5. Percent publicly-owned land	18. Storm water outfall density
6. Percent detached residential land	20. Connection to downstream waters *
7. Age of subcatchment development *	21. Public ownership of corridor
8. Percent industrial land	22. Violations of water quality standards *
9. Storm Water hotspot density *	23. Fishery status *
10. Condition of sewer system *	24. Steam corridor recreational value *
11. Sum of forest/parks/wetlands	25. Water quality regulatory status *
12. Citizen concern *	26. Severity of streambank erosion *
13. Community organization *	27. Severity of flooding problems *
Note: an asterisk indicates that metrics are derived from non-GIS sources of subcatchment information, such as stakeholder input, interviews, or analysis of water quality data.	

Table 15 Pollution Indicators[13]

Pollutant	Potential Cause
Nutrients	Fertilizer
	Lawn clippings
	Organic matter (Leaves, Lawn Clippings)
Oil and Grease	Stained driveways
	Long-term car parking
Trash/Litter	Trash in yards
	Dumping
Bacteria	If *not* present, potential from septic tanks
	Pet waste
Sediment	Erosion
	Driveways that are breaking up
	Sediment in curb and gutter

[12] Sourced from the documents found on the website for the Centre for Watershed Protection
[13] Sourced from the documents found on the website for the Centre for Watershed Protection

Table 16 Examples of Sentinel Monitors Indicators to Measure Progress Toward Goals[14]

Dry Weather Water Quality Indicators	
Fecal coliform (or other pathogen indicator)	●
Ammonia or phosphorus concentration	●
Benthic algal growth	O
Intra-gravel dissolved oxygen	O
Pesticide concentrations	O
Metal enrichment in bottom sediment	O
Turbidity	⦿
Biological Indicators	
Fish diversity (Fish IBI)	●
Aquatic insect diversity (Benthic IBI)	●
Single indicator species (e.g., trout, salmon, mussels)	●
Spawning or migration success	⦿
Riparian plant diversity	O
Pesticide levels in fish tissue	O
Physical and Hydrologic Indicators	
Stream habitat index (RBP or RSAT)	●
Riparian habitat index	⦿
Channel/Bank stability	⦿
Summer stream temperature	O
Average summer baseflow	O
Community Indicators	
Trash and debris levels during annual cleanup	●
Recreational use	⦿
Public access	●
Citizen attitudes toward streams	⦿

Key:
● = Excellent indicator, meets all of the selection criteria
⦿ = Decent indicator, meets 2 or 3 of the selection criteria
O = Specialized indicator, meets only one selection criteria

In the next chapter we apply the assessment framework (described in section 4.6), specifically the CHI and the additional assessments within the Dunedin City where two urban streams – the Kaikorai and the Leith – are found.

[14] Sourced from the documents found on the website for the Centre for Watershed Protection

Chapter 6: Stream Cultural Health Assessment – The Dunedin Case Study

In this chapter we take the assessment framework that we proposed in Chapter 4.6 and apply it to the Dunedin area and our two case study streams. The Dunedin City Council manages the collection, supply, treatment and distribution of water to domestic and commercial residents in Dunedin. This includes 21,000 hectares of water catchment, 16 treatment stations, 35 pumping stations and 57 reservoirs (raw and treated water). The total water pipe network has a length of 1,074km that conveys water from the source to individual property boundary. Although the case involved two streams, the urban footprint extended to the Taieri Catchment. As a consequence the Taieri was included part way through the assessment.

6.1 PROCESS

Consistent with the recommendation in 4.6 the following process was implemented.

- a catchment wide approach to the assessment was adopted;
- Tangata whenua undertook a range of assessments;
- The assessment process was not solely an assessment of present condition. Changes over time were recorded.
- Tangata whenua identified areas that required in-depth investigation. The results of these are also reported.

As noted above, the Taieri was included in response to concerns expressed by participants that urban impacts extended into the water supply catchments and it was therefore important to assess the cultural health of these rivers. Table 17 summarises how the different parts of the process were applied to the respective rivers.

Table 17: Summary of assessment process followed for Leith / Kaikorai compared with that for Taieri

Report Section	Description	Leith / Kaikorai	Taieri
Collection and interpretation of contextual information			
6.2	Urban water infrastructure footprint	✓	✓
6.3.1	Tangata whenua associations – Dunedin area	✓	✓
6.3.2	Tangata whenua associations – specific rivers	✓	
6.4	Catchment characteristics	✓	
6.5	Tangata whenua associations – urban water management	✓	✓
6.6	Impact assessment / historic changes – specific rivers	✓	
6.7	Changes to functioning of specific rivers	✓	
6.7	Changes to functioning - fundamental concerns	✓	✓
Assessment of current state			
6.8	Status of site	✓	✓
6.8	Cultural use	✓	✓
6.8	Cultural stream health	✓	✓
6.8	Biophysical parameters	✓	✓
6.8	Chemical parameters	✓	
6.8	Toxicity testing	✓	

6.2 PART A OF THE ASSESSMENT FRAMEWORK - A DESCRIPTION OF THE FOOTPRINT OF THE URBAN WATER INFRASTRUCTURE

The first part of the proposed assessment requires Tangata whenua to become familiar with the footprint of the infrastructure associated with water supply and waste management within Dunedin City.

6.2.1 The sources of water

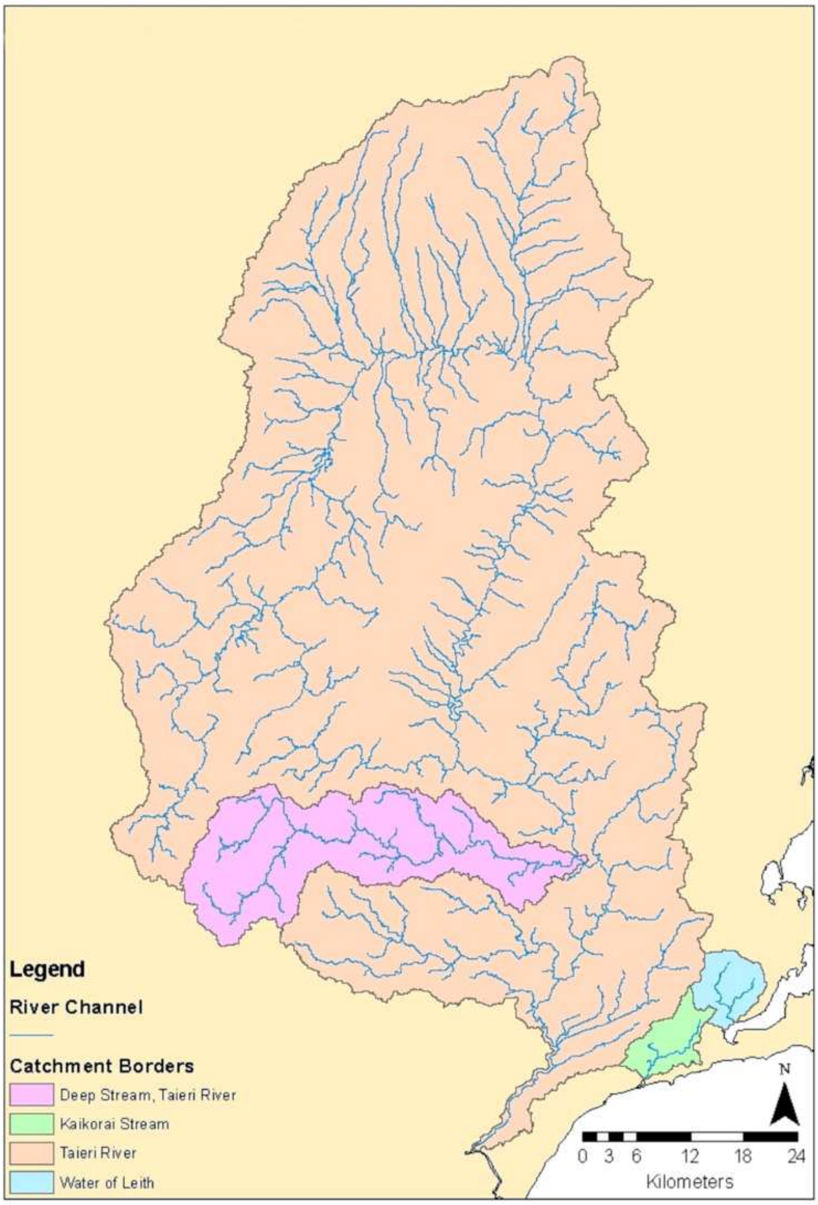
- Deep Stream, Deep Creek, the Silverstream and its tributaries are the main sources for Dunedin City.

Deep Stream and Deep Creek where they share the system with Trustpower….

- The Taieri Bores are used to augment the supply from these sources. The bores are an infiltration gallery on the banks of the Taieri River near Outram.
- The water for Mosgiel comes from wells which obtain water from the aquifer beneath Mosgiel
- Waikouaiti, West Taieri, Waitati and Warrington source water from the Waikouaiti River, Waipori River, Weatherstons Creek and unconfined springs respectively[15].

The location of these streams is shown in Figure 7 while their characteristics are summarised in Table 18.

Figure 7: The location of Taieri, Kaikorai & Leith Catchments from which Dunedin's water is sourced.



[15] Please note that for the rest of this report, we do not focus on water supply to outlying towns. The focus is largely the metropolitan area.

CATCHMENT	AREA (HA)	ELEVATION	MEAN FLOW	LOW FLOW	DESCRIPTION	KAIORA	CULTURAL VALUE[16]
Deep Stream and Deep Creek 16,150ha							
Deep Stream	10,350	424	2890	400	Situated in steep sided valley. Tussock vegetation over most of area. Deep Stream flows in deep valley downstream. Gravelly streambed upstream and rocky downstream of intake. Deep Creek flows in a deep native bush clad valley. Rocky streambed up and downstream of the intake.	Galaxiids	For the Taieri River in general - Kaitiakitanga, Mauri, Waahi tapu and/or Waiwhakaheke, Waahi taoka, Mahika kai, Kohanga, Trails, Cultural materials
Deep creek	5800	675	1450	164			
Silverstream 3880ha							
Silverstream Pumping Station		81	630	70	Topography varies from a large plain at sea level through to hills up to 1000m. There are 8 main tributaries and 4 major lakes in the catchment. The Silverstream is a major catchment of the Taieri. Native bush and forest largely cover the catchment area with tussock at higher elevations.	Trout, koura, eels, bullies, koaro, banded kokopu	For the Taieri River in general - Kaitiakitanga, Mauri, Waahi tapu and/or Waiwhakaheke, Waahi taoka, Mahika kai, Kohanga, Trails, Cultural materials
Whare Creek	320	158	71	8		Trout, galaxiids, koura,	
McQuilkans Creek	166	155	40	4		Trout, koura, koaro, eel,	
Sligos creek	410	155	100	11		Trout, koura, galaxiids	
Taieri Bores		1	35770	2550			
Ross Creek 4273ha							
Run off from Sullivans Dam					A steep sided dense bush clad valley. Tributaries have rock streambeds both up and downstream of intake.	Trout, eels, bullies, brook char	For Leith in general Waahi tapu and/or Waiwhakaheke, Waahi taoka,
West Creek Br	148	301	37	4			
Morrisons Burn (u)	93	309	29	3		Koaro	
Morrisons Burn (l)	148	208	36	4		Trout, koura	
Nicols Creek	144	175	35	4			
Ross Creek	175	149	41	5			
Upper Leith (Waitati) 5143ha							
Williams Creek	151	377	40	4	Very steep sided dense bush. Tussock at higher elevations.		For Leith in general Waahi tapu and/or Waiwhakaheke, Waahi taoka,
Burns Creek	152	385	39	4			
Jeffersons Creek		380	20	2			
Please note that we have not included Warrington or Sawyers Bay in the above table.							

Values for the Kaikorai include - Kaitiakitanga, Mauri, Waahi tapu and/or Waiwhakaheke, Waahi taoka, Mahika kai, Kohanga, Trails, Cultural materials

[16] Extracted from Schedule 1D of the Otago Region's Regional Water Plan.

Identifying the sources of water confirmed that Dunedin's water infrastructure cannot be understood by focussing solely on the Leith and the Kaikorai catchments. The "footprint" extends well into the Taieri Catchment, and the health of that catchment also requires analysis.

6.2.2 Treatment of raw water

It comes from the big reservoir up Brockville

Dunedin's water treatment plants use a variety of treatment methods to make the water clear and safe to drink. Raw water from the catchments can be dirty or contain harmful bugs, especially if there has been heavy rain. Each treatment plant also receives a grade from the Ministry of Health

- Two main treatment plants, Mt Grand and Southern, service the majority of Dunedin.
- The new Southern water treatment plant was commissioned in July 2005.
- Mosgiel's water is treated by five separate treatment plants.
- Port Chalmers water treatment plant is generally operated in the summer months only.
- The Outram treatment plant treats water for the Outram township.

I think the city water is poor. It tastes pretty bad. The city has a bit of a problem there,

I don't have any concerns about the drinking water except for probably some parts of town. When I used to live in High Street, every now and then our drinking water would be quite sort of rusty, because they've got really old infrastructure.

Our drinking water in Dunedin was of a lower quality but since Mount Grand that system is very good (see Mount Grand reservoir in photo below).

6.2.3 Distribution

From up the back in the Lammerlaws and the Lammemores …it conveys water about 60 kilometres

Distribution, from the water treatment plant to the customer, is achieved using a network of pipes, treated water reservoirs and valves. The primary distribution system conveys water from storage at the treatment plant to service reservoirs in outlying areas. The primary distribution network has 174km of pipe that varies in size from 25mm to 750mm in diameter. The majority of the pipelines are steel and asbestos cement pipes. The reticulation system has 726km of pipeline made of a variety of materials. In urban areas, water is reticulated to the property boundary of houses and businesses. The actual connection for supplying water to a property is located at the roadside boundary of each property. A schematic showing the sources of water, the location of treatment plants and the areas they service is provided in Figure 8.

6.2.4 Treatment plants

Dunedin's eight wastewater treatment plants service communities ranging in size from 100 to 83,000. The following table shows the details of each community's reticulation system.

Community	Reticulation	Treatment Method	Annual discharge
Metropolitan	568.6	Primary sedimentation with treated wastewater discharged at Lawyers Head	18,993,000
Green Island	131.6	Secondary treatment with UV disinfection. Treated wastewater discharged to ocean outfall	2,447,000
Mosgiel	74	Secondary treatment and disposal via Green Island WWTP	1,653,000
Port Chalmers	34.5	Via metropolitan scheme	N/A

Green Island treatment plant - The Green Island Wastewater Treatment plant is to the south of Green Island and borders the Green Island Landfill and the Kaikorai Estuary.

- Grit and plastics etc within the wastewater are removed by grit traps and 1 mm milli-screens. The wastewater then goes through several processes before it reaches the secondary treatment process, UV disinfection.
- The screened liquid enters the first of three aeration tanks. Rotary lobe air compressors supply process air through a series of pipes and diffusers. The diffusers emit air as tiny bubbles into the wastewater from the base of the aeration tank. A surface aerator is also used.
- A bacterial mass or "floc" is formed containing large numbers of very active bacteria, together with ciliates, rotifers and protozoa. The bacteria grow rapidly under these ideal conditions, consuming the organic

material in the wastewater.

- After leaving the activated sludge tanks, the mixed liquor suspended solids flow to a large circular tank known as a clarifier. The sludge, which settles to the floor is removed and a proportion returned to the inlet end of the activated sludge reactor where it "seeds" the incoming influent.
- The process is repeated again with the liquid being pumped into aeration tanks.

For activated sludge,

- A proportion of the sludge produced in the A & B processes is returned to the aeration tank it came from. This is known as returned activated sludge.
- The other portion of sludge, called waste activated sludge, is sent to the thickener. The thickener concentrates the sludge by removing excess water. This sludge is then transferred to the thermophylic digester and then to the mesophylic digester.
- Sludge from the mesophylic digester is transferred to one of two centrifuges.

Disposal and discharge - With respect to disposal and discharge, centrate is returned to the wastewater stream for processing. Sludge is mixed with lime and disposed of at the Green Island Landfill. The final treated effluent from clarifier No. 2 is UV disinfected and discharged via diffusers at the end of an 850m long ocean outfall.

Mosgiel wastewater treatment plant - The Mosgiel Wastewater Treatment Plant is at the end of Carlyle Road, Mosgiel. This secondary plant treats the wastewater of approximately 10,000 people as well as minor trade wastes. Major industrial wastes near Mosgiel are piped separately through to the Green Island Treatment Plant.

- Wastewater passes through a stepscreen removing gross solids. A grit trap collects heavier particles. Next it passes through a primary clarifier, a biological rock filter and a secondary clarifier.
- The treated effluent is stored in the effluent holding tank and then pumped to the Green Island Wastewater Treatment Plant. Mosgiel secondary wastewater is UV treated at Green Island before discharge to the ocean outfall.

Musselburgh pump station - The Musselburgh Pump Station is the main pumping station for metropolitan Dunedin. Wastewater largely gravitates to Musselburgh and from there it is pumped to the Tahuna wastewater treatment plant.

- Wastewater is screened through 2mm screens. Screenings are collected and taken to the Green Island Landfill for disposal. Approximately 300kgs of screenings are removed each day.
- There are seven pumps available to pump the wastewater to the Tahuna wastewater treatment plant. Under normal, dry weather, conditions only one pump is used.

- The air within the plant is removed and filtered through a bio-filter to remove odours before being discharged to the atmosphere.

Tahuna wastewater treatment plant - This plant (see photo below) formerly known as the Dunedin Water Pollution Control Plant, was constructed in 1981. Since then, it has undergone a number of improvements.

- Screened wastewater from the Musselburgh pump station enters three primary sedimentation tanks. Here around 65.7% of the suspended solids, 61.2% of oils and greases and 33.8% of BOD is removed.
- Oil and grease, which float to the surface, and sludges that have settled on the bottom are collected by moving bridges with surface and bottom skimmers. The scum and sludge is transferred to a thickening tank. Oil and grease skimmed off the surface of the thickening tank are concentrated and sent to the scum tank. Sludges are concentrated in the bottom of the thickening tank.
- Sludge is de-watered and is pumped to one of three belt presses where, aided by polyelectrolytes, more water is removed. The de-watered sludge, at between 30% - 35% dry solids, is fed into the incinerator. The fluidised bed incinerator burns the sludge, oil and grease at around 825 degrees C.
- The gases produced are mechanically washed with water to remove ash and to cool the gases. The gases from incineration and ventilation air from other areas of the plant are collected and passed through a bio-filter to remove odours before being discharged to the atmosphere.
- Treated wastewater flows by gravity to Lawyers Head where it discharges into the sea.

While tangata whenua supported the upgrade at Tahuna they remain cautious –

It's going into the ocean now, and the concern there is that the city sticks to the program of upgrading their treatment plant to maximise available technology and reduce even further, the contaminants going into the ocean. But in the harbour it's good because they've taken out, you know – those sewerage discharge points, mainly from the peninsula and those communities down towards Port Chalmers. It .. now goes out of Tahuna.(see below)

6.2.5 Monitoring the changing hydrology, quality and biota of receiving waters

The Lawyers Head wastewater outlet was commissioned in 1908. At the time it was a huge improvement from previous methods of wastewater disposal dispersing the waste into the upper Otago Harbour. Discharged wastewater was untreated until the mid 1950s when coarse screens were installed at the Musselburgh Pump Station. In 1966, additional treatment was provided with the installation of comminutors at the Tahuna Waste Water Treatment Plant. Since 2000, the DCC no longer discharge wastewater into the Otago Harbour.

The DCC has monitored some 60km of coastline stretching from Akatore in the south to Victory Beach in the North for over ten years. Sites include: Akatore, Taieri Mouth, Bruce Rocks, Brighton, Black Head, Second Beach, Lawyers head, Smaills Beach, Boulder Beach, Sandfly Bay (south end and north end), Allans Beach and Victory Beach.

This monitoring has revealed no adverse environmental effects attributable to either the Green Island sewage outfall at Waldronville or the Tahuna sewage outfall west of Lawyers Head. All sandy and rocky shore communities examined remain healthy and exhibit no change outside natural variability. Mussels and seawater are regularly sampled at each of the above sites and analysed for microbiological contamination. To date, these analyses have shown that there is some contamination of shellfish at Second Beach, Lawyers Head, Smaills Beach and Boulder Beach on rare occasions. All other beaches are essentially free from microbiological contamination that could be linked to sewage.

The commissioning of the new extended wastewater outfall from the Tahuna wastewater treatment plant has led to a decrease in bacterial levels on Second Beach, Lawyers Head, Smaills Beach and Boulder Beach bacterial such that an acceptable recreational standard is now the norm.

Whole effluent toxicity testing (WETT) is carried out on Dunedin effluent annually by NIWA. This tests the toxicity, or effect, of the treated wastewater discharged from the two wastewater outfalls on a variety of small marine organisms. This testing shows that the wastewater at both sites is sufficiently dilute within the allowable mixing zone as to have no effect on local marine life. Indeed, divers examining the Green Island and Tahuna outfalls report healthy and varied marine life, including sponges, blue cod and crayfish, actually living around and under the outfall diffusers.

Additionally, the discharge consent for the Green Island Treatment Plant requires that water quality to the east and west of the Green Island outfall be monitored annually. To date this monitoring has shown that nutrient levels in the water either side of the outfall has nutrient (nitrate and ammonia) levels no different to levels in the coastal waters off other parts of the Otago coastline.

Tahuna Wastewater Outfall results

Since the Tahuna Wastewater Outfall began operating, the DCC have been monitoring the bacterial count around the outfall, from Second Beach to Maori Head, almost every day. The 1100m length of the outfall means that the wastewater is being discharged into approximately 20-25 metres of water. This is the first time in 100 years that it has been safe to swim at Tomahawk Beach.

DCC measure enterococci and faecal coliforms as indicator organisms. The more there are of these, the more likely it is that there will also be pathogens, such as viruses, present.

While faecal coliforms come from many sources, including farm runoff and wildlife, the DCC also measure the amount of Fluorescent Whitening Agents (FWA) in stormwater discharges in the area. High levels of FWAs indicate that the faecal coliforms are more likely to come from human sources. (FWAs are the whitening agents used in many detergents and cleaning products.)

DCC flush the outfall daily for about ten minutes so it continues to work properly. The results of this can be seen as a plume for about half an hour after the flushing is completed because of the much higher flows than normal. The plume can also be seen during wet weather events, again due to the higher flows. This is despite the fact that Dunedin has carried out a lot of stormwater and wastewater separation, as stormwater still gets into the foul sewers during very rainy weather.

Near the end of the outfall, there are eight diffuser units. Each unit has four tideflex valves (32 in total) that diffuse the wastewater over a larger area rather than sending one big gush out of the end of the outfall. At this point at normal flows the wastewater and seawater mix together thoroughly.

It is important to note stormwater outlets affect the levels of indicator organisms in the water but they are in no way related to the effective operation of the wastewater outfall. The stormwater system carries natural runoff from land, roads, gutters and roofs (rain) directly to the nearest watercourse. The likelihood of pollution getting to sea is related to the amount of rain and where the pollution comes from. The four main stormwater outlets that affect readings at monitoring sites are situated at:

- Second Beach - stormwater outfall for much of St Clair
- Beside the St Clair Hot Salt Water Pool - a watercourse coming from above and through St Clair on the

hillside above St Clair beach

- Tomahawk Lagoon - usually filtered through sand unless the lagoons are particularly high
- Tomahawk Creek at the base of Maori Head on Smaills Beach - a watercourse draining much of Smaills valley

6.3 PART 2 OF THE ASSESSMENT FRAMEWORK - TANGATA WHENUA ASSOCIATION WITH WATERWAYS

6.3.1 HISTORIC ASSOCIATIONS WITH THE DUNEDIN AREA

In pre-contact times the land area was almost completely clothed in mature native bush providing for a myriad of needs of takata whenua, be it edible plants and roots, medicinal needs, weaving resources for clothing and daily accessories, firewood, materials for daily hunting and fishing purposes or for whare and waka construction. The forests were festooned with bird life that provided an important source of food and cultural materials for clothing and decorative purposes.

Ingoa tawhito - Place names along the coast record Kai Tahu history and point to the landscape features which were significant to people for a range of reasons. For example, some of the most significant rivers which enter the coastal waters of Otago include: Waitaki, Kakaunui, Waihemo (Shag), Waikouaiti, Kaikarae (Kaikorai), Tokomairiro, Mata-au (Clutha), and Pounawea (Catlins). Estuaries include: Waitete (Waitati), Ōtākou (Otago), Makahoe (Papanui Inlet), Murikauhaka (Mata-au and Kōau estuaries), Tāhaukupu (Tahakopa Estuary), and Waipātiki (Wapati Estuary). Islands in the coastal area include Ōkaihe (St Michaels Island), Moturata (Taieri Island), Paparoa, Matoketoke, Hakinikini, and Aonui (Cooks Head).

Tupuna – ancestors - T□puna such as Waitai, Tukiauau, Whaka-taka-newha, Rakiiamoa, Tarewai, Maru, Te Aparangi, Taoka, Moki II, Kapo, Te Wera, Tu Wiri Roa, Taikawa, and Te Hautapanuiotu are among the many illustrious ancestors of Ng□ti Mamoe and Kai Tahu lineage whose feats and memories are enshrined in the landscape, bays, tides and whakapapa of Otago.

Urupa - Numerous urupa are being exposed or eroded at various times along much of coast. Water burial sites on the coast are also spiritually important and linked with important sites on the land. Places where kaitangata (the eating of those defeated in battle) occurred are also wahi tapu.

Mahika kai

The head of the harbour was a strong activity place for mahinga kai, there would have been huge areas of tidal estuary … the breeding grounds for all the fisheries and what have you, plus whatever else they could – flounders, you name it – they would have been rich in kai. … So it was quite a strong mahika kai place and there were some villages up here, but the main villages were down at the mouth of the harbour….mainly on Te Otakou side of the harbour.

The whole of the coastal area offered a bounty of mahika kai, including a range of kaimoana. Many reefs along the coast are known by name and are customary fishing grounds, many sand banks, channels, currents and depths are also known for their kaimoana. One example is Poatiri (Mt Charles - Cape Saunders) the name of which refers to a fish hook. Poatiri juts out into the Pacific, close to the continental shelf, and is a very rich fishing ground. Another example is Blueskin Bay which was once a kōhanga (breeding ground) for the right whale, although it is well over 150 years since it has seen this activity.

Cockles from Otago Harbour – a taonga for which the area is renown

Ara tawhito - The Otago coast was also a major highway and trade route, particularly in areas where travel by land was difficult. Pounamu and titi were traded north with k□mara, taro, waka, stone resources and carvings coming south. Travel by sea between settlements and hapu was common, with a variety of different forms of waka, including the southern waka hunua and, post-contact, whale boats. Hence tauraka waka occur up and down the coast in their hundreds.

Settlements - Chiefs such as Kōrako (several), Tahatu, Honekai, Ihutakuru, Karetai, Taiaroa, Pōtiki, Tuhawaiki, and Pokene were some who had their own villages and fishing grounds. Otago Peninsula (Muaupoko) had many kāinga nohoanga with a multitude of hapu occupying them.

At one time up to 12 kāinga existed in the lower Otago harbour, some larger and more important than others.

Notable p□ on the Otago coast include: Makotukutuku (Oamaru), Te Raka-a-hineatea (Moeraki), Te Pa Katata, Pa a Te Wera, (Huriawa Peninsula), Māpoutahi (Pūrākaunui), Pukekura (Taiaroa Head), and Moturata (Taieri Island). The estuaries from the Waitaki River to the Chaslands also supported various hapū.

Dunedin City with Otago Harbour (centre) and Otago Peninsula (right)

Additional contemporary ties

- Otago Peninsula is the centre for Te Runanga o Otakou
- Whanau still retain significant landholdings on the peninsular.
- Ngai Tahu are now joint mangers of Pukekura, the fortified pa at Taiaroa Head, and the Otago Harbour.
- Te Runanga o Otakou have aspirations to establish a mataitai in Otago Harbour.
- Arai te uru Marae is found in Shetland Street, Kaikorai.

The taoka species, kai moana and cultural materials associated with Otakou Peninsula The coastal area offered a bounty including sea fishing; eeling and harvest of other freshwater fish in lagoons and rivers; marine mammals providing whale meat and seal pups; waterfowl, sea bird egg gathering and forest birds; and a variety of plant resources including harakeke (flax), fern and ti root. In many areas the reliance on these resources increased after the land sales of the 1840s and 1850s, and the associated loss of access to much traditional land-based mahinga kai. Other resources were also important in the coastal area. Paru (black mud used for dyeing) was obtained from some areas. Some of the permanent coastal settlements, such as those at the mouth of the Mata-au (Clutha River), and at Otakou and Purakaunui, were important pounamu manufacturing sites. Trading between these villages to the south and north via sea routes was an important part of the economy.

Customary fisheries today

As a result of the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 and the Ngai Tahu Claims Settlement Act 1998, Kai Tahu has assumed a greater role in the management of fisheries, in particular customary fisheries. Provisions available to Ngai Tahu to protect their interests include:

- establishment of taiapure
- establishment of mataitai
- establishment of marine reserves
- closures pursuant to s.186 of the Fisheries Act 1996

Figure 9 below shows where these mechanisms have been applied in southern waters. As noted previously Te Runanga o Otakou want to establish a mataitai in Otago Harbour.

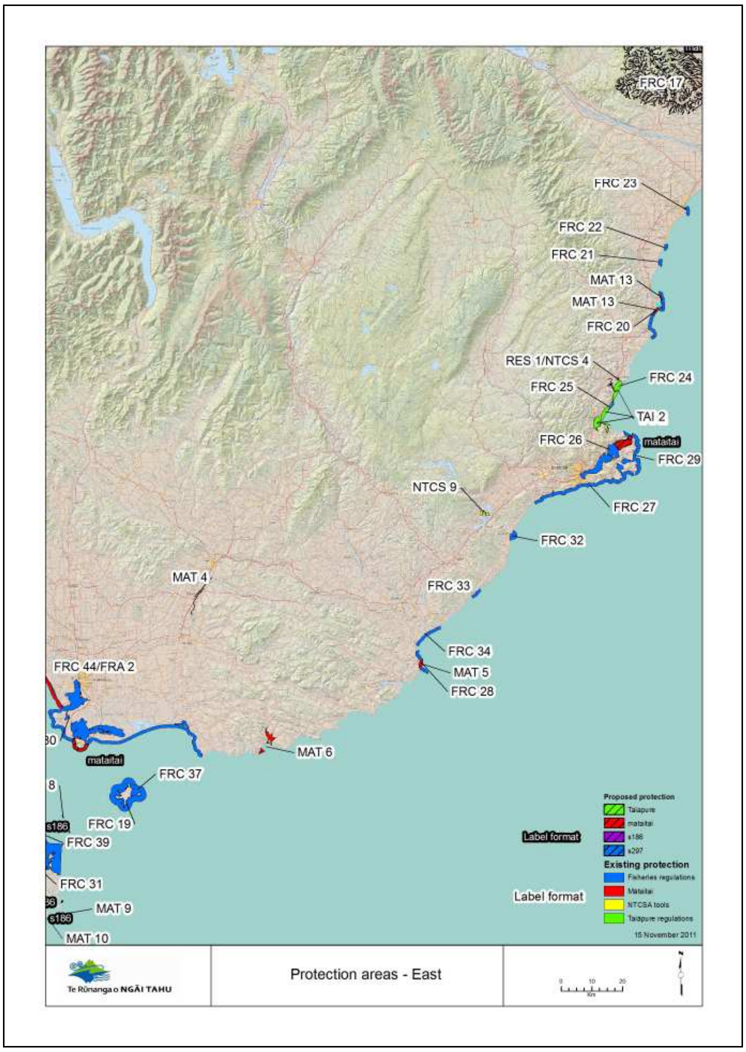


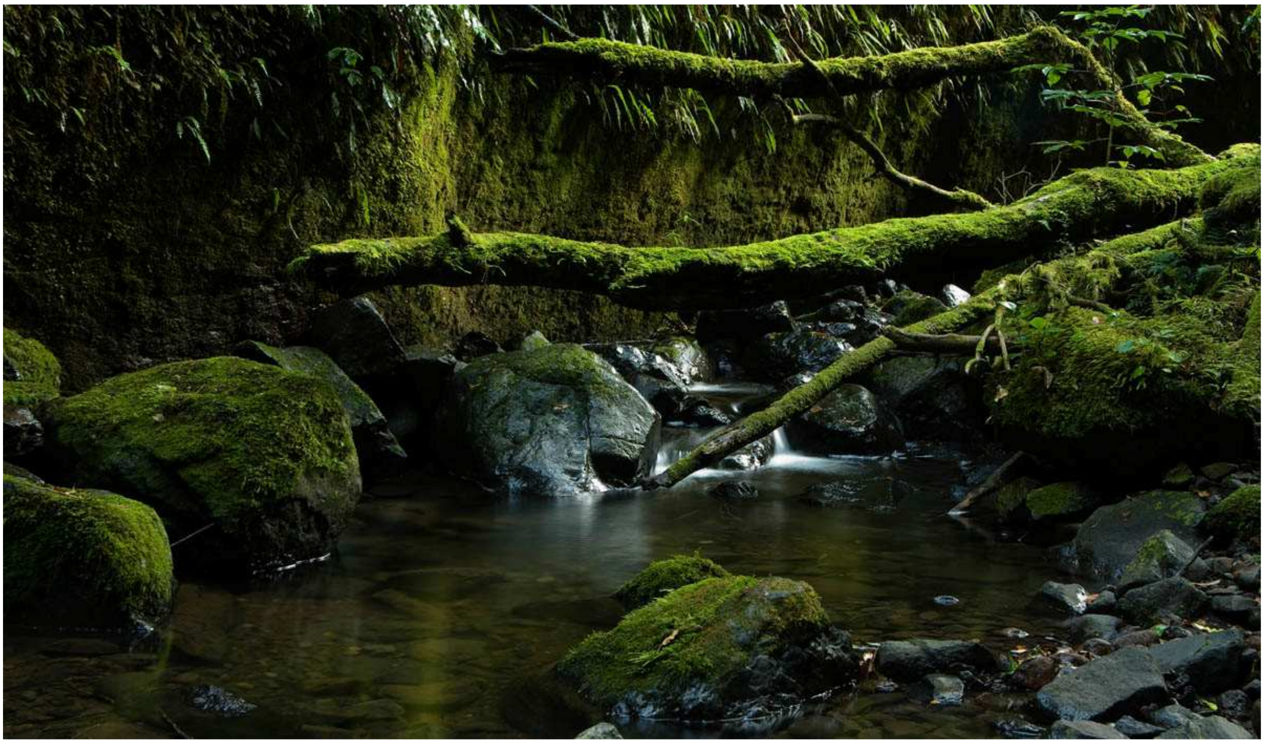
Figure 9: Protective measures for coastal resources of Southern New Zealand

Having reflected on the environment in and around the Dunedin area it is necessary to focus on the two case study catchments – the Leith and the Kaikorai.

6.3.2 HISTORIC ASSOCIATIONS WITH THE LEITH AND KAIKORAI

Owheo (Leith Valley)[17]

Its natural state would have been a place for tuna, for eels, and inaka as well, and access up into those valleys for manu and various mahika kai that they could gather in that catchment. And there were villages near there as well, down by the lower end of the Leith or the Owheo – Owheo we call it.



One particular story tells of Pakihiwitahi, a senior crew member, who sent his servant girl, Puketapu, to collect firewood following the wreck. She travelled as far as Southland to gather the wood and was carrying it back tied Maori style to her back when some of the firewood fell off at the Ōwheo Leith River . A clump of forest immediately sprang up at the point the wood fell to the ground becoming the bush around Ōtepoti. Other firewood fell at Waitete Waitati , Puketeraki, Kā Iwi-O-Te-Weka (Mount Baldie) and Ōwhata (Goodwood). Eventually the sun caught Puketapu just before she returned to her master. Puketapu is now known as the conical hill that overlooks Palmerston whilst Pakihiwitahi is the one-shouldered hill that State Highway 1 cuts through at the southernmost point of the Katiki straight.

It's fairly steep so if it rains it comes down, it rises, they rise quickly …The channel is a fairly tight channel as well.

[17] These two descriptions of the historical associations are drawn entirely from the Thematic Study by Potiki 2012. Quotes of whanau are once again shown in italics.

A natural route would be off the Owheo Stream came right up to Saddle Hill … it was a waterway that would carry waka, so they would get into the Taieri and end up in the wetland… So it was sort of a bit of a motorway.

Kaikorai

The Kaikorai is important in one aspect because in our traditions Rakaihautu who was the first known human explorer of the South Island… camped at the mouth of the Kaikorai and had a feed of Karae or sea bird - Kai-kar-ae…..And so the place was named Kaikarae – k-a-r-a-e - you could say that is the first name ever given to a place here in Ōtepoti, in Dunedin.

Rākaihautu is associated with the Uruao canoe and the Waitaha people. There are several different versions of the journey but the storyline recounts Rākaihautu leading the people away from war on a small island in the Pacific. Their canoe made landfall in Marlborough and then the party split up. Rokohouia, Rākaihautu's son, took the canoe and explored the coastline of the South Island while Rākaihautu led the exploration of the land on foot. With the help of a mighty digging stick Rākaihautu discovered, named and dug out nearly all the significant freshwater lakes in the South Island. He started at Rotoiti and continued his inland journey through the McKenzie Country and Central Otago, discovering all of the interior, glacial fed lakes.

Eventually Rākaihautu circled through Southland and while heading north he came upon, and dug out, Lake Waihola. Rākaihautu and his party then stopped at the mouth of Kaikorai Stream.

Now where that bridge is a very strong archaeological site. It was also a site, a sand mining site. We believe the company who owned that had the rights for 50 years, picked up an awful lot of taonga…..Disturbed an awful lot of archaeological values, but that's where an old village was….That village would have been there for a long time, and the estuary would have been a major mahinga kai site because it was much bigger in a much natural state and there would have been water fowl, eels, inanga – all of those things you get in and around a lovely wetland

Hamel (2001) identified approximately 30 moa hunter sites within the Dunedin area. They include sites ranging from Tumai in the north to Kaikorai Estuary in the south. The most significant sites identified, in terms of the extent of archaeological evidence of activity and occupation, were Warrington, Harwood, Little Papanui and Kaikorai Estuary. Kaikorai was occupied in the archaic phase of New Zealand pre-history. Burnt moa bones, adzes, blades, small stone statues, fish hooks, obsidian and nephrite flakes have been recovered from this area. Much of this excavated material is now housed in the Otago Museum. Settlement was centred around sand-dunes on the north side of the Kaikorai stream. Maori in the area lived off shellfish and moa. This area was not occupied at the time of European arrival.

The significance of Kaikarae as a place of mahika kai stems from the time of Waitaha and the Rākaihautu traditions. Since that time the area was the site of seasonal and semi-permanent camps. Kāi Tahu utilised the Kaikarae area to supplement their seasonal food supplies, the mouth of the estuary being the favoured camping site. The mahika kai resources included eels, waterfowl, birds and kaimoana.

6.4 CHARACTERISING THE CATCHMENTS

Owheo – Once again we have chosen to use the words of whanau to characterise the two study catchments.

[The Leith] was probably bush clad both sides, a rocky stream, it wouldn't rise and fall much like it does now because if you go upstream, where it's just native bush, it's gotta rain a lot to get the stream to even start going up…Te bush absorbs it all and lets it go out slowly. So it rises a little bit, it takes a while to settle back down, but one thing we definitely are missing is an estuary. It would've flowed out into the harbour. There was Lake Logan and it would've progressed out into the harbour through one or several different branches or channels going across mudflats….At low tide some of those channels may dry up, some may be small amount of water, there may be a main channel, and then at low – as tide increases, it will cover those and flow up the lower part of the channel.

There would be some eels through it, long fin eels, no short finned. So that part of the stream, probably not changed markedly except there may have been some common bullies, there may well have been some form of galaxid, a non-migratory type galaxid in its reaches, which since brown trout have found their way in, no longer exist. There would be some of the other whitebait species

The Leith is still steep, it's got good access 'cos there's a road through there now.

Come downstream to the gardens area, the Woodhaugh Gardens, the stream then enters areas where there's been concrete channels built to contain the stream, and at that point the quality of the habitat is diminished, it doesn't have the same riparian zone qualities, therefore it won't get terrestrial bugs and so on forming into the river to the same degree that it does upstream

The Leith's getting there it just needs some sorting out of those concrete channels and areas in the bottom.

Down into the university campus, some of the areas got grassed areas where there's scope for widening the channel and getting proper stream structure.

Where they've got the space in the DCC reserve areas of the gardens and so on, upstream of Dundas Street, they've been able to think more ecologically with an amenity focus.

Kaikorai

The Kaikorai River behind Kaikorai Valley High School

It starts there in a relatively small little channel, which at the marae was just a bog hole for many years, but has actually been planted out and not mowing it to the waters edge anymore, and although it appears to be a ditch about a metre or so wide and half a metre deep, it probably –does provide quite good habitat. Gravel bottom, overhang – banks with lots of overhanging grass. But it only goes a short distance to an area where the DCC have actually recently built a little wetland area behind some houses between Nairn Street and the playing fields just near Stuart Street….Then below that it goes into a pipe, underneath the playing fields, underneath Stuart Street and Taieri Road and joins on not far below to Fraser Creek

So in the upper parts of the Kaikorai it's largely residential/domestic, a few schools and the golf course. And then the lower parts it goes through the Green Island built up area, which is more commercial and older industrial. And the Leith/Lindsey goes through parks and reserves, and mostly through urban areas, domestic/residential and then a few sort of that commercial and that lower stretch going out to the harbour pass the art school,

As you go further down on the Kaikorai Stream though, it goes into an industrial area, and that whole stretch has a history of regular fish kills through discharges of all sorts of stuff into the river – on average I wouldn't be surprised if fish kills were reported in that stream on average of once a year. …I've seen car auto paint shops about halfway down through the valley, just tipping their waste, thinners and so forth, just straight down the bank

And as you get further down then there's the Burnside Freezing Works. In past years waste was discharged directly into the river, and then you had the cement works, where I actually worked at in summer and appalling coloured stuff used to go in the river there, black stuff, probably come out of the kiln, or wash water for the coal, -

Nowadays, the area's probably not much better, it's just not noticed as much. Timber around there been cut up for firewood and other things, and lots of areas have just dug up mud and so on, with different industrial type things going on. When it rains all that's gonna end up in the river. And then it goes down through Green Island, which probably isn't so bad for it nowadays, there would've been, there was the tanneries there – and they once would've discharged anything and everything into the river . After that though is the landfill. It has a leachate catchment system around it, and I would hope that that system is working well.

And then down into its lagoon at the end, and finally into the sea. With no surge discharges going to it, it in theory should be nice, clean, estuary water – but it's not. It's not because of the industrial waste and so forth that is still going into it and the urban wastes and runoff – from the roads and all the rest that go into it, and it gets down into that estuary, and because the bar's blocked off at the Waldronville beach for 70 percent of the time, it just sits down there and accumulates whereas in the Leith, it'll get a lot of that urban runoff from roads and homes and houses, but it goes straight into the harbour and out with the next tide.

The estuary also got a huge amount of bird life in that estuary…There's black swans swimming in the area but there would've been paradise shelducks in smaller numbers, but there would've been a lot of grey duck and there would've been shovellers and there would've been pukeko, and they would be the main species in that area, and they would've been all easily available to harvest…. So in that area you've probably got black flounder plus yellow belly flounder probably, and short and long fin eels spoonbills.. And there probably would've been also the little black scaup or diving duck around too in great numbers.

It would've meandered through a bigger wetland, perhaps a miniature version of the Taieri Wetland, and probably had a central channel.

The Kaikorai Stream I don't consider a healthy stream…..If you look at the Abbotts Creek sub-catchment, having driven through that catchment in the last few days and studied it on Google Earth, that part of the sub-catchment, is absolutely stuffed.

The positives for the Kaikorai is the amount of freshwater that gets introduced from Mount Grand, coming down Frasers Gully.

The negatives are the golf course (in my mind), and then runoff from streets and domestic homes, I'm sure that people use horrifying amounts of pesticides and herbicides in their gardens that will filter into the river. But my understanding is that the biggest thing is runoff from the roads…And then it has to get down passed the dump….On the other side the Fulton Hogan dump, has made me a bit worried cos they handle more industrial waste.

"I feel sad" for the Kaikorai, understanding how it used to be.

6.5 ASPIRATIONS OF TANGATA WHENUA WITH RESPECT TO URBAN WATER MANAGEMENT

Tangata whenua will engage in water management to achieve specific outcomes. The data collected from any assessments completed needs to be analyzed within the context of Tangata whenua aspirations for urban environs and urban streams. In addition to the words of whanau themselves, Iwi Resource Management Plans often provide such descriptions.

It's really those iconic rivers and streams that we could try and restore and make a centre piece …. particularly the Leith.

Improving the water quality, the access, and those riparian margins, bringing back that naturalness

Enhancing mahika kai values even to the point perhaps of being able to catch something and eat it. Those sort of things I think would attract me, or people back to recreate

It's just managing better the entire length of the Kaikorai and doing what they can and creating a long term vision to incrementally lift and improve that whole stretch including the wetland, over time – it could be a hundred year plan

You'd eat the kai out of them and fish safely

The water would be look pristine.

I could take my kids to play in that water safely, that I could safely drink out of it if needed. So that I could engage with it in a recreational way, and that I knew there were no run-offs running into that stream. That it was safe.

Other aspirations that are articulated in the KTKO Iwi Resource Management Plan include

- Protecting the harbour and the resources it affords tangata whenua;
- Protecting and enhancing natural water systems;
- Integrating stormwater treatment into the landscape – to maximise the visual and recreational amenity of the stormwater drainage system with park and walking paths, making use of natural topography such as creeks and ponding areas;
- Protecting water quality from urban developments into receiving environment;
- Reducing runoff and peak flows - reducing peak flows and the frequency of runoff events from urban development by local detention measures and minimising impervious areas;
- Adding value while minimising development costs - The reduction of drainage infrastructure due to reduced peak flows and runoff minimises the development costs for drainage, whilst enhancing more natural features;
- Protecting the health of riparian/wetland areas and ensuring they are not subject to degradation from upland catchment;
- Protecting water quality ensuring that it maintains healthy aquatic, soil and vegetation communities that support biodiversity;
- Maintaining a diverse composition of species and vegetation types/structure;
- Protecting native (and/or desired) species from invasive species;
- Preventing excessive erosion, deposition or soil loss;
- Maintaining physical/chemical properties (e.g. texture, pH, salinity, permeability, organic C, pollutant levels) appropriate for the given landscape and the habitat needs of taonga species; and
- Maintaining nutrients via natural processes in levels and frequency similar to pre-disturbance condition.

The outcome for tangata whenua, if all of these actions were implemented for either the Kaikorai or the Leith, would be -

To give it back its mauri, we need to give it back its life

Protecting the mauri of a waterway is the fundamental management principle of tangata whenua.

Policy Framework

Te Runanga o Otakou has also identified in the Kai Tahu Ki Otago Iwi Resource Management Plan a number of policies to help realise their aspirations.

1. To establish a Mātaitai in the lower harbour/outer peninsula.
2. To promote efficient use of domestic water within the Otago Harbour Catchment, including dual flush toilets in new housing, water efficient shower systems.

3. To require the reticulation of stormwater from roading in the Dunedin central business district and industrial area.
4. To promote best practice methodologies for drain maintenance, diversion and channel cleaning within the Catchment.
5. To promote best practise methods for waterway, river and harbour works that:
    a. Provide for fish passage at all times.
    b. Minimise sedimentation during proposed works.
    c. Minimise the risk of contaminants entering any waterway
6. To require the reticulation of all industrial discharge.
7. To encourage the development of sewerage infrastructure to receive and treat all waste water discharge from tourist vessels.
8. To protect pa sites from earth disturbance and modification.
9. To identify and protect mahika kai sites of importance to Ka Papatipu Runaka in the Otago Harbour Catchment.
10. To restore and enhance biodiversity with particular attention to fruiting species to facilitate and encourage the breeding of native birds.
11. To encourage the reintroduction of species of importance to Ka Papatipu Runaka that are no-longer present in the Otago Harbour Catchment.
12. To promote the adoption of Statutory Acknowledgements into regional and district plans and regional policy statements
    a. To promote the recognition of place names amended under the NTCSA and their use in regional and district plans, policy statements and non-statutory planning documents
13. To encourage the use of Kāi Tahu place names in addition to those amended under the NTCSA 1998.
14. To protect important landscapes, landforms and features of significance from inappropriate activities such as mining and earthworks, subdivision roading, telecommunications.

6.6 PART C OF THE ASSESSMENT FRAMEWORK APPLICATION - TANGATA WHENUA IMPACT ASSESSMENT

To help understand the concerns of Tangata whenua, it is advantageous to know how the urban environs and waterways in particular, have changed. Many of these changes and their impacts have occurred within the living memory of Tangata whenua informants.

Some of the earliest public works in Dunedin was to put that stream underground, ‘cos it used to come down near the door of the casino.

6.6.1 Change to the Leith

Looking downstream towards the outlet of the Leith to the harbour

Looking downstream at a high flow in the Leith as it flows through the University.

Table 19 - The changes over time to the Leith

TIMELINE – URBAN DEVELOPMENT WITH A FOCUS ON THE LEITH STREAM	
Mid 1800s	Settlers drew water from the creeks and springs in the area below the town belt especially Mclaggan Street, London Street and Regent Road creeks
1860	The Town Board tapped a spring in High Street and erected a public pump at the Manse Street corner.
1864	The private Water Works Company (WWC) was formed
Sept 1865	Dunedin water works construction started to supply water to all parts of city. This involved Ross Creek and creation of a reservoir with a storage capacity of 70,000,000 gallons.
1867	Ross Creek reservoir was opened on 9 December
Feb 1868	Flood occurred damaging lower reaches including the Botanic Gardens.
1869 - 1870	Brown trout fry distributed: 75 Water of Leith, 40 Water works reservoir, 89 Leith Stream
Jan 1870	"Large portions" of the Leith banks were swept away and the new bridge near the Water of Leith Hotel and one at the Botanic Gardens was destroyed by a flood.
Feb 1874	Resident magistrates court heard question concerning pollution of natural watercourses. Leith was mentioned.
Feb 1877.	A house swept away, botanic gardens damaged and protective works constructed after last flood also swept away in a flood.
1881	After droughts and a major fire in 1877, a new supply from the Silverstream Catchment. A 29 km race from the Silver Stream to the Southern Reservoir was constructed. This system was officially opened in 1881
Nov 1882	Trout was caught in Leith Stream during a fishing competition
Nov 1883	Flood caused bridges to be "severely damaged" in Woodhaugh and the banks of stream were "undermined"
July 1897	Complaint made at City Council meeting by several representatives of the community in relation to alleged pollution of Leith Stream by Woodhaugh Paper Mills. Issue was referred to general committee.
1904	By 1904, the main tributary of the Leith had been tapped and water was piped so that the Maori Hill, Roslyn and Mornington suburbs could be reticulated.
July 1908	Reported to Acclimation society: Fine run of trout in the Leith with a "good supply of ova being taken" Rangers reported fish running in stream with some "very large".
July 1909	Mentioned in an Acclimation Society meeting was a "very heavy run of spawning fish up the Water of Leith"
1911	Flood leads to overflows causing "considerable damage" to lower reaches of Leith.
Aug 1913	Overflow at Harbour terrace caused by the "minor flood" which occurred and in part by work being done by Otago harbour board on reclamation channel.

TIMELINE – URBAN DEVELOPMENT WITH A FOCUS ON THE LEITH STREAM	
Sept 1913	September 1913 – Correspondance (report) by Engineer J. Blair Mason to Chairman of the Otago Harbour Board. Mentioned in the report includes: On the 13th August 1913 flood occurred "during night of rising tide, an overflow took place from the Leith into the Harbour Terrace". This lead to 16 houses having water rise from 1/2in to 24in above their floors. Water also entered Messrs Gregg and Cos Starch works and Duncan and Son workshop. At the end of the report the engineer put foward recommendations to address this issue of flooding including a permanent channel of concrete to prevent shingle lodgment and to keep channel at maximum capacity.
1913 - 1914	A concrete channel from Forth Street to Harbour is constructed
1916	Sullivans Dam at the headwaters of the Leith was completed
Sept 1923	Correspondence by Mr J. Blair Masons report re Leith Canal, on results of April 21st and May 13th floods. With the flood debris of “large boulders and stones brought down stream" were deposited in the canal reducing canal capacity. A few large stones would be carried as far as the Mouth with others being deposited during floods and freshes in water holes and flatter reaches of stream. This was "exemplified" in the old and natural bed between Leith and Clyde streets where before the "conduit" construction the widening of the stream lead to much debris being deposited. The floods have caused shingle and boulders from bed of Leith and tributaries to be carried into lower reaches and into Leith Canal. Under the old "natural" conditions only a "small percentage of heavier eroded material including boulders and shingle reached the mouth of the Leith". The need for "united action" to control this erosion.
1923	In 1923, the storage of the Southern Reservoir was increased from 103,400 cubic metres to its present day capacity of approximately 204,090 cubic metres.
March 1929	Highest flood in history of Leith with peak of flood estimated at 200 cumecs. Following this flood was two smaller floods in June and December.
Nov 1933	No damage occurred when Leith broke banks in one place
Nov 1936	Dunedin's water supply system was expanded to take water from Deep Creek, approximately 64 km from Dunedin.
Nov 1938	“Serious flooding in Dunedin city”
1940s	In the late 1940s, the water supply position was again precarious
Early 1950s	Channel extended upstream from Forth Street by Dunedin City Council
1951 - 1956	The Taieri bores system was developed and completed in 1956
Late 1950s	High velocity concrete channel straightened channel from George Street to Great King Street
Late 1960s	Upstream of Malvern Street bridge a large boulder trap was built
1967-1977	By 1967, it was apparent that Dunedin's water supply system would soon be unable to cope with increasing demands. The construction and commissioning of the Deep Stream water supply scheme followed by 1977.
June 2008	Report points to issues of high bacterial contamination in Kaikorai Stream with it exceeding recommended guidelines.
Feb 2010 -	“Otago Regional Council chief executive Graeme Martin is clear about his council's priority for the Leith. It is: "Getting the flood through safely. Everything else he describes as "enhancements and garnishings…Now, there are a whole lot of garnishings and enhancements that are not compatible with a high velocity concrete channel”. Mr Martin was responding to ideas about the Leith put up by Dunedin architect Tim Heath. (Magazine, ODT, 12 Feb 2011)
May 2010 -	'Flooding alert: Latest updates" (ODT, 25 May 2010)”First flood alert triggered in Silver Stream and Water of Leith waterways. Water of Leith running very high but not expected to spill its banks”.
Dec 2010 -	Four years on from the last work done as part of the Leith Lindsay flood protection scheme, another section of work has begun….Workers have begun felling trees on the bank of the Water of Leith between Cumberland and Dundas Sts, on a stretch of the river in the Dunedin Botanic Garden, in preparation for widening the true left bank. … The last work done as part of the scheme was the about $380,000 re-grading and widening of the Water of Leith and underpinning existing concrete walls and bridge abutments in Rockside Rd, which was completed in early 2007”. (R. Fox, ODT, 16 Dec 2010)

[The Leith] comes through the university, which is prime real estate in this city, and all through there it’s been played around with. It has had flood protection work done, but it’s very unattractive.

Of course it flows up the lower part of the river now, but it's in a concrete channel

6.6.2 Change to the Kaikorai

The trouble with the Kaikorai Stream is there is a lot of industry

There used to be a meatworks, tannery, a whole lot of vehicles and industrial sites, and basically poison, they were poisoning the stream. They'd have spills, you wouldn't eat and drink anything out of the Kaikorai Stream or the estuary.

But there have been very serious acidic type fluids spilt into that stream. Whereas for the Leith there is less industrial but it's been modified. It has been channelised and played around with and confined into a narrow channel, and hence we get flooding issues with those flash floods.

Table 20 - The changes over time in the Kaikorai

TIMELINE – KAIKORAI STREAM	
June 1886	Council discuss issues around pollution in Kaikorai Stream
Feb1890	Taieri County Council resolves the new inspector to find out what is causing pollution in Kaikorai Stream
Dec 1890	Inspector reports to council pollution still continuing into Kaikorai Stream
May 1981	Sanitary inspector reported to Taieri County Council that: Cleaning sheep guts or runners for sausage skins & drainage went all into the Kaikorai Stream and caused pollution and a offensive smell; one fellmongery was clean and very little pollution from it; another fellmongery was "very dirty and a large quantity of refuge lying about" with all drainage flowing into stream and it was at this fellmongery that it lost its natural colour; liquid from a bone digester discharged into stream - was causing one of the "greatest pollutions to the stream"; tallow melting works had two digestors with liquid contents running into the stream causing pollution. They also had pigs running around with their food thrown all over the place causing in wet weather to run into the stream. Woollen mills had three drains into stream. One with soap and water with not much pollution, one from dyeworks caused great pollution and one from wool scouring machine was worst of all. Slaughter yards was causing pollution. Skincleaning establishment was causing pollution. New Zealand Drug Company's works liquid digesters discharge was causing pollution. Refrigerating works was causing pollution from continual flow of blood and a offensive matter. Slaughter yards was causing pollution by discharging a liquid. Soapworks manager given notice to stop liquid discharge from digesters at works into stream.
Sept 1891	Sanitary inspector reported to Taieri County Council that: Abbotts Creek works inspected and found "very satisfactory condition". Mouth opened and flood caused Kaikorai Stream to be cleaned out. But were complaints from residents in Caversham about smell possibly coming from works .
Jan 1892	Sanitary inspector reports to Council he had to caution some individuals concerns Abbots Creek pollution
Nov 1892	Sanitary inspector reported to Taieri County Council that at works on Kaikorai Stream measures were being taken to stop pollution. Water was said to be sometimes "very discoloured"
Aug 1897	A Taieri County Council meeting mentioned that the Kaikorai Stream was in "very filthy condition" because of the dry weather.
April 1898	From the Taieri County Council meeting "the condition of the stream had been diabolically bad' and "got so bad lately that he had to shut down his mill, simply because he could not get the water through the pipes". Ross and Glendining factory when visited they were "polluting the stream" Chemical works didn't pollute the water much they coloured it to some extent but this wouldn't normally be noticed. Fellmongery had fluff from wool going into the stream. The inspector, said that the works above Ross and Glandining's factory did not pollute the stream to any extent.
June 1899	Sanitary inspector reported to Taieri County Council that the Kaikorai Stream was in "first class condition".
Jan 1900	Sanitary inspector reported to Taieri County Council that "Kaikorai Stream was in good order".
April 1900	Residents of Green Island meet who are concerned with pollution in Kaikorai Stream.
May 1900	Inspector reports to Taieri County Council that Kaikorai Stream "was in good order". Mayor and councilors visit stream to look at "offensive discharge" of abattoirs
Nov 1900	Kaikorai Stream in flood and "low grounds were sheets of water".
Nov 1900	Kaikorai Stream running through Green Island was said to be in flood.
Dec 1900	At Taieri County Council meeting plans for a drainage scheme from abattoirs at Burnside to Kaikorai Mouth. The Sanitary inspector also reported that the Kaikorai Stream was in "very fair condition" with a flood contributing to this.
April 1901	An individual was charged with polluting the Kaikorai Stream by discharging blood water.
Dec 1901	An individual was fined for polluting the Kaikorai Stream by allowing foul water from tannery into it
Jan 1902	Sanitary inspector reported to Taieri County Council in last month was in "very fair condition". Although pollution coming from Borough of Rosyln. In one instance the stream was "simply black".
Feb 1902	Sanitary inspector reported to Taieri County Council that Kaikorai Stream during last mouth was in "first class condition".
March 1903	At the Acclimatisation Society it was reported lime water emptied into the Kaikorai Stream the result that about a dozen large fish dead.
April 1903	• Sanitation engineer reported to Taieri County Council: stream in "good condition" • The NZ Drug company also wrote to the council asking permission to deviate the Kaikorai Stream as it flowed through the company's property at Burnside. The council had no objection to the deviation of the stream.
Feb 1904	Manager of NZ Drug company works at Green Island was fined for polluting the Kaikorai Stream
May 1904	Manager in charge of corporation of abattoirs fined for creating a nuisance and discharging foul water in to Kaikorai Stream.
Nov 904	Article in Otago Witness in letters to editor section mentions that "along the Kaikorai Stream kowhai was also plentiful".
July 1905	Sanitary inspector reported to Taieri County Council that in the last mouth the Kaikorai Stream was in "very fair condition".
	Meeting held to discuss how to stop pollution in the Kaikorai Stream. Was mentioned was that the stream was in a bad and filthy state. The stench was a direct menace to public health
Dec 1907	The unanimous opinion of the city council was "that the city council was doing all it can to in meantime to stop the pollution of the Kaikorai Stream.
Dec 1907	In duplicating the railway line from Dunedin to Mosgiel part of the Kaikorai Stream was diverted.
July 1908	Commission setup to look at the pollution of the Kaikorai Stream. Varies local stakeholders were involved. The four areas the commission were to investigate were extent of pollution, best means of preventing pollution, what authority should be invoked in dealing with it and how the cost of any scheme would be spread amongst the varies local bodies.
Sept 1908	Commissions reports: The filthy nature of the stream and recommended that a river and drainage board be setup with varies members from local authorities to manage sewage and drainage of the Kaikorai Valley watershed and a small part of Dunedin drainage district.
Dec 1908	Sanitary inspector reported to Taieri County Council that Kaikorai Stream was same as usual but was getting lower and dirtier.
1951	The Silverstream race was piped in two stages - in 1951 in anticipation of the Taieri bores installation, and later in conjunction with the development of the Wingatui supply. The Wingatui supply was developed to provide water to the townships of Wingatui, Fairfield, and Waldronville in what was known as the Taieri County
June 2008	Report released points to issues of high bacterial contamination in Kaikorai Stream exceeding recommended guidelines.
May 2009	A replacement pedestrian bridge over Kaikorai Stream expected to be opened
Feb 2010	A blocked sewer pipe forced emergency overflow leading to raw sewage being spilled into Kaikorai Stream near a school.
Dec 2010	Algae found in Kaikorai Stream could have possibly killed fish.

These changes have occurred over successive generations and have impacted the functioning of waterways and the cultural values dependent on the healthy functioning of such waterways.

6.7 CHANGES TO THE FUNCTIONING OF THE RIVER

A vibrant mauri is reflected in a healthy functioning river. In Table 21 we have drawn from the quotes of informants to describe how the functions and natural processes of the Kaikorai and the Leith have been modified by urbanization.

We treat our waterways incredibly nonchalantly,

Polluted, infected, not in a natural state.

They're dirty, polluted and mostly down steep banks or in concrete channels.

Nasty, paru, filthy, can't swim, can't play, can't do shit, just in those culverts, just like big huge gutters.

Sad, tiny, long, squashed rivers that puke out the end

The channel of the Leith at Dundas Street showing weirs across the river.

Table 21 - The changes observed by whanau and the consequent cultural impact

STREAM CHANGE	DESCRIPTION		
	Kaikorai	Leith	Example of some of taonga impacted
Increased flow volumes/Channel forming storms	*Fraser Creek runs up the hill to Mount Grand and gets all the overflow water from deep stream….And that goes through native bush that is quite a nice area, except now it's probably getting bit more flow because it gets this deep stream water. And it gets a whole lot of trout.*	*You've got buildings and cars and people and lives at risk* *Volatile.., when you think of the Lindsey that comes down North East Valley, it has got an alpine catchment and you can get an incredible amount of rain in a short space of time, so the Lindsey could potentially rise really quickly.*	Wai Maori
Decreased base flows		*The Leith the lower down you get the more stagnant if you don't have a good flow it gets and more unhealthy it looks. When there's a bit more of a flow through there. It flushes it, it smells healthier, it looks healthier, you feel healthier being next to it.*	Wai Maori
Increase in sediment transport	*Timber around there been cut up for firewood and other things, and lots of areas have just dug up mud and so on, with different industrial type things going on. When it rains all that's gonna end up in the river.* *Kaikorai Stream could have been very similar all the way down to where the estuary is now, the bottom's changed to a soft bottom and that's because of lots of sediments coming in, especially out of Abbotts Creek, which has been affected by quarrying – clay quarrying for brickworks.*		Wai Maori Mahinga kai Taonga species Wahi tapu
Loss of pools and riffles		*You go down to the university area and come upon an area of concrete sides, quite steep, five metres high – with concrete weirs across to give the impression of pools and a riffle but it does not provide the same sort of habitat that fish rely on to get further upstream….*	Wai Maori Mahinga kai Taonga species
Increase in temperature		*It's very open; there's no riparian zone at all, there's no hanging plants or material so there's no cover. In the summer it probably heats up, it's difficult.*	Mahinga kai Taonga species
Channel straightening or hardening		*Even Lindsay's Creek if you go up into Botanical Gardens and walk across the bridge there you can see how the two sides of the waterway are completely battered in concrete.*	Wai Maori Mahinga kai Taonga species Wahi tapu

Creation of fish blockages		*Probably the biggest barrier, there's a concrete channel through the bottom of Woodhaugh Gardens and that's an absolute fish barrier for trout, salmon, the exotic species, but also for eels… Elvers could possibly find their way all the way through, however they're open to predation all the way through*	Mahinga kai Taonga species
Reduction in water quality	*You've got the tarseal roads, all the roading infrastructure – so that's picking up oil and contaminants off vehicles going straight down the stormwater, wherever they end up. Invariably they must go into those streams .* *I know that the Kaikorai is quite often contaminated and, I wouldn't drink out of it.*	*You know you're not going to go near a waterway that stinks and smells stagnant. I mean seeing shopping trolleys and other bits and pieces floating down at times, and things like that, you know it's not that healthy – and rubbish bags whatever.*	Wai Maori Wai tapu Mahinga kai Taonga species
Increase in turbidity	*I've seen car auto paint shops about halfway down through the valley, just tipping their waste, thinners and so forth, just straight down the bank..And as you get further down then there's the Burnside Freezing Works. In past years waste was discharged directly into the river, and then you had the cement works, where I actually worked at in summer and appalling coloured stuff used to go in the river there, black stuff, probably come out of the kiln, or wash water for the coal…Nowadays, the area's probably not much better, it's just not noticed as much.*	*[The Leith} with the rocks and the pebbles and you know, trees on the side. The water looks fairly clear, there's a wee bit of moss sort of growing on the rocks on the side.*	Wai Maori Wai tapu Mahinga kai Taonga species
Estuarine / lagoon health	*But on the Kaikorai estuary I couldn't imagine they've got any other choice but to feed it into the Kaikorai.* *The Kaikorai is a major issue – a lot of the wetlands have been reclaimed with a tip, with rubbish, some of that'll be toxic. So you've got a real challenge at the bottom there in the estuary, and they are containing it but it's still an active on both sides of the wetland. This waste minimisation and recycling and all that's doing wonders and extending – It'll extend the life of the landfill…*	*Then you get right down to the bottom where you would expect some sort of estuary qualities, and what you get is a long channel stretching, virtually straight channel, straight into the harbour,* *Quite a lot of it [pollutants] will go straight into the harbour.*	Wai Maori Repo raupo Mahinga kai Taonga species Wahi tapu
Fisheries	*As you go further down on the Kaikorai Stream though, it goes into an industrial area, and that whole stretch has a history of regular fish kills through discharges of all sorts of stuff into the river – on average I wouldn't be surprised if fish kills were reported in that stream on average of once a year. …*	*It doesn't actually provide any overhead cover for any fish. The only thing it does provide is a wee bit of habitat for a few ducks.*	Mahinga kai Taonga species
Coastal fisheries	*I don't really agree with obviously dumping it out to the ocean, even though they're creating the new outfall and it's treated better and all that sort of thing. But I also understand the constraints on the DCC as well – the amount of land that they would need to discharge it to*		Mahinga kai Taonga species

Informants also identified a number of fundamental concerns.

Unnatural mixing of the waters used to supply the urban area;

Figure 10 highlights areas of cross mixing.

- Source waters from the Taieri catchment are conveyed to users located within the Leith and Kaikorai catchments. This water is lost to the Taieri system. Flows in the Fraser are augmented by Taieri waters.
- Water from the Kaikorai Stream may augment Taieri supplies.

Although Tangata whenua may not support cross mixing it is important to manaaki visitors to the city through the provision of safe and secure drinking water and sanitation services.

Extent of "separation" that is provided for within the system. Sadly, of concern to Tangata whenua, sewage is still discharged to Dunedin's waterways.

Why would you want to go there when you know that they discharge bloody sewerage in there

We get human waste in the Leith and we get industrial waste in the Kaikorai,.

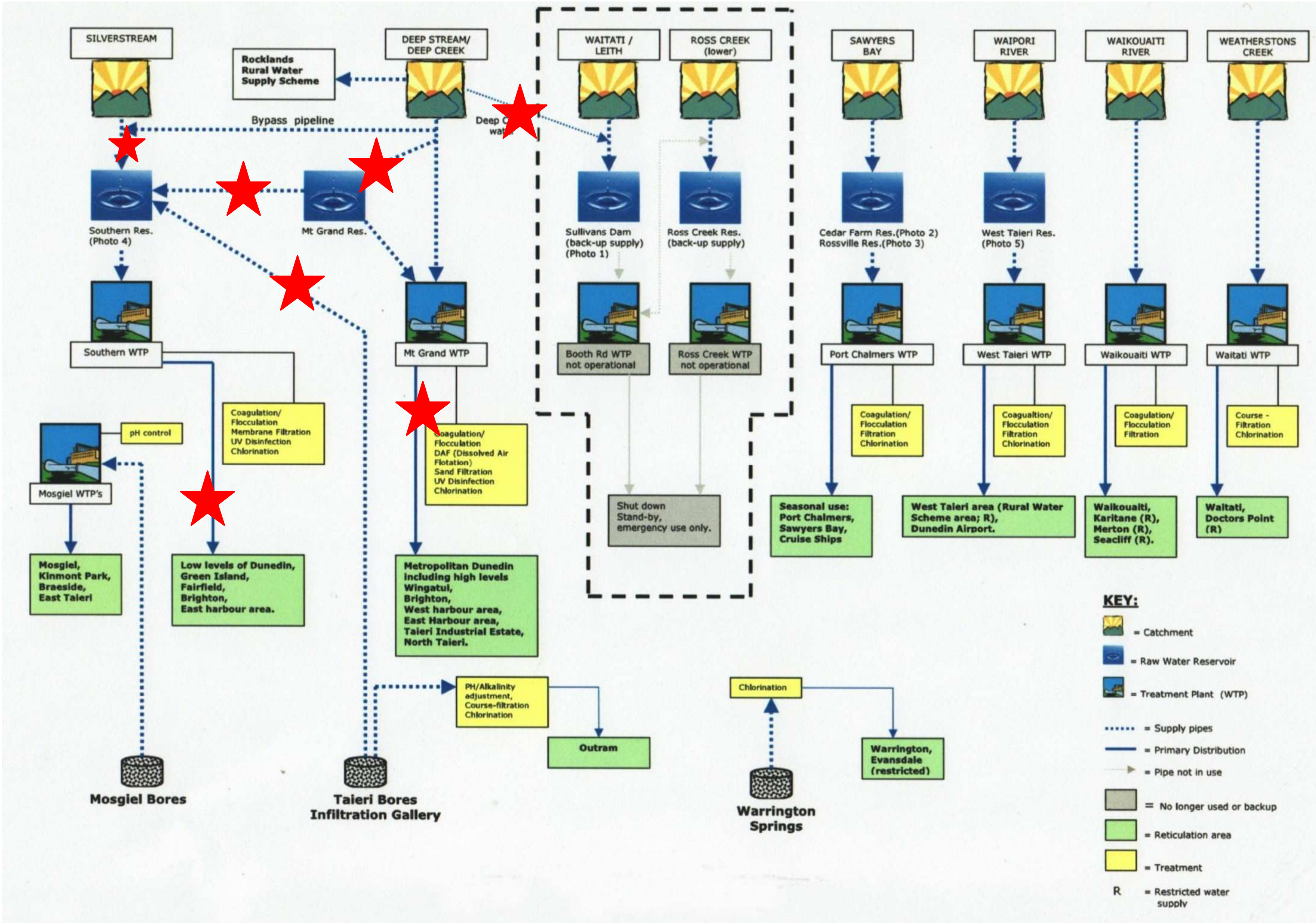
The beach….. they keep closing the beach cos there's poos in the water…. we can't go swimming all the time, which is stupid.

The fact that you can't even have a swim in Tangaroa is stupid.

It must be acknowledged that the discharge of human waste to waterways is culturally abhorrent. It also illustrates a fundamental difference in world views.

Because the difference between council and what I perceive as manawhenua are slightly different values - minute traces of A, B and C, versus, the mauri's okay and you can feel that the mauri's okay, you know that there's life back in the water.

Figure 10: Cross mixing examples (shown in red)



Wellbeing - Indigenous conceptualisations of well-being are influenced by the natural, social, spiritual and cultural worlds within which that indigenous community lives. Panelli & Tipa (2007) explain that the restorative benefits of the environment have been espoused by international researchers (for example Kaplan and Kaplan (1978, 1989; Korpela and Ylén, 2007) which has contributed to a proliferation of health and social services that include environmental experiences as part of their intervention. Urban water management has the potential to influence health and social sector planning within New Zealand if it is accepted that cultural activities requiring interaction with lands and waters within a defined takiwa, such as customary kai gathering or waka ama, can positively enhance the health and wellbeing of whanau and hapu.

The impact of environmental change of the use patterns of Tangata whenua can be used to illustrate the consequent impact on the wellbeing of whanau, hapu and iwi. Tangata whenua remain dependent upon uses (such as mahinga kai) both physically and culturally. Mahinga kai has been the primary food and the basis of the economy of Tangata whenua for generations who have relied directly on the land and rivers for food. Today Tangata whenua are denied access to a significant percentage of their traditional foods. When obtainable these former staples of their highly nutritious diet are available in quantities insufficient to even approach being their primary food sources. Often the quality is compromised as well.

Acquiring kai provided exercise that kept people in good physical condition. Because hunting, gathering, fishing, storing and preparing food was an integral part of daily life and seasonal celebration, kai held great cultural and social meaning. These activities served as an important social glue by bringing people together to work, socialize, and pass down values and information from one generation to the next. Food is central to some of the most serious social obligations of Tangata whenua to manaaki manuhiri (guests, visitors). The cultural and spiritual dimensions of mahinga kai has probably received more recent attention than any other recent iwi issue. Existing documents provide in-depth and critical testimony concerning the cultural and spiritual importance of aquatic species and of water bodies themselves. Using Ngai Tahu as an example, mahinga kai activities are at the very heart of Tangata whenua culture. At stake with a loss of mahinga kai is nothing less than cultural survival. The activities of managing, gathering, preparing and consuming kai serves the functions of passing on knowledge within the hapu and from one generation to the next.

Mahinga kai change can also leads to loss of culture and identity. The present ongoing damage to the resource base leads to further cultural disruption today. Just as the everyday activities of fishing, eeling and gathering cultural materials creates and maintain whanau and hapu ties and provide identity, so too does their absence and decline lead to further cultural disruption. The present decreasing access to rivers for cultural uses must therefore be understood in the broader context of cultural loss. Without doubt, access to waterways and the many resources that they sustain plays an important role and cultural continuity and identity - the loss of the same resources can lead to cultural, social and economic stress experienced by whanau. Our informants very clearly articulated their sense of loss, and the impact of such losses on future generations.

I measure it by would I feel safe letting my daughter do it, would I feel safe letting myself do it. Because my daughter I'm so protective over her as you know, that if I don't feel safe her doing, then I know it's going to be safe. I remember I grew up in Karitane – we were swimming from a very young age. We were surrounded by water. We used the inlet where we would row across to right near the boats, we'd swim at the beach, we'd swim in the inlet. We went once a week to swimming at Cherry Farm.. That bigger picture …we're growing up in this urban setting, my daughter's growing up in this urban setting, we're losing all those sort of things.

I think because we live in an urban environment, we're so disconnected.

Our children aren't exposed to freshwater - we don't take them to rivers, we don't take them to streams….. Our parents took us to rivers and streams and the ocean….But we can't see them, they're not part of our everyday life, because they've either been hidden or they're in parts of the city that, if you don't know that they're there, like Frasers Gully …and we go to Leith Valley because it appears to be closer, it has a feeling of connectedness, it's accessible because, you know, we can afford to go that far, you know you wanna access the environment you actually have to leave the city,

Therefore, when planning restoration initiatives, it is equally important to restore the relationship of whanau to waterways.

Improvements to the stream shouldn't just be thought of in terms of engineering and design physical landscape things. They should also be thought of in terms of our relationship and understanding on a variety of levels …people sharing understandings, feelings, relationships, histories and stories with demonstrations of relationship to those waterways.

Waters in and around marae – Araiteuru Marae is located in the Kaikorai catchment. If we accept that the health of waterways impacts the wellbeing of whanau, then the comments of one informant are of concern.

There's a waterway that goes through the wetlands by the Marae and then back behind all those houses and that's just as disgusting as any of them

Waters of special significance within the footprint of the urban water infrastructure - One informant explained how traditionally there was no gathering in part of the Leith Catchment.

The Leith was only tapu up as far as Nichols Stream. Further up the main channel of the Leith you could catch things and eat them if you wished to. But the prohibition was so strong on the lower Leith that you weren't even allowed to collect firewood from the Leith. From the bank of the stream, and you know – no ducks, no crayfish, no fish. It just wasn't on.

The main issue I have with the Leith is spiritual pollution, people don't respect the fact that it was used for spiritually rejuvenating purposes, our people had prohibitions on it, and I like to observe those old prohibitions.

In Chapter 3 we provided a description of a traditional water classification. Changes to waterways over time clearly will impact such classifications. In Table 22 we have tried to show how classifications may change.

Table 22: Impact of changes to Leith and Kaikorai on Traditional Water Classification (links to Table 3)

Classifications by *Ki uta ki tai*	Classifications by spiritual description	Classification by physical description	Classification by special uses
Waimaori **freshwater**	***Waimaori***	***Waimaori***	***Waimaori***
	Waiora	***Waiora***	***Waiora***
	Wai whakaheke tupapaku		***Wai whakaheke tupapaku***
	Wai tohi		***Wai tohi***
	Waikino ↑[18]	***Waikino*** ↑ .	
	Waimate ↑[19]	***Waimate*** ↑	
.			***Wai tapu*** **X**[20]
Waimataitai ↓			
Waitai ↓[21]	***Waitai*** ↓	**Waitai** ↓	

[18] The arrow shows that the waters in a degraded state are increasing. The discharge of human waste to waterways is culturally abhorrent regardless of its level of treatment.
[19] The arrow shows that the waters in a degraded state are increasing. The discharge of human waste to waterways is culturally abhorrent regardless of its level of treatment.
[20] The "X" shows that the tapu status of waters in a reach of the Leith is not recognised and provided for by urban water managers.
[21] The arrow shows that the health of coastal waters is impacted by the discharge of contaminants.

Table 23: Summary of the impacts of change on wahi taonga and wahi tapu

WAHI TAONGA	IMPACT & ASSESSMENT OF CURRENT STATE
Mahinga kai	*The Kaikorai, you couldn't eat, I don't think you'd be wise to eat anything out of it. Mainly because of those severe pollution events, and continuing discharges…..It was once a food basket – I wouldn't touch it. And you've got the land fill down the bottom there, which is going to be leaching away for a long, long time. Because it was taking everything and anything, and you just tipped it off the face there and they pushed it out* *I still wouldn't fish or eat anything out of there [Kaikorai]*
Taonga species	• Impact of invasive aquatic species such as exotic seaweeds on kaimoana and wahi taoka. • Loss of important cultural species from the Otago Harbour Catchment. • Impact of commercial and other activities on tuaki (cockles). • Loss of productive fishing reefs. • Some mahika kai species within the Otago Harbour Catchment are considered culturally unsafe for consumption. • Risks to kaimoana from discharges in the Harbour including sedimentation and storm water runoff.
Pa tawhito – ancient pa sites	Loss or modification of Pa sites
Ara tawhito	*I know that when canoes from Otakou were heading south, rather than go out around the head and into the heavy seas, they actually used to paddle them down the harbour into Anderson's Bay inlet, portage them across to Kaikorai.* Today there is no evidence and no recognition of the past cultural landscape.
Wai Maori	• Increase in domestic water use in the Otago Harbour Catchment. • Point source discharge of wastewater and other contaminants into the Otago Harbour. • Discharge of sewage and ballast from ships.
Repo raupo	• Loss of important wetlands.
Cultural use	*We don't actually practically use it because you can't.* *I don't even see people on its banks.*

Wahi ingoa	• Displacement of traditions and placenames.
	• Lack of recognition and implementation of the Cultural Redress components of the Ngāi Tahu Claims Settlement Act 1998 by local authorities, namely[22]:
	    o Statutory Acknowledgements
	    o Place names
	    o Nohoaka sites

Wai tapu	• Exposure and erosion of urupā at various times along much of coast. • Discharge of sewage to wāhi tapu sites. • Historical loss of wāhi tapu to development.

[22] See Ngai Tahu Claims Settlement Act 1998..

6.8 PART D OF THE ASSESSMENT FRAMEWORK TANGATA WHENUA ASSESSMENT OF THE CURRENT STATE

The purpose of this project is to develop an assessment framework for application by Tangata whenua. The framework to be tested was the existing CHI for streams. Our interviews confirmed that the framework for the CHI was still appropriate however this needed to be complemented by further in depth studies. In this section we present the results of our assessment of the state of a selection of sites in the Taieri, Leith and Kaikorai catchments. Consistent with Ki ut ki tai, sites were selected throughout the catchment. Another perspective on our site selection is to confirm that we had sites from rural, peri urban and urban parts of a catchment. Photos of our six sites are included in Appendix 1.

Cultural Assessment

Table 24: Summary of the results of applying the CHI

Tributary	Status of Site[23]	Cultural Use	CSHM
Kaikorai			
Fraser (Car Park)	A-1	3.0	3.5
Kaikorai (Green Island)	A-0	2.7	3.0
Kaikorai (Townleys Rd)	A-0	1.75	3.5
Leith			
Leith (Brook St)	A-0	2.1	3.0
Leith (Forth St)	A-0	1.25	2
Lyndsay (Felix St)	A-0	1.5	3.5
Ross (Waterwheel)	A-0	3.7	3.5
Taieri[24]			
Creek in Deep Stream catchment	B-0	1.3	3.02
Silverstream	A-0	3.13	2.00
Taieri (Outram Glen)	A-1	2.5	3.53
Deep Stream	B-0	2.19	2.90

The forms used for the assessment are included in Appendix 2

[23] Red is unhealthy and not sustaining cultural values. Green is healthy and sustaining values.
[24] Sites in the Taieri catchment were only added after the "footprint" of the urban infrastructure was described. Source waters from the Taieri are an essential part of Dunedin's urban water cycle.

Outram Glen (above) which is a heavily used site in summer was rated by whanau as a stream in good health. Frasers Creek (below) also scored highly.

Biophysical parameters

We chose MCI as our measure of stream health. The MCI looks at the whole macroinvertebrate population structure and provides a score that indicates general water quality. Generally, an SQMCI score of less than 6 indicates poor water quality and a score of greater than 7 indicates excellent water quality. Some macroinvertebrates are particularly sensitive to pollution, so are good indicators of water quality degradation that has been caused by human activity.

Table 25: Summary of the results of SQMCI and Electric Fishing

Tributary	Site	Site Area (m2)	SQMCI	Number of Fish	Number of Fish Species	Fish (g/m2)	Comments
Kaikorai							
Fraser	Car Park	258	7.7	6	1	0.45	
Kaikorai	Green Island	431	3.9	4	3	0.71	
Kaikorai	Townleys Rd	233	5.3	14	1	0.06	Large number of juvenile bullies caught
Leith							
Leith	Brook St	579	3.7	17	2	0.99	
Leith	Forth St	122	2.0	3	2	0.16	Includes two bullies caught in kick sampling net
Lindsay	Felix St	410	3.5	23	1	0.79	
Ross	Waterwheel	211	7.1	4	2	7.18	One large eel in catch increases g/m2 significantly. Without eel g/m2 = 0.83
Taieri							
Creek in Deep Stream	At pipeline		6.0	0	0		
Silver Stream	Riccarton Rd		5.0	3	26		
Taieri	Outram Glen		3.9	2	22		
Deep Stream			5.3	1	1		

Chemical parameters

We chose to measure E-coli. However, a number of parameters are recorded by other agencies so we also collated those data. (in Table 26 which follows). In Table 26,

“A” means the results is an average

“S” means that the result is from a single score.

Table 26: Summary of the results using a range of bio-physical indicators

KAIKORAI CATCHMENT - KAIKORAI AT TOWNLEYS ROAD									
Above or below ANZECC trigger value or DoH guideline level									
Date	**Bacteria (Ecoli)** *(DoH = 126cfu/ml) (MfE = 260cfu/ml)*	**Total nitrogen (TN)** *0.614mg/l*	**Ammonical Nitrogen (NH3)** *(0.9mg/l)*	**Total phosphorus (TP)** *(0.033mg/l)*	**Dissolved reactive phosphorus** *(0.01mg/l)*	**Dissolved oxygen** *(Above 80%)*	**Nitrate – Nitrate** *(0.444mg/l)*	**Turbidity** *(5.6NTU)*	**PH (Lab)** *(6.5-9.0)*
2005	1045(A)	0.48(A)	0.015(A)	**0.0405(A)**	**0.011(A)**	94.6	0.1995	3.4(A)	7.28
2006	270	0.38	0.01	0.026	**0.011**	99.3	0.148	3.31	7.8(S)
2008	330(A)	**0.825(A)**	0.02(A)	**0.042(A)**	**0.0165(A)**	94.25(A)	**0.5675(A)**	**6.24(A)**	7.9(A)
2009	58.5(A)	0.385(A)	0.005(A)	0.024(A)	**0.0105(A)**	100(A)	0.2545(A)	2.32(A)	7.6(A)
2011	70.8(MPN)								
KAIKORAI CATCHMENT - KAIKORAI STREAM AT BRIGHTON ROAD									
2007	**1100**	**0.64**	0.02	**0.04**	**0.016**	99.5	0.326	3.85	7.8
2008	**400**	**0.71**	0.01	**0.049**	**0.017**	90.1	0.342	4.2	8.55
2009	90(A)	**0.42(A)**	0.0075(A)	0.0275(A)	**0.011(A)**	102.05(A)	0.24(A)	3.015(A)	8.15
2010	**182(A)**	**0.78**	0.07	0.029	**0.016**	93.3	**0.504**	2.85	8.3
2011	98.8(MPN)								
KAIKORAI CATCHMENT - : KAIKORAI ESTUARY									
2004	560*(S)	1.15(S)		0.232(S)	0.043(S)				
2005	295(A)	0.695(A)		0.0935(A)	0.04(A)				
2006	335(A)	0.425(A)		0.0025(A)	0.0155(A)				
2007	400(A)	0.62		0.026(A)	0.025(A)				
2008	24	0.33		0.03	0.014				
2009	1900	2.19		0.087	0.022(A)				
LEITH CATCHMENT - LINDSAYS CREEK U/S LEITH									
2004	**1150(A)**	**1.175(A)**	0.035(A)	0.0635(A)	**0.024(A)**	110.3(A)	**0.743(A)**	4.15(A)	7.985
2005	**940(A)**	**1.15(A)**	0.025(A)	**0.0495(A)**	**0.0245(A)**	98.7(A)	**0.6445(A)**	3.35(A)	8.4
2006	**1600(A)**	**1.09**	0.02	**0.063**	**0.036**	96.8	**0.604**	4.06	7.6(S)
2007	**550(A)**	**1.16(A)**	0.015(A)	**0.0375(A)**	**0.019(A)**	98.1	**0.9075(A)**	3.19(A)	7.7(A)
2008	**3500(A)**	**0.89(A)**	0.02(A)	**0.0545(A)**	**0.0325(A)**	91.55(A)	**0.5785(A)**	2.84(A)	7.75(A)
LEITH CATCHMENT - LINDSAYS CREEK AT NORTH RD BRIDGE – BOWLING CLUB									
2007	96	0.54	0.02	0.03	0.019	100.5	0.318	2.4	7.7
2008	360	0.94	0.01	0.049	0.021	95.5	0.792	4.17	7.85
2009	119.5	0.87	0.0075	0.038	0.021	101.05	0.743	2.87	7.75
2010	334.5	0.6*	0.01*	0.045*	0.0305	111.4	0.519	3.29*	8
2011	**390**								
LEITH CATCHMENT - SITE: WATER OF LEITH AT DUNDAS STREET									
2007	**210(A)**	**0.6(A)**	0.02(A)	**0.043(A)**	**0.026(A)**	106.1(A)	0.362(A)	2.46(A)	7.85
2008	**1030(A)**	**0.65(A)**	0.01(A)	**0.041(A)**	**0.027(A)**	91.85(A)	0.4385(A)	2.505(A)	8.05
2009	**242(A)**	**0.595(A)**	0.005(A)	**0.0385(A)**	**0.029(A)**	107	**0.461(A)**	1.785(A)	8.1(A)
2010	**136**	0.37	0.005	**0.037**	**0.032**	98.9	0.23	2.96	8.9
2011	**690(MPN)(S)**								

Specialist testing – taonga species

The principle concern of whanau was determining if the floods in the Leith River which carried pollutants including toxic pollutants, had impacted kaimoana in the harbour. A whanau member (Dr Terry Broad) collected cockles from Otago Harbour for testing by Hills Laboratory. The other kai tested were eels gathered from each of the study sites in the Leith and the Kaikorai. The results were as follows:

- The Food and Drug Administration considers fish safe to eat if they contain less than 1mg/kg of mercury. All eel and cockle samples were below this limit.
- Levels were low for zinc, copper and chromium.
- DDE and DDD (both break down products of DDT) were detected in eels. However, the levels were considered unlikely to cause human health impacts.

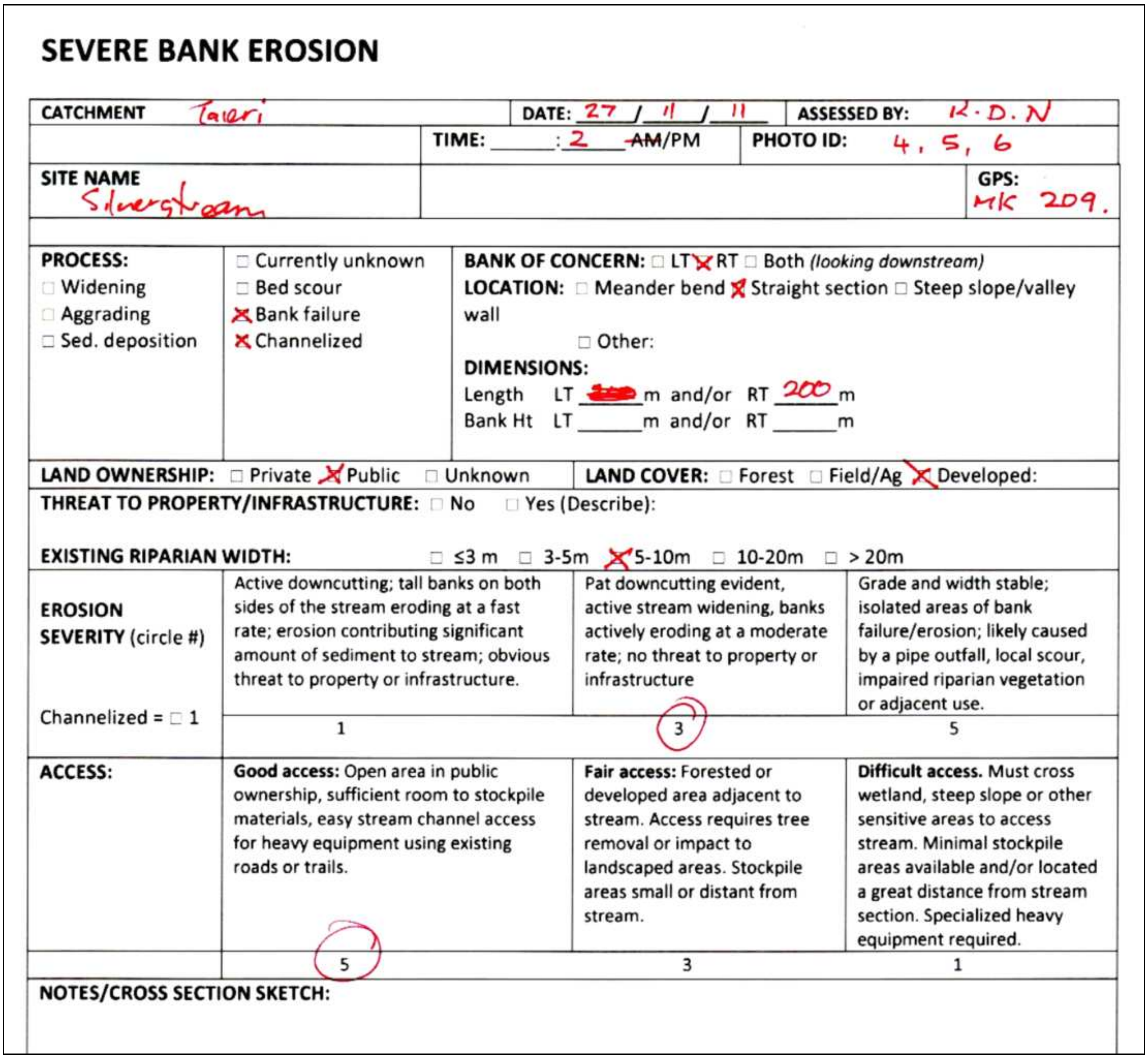
In depth investigations to aid the identification of cause

In addition to the CHI we undertook a number of in depth field assessments to increase understanding of cause. These are summarised in Table 27 and an example is provided in Figure 11.

Table 27: Additional impact assessment forms to help identify causes

ASSESSMENT FORM	WHAT IT ASSESSES	INFORMATION COLLECTED
Outfalls	All discharge pipes or channels that discharge storm water or wastewater	Basic type source, and condition. If flowing, then flow conditions should be recorded and potentially reported to authorities.
Bank Erosion	Slope failure, bank sloughing, head cuts, and incision or widening in areas noticeably worse than the average erosive condition of the survey reach. Also infrastructure or property threatened by erosion.	Location (meander or straight section), threat to property or infrastructure, accessibility; and basic bank measurements (height, angle, and bottom and top widths).
Impacted Riparian Margins	Corridor lengths that lack at least a 20m wide, naturally-vegetated riparian buffer on one or both sides of stream.	Diversity and density of vegetation, flood plain conditions, adjacent land use, available area for reforestation
Infrastructure in Stream Corridor	Leaking or exposed sewer, water, or other utility lines causing water quality, habitat, or channel stability problems. Includes manhole stacks, pipes along bottom, in the bank, or above the stream susceptible to damage due to lack of maintenance or exposure.	Type, condition, and discharge characteristics associated with leaks (odors, color, etc). If leaking, report immediately to authorities. Record relevant information if potential fish barrier
Stream Crossings	All man-made or natural structures that cross the steam, such as roadways, bridges, railroad crossings, or dams. Pipe crossings and other overhead utilities are assessed	Type of crossing, culvert dimensions, relative information if suspected fish barrier (water drop and water depth during normal flow conditions)
Channel Modification	Channelized, concrete-lined, or reinforced sections of stream >20m in length, regardless of construction material used. Locations of existing stream restoration or bank stabilization projects included.	Type of modification, length of stream impacted
Trash and Debris	Areas of significant trash and debris accumulation greater than average levels observed across the survey reach. Any areas where potentially hazardous or unknown chemicals have been dumped.	Mobility, dispersal, amount and type of trash; level of effort and type of equipment required for removal; location on public or private property
Miscellaneous. Impacts	High quality areas or unusual feature or activity impacting the stream corridor that doesn't fit into other seven impact assessments. This may include fish kills, cattle access, near stream construction, flood plain excavation, adjacent wetlands, grade controls, or other notable features.	

Figure 11: A form that was used to mark the location of specific sites of erosion



SEVERE BANK EROSION

CATCHMENT Taieri	DATE: 27 / 11 / 11		ASSESSED BY: R.D.N
	TIME: ____ : 2 ~~AM~~/PM		PHOTO ID: 4, 5, 6
SITE NAME Silverstream			GPS: MK 209.

PROCESS:
- [ ] Widening
- [ ] Aggrading
- [ ] Sed. deposition
- [ ] Currently unknown
- [ ] Bed scour
- [x] Bank failure
- [x] Channelized

BANK OF CONCERN: [ ] LT [x] RT [ ] Both *(looking downstream)*
LOCATION: [ ] Meander bend [x] Straight section [ ] Steep slope/valley wall [ ] Other:
DIMENSIONS:
Length LT ______m and/or RT 200 m
Bank Ht LT ______m and/or RT ______m

LAND OWNERSHIP: [ ] Private [x] Public [ ] Unknown
LAND COVER: [ ] Forest [ ] Field/Ag [x] Developed:
THREAT TO PROPERTY/INFRASTRUCTURE: [ ] No [ ] Yes (Describe):
EXISTING RIPARIAN WIDTH: [ ] ≤3 m [ ] 3-5m [x] 5-10m [ ] 10-20m [ ] > 20m

EROSION SEVERITY (circle #) Channelized = [ ] 1	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.	Pat downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.
	1	3 (circled)	5
ACCESS:	**Good access:** Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair access:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult access.** Must cross wetland, steep slope or other sensitive areas to access stream. Minimal stockpile areas available and/or located a great distance from stream section. Specialized heavy equipment required.
	5 (circled)	3	1

NOTES/CROSS SECTION SKETCH:

A full set of the forms are included in Appendix 3.

6.9 COLLATING THE PARTS OF THE ASSESSMENT

As Table 28 below illustrates, the streams at the head of the Leith and the Kaikorai (Ross Creek and Frasers Creek respectively) were considered to be in good health, although Fraser Creek is impacted by cross mixing of water from the Taieri Catchment. In contrast, all other sites were assessed as being in poor health. On a positive note however, the samples of cockles and eels that were tested, confirmed that the pollutants did not represent a human health risk.

Table 28: A comparison of the results applied

Tributary	Cultural assessment of state[25]	Cultural Impact[26]	Biophysical parameters of state[27]	Chemical parameters of state	Specialist testing
Kaikorai					
Fraser (Car Park)		Primary impact is cross mixing			
Kaikorai (Green Island)					
Kaikorai (Townleys Rd)					
Leith					
Ross (Waterwheel)					
Leith (Brook St)					
Leith (Forth St)					
Lyndsay (Felix St)					
Taieri					
Deep Stream		Primary impacts result from • low flows resulting from extraction out of catchment • channel modification • adjacent landuse		N/A	N/A
Creek in Deep Stream				N/A	N/A
Silver Stream				N/A	N/A
Taieri (Outram)				N/A	N/A

In the Chapter that follows we reflect on the process applied in Dunedin and recommend a process for application by tangata whenua in other urban environs.

25 Colour coding is based on the scores for component 1 of the CHI as shown in section 6.8 on page 100. This component summarises the health of the sites as whanau have concluded that the site does not sustain cultural values and they would not return to the site and use it.

26 This assessment comes from the full range of contextual data provided in the earlier sections.

27 Colour coding is based on the SQMCI score.

Chapter 7: Recommending a tool for a Cultural Health Assessment for Urban Streams

7.1 A CULTURAL HEALTH ASSESSMENT FRAMEWORK FOR URBAN STREAMS

Our process to assess the health of urban waterways started with an exploration of the Dunedin urban water system. This immediately identified the need to widen the streams to be assessed as the Taieri is impacted because of the extraction of water to supply metropolitan Dunedin.

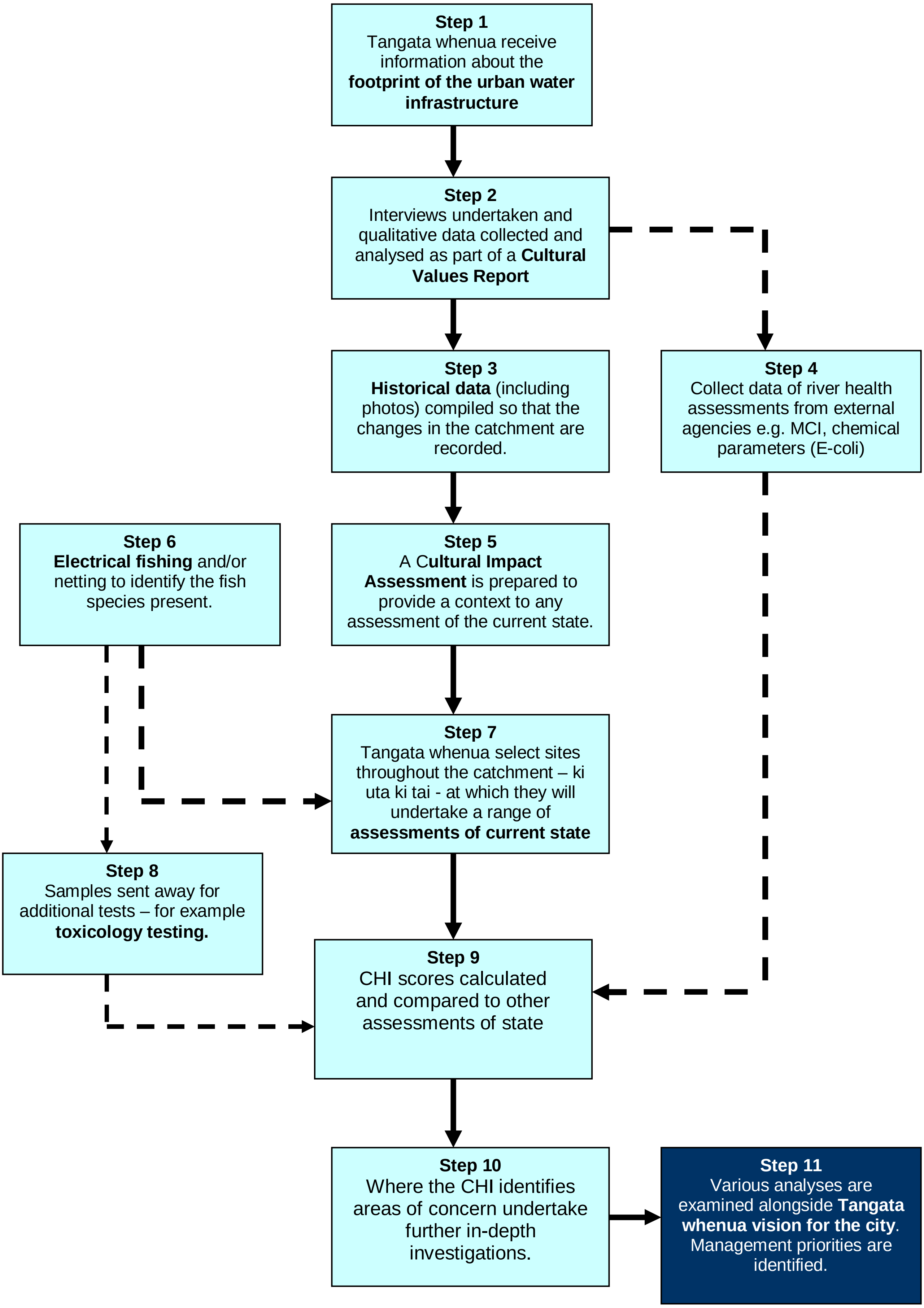
Dunedin City had its origins in the arrival of European settlers in the mid 1800s. At this time there were already established and flourishing kaika around the Otago Harbour. Ngai Tahu had been resident for hundreds of years. A starting point was to document the associations of tangata whenua with the Dunedin area. This discussion of the natural and extent of cultural association was accompanied by the stated aspirations of whanau to restore valued ecosystems.

Urbanisation changes environments and waterways in particular. From historical records it is possible to document changes over time and the impact that these have had on urban waterways and the values of tangata whenua with respect to those same waterways. This background equipped the team responsible for undertaking the fieldwork. As noted earlier, a team representing Tangata whenua undertook Cultural Health Index assessments at selected sites in both catchments. Finally, the quantitative assessments included: toxicology testing; E-coli tests; MCI tests; and electric fishing.

Where the CHI identified areas of specific concern, we also undertook more detailed investigations for example:

- to record the placement of outfalls to the river; and
- to record areas of severe erosion that were contributing sediment to the waterway.

We believe that each of these steps is necessary if a comprehensive and meaningful assessment is to be completed. The level of specificity the process (in Figure 12) provides in necessary to meaningfully inform urban planning processes.


Step 1
Tangata whenua receive information about the **footprint of the urban water infrastructure**
Step 2
Interviews undertaken and qualitative data collected and analysed as part of a **Cultural Values Report**
Step 3
Historical data (including photos) compiled so that the changes in the catchment are recorded.
Step 4
Collect data of river health assessments from external agencies e.g. MCI, chemical parameters (E-coli)
Step 6
Electrical fishing and/or netting to identify the fish species present.
Step 5
A **Cultural Impact Assessment** is prepared to provide a context to any assessment of the current state.
Step 7
Tangata whenua select sites throughout the catchment – ki uta ki tai - at which they will undertake a range of **assessments of current state**
Step 8
Samples sent away for additional tests – for example **toxicology testing.**
Step 9
CHI scores calculated and compared to other assessments of state
Step 10
Where the CHI identifies areas of concern undertake further in-depth investigations.
Step 11
Various analyses are examined alongside **Tangata whenua vision for the city**. Management priorities are identified.

In the paragraph that follow we summarise what each step entails.

Step 1: Base information will be to Tangata whenua including

- a description of the footprint of the urban water infrastructure to identify all waterways where the cultural health could be impaired.
- identifying all the sources of water,
- identifying any crossing mixing of waters;
- identifying all receiving waters
- defining the quantity and the quality of the waste discharged after use
- identifying how the hydrology, quality and biota of receiving waters has changed and is expected to change in the future as a result of urban activities
- identifying how the coastal waters may be impacted.

Step 2: Cultural Values Rports (CVR) can be used in assessing or providing background information when preparing restoration/management plans. Cultural Values Reports generally identify and describe values pertaining to an area or resource. They differ from CIAs in that they may not include a description of effects as they do not relate to a specific activity. However, they may address broad level impacts of development occurring or anticipated in that area. Cultural Values Reports can provide guidance as to the relevant issues and how these should best be addressed.

Step 3: A range of historical data should be collected as it provided further context to the impacts of concern to whanau.

Step 4: Agencies will already be collecting data specific to a number of stream health parameters. Rather than duplicate data collection processes, it is recommended that existing data sources be accessed.

Step 5: A CIA is a report documenting and the impacts of activities on cultural interests. CIAs are a tool that can facilitate meaningful and effective participation of Maori in future urban water management. CIAs need not be limited to a resource consenting (and adversarial) process.

Step 6: Electric fishing is on of the supplementary data collection processes recommended.

Step 7: Where appropriate and identified by Tangata whenua, in depth analysis of kai species is recommended.

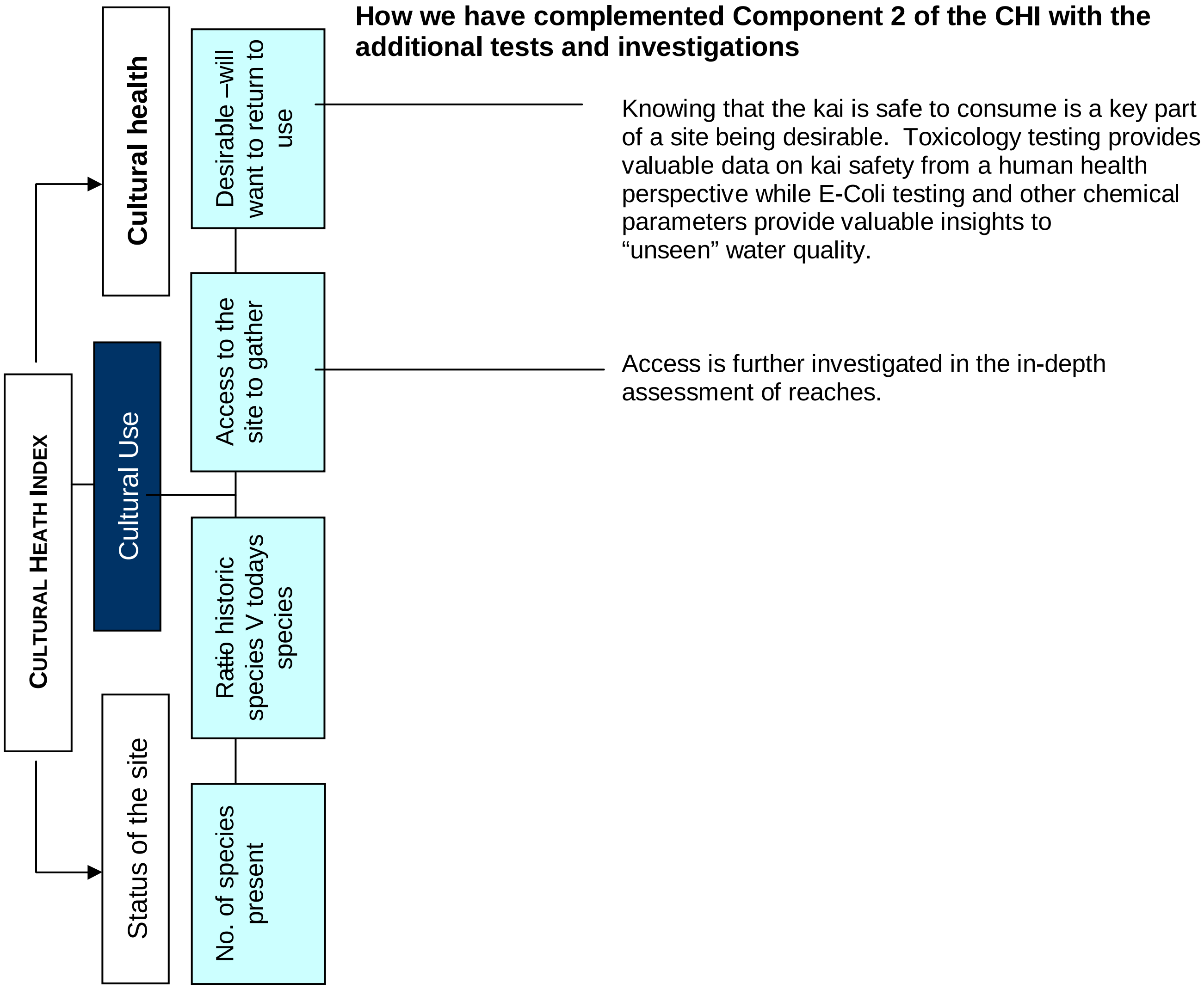
Step 8: It is essential that the focus of any toxicology testing is the species that are eaten by Tangata whenua. Further samples sent away to be tested should be gathered from the sites that are actually used by Tangata whenua. Testing that is unrelated to use risks being meaningless.

Step 9: See section 7.3 below for advice on how the CHI is to be implemented. As noted earlier the form is included in Appendix 2.

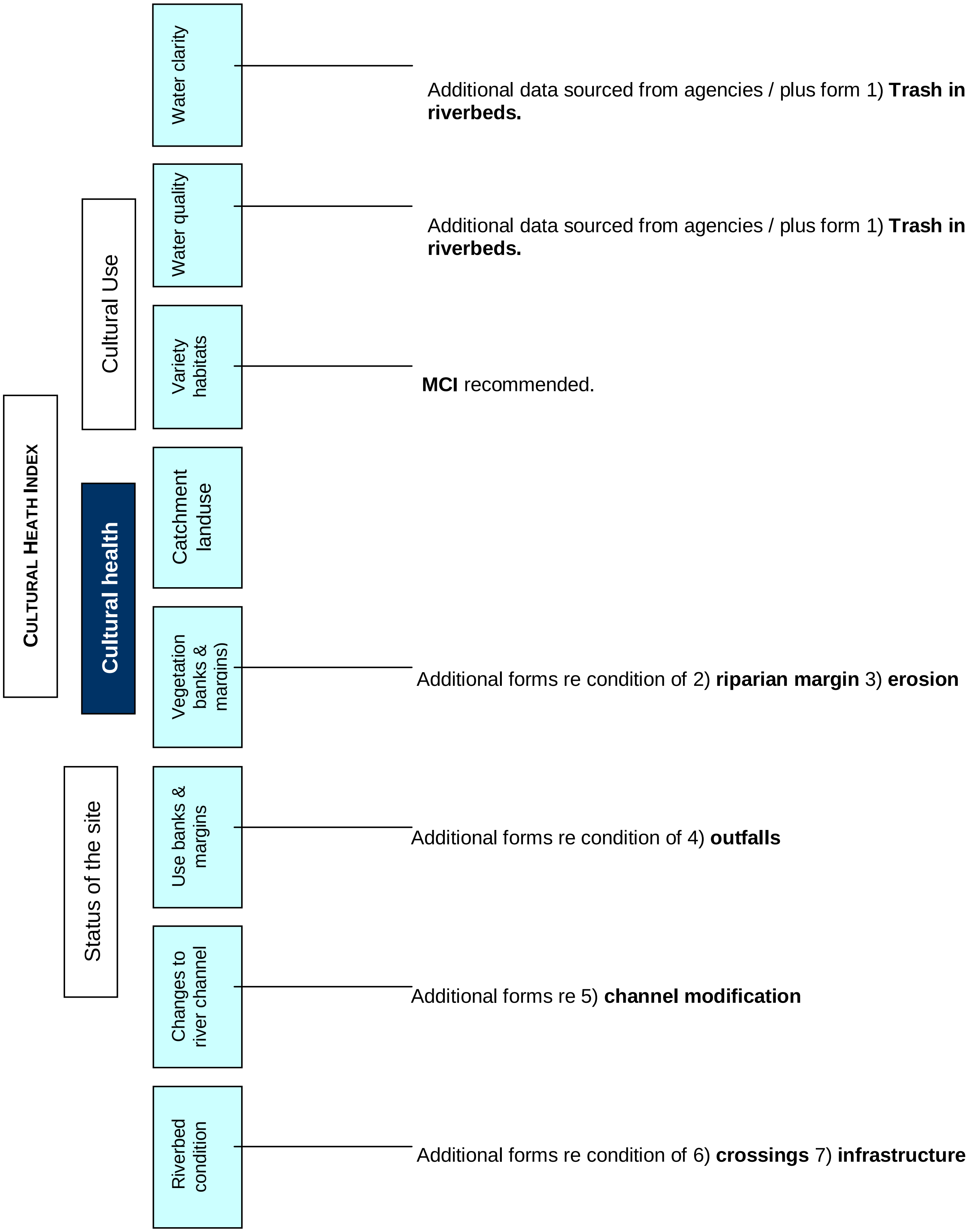
Section 10: If the CHI identifies a concern, it is important that Tangata whenua follow-up with in-depth investigation. Forms to be used are described in section 7.2 and included in Appendix 3.

In Chapter 5 we explained how our interviews supported the structure and content of the current CHI. However in the figures that follow we illustrate how the proposed process complements and builds on the CHI.

How we have complemented Component 2 of the CHI with the additional tests and investigations



How we have complemented Component 3 of the CHI with additional tests and investigations



7.2 ADDITIONAL FORMS

As noted earlier, a set of the forms to be used for in-depth investigation of issues is included in Appendix 3.

7.3 IMPLEMENTING THE CHI

The CHI was developed as a tool for Tangata whenua to use to assess sites of significance to them. It is a tool that is primarily intended to facilitate the participation of Tangata whenua in freshwater management.

The Ministry for Environment has published a guide to assist those wanting to undertake a CHI study. When reading that guide, it is important for everyone to understand that the CHI is a tool that was developed by Tangata whenua working in partnership with western trained scientists and technicians. It is to be applied by Tangata whenua, with all aspects of the design of the CHI study being decided by Tangata whenua. Finally, by analysing the data collected priorities for management can be set by Tangata whenua. These can then form the basis of discussions with councils and other charged with statutory management functions.

Chapter 8: Conclusions

This research examines cultural dimensions of urban water management for the purpose of developing an assessment tool for use by tangata whenua. In addition to the CHI which will assess stream health, we recommend in-depth investigation to identify the cause of any perceived impacts of concern. Table 29 summarises the additional assessments that can be undertaken.

Table 29: Additional in-depth impact assessment forms to help identify causes

Assessment Form	What It Assesses	Information Collected
Outfalls	All discharge pipes or channels that discharge storm water or wastewater	Basic type, source and condition. If flowing, then flow conditions should be recorded and potentially reported to authorities.
Bank Erosion	Slope failure, bank sloughing, head cuts, and incision or widening in areas noticeably worse than the average erosive condition of the survey reach. Also infrastructure or property threatened by erosion.	Location (meander or straight section), threat to property or infrastructure, accessibility; and basic bank measurements (height, angle, and bottom and top widths).
Affected Riparian Margins	Corridor length that lack at least a 20m, naturally-vegetated riparian buffer on one or both sides of stream.	Diversity and density of vegetation, flood plain conditions, adjacent land use, available area for reforestation
Infrastructure instream or on riverbank	Leaking or exposed sewer, water, or other utility lines causing water quality, habitat, or channel stability problems. Includes manhole stacks, pipes along bottom, in the bank, or above the stream susceptible to damage due to lack of maintenance or exposure.	Type, condition, and discharge characteristics associated with leaks (odors, color, etc). If leaking, report immediately to authorities. Record relevant information if potential fish barrier
Stream Crossings	All man-made or natural structures that cross the steam, such as roadways, bridges, railroad crossings, or dams. Pipe crossings and other overhead utilities are assessed	Type of crossing, culvert dimensions, relative information if suspected fish barrier (water drop, or water depth during normal flow conditions)
Channel Modification	Channelized, concrete-lined, or reinforced sections of stream, regardless of construction material used. Locations of existing stream restoration or bank stabilization projects included.	Type of modification, length of stream impacted
Trash and Debris	Areas of significant trash and debris accumulation greater than average levels observed across the survey reach. Any areas where potentially hazardous or unknown chemicals have been dumped.	Mobility, dispersal, amount and type of trash; level of effort and type of equipment required for removal; location on public or private property
Miscellaneous. Impacts	High quality areas or unusual feature or activity impacting the stream that doesn't fit into other seven impact assessments. This may include fish kills, stock access, near stream construction, flood plain excavation, grade controls, or other notable features.	

Ultimately the purpose of any assessments of stream health that are undertaken by tangata whenua are to inform water policy making and planning. In Table 30 we summarise how the data that are collected can be utilised by tangata whenua.

Table 30: Examples of Management Actions to Address Stream Problems

		Problem Assessed	Potential management action
COMPONENT 1	Status of site	• Knowledge of site • Usage of site by whanau – historically and currently • Ability of site to sustain cultural use	• Signage to inform community of history of the site • Identify actions needed to improve usage
COMPONENT 2	Cultural use (including mahinga kai)	• Resource present and available to whanau • Ability of site to sustain cultural use • Ability to access site for cultural use • Any human health risks from gathering kai	• Signage to inform community of any health risks • Identify actions needed to improve usage • Improve access
COMPONENT 3	Outfalls	• Suspected illicit discharge • Enclosed stream • Outfall location • Outfall damage	• Discharge investigations by agencies • Retrofit below outfall • Local stream repair/outfall stabilization
	Bank Erosion	• Nature and type of channel erosion • Severity of bank erosion • Threatened infrastructure	Potential sites for bank stabilization
	Riparian	• Vegetative condition	• Greenway design • Natural regeneration • Riparian site restoration
	Infrastructure instream or on margin	• Sewer overflows • Leaking sewer pipes and manholes • Sewers crossing streams • Power line rights-of-way impacting stream	• Structural repairs • Pipe testing • Citizen hotlines • Dry weather stream sampling • Site restoration
	Stream channel including any crossings	• Trash/debris in the stream • Dumping in stream corridor	• Stream clean-up sites • Stream adoption segments • Removal of trash/debris • Storm drain marking
	Channel including any modification	• Fish barriers • Stream interruption • Potential runoff storage • Scour/erosion below crossing	• Fish barrier removal • Culvert repair/replacement • Upstream retrofit • Local stream repair
	Water quality, clarity, trash and debris	• Channelization • Habitat degradation	• Natural channel design • De-channelization
	Misc. Impacts	• Wetlands and natural area remnants • Land disturbance and erosion • Livestock access/hobby farms • Fish kills	• Riparian wetland restoration • Enforcement • Exclusionary fencing, alternative water source • Discharge prevention

This report documents the process followed to develop an assessment process that was responsive to the values and conceptualisations of tangata whenua. Although the starting point was to be the CHI, the interviews with informants served to confirm the structure and content of the CHI. However the need for additional studies was confirmed. In section 4.6 we proposed an assessment framework that we trialled in the Dunedin area. After reflecting on the process used in the Dunedin area and the data collected, we recommend a tool for the assessment of urban streams in Chapter 7.

A key part of the present research is to advise tangata whenua how the data collected can meaningfully inform urban water management and more generally regional and district planning. Table 24 introduces some practical steps that can be taken.

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Glossary

Anadromous	Migrates from sea to freshwater to spawn.
Ara Tawhito	Ancient Trails.
Aruhe	Edible fernroot.
Diadromy	Migrates up or downstream, or to or from the sea.
Eutrophication	Process involving increased fertility of water due to presence of high nutrient levels, often accompanied by extreme plant growth and/or algal bloom.
Galaxias	Native fish species.
Hapū	Sub-tribe, extended whanau.
Harakeke	Flax.
Hau kaika	People that uphold the ahi kaa of a particular area.
Hikoi	Journey.
Hinaki	Pots.
Hui	Meeting, assembly.
Inanga/Inaka	A variety of whitebait; also a variety of pounamu.
Iwi	Tribe.
Iwi authority	The authority which represents an iwi and which is recognised by that iwi as having the authority to do so.
Kai Tahu	Descendants of Tahu, the tribe.
Kāi Tahu ki Otago	The four Papatipu Rūnaka and associated whānau and rōpū of the Otago Region.
Kai Tahu Whānui	The collective of the individuals who descend from one or more of the of the five primary hapū of Kai Tahu, Kati Mamoe and Waitaha.
Kaika/Kaik'	Settlement.
Kaika/Kainga nohoaka	Place of residence.
Kaimoana	Food obtained from the sea.
Kaitiaki	Guardian.
Kaitiakitaka	The exercise of customary custodianship, in a manner that incorporates spiritual matters, by tangatawhenua who hold Manawhenua status for particular area or resource.
Kanakana	Lamprey.
Karakia	Prayer, incantation.
Ka Tiritiri o te Moana	Southern Alps.
Kaumatua	Respected elder.

Kekeno	Furseals.
Ki Uta Ki Tai	Mountains to the Sea.
Koaro	A variety of whitebait.
Koiwi Takata	Human skeletal remains.
Kohaka	Breeding Ground.
Kohatu Taoka	Treasured Stone Resources.
Kokopara	Giant kokopu (common).
Koparapara	Bellbird.
Korero	Discussion.
Kotukutuku	Native fuschia.
Koura	Crayfish.
Kukupa	Native wood pigeon, kereru.
Kupenga	Net.
Mahika Kai	Places where food is produced or procured.
Mahika Mataitai	Places where food is obtained from the sea or seashore.
Makaa	Baracoutta
Mana	Authority, prestige, influence.
Mana Whenua	Customary authority or rangatiratanga exercised by an iwi or hapū in an identified area.
Manaaki	Show kindness to, look after, entertain.
Manawhenua	Those who exercise customary authority or rangatirataka.
Manuhiri	Visitor, guest.
Marae	Courtyard, meeting place for tangata whenua.
Marine Reserve	Marine reserve declared under the Marine Reserves Act 1971.
Matauraka Maori	Maori knowledge
Mate	Death.
Mauri	Essential life force or principle; a metaphysical quality inherent in all things both animate and inanimate. (Ngai Tahu Fresh Water Policy)
Mauka	Mountain.
Miro	A native tree species.
Moana	Sea, lake.
Mohoao	Black Flounder.
Mokopuna	Grandchild, descendant.
Murihiku	That area south of the Waitaki River.
Nga Whenua Kawenata	An agreement entered into under s.27A of the

	Conservation Act 1987.
Noa	Free from tapu, ordinary.
Non-diadromous	Do not migrate.
Pa	Fortification.
Papakaika	Traditional settlement or settlement on traditional land.
Papatipu	Original Maori land.
Papatipu Rūnaka	Traditional Rūnaka.
Papatuanuku	Earth mother.
Paraki/Ngaiore	Common Smelt
Patiki	Flounder.
Piripiri Pohatu	Torrent Fish.
Poha	Kelp bag (used for storing preserved food).
Pou	Post.
Pounamu	Nephrite, greenstone, jade.
Pūrākau	Stories.
Putakitaki	Paradise shelduck.
Rahui	Temporary protection of a resource.
Rakau	Tree.
Rakatira	Chief.
Rakatirataka	Chieftanship, decision-making rights.
Raupo	Bulrush.
Rimurapa	Bull kelp – used to make the poha in which titi were and still are preserved.
Rohe	Boundary.
Rohe potae	Traditional tribal area.
Rōpū	Group.
Rūnaka	Local representative group or community system of representation.
Ruru	Morepork, native owl.
Samonid	Salmon and trout species.
Taiapure	Local fishery declared under Part IIIA of the Maori Fisheries Act 1989.
Takaroa	Deity of the sea.
Takata	Person.
Takatapora	Pakeha/European (lit. 'boat people').
Takatawhenua	The iwi or hapū that holds mana whenua in a particular area.

Takiwā	Area, region, district.
Tangi	Bereavement ceremony.
Taniwha	Legendary serpent-like creature.
Taoka	Treasure.
Taoka Tuku Iho	Treasure handed down from the ancestors.
Tapu	Sacred.
Tauihu	Prow of the waka.
Tauraka Ika	Fishing ground.
Tauraka Waka	Canoe mooring site.
Te Ao Tūroa	The natural environment.
Te Wai Pounamu	The South Island.
Ti (kouka/rakau)	Cabbage tree; also edible products from ti.
Tiaki	Guardianship.
Tikanga	Lore and custom.
Tikanga Atawhai	Funding provided by the Department of Conservation for specific iwi initiated projects.
Tikaka	Customary values and practices.
Tino Rangatirataka	Full chiefly authority.
Titi	Muttonbird, sooty shearwater.
Tohu	Marker.
Tohuka	Specialist in a particular field of expertise.
Tohuka Whakairo	Master carver.
Toroa	Albatross.
Trophic	Of nutrition.
Tuaki	Cockle.
Tuhituhi nehera	Rock art.
Tuna	Eel.
Tupapaku	Human corpse.
Tupuna wahine	Female ancestor.
Tupuna/tipuna	Ancestor.
Turangawaewae	Place of belonging through ancestral rights linked to land, place to stand.
Umu-ti	Earth oven used for cooking ti.
Urunga Waka	Canoe landing site.
Urupa	Burial place.
Wahi Ingoa	Placenames.
Wahi Kohatu	Rock Formation.

Wahi Mahi Kohatu	Quarry Sites.
Wāhi Taoka	Resources, places and sites treasured by Manawhenua.
Wāhi Tapu	Places sacred to tangata whenua.
Waiata	Song.
Waikoura	Freshwater lobster.
Wairua	Life principle, spirit.
Waka	Canoe.
Waka Hunua	Double Hulled Canoe.
Wananga	Customary learning method.
Waterway	Water in a river, stream, lake, pond, wetland, estuary or acquifer, or any part thereof, including land water margins, beds and banks which the mauri of the waterway is reliant on.
Whakapapa	Genealogy.
Whakatauki	Proverb, saying.
Whanau	Family.
Whare	House.
Whare Tupuna/Wharenui	Ancestral meeting house.
Whenua	Land.

Appendix 1 – Site photographs

Fraser Creek (Kaikorai)

Kaikorai (at Brighton Road – near landfill)

Kaikorai (at Townleys Road – near Scott's Technology)

Leith Stream at Brooks Road

Leith Stream at Dundas Street

Lindsay Creek

Ross Creek

Appendix 2 – CHI Form

CULTURAL STREAM HEALTH ASSESSMENT Date: Site no:

INDICATORS	UNHEALTHY				HEALTHY
1 Catchment land use	1. Land heavily modified Wetlands, marshes lost	2	3	4	5. Appears unmodified
2 Vegetation – banks & margins (100m either side)	1. Little or no vegetation - neither exotic or indigenous	2	3	4	5. Complete cover of vegetation – mostly indigenous
3. Use of the river banks + margins (100m either side)	1. Margins heavily modified	2	3	4	5. Margins unmodified
4. Riverbed condition (sediment)	1. Covered by mud/sand slime, weed	2	3	4	5. Clear of mud/sand/sediment/weed
5. Changes to river channel	1. Evidence of modification e.g. stopbanks, straightening, gravel removal, shingle build up	2	3	4	5. Appears unmodified
6. Water quality	1. Appears polluted eg foams, oils slime, weeds etc	2	3	4	5. No pollution evident
7. Water Clarity	1. Water badly discoloured	2	3	4	5. Water is clear
8 A variety of habitats	1. Little or no current, Uniform depth and limited Variety of flow related habitatst	2	3	4	5 Current and depth varies creating a variety of different flow related habitats

9. Are you satisfied that the present condition of the river protects cultural values at this site?

1(No)	2	3	4	5(Yes)

10. What actions would you like to see taken at this site to improve its condition?

____

____

____

____

____

____

11. How would you describe the overall health of the river at this site?

1. Very unhealthy 2 3 4. 5. Very healthy

12. BIRDS: Please list the mahinga kai bird species that you can see at this site

1. 2. 3. 4.

5.______ 6.______ 7.______ 8.______

13. PLANTS: Please list the mahinga kai plant species that you can see at this site

1.______ 2.______ 3.______ 4.______

5.______ 6.______ 7.______ 8.______

14. ACCESS: Do you consider access to this site is sufficient to enable the gathering of mahinga kai?

1. Not able to gather at this site 2. 3. 4. 5. Able to gather - no restrictions

15. Would you return to this site in the future?

1. NO 5. YES.

Appendix 3 – In-depth impact assessment forms

STORM WATER OUTFALLS

CATCHMENT	**DATE:** ______/______/______	**ASSESSED BY:**
SURVEY REACH ID:	**TIME:** ______:______ AM/PM	**PHOTO ID:**
SITE ID		**GPS:**

BANK: ☐ LT ☐ RT **FLOW:** ☐ None ☐ Trickle ☐ Moderate ☐ Substantial ☐ Other:	**TYPE:** ☐ Closed Pipe	**MATERIAL:** ☐ Concrete ☐ Metal ☐ PVC/Plastic ☐ Brick ☐ Other:	**SHAPE:** ☐ Single ☐ Circular ☐ Double ☐ Elliptical ☐ Triple ☐ Other:	**DIMENSIONS:** **SUBMERGED:** Diameter: ___(m) ☐ No ☐ Partially ☐ Fully
	☐ Open channel	☐ Concrete ☐ Earthen ☐ Other:	Depth: ______ (m) Width (Top): ______(m) (Bottom): ______ (m)	

CONDITION: ☐ None ☐ Chip/Cracked ☐ Peeling Paint ☐ Corrosion ☐ Other:	**ODOUR:** ☐ No ☐ Gas ☐ Sewage ☐ Rancid/Sour ☐ Sulfide ☐ Other:	**DEPOSITS/STAINS:** ☐ None ☐ Oily ☐ Flow Line ☐ Paint ☐ Other:	**VEGGIE DENSITY:** ☐ None ☐ Normal ☐ Inhibited ☐ Excessive ☐ Other:	**PIPE BENTHIC GROWTH:** ☐ None ☐ Brown ☐ Orange ☐ Green ☐ Other: **POOL QUALITY:** ☐ No pool ☐ Good ☐ Odours ☐ Colours ☐ Oils ☐ Soaps ☐ Algae ☐ Floatables ☐ Other:

FOR FLOWING ONLY	**COLOR:**	☐ Clear ☐ Brown ☐ Grey ☐ Yellow ☐ Green ☐ Orange ☐ Red ☐ Other:
	TURBIDITY:	☐ None ☐ Slight Cloudiness ☐ Cloudy ☐ Opaque
	FLOATABLES	☐ None ☐ Sewage (toilet paper, etc.) ☐ Petroleum (oil sheen) ☐ Other:
OTHER CONCERNS:	☐ Excess Trash (paper/plastic bags) ☐ Dumping (bulk) ☐ Excessive Sedimentation ☐ Needs Regular Maintenance ☐ Bank Erosion ☐ Other:	

OUTFALL SEVERITY: *(circle #)*	Heavy discharge with a distinct colour and/or a strong smell. The amount of discharge is significant compared to the amount of normal flow in receiving stream; discharge appears to be having a significant impact downstream.	Small discharge; flow mostly clear and odourless. If the discharge has a colour and/or odour, the amount of discharge is very small compared to the stream's base flow and any impact appears to be minor/localized.	Outfall does not have dry weather discharge; staining; or appearance of causing any erosion problems.
	1	3	5

SKETCH/NOTES:

REPORTED TO COUNCIL: ☐ YES ☐ NO

SEVERE BANK EROSION

CATCHMENT		**DATE:** ______/______/______		**ASSESSED BY:**
SURVEY REACH ID:	**TIME:** ______:______ AM/PM		**PHOTO ID:**	
SITE ID				**GPS:**

PROCESS: ☐ Widening ☐ Aggrading ☐ Sed. deposition	☐ Currently unknown ☐ Bed scour ☐ Bank failure ☐ Channelized	**BANK OF CONCERN:** ☐ LT ☐ RT ☐ Both *(looking downstream)* **LOCATION:** ☐ Meander bend ☐ Straight section ☐ Steep slope/valley wall ☐ Other: **DIMENSIONS:** Length LT ______m and/or RT ______m Bank Ht LT ______m and/or RT ______m

LAND OWNERSHIP: ☐ Private ☐ Public ☐ Unknown | **LAND COVER:** ☐ Forest ☐ Field / pasture ☐ Developed:

THREAT TO PROPERTY/INFRASTRUCTURE: ☐ No ☐ Yes (Describe):

EXISTING RIPARIAN WIDTH: ☐ ≤3m ☐ 3-5m ☐ 5-10m ☐ 10-20m ☐ > 20m

EROSION SEVERITY (circle) Channelized = ☐ 1	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.	Part downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, riparian vegetation or adjacent use not impaired.
	1	3	5
ACCESS:	**Good access:** Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair access:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult access.** Must cross wetland, steep slope or other sensitive areas to access stream. Minimal stockpile areas available and/or located a great distance from stream section. Specialized heavy equipment required.
	5	3	1

NOTES/CROSS SECTION SKETCH:

REPORTED TO COUNCILS: ☐ YES ☐ NO

IMPACTED RIPARIAN MARGIN

CATCHMENT

DATE: ______/______/______

ASSESSED BY:

SURVEY REACH ID:

TIME: ______:______ AM/PM

PHOTO ID:

SITE ID

GPS:

IMPACTED BANK: ☐ LT ☐ RT ☐ Both

REASON INADEQUATE: ☐ Lack of vegetation ☐ Too narrow ☐ Widespread invasive plants ☐ Recently planted ☐ Other:

LAND USE: *(Facing downstream)*

	Private	Institutional	Golf Course	Park	Other Public
LT BANK	☐	☐	☐	☐	☐:
RT BANK	☐	☐	☐	☐	☐:

DOMINANT LAND COVER:

	Paved	Bare ground	Turf/lawn	Tall grass	Shrub/scrub	Trees	Other:
LT BANK	☐	☐	☐	☐	☐	☐	☐:
RT BANK	☐	☐	☐	☐	☐	☐	☐:

EXOTIC / INVASIVE PLANTS: ☐ None ☐ Rare ☐ Partial coverage ☐ Extensive coverage ☐ unknown

STREAM SHADE PROVIDED? ☐ None ☐ Partial ☐ Full

POTENTIAL RESTORATION CANDIDATE ☐ Active reforestation ☐ Greenway design ☐ Natural regeneration ☐ No ☐ Invasives removal ☐ Other:

RESTORABLE AREA

	Left	**Right**
Length (m):	______	______
Width (m):	______	______

REFORESTATION POTENTIAL: *(Circle)*

Impacted area on public land where the riparian area does not appear to be used for any specific purpose; plenty of area available for planting	Impacted area on either public or private land that is presently used for a specific purpose; available area for planting adequate	Impacted area on private land where road; building encroachment or other feature significantly limits available area for planting
5	3	1

POTENTIAL CONFLICTS WITH REFORESTATION ☐ Widespread invasive plants ☐ Potential contamination ☐ Lack of sun ☐ Poor/unsafe access to site ☐ Existing impervious cover ☐ Severe animal impacts (deer, beaver) ☐ Other:

NOTES:

INSTREAM CROSSING

CATCHMENT		**DATE:** ______/______/______		**ASSESSED BY:**	
SURVEY REACH ID:	**TIME:** ______:______ AM/PM		**PHOTO ID:**		
SITE ID				**GPS:**	
TYPE: ☐ Road Crossing ☐ Railroad Crossing ☐ Manmade Dam ☐ Geological Formation ☐ Other:					
FOR ROAD/ RAILROAD CROSSINGS ONLY	**SHAPE:** ☐ Arch ☐ bottomless ☐ Box ☐ Elliptical ☐ Circular ☐ Other:	**# BARRELS:** ☐ Single ☐ Double ☐ Triple ☐ Other:	**MATERIAL:** ☐ Concrete ☐ Metal ☐ Other:	**ALIGNMENT:** ☐ Flow-aligned ☐ Not flow-aligned ☐ Do not know	**DIMENSIONS:** *(if variable, sketch)* Barrel diameter: ____(m) Height:________(m) Culvert length: _____ (m) Width: _____ (m) Roadway elevation:__(m)
	CONDITION: (*Evidence of …)* ☐ Cracking/chipping/corrosion ☐ Downstream scour hole ☐ Sediment deposition ☐ Failing embankment ☐ Other *(describe):*				
POTENTIAL RESTORATION CANDIDATE ☐ Fish barrier removal ☐ Culvert repair/replacement ☐ no ☐ Upstream storage retrofit ☐ Local stream repair ☐ Other:					
If yes for fish barrier	**EXTENT OF PHYSICAL BLOCKAGE:** ☐ Total ☐ Partial ☐ Temporary ☐ Unknown **CAUSE:** ☐ Drop too high Water Drop: ______ (m) ☐ Flow too shallow Water depth: ______ (m) ☐ Other:	**BLOCKAGE SEVERITY:** *(circle)*			
		A structure such as a dam or road culvert on a 3rd order or greater stream blocking the upstream movement of anadromous fish; no fish passage device present.	A total fish blockage on a tributary that would isolate a significant reach of stream, or partial blockage that may interfere with the migration of anadromous fish.	A temporary barrier or blockage at the very head of a stream with very little viable fish habitat above it; natural barriers such as waterfalls.	
		1	3	5	

NOTES/SKETCH:

REPORTED TO COUNCIL: ☐ YES ☐ NO

CHANNEL MODIFICATION

CATCHMENT	**DATE:** ______/______/______	**ASSESSED BY:**
SURVEY REACH ID:	**TIME:** ______:______ AM/PM	**PHOTO ID:**
SITE ID		**GPS:**

TYPE: ☐ Channelisation ☐ Bank armouring ☐ concrete channel ☐ Floodplain encroachment ☐ Other:

MATERIAL:		
☐ Concrete ☐ Gabion ☐ Rip Rap ☐ Earthen ☐ Metal ☐ Other:	Does channel have perennial flow?	☐ Yes ☐ No
	Is there evidence of sediment deposition?	☐ Yes ☐ No
	Is vegetation growing in channel?	☐ Yes ☐ No
	Is channel connected to floodplain	☐ Yes ☐ No

BASE FLOW CHANNEL	**ADJACENT STREAM CORRIDOR**
Depth of flow ___________	Available width LT ______ (m) RT ______ (m)
Defined low flow channel? ☐ Yes ☐ No	Utilities Present? ☐ Yes ☐ No
% of channel bottom ___________%	Fill in floodplain? ☐ Yes ☐ No

POTENTIAL RESTORATION CANDIDATE ☐ Structural repair ☐ Base flow channel creation ☐ Natural channel design ☐ No ☐ Can't tell ☐ De-channelization ☐ Fish barrier removal ☐ Bioengineering

CHANNELIZATION SEVERITY: *(Circle #)*	A long section of concrete stream (>250m) channel where water is very shallow (<15cm deep) with no natural sediments present in the channel.	A moderate length (>100m), but channel stabilized and beginning to function as a natural stream channel. Vegetated bars may have formed in channel.	An earthen channel less than 50m with good water depth, a natural sediment bottom, and size and shape similar to the unchannelized stream reaches above and below impacted area.
	1	3	5

NOTES:

TRASH AND DEBRIS

CATCHMENT	**DATE:** ______/______/______	**ASSESSED BY:**
SURVEY REACH ID:	**TIME:** ______:______ AM/PM	**PHOTO ID:**
SITE ID		**GPS:**

TYPE:	**MATERIAL:**	**SOURCE:**	**LOCATION:**	**LAND OWNERSHIP**:
☐ Industrial ☐ Commercial ☐ Residential	☐ Plastic ☐ Paper ☐ Metal ☐ Tires ☐ Construction ☐ Medical ☐ Appliances ☐ Yard Waste ☐ Automotive ☐ Other:	☐ Unknown ☐ Flooding ☐ Illegal dump ☐ Local outfall	☐ Stream ☐ Riparian Area ☐Lt bank ☐ Rt bank	☐ Public ☐ Private ☐ Unknown **AMOUNT** *(# Pickup truck loads):*

POTENTIAL RESTORATION CANDIDATE ☐ Stream cleanup ☐ Stream adoption segment
☐ no ☐ Removal/prevention of dumping ☐ Other:

If yes for trash or debris removal	**EQUIPMENT NEEDED:** ☐ Heavy equipment ☐ Trash bags ☐ Unknown
	WHO CAN DO IT: ☐ Volunteers ☐ Local Gov ☐ Hazardous Substance Team ☐ Other

CLEAN-UP POTENTIAL: (Circle)	A small amount of trash (i.e., less than two pickup truck loads) located inside a park with easy access	A large amount of trash, or bulk items, in a small area with easy access. Trash may have been dumped over a long period of time but it could be cleaned up in a few days, possibly with a small backhoe.	A large amount of trash or debris scattered over a large area, where access is very difficult. Or presence of drums or indications of hazardous materials
	1	3	1

NOTES:

REPORTED TO CONCIL: ☐ YES ☐ NO

INFRASTRUCTURE IMPACTS

CATCHMENT	**DATE:** ______/______/______	**ASSESSED BY:**
SURVEY REACH ID:	**TIME:** ______:______ AM/PM	**PHOTO ID:**
SITE ID		**GPS:**

TYPE: ☐ Leaking sewer ☐ Exposed pipe ☐ Exposed manhole ☐ Other:	**MATERIAL:** ☐ Concrete ☐ Corrugated metal ☐ Smooth metal ☐ PVC ☐ Other:	**LOCATION:** ☐ Floodplain ☐ Stream bank ☐ Above stream ☐ Stream bottom ☐ Other:	**POTENTIAL FISH BARRIER:** ☐ Yes ☐ No **CONDITION:** ☐ Joint failure ☐ Pipe corrosion/cracking ☐ Protective covering broken ☐ Manhole cover absent ☐ Other:

EVIDENCE OF DISCHARGE:	**COLOR**	☐ None ☐ Clear ☐ Dark Brown ☐ Lt Brown ☐ Yellowish ☐ Greenish ☐ Other:
	ODOR	☐ None ☐ Sewage ☐ Oily ☐ Sulfide ☐ Chlorine ☐ Other:
	DEPOSITS	☐ None ☐ Toilet Paper etc ☐ Lime ☐ Surface oils ☐ Stains ☐ Other:

POTENTIAL RESTORATION CANDIDATE ☐ Structural repairs ☐ Pipe testing ☐ Citizen hotlines ☐ Dry weather sampling ☐ Fish barrier removal ☐ Other:
☐ no

If yes to fish barrier, Water Drop: _______ (m)

UTILITY IMPACT SEVERITY: *(Circle)* Leaking = ☐ 5	Section of pipe undermined by erosion and could collapse in the near future; a pipe running across the bed or suspended above the stream; a long section along the edge of the stream where nearly the entire side of the pipe is exposed; or a manhole stack that is located in the center of the stream channel and there is evidence of stack failure.	A moderately long section of pipe is partially exposed but there is no immediate threat that the pipe will be undermined and break in the immediate future. The primary concern is that the pipe may be punctured by large debris during a large storm event.	Small section of exposed pipe, stream bank near the pipe is stable; the pipe is across the bottom of the stream but only a small portion of the top of the pipe exposed; the pipe is exposed but is reinforced with concrete and it is not causing a blockage to upstream fish movement; a manhole stack that is at the edge of the stream and does not extend very far out into the active stream channel.
	1	3	5

NOTES:

REPORTED TO LOCAL AUTHORITIES: ☐ YES ☐ NO