Waikato River Independent Scoping Study

NIWA Client Report: HAM2010-032
September 2010

NIWA Project: MFE10201

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Acknowledgements

Waikato horo pounamu

Waikato taniwha rau

He piko he taniwha

He piko he taniwha

Kei taku ariki, a Kiingi Tuuheitia e noho nei i runga i te ahurewa tapu o oona maatua tuupuna raaua ko toona whaea anoo hoki, aa tae noa ki too hoa rangatira a Te Atawhai raatou ko aa koorua tamariki otiraa te whare kaahui ariki whaanui tonu tuu tonu, tuu tonu, tuu tonu raa.

The National Institute of Water & Atmospheric Research Limited (NIWA) would like to acknowledge and thank the multidisciplinary team of scientists, social scientists, practitioners in maatauranga Maaori, farming systems specialists, economists, engineers and planners who have made valuable contributions to the Waikato River Independent Scoping Study. They include specialists from AgResearch, Beca, Diffuse Sources Limited, Nimmo-Bell & Company Limited, Enveco, Market Economics Limited and Tipa and Associates.

E te roopuu kaimaatai puutaiao, kaimaatai haapori, kaimaatai puutea otiraa koutou e matatau ana ki ngaa hoohonutanga o te maatauranga Maaori e kore e mumutu te aroha ki a koutou katoa naa koutou i whakapau kaha ki te whakatutuki pai kia tika teenei o ngaa puurongo, teenei kaupapa whakahirahira o taatou. Ehara te kuumara e koorero moo toona reka, moo toona maangaroa, heoti anoo te kupu mihi ki too taatou nei roopu whaanui a WRISS - NIWA. Mei kore ake ngaa iwi o te Awa Tupuna o Waikato e tautoko ka kore rawa atu teenei kaupapa e ora ai. Noo reira teenaa raa koutou katoa e ngaa rangatira.

The Waikato River Independent Scoping Study team would also like to acknowledge and thank Tumu Te Heuheu, Paramount Chief of Tuwharetoa, members of the five river iwi (Waikato-Tainui, Maniapoto, Raukawa, Tuwharetoa and Te Arawa River Iwi) and the wider Waikato community who have participated in the Study. Your participation in hui and other meetings to share your maatauranga (knowledge) and aspirations for a healthy and well Waikato River will ensure this taonga and national asset is restored and protected for future generations.

E te Ariki o Tuwharetoa, Tumu Te Heuheu, ngaa iwi tokorima o te awa, (Waikato-Tainui, Maniapoto, Raukawa, Tuwharetoa and Te Arawa River Iwi) me ngaa haapori, mai i te wairere o Huka, heke atu ki Ngaaruaawahia, te tuutakitanga o te awa o Waipaa, tae noa ki te kongutu awa - Te Puuaha o Waikato. Nei raa te karamihi o te ngaakau ki a koutou e noho nei ki ngaa tahataha o te Awa Tupuna o Waikato. Kaaore e aarikarika ngaa mihi ki a koutou katoa moo too koutou nei ngaakaunui me te aroha ki te tautoko i teenei kaupapa rongomaiwhiti o taatou. Mai i teeraa tau kua paahemo ki muri, aa, tae noa ki teenei waa tonu kei konaa koutou katoa ngaa kaitiaki, Maaori mai, Paakehaa mai, i runga anoo i te ngaakau tautoko ki te kimi, ki te rapu he oranga hei whakapiki i te mauri me te wairua o te Awa Tupuna o Waikato. Noo reira, me mihi ka tika ki a koutou ngaa maareikura, ngaa whatukura otiraa ngaa whakamireirei o te marae, huri noa teenaa koutou, teenaa koutou, otiraa teenaa hoki taatou katoa – Pai Maarire.

Finally, the Study team would like to thank the following people for their work on the Waikato River Independent Scoping Study. Their work behind the scenes has made a huge contribution to the Study. They are: Alison Bartley, Mark James, Grant McGough, Aroon Parshotam, Mike Stevens, Mark Tucker, Sanjay Wadhwa, Penny Wakelin and Emilie Williams.

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Executive Summary

"Tooku awa koiora me oona pikonga he kura tangihia o te maataamuri."

"The river of life, each curve more beautiful than the last."

These words are taken from the maimai aroha, or lament, by Kiingi Taawhiao, the second Maaori king in which he recorded his adoration for the Waikato River and the significance of the river as a taonga for all generations. They form part of the vision for the Waikato River and inspire the recommendations of this Scoping Study.

Context for the Study

The Waikato River Independent Scoping Study provides a foundation for a new era of co-management between the Crown, the four Waikato River iwi (Waikato-Tainui, Raukawa, Tuwharetoa[1] and the Te Arawa River Iwi) and Waipa[2] River iwi (Maniapoto), to restore and protect the health and wellbeing of the Waikato River for future generations[3].

Co-management

The Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 gives special and unique status to a 'vision and strategy' known as Te Ture Whaimana o Te Awa o Waikato, which is now the primary direction-setting document for the Waikato River. A new co-management entity called the Waikato River Authority, with a 50:50 Crown-Maaori membership, comes into being in November 2010 to:

1. Provide direction through Te Ture Whaimana o Te Awa o Waikato to achieve the restoration and protection of the health and wellbeing of the Waikato River for future generations.
2. Promote an integrated, holistic and coordinated approach to the implementation of Te Ture Whaimana o Te Awa o Waikato and the management of the Waikato River.
3. Fund rehabilitative initiatives for the Waikato River in its role as trustee for the Waikato River Clean-Up Trust (also established under the Act).

The co-management arrangements are supported by the other river iwi.

[1] Tuwharetoa has requested that Tuwharetoa be spelt with one 'u' for the purposes of this Study.
[2] Maniapoto has requested that Waipa be spelt with one 'a' for the purposes of this Study.
[3] From this reference onwards the four Waikato River iwi (Waikato-Tainui, Raukawa, Tuwharetoa and the Te Arawa River Iwi), and the Waipa River iwi (Maniapoto) are referred to as the river iwi. Note: These iwi are currently recognised by the Crown for the purposes of the settlement. Others continue to seek recognition via Treaty settlement processes.

Te Ture Whaimana o Te Awa o Waikato – Vision and Strategy for the Waikato River

Te Ture Whaimana o te Awa o Waikato[4] was developed by the Guardians Establishment Committee, a temporary co-management group comprised of six appointees of the Crown, two appointees of Waikato-Tainui and one appointee from each representative body of Tuwharetoa, Raukawa, Te Arawa River Iwi and Maniapoto.

The overarching vision is:

> *"…for a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come."*

Study origins and scope

After the delivery of Te Ture Whaimana, the Guardians Establishment Committee were also tasked with acting *"as a governance group for a scoping study to identify rehabilitation priorities in relation to the Waikato River, identify the likely cost of priority activities, and provide useful background information to the establishment and operation of the Waikato River Clean-Up Trust."*

The multidisciplinary Study team contains scientists, social scientists, practitioners in maatauranga Maaori, farming systems specialists, economists, engineers and planners.

The area covered by this Study includes the Waikato River from Taaheke Hukahuka to Te Puuaha o Waikato, and its tributaries, wetlands and lakes. This includes the whole of the Waipa River catchment but not the catchment of Lake Taupoo. Subsequent references to the Waikato River include this entire Study area.

The Crown and the five river iwi will use the findings to help finalise the amount, scope and key components of the Crown contribution to a clean-up fund to restore and protect the health and wellbeing of the Waikato River. The Study itself does not make final decisions about which actions to fund – that will be solely the responsibility of the Waikato River Authority in its role as trustee for the Waikato River Clean-Up Trust.

The context for the Study is outlined in more detail in Section 1 of this report.

Study methods

Around the world, there are many studies relating to river restoration. Some are at a catchment-wide scale, some use social science and some incorporate indigenous environmental knowledge. This Study is unusual in that it has all those features. Moreover, its findings will be used by a decision-making body on which indigenous and non-indigenous people have an equal say – globally, that is rare indeed.

[4] From this reference onwards Te Ture Whaimana o Te Awa o Waikato is referred to as Te Ture Whaimana.

Integrating maatauranga Maaori and Western science

By integrating maatauranga Maaori and Western science, this Study provides the Waikato River Authority with a sound and objective platform for decision making. The Study team take the view that neither maatauranga Maaori nor science is superior in understanding and responding to environmental problems. They are both knowledge systems primarily concerned with observing, understanding and predicting effects of various behaviours on future outcomes. Maatauranga Maaori and science have been integrated through all the main steps of this Scoping Study.

The Study methods are outlined in more detail in Section 2 of this Report.

The current state of the Waikato River

Te Ture Whaimana recognises that the Waikato River is *"seriously degraded along much of its length"*.

For the river iwi, the Waikato River is their awa tupuna (ancestral river). It is seen as an indivisible entity and any harm to the mauri (life principle or life force) of the river is harm to the mauri of the iwi.

In this Study, therefore, the *health and wellbeing* of the river is defined much more broadly than just the biophysical *health* of the river (its water quality, biodiversity and ecosystem health). Health and wellbeing is regarded as almost synonymous with mauri. As a result, the definition of health and wellbeing of the river includes people's *economic, social, cultural and spiritual relationships*[5] with it.

Key points include:

1. The ability of river iwi to exercise kaitiakitanga (guardianship) according to their tikanga (correct procedure, custom) and kawa (ceremonial rituals, protocol) has been compromised.
2. Iwi feel particularly distressed by human sewage discharges into the river.
3. Access to the river is patchy, despite some recent improvements.
4. Many significant cultural and historical sites have been lost or degraded. Many Maaori place names along the river are either used incorrectly or not used at all.
5. The aesthetic values of the river have changed markedly since pre-European times, especially its colour and clarity but also vegetation and landscape values along its banks.
6. Water quality varies systematically across the catchment. In general, water quality is very good in the upper Waikato main stem but poor in the lower Waipa, the lower Waikato and most of the tributaries.
7. Three groups of contaminants pose the highest risk to the safety of drinking-water and kai taken from the river, as well as contact recreation: geothermal chemicals (mercury and arsenic), cyanotoxins (during some algal blooms) and faecal contaminants.

[5] Objectives B, C and D of Te Ture Whaimana all use this phrase.

8 About 80 percent of the nutrients, disease-causing organisms and sediment going into the Waikato River catchment now come from 'diffuse sources' (mostly farm run-off). As a result:

   a. The lower Waikato River, hydro lakes and most of the shallow lakes are prone to algal blooms.

   b. Most tributaries and some parts of the lower Waipa and lower Waikato do not meet bathing water guidelines.

   c. Colour and clarity are degraded, especially in the lower Waipa and lower Waikato.

9 The tuna fishery in the Waikato has declined by about 75 percent in the past two decades, and there is evidence of decline in the whitebait fishery.

10 The piiharau (lamprey) fishery no longer exists in the Waikato River main stem but a remnant fishery exists in the Waipa River.

11 Kooura (freshwater crayfish) and kaaeo (freshwater mussels) are no longer common in the lower Waikato River, the Waipa River and the shallow lakes.

12 Plants used for traditional, cultural purposes are now much less abundant.

13 Wetland habitat in the catchment has been reduced by 90 percent since pre-European times.

14 Invasive plants and pest fish cause widespread adverse effects.

Section 3 of this Report presents extensive evidence of the degraded health and wellbeing of the river from maatauranga Maaori and science.

The desired state of the Waikato River

Te Ture Whaimana was developed by the Guardians Establishment Committee after hui, public open days, stakeholder meetings and a call for submissions. It encapsulates, at a high level, the community's desired state for the river:

> *"As the Waikato River is important to all the people of the region, the ultimate measure of this Vision and Strategy will be that the Waikato River will be safe for people to swim in and take food from over its entire length."*

Hui, workshops and a review of other publicly available information provided the Study team with a rich source of supporting material, which was synthesised into 15 aspirations (see Table 1). These aspirations affirm and support the objectives and strategies set out in Te Ture Whaimana (see Table 2) and provide the basis for establishing more specific targets and actions required to restore the Waikato River to a desired state. 'Desired state' describes the state that would be achieved when all of aspirations had been met and the objectives and strategies in Te Ture Whaimana had been achieved (i.e., what is desired by iwi and the wider community for the health and wellbeing of the Waikato River) (see Section 4 for more details).

Table 1: Aspirations for a healthy and well Waikato River, including its lakes, wetlands and tributaries

1	That management of the Waikato River to protect its health and wellbeing is conducted in a holistic, integrated way.
2	That people feel engaged with the Waikato River, and processes, initiatives or actions to restore and protect its health and wellbeing.
3	That the spiritual values of the Waikato are restored and protected.
4	That significant and historic sites along the Waikato River are restored and protected.
5	That greater access to the Waikato River will improve people's use and enjoyment.
6	That the recreational value of the Waikato River is improved.
7	That the aesthetic and landscape value of the Waikato River is improved.
8	That the risk of illness from contact with the Waikato River for recreation or as a source of food or water supplies is minimised.
9	That the water quality of the Waikato River is improved.
10	That the abundance of fish and other kai in the Waikato River is restored and protected.
11	That the abundance of treasured plant and animal species (including cultural materials) in the Waikato River is restored and protected.
12	That the ecological integrity of the Waikato River is restored and protected.
13	That the people of the Waikato have a secure supply of water from the Waikato River.
14	That actions chosen to restore and protect the health and wellbeing of the Waikato River are considered in the context of their effect on the prosperity of the local community.
15	That actions chosen to restore and protect the health and wellbeing of the Waikato River are considered in the context of their effect on the region's and New Zealand's economic prosperity.

Table 2: How the objectives outlined in Te Ture Whaimana relate to the aspirations for a healthy and well Waikato River.

	Objectives outlined in Te Ture Whaimana – the Vision and Strategy for the Waikato River[6]	*Meeting the following aspirations will achieve this objective*
A.	The restoration and protection of the health and wellbeing of the Waikato River.	All
B.	The restoration and protection of the relationship of Waikato-Tainui with the Waikato River, including their economic, social, cultural and spiritual relationships.	All
C.	The restoration and protection of the relationship of Waikato River iwi according to their tikanga and kawa, with the Waikato River, including their economic, social, cultural and spiritual relationships.	All
D.	The restoration and protection of relationships of the Waikato Region's communities, with the Waikato River, including their economic, social, cultural, and spiritual relationships.	All
E.	The integrated, holistic and coordinated approach to management of the natural, physical, cultural and historic resources of the Waikato River.	1, 5, 6, 8, 9, 10, 12, 13, 14, 15
F.	The adoption of a precautionary approach towards decisions that may result in significant adverse effects on the Waikato River, and in particular those effects that threaten serious or irreversible damage to the	1, 8, 9, 12

[6] See Appendix 3: Te Ture Whaimana – the Vision and Strategy for the Waikato River.

	Objectives outlined in Te Ture Whaimana – the Vision and Strategy for the Waikato River[6]	Meeting the following aspirations will achieve this objective
	Waikato River.	
G.	The recognition and avoidance of adverse cumulative effects, and potential cumulative effects, of activities undertaken both on the Waikato River and within its catchments on the health and wellbeing of the Waikato River.	1, 8, 9, 12, 13
H.	The recognition that the Waikato River is degraded and should not be required to absorb further degradation as a result of human activities.	1, 3, 7, 8, 9, 12
I.	The protection and enhancement of significant sites, fisheries, flora and fauna.	4, 7, 10, 11, 12
J.	The recognition that the strategic importance of the Waikato River to New Zealand's social, cultural, environmental and economic wellbeing requires the restoration and protection of health and wellbeing of the Waikato River.	8, 12, 13, 15
K.	The restoration of the water quality within the Waikato River so that it is safe for people to swim in and take food from over its entire length.	1, 5, 6, 8, 9, 11
L.	The promotion of improved access to the Waikato River to better enable sporting, recreational and cultural opportunities.	4, 5, 6, 9, 10
M.	The application to the above of both maatauranga Maaori and latest available scientific methods.	All

Actions to restore the river

The Study team were asked to recommend a list of bold and innovative priority actions that, together, would lead to the restoration of the health and wellbeing of the Waikato River.

The Study team first identified a diverse range of actions which had the potential to 'bridge the gap' between the current and desired state of the river, and so contribute to Te Ture Whaimana. The actions, and their individual costs, are described in Section 5 of this Report, with technical information in associated appendices.

The Study team then produced three 'scenarios' or alternative views of the future, based on different bundles of actions, and assessed their benefits to the Waikato River and their economic effects. This provided a useful guide to decision making since it indicates the amount of money that could be required to improve the river by varying degrees. Section 6 of this Report describes the scenarios and presents the results of the scenario modelling.

Amongst other things, the scenarios demonstrate that applying current practices to meet existing rules and industry codes of practice will deliver measurable benefits but would not be enough to meet the aspirations held for the river. Extra investment is clearly required.

Recommended priority actions

The final recommended bundle of actions represents what the Study team believe is the best combination of technically feasible, cost effective actions for addressing all aspects of the health and wellbeing of the river. More than 60 priority actions are recommended (see Section 7 for more details). They include the following 'Ten Tonics':

1. Governance: Appropriate weight being given to Maaori aspirations for the protection and restoration of the Waikato River through the implementation of the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 by the Waikato River Authority and those with statutory obligations and responsibilities under the Act (local authorities and government departments). The relationship between the Waikato River Authority, Environment Waikato and other local authorities will be essential to the implementation of actions the Waikato River Authority chooses to fund.
2. Engagement: A strategic engagement/public outreach plan building on existing activities, including work with farmers, taangata whenua, schools and environmental groups.
3. Dairy farms: A suite of actions to reduce pollutant run-off, including improved nutrient and effluent management, preventing stock access to streams and use of nitrification inhibitors.
4. Dry stock farms: Measures to keep stock out of streams and afforestation of 68,000 hectares of marginal, erodible hill country pasture.
5. Point source discharges: Land disposal of all treated human sewage, a review of consent conditions for discharges and investigation of better treatment of some large point source discharges near Hamilton and of discharges to small streams.
6. Public health: Reductions in faecal contamination through actions on farms, the installation of safe drinking-water supplies on marae, and determining the safe limits for eating kai taken from geothermal areas (affected by toxic chemicals).
7. Access: More footpaths, cycleways, boat ramps and other measures to improve access to, and along, the Waikato River (where appropriate) for recreation and traditional uses.
8. Fisheries, kai, taonga species: Increasing the area and quality of habitat through riparian fencing and planting, creation of new wetland habitat and removing barriers to migration. Enhance tuna populations through elver capture, aquaculture and release.
9. Lakes restoration: A phased programme of restoration, focusing on two dune lakes, four peat lakes, and two larger riverine lakes (Waahi and Whangapee).
10. Protection: Application of a precautionary approach when revising policies and plans, and making decisions on resources so as to protect the Waikato River against adverse effects from continuing land use intensification and population growth.

For this bundle of recommended priority actions, economic analysis and modelling predicts that total cost of restoration over the 30 year model duration are $4,840 million (present value of $1,930 million), with a net cost of $2,240 million (net present value of $1,400 million) (see Table 2). Overall, however, the analysis predicts that the economic effect will be small because the recommended actions stimulate the local economy at the expense of a small contraction in the rest of New Zealand (Table 3). This economic analysis is likely to be pessimistic as it does not include:

- Valuation of non-market benefits (e.g., recreation, cultural, spiritual, aesthetic, biodiversity, educational, some aspects of ecosystem services and existence values). The Study team's review of the limited existing case studies indicated that non-market values are of comparable size to the market cost of restoration even when they do not include all benefits important to this Study (e.g., cultural or spiritual values).

- Benefits that would accrue from the harvesting of planted forests beyond the 30-year analysis period.

- Benefits that would accrue from the Emissions Trading Scheme as a result of afforestation. This was not included in the formal analysis because of the high uncertainty associated with carbon markets over the next 30 years.

Table 2: Total direct costs and benefits for the recommended priority actions ($\$_{2010}$ million)

	Total	*PV*
CAPEX	1,000	740
OPEX	3,830	1,230
Total	**4,840**	**1,930**
Benefit	2,590	570
Net cost	**2,240**	**1,400**

Table 3: Estimated economic impacts for the recommended priority actions, 2011–2040

	Cumulative net economic impacts		*Average net economic impacts per year*	
	Value added $\$_{2007}$million	Jobs MEC[1] years	Value added $\$_{2007}$million	Jobs MEC[1] years
Waikato region	148	1,590	4.9	53
Rest of New Zealand	-1,466	-21,160	-48.9	-705
Total[2]	-1,317	-19,570	-43.9	-652

Notes:

1 Modified Employment Count (MEC). This includes both employment counts and working proprietors.

2 Figures may not add due to rounding.

3 $\$_{2007}$million – The IO modelling is based on an IO table for the year ending March 2007 developed by Market Economics Limited. This is the latest year for which all economic data required to produce an updated IO table are available. A regional table was also produced from the 2006/2007 national table.

The priority actions recommended in this Report, if fully implemented, will restore the health and wellbeing of the Waikato River, as required by Te Ture Whaimana, with all aspirations reaching a 'Good' (B) to 'Excellent' (A) ranking (see Figure 1).

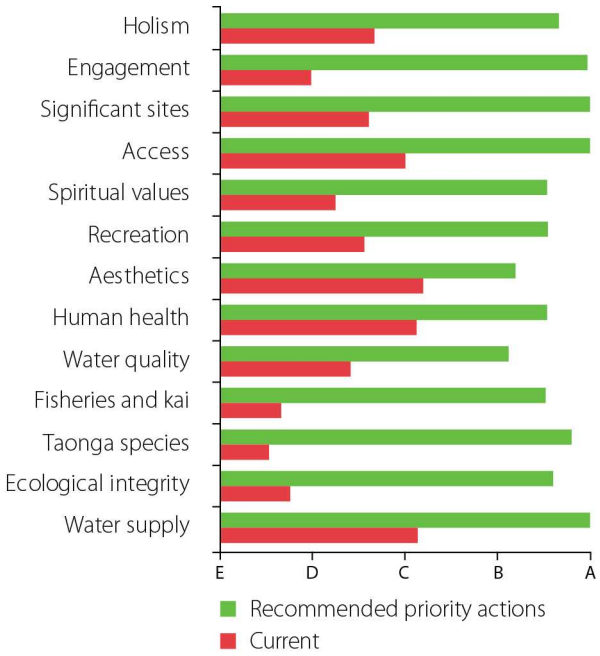


Figure 1: Predicted progress for each aspiration, compared with the current state, assuming full implementation of the recommended priority actions. Green bars are scores for the recommended priority actions and red bars are scores for the current state.

Detailed discussion is contained in Section 7 of this Report.

In summary, water quality will be safe for swimming in the main stem and people will be able to gather food over the length of the river. Kai, such as tuna and whitebait, will be more abundant and the needs of traditional harvest by river iwi will be met.

Over time, the waters of the Waipa and lower Waikato will become clearer, returning to their condition pre-1920s (before the hydro dams and recent intensification of agriculture). Their colour will shift from a yellow-green to a blue-green. Some tributaries will be a natural, peat-stained brown.

The ecological integrity and recreation potential of the Waikato's currently degraded lakes will greatly improve. The restored lakes will once more be high quality habitat suitable for supporting good stocks of whitebait, tuna and other taonga species, with flourishing native plants in and around the lakes.

All waahi tapu will be identified and protected. Footpaths, cycleways, boat ramps and reserves along the river will be created. Finally, as people become more engaged in restoration and use of the river, they will see the Waikato River as the jewel in the region's crown.

Monitoring and evaluation

One key lesson from restoration projects around the world is that monitoring is essential. The community needs to be involved in the monitoring process and see the results of their actions. Everyone needs to learn from monitoring (adaptive management).

This Study takes a widely used tool for reporting restoration progress – Report Cards – and extends it in new ways. Report Cards are used extensively in New Zealand and elsewhere, but mostly only to monitor water quality and ecological health. Typically, they take a group of indicators of the state of the environment (e.g., nutrient concentrations) and assign a 'grading', sometimes simply A, B, C, D, and E – much like an old-fashioned school report card.

This Study provides observations and guidance to the Waikato River Authority on how to implement a holistic Report Card framework, which incorporates both maatauranga Maaori and science (including social science).

Monitoring and evaluation is discussed in detail in Section 8 of this Report, with technical information provided in the associated appendices.

The way forward

There are some risks to successful implementation of a programme to restore and protect the health and wellbeing of the river. Section 7 sets out some of the key impediments and discusses how they can be overcome. It also provides guidance on how to timetable implementation. Critical success factors identified from other restoration projects both in New Zealand and overseas are outlined in Section 9 and below:

1. Restoration requires investment – restoration projects on a catchment-scale can typically require budgets of many millions of dollars.
2. Restoration is long-term – it may be several decades before significant restoration is achieved.
3. Collaboration is needed – Restoration often requires participation, cooperation and collaboration from many parties including state and local government agencies, industry, universities, and representatives of indigenous groups, environmental care groups, recreational sports groups and the wider community.
4. Build on existing initiatives – attempts should be made to build on existing restoration activities, environmental management and monitoring activities.
5. Define the desired outcome– the overall outcome that is desired from restoration needs to be well defined. Te Ture Whaimana provides that in this case.
6. Set agreed objectives – it is important to have clearly defined and agreed restoration objectives that will meet the desired outcome, and all partners need to be committed to achieving these.
7. Use traditional knowledge and science – successful restoration relies on incorporating traditional knowledge (in this case, maatauranga Maaori) and science. Also, scientific input must incorporate multi- and interdisciplinary approaches (e.g., drawing on physical, chemical, geomorphological and ecological expertise).
8. Use science – use the extensive and growing body of restoration science to inform actions, monitoring and analysis.
9. Track expenditure and progress – records of expenditure and completion of specific restoration activities need to be recorded and audited.

10 Monitor – progress towards completing restoration activities, achievement of objectives and progress towards the overall outcome need to be monitored and the results publicised.

11 Learn from monitoring – monitoring results need to be analysed to determine the effectiveness of the actions undertaken.

12 Use adaptive management – because the outcome of specific restoration actions will not be reliably predictable there needs to be ongoing review of progress and if necessary modification and re-setting of objectives and actions.

13 Outreach – there needs to be easy access to project information, objectives, planned actions, resources and monitoring results for all stakeholders and the community.

14 Plan for the future – restoration projects are typically of a long duration and this needs to be considered when setting up administrative and management systems. Staff turnover and operational restructuring need to be allowed for with robust systems able to survive in the long-term. Planning has to include information security and backup and archiving. Standardised data systems and mandatory reporting are needed and changes in computing systems need to be considered so that information is not lost.

This is a Scoping Study – it is not the final word on the matter. The Study revealed information gaps that often required the team to take a 'weight of evidence' approach. Nevertheless, uncertainty is not uncommon in river restoration projects and should not be used to delay action but rather as a signal to monitor the results of actions and modify appropriately (adaptive management). Like the Guardians Establishment Committee, the Study team believe that "*to do nothing until you know everything*" is not an option.

1. Introduction

This Study provides a foundation for a new era of co-management between the Crown, the four Waikato River iwi (Waikato-Tainui, Raukawa, Tuwharetoa[7] and Te Arawa River Iwi) and the Waipa[8] River iwi (Maniapoto)[9]. This Study provides the Crown and the river iwi with a sound and objective basis on which to make final decisions about the priority actions required to restore and protect the health and wellbeing of the Waikato River for future generations.

The Study is nationally significant because it will guide the most comprehensive co-management agreement established in New Zealand history between the Crown and iwi to restore and protect the health and wellbeing of a national asset. It also provides an internationally significant example of integrating the values of an indigenous people with Western science and culture.

1.1 Study context: A new era of co-management

To Waikato-Tainui the Waikato River is a tupuna (ancestor), while all five river iwi acknowledge that the river has mana (prestige) and, in turn, represents the mana and mauri (life principle) of its people. The Waikato River's cultural and historical importance to the people of all five river iwi cannot be underestimated.

"The River belongs to us, just as we belong to the River. The Waikato iwi and the River are inseparable. It is a gift left to us by our ancestors and we believe we have a duty to protect that gift for future generations." – The late Sir Robert Te Kotahitanga-a-Koroki Mahuta (1975)

On 16 March 1987 Sir Robert Mahuta filed a claim with the Waitangi Tribunal on behalf of the Waikato-Tainui iwi. It sought redress for the Crown's raupatu (invasion and war by land and by the Waikato River, and subsequent confiscation of Waikato lands) in the 1860s which denied Waikato-Tainui their rights and interests in the Waikato River. In 2005 the Crown recognised the mandate of the Waikato-Tainui iwi to negotiate the settlement of their historical Treaty claims in relation to the Waikato River. A Deed of Settlement was ratified by the members of the Waikato-Tainui iwi and signed on 22 August 2008.

The overarching purpose of the Deed of Settlement was to reflect the commitment of the Crown and Waikato-Tainui to enter a new era of co-management over the Waikato River to restore and protect its health and wellbeing for future generations. The Crown acknowledged that its past dealings with Waikato-Tainui, in relation to the Waikato River, breached the Crown's obligations under the Treaty of Waitangi. These included:

- The Crown's raupatu in the 1860s which denied Waikato-Tainui their rights and interests in the Waikato River.
- The failure of the Crown to respect, provide for and protect the special relationship Waikato-Tainui has with the Waikato River.

[7] Tuwharetoa has requested that Tuwharetoa be spelt with one "u" for the purposes of this Study.
[8] Maniapoto has requested that Waipa be spelt with one "a" for the purposes of this Study.
[9] From this reference onwards the four Waikato River iwi (Waikato-Tainui, Raukawa, Tuwharetoa and the Te Arawa River Iwi), and Waipa River iwi (Maniapoto) are referred to as the river iwi. Note: These iwi are currently recognised by the Crown for the purposes of the settlement. Others continue to seek recognition via Treaty settlement processes.

- The degradation of the Waikato River and its once rich fisheries that has occurred while the Crown has had authority over the river, causing distress to Waikato-Tainui.

In 2009 the Crown decided to review aspects of the co-management arrangements for the Waikato River to assess whether it was possible to do better and, with the agreement of Waikato-Tainui, appointed an advisory panel. Following the advisory panel's recommendations, Waikato-Tainui and the Crown agreed to enhanced co-management arrangements for the Waikato River, which formed the basis of the revised Deed of Settlement between Waikato-Tainui and the Crown, signed in December 2009. The Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010, giving effect to the 2009 Deed, received Royal Assent on 7 May 2010. The Act is expected to be fully in force in November/December 2010.

The Act is clear that *"the overarching purpose of the settlement is to restore and protect the health and wellbeing of the Waikato River for future generations*[10]*".*

The Act includes giving Te Ture Whaimana, a Vision and Strategy document, a special and unique status as the primary direction-setting document for the Waikato River. It focuses on restoring and protecting the health and wellbeing of the river for future generations and will be:

- Incorporated directly into the Waikato Regional Policy Statement.
- Reviewed by the new Waikato River Authority to add targets and methods as necessary.
- Given effect under the Resource Management Act 1991 and conservation and other relevant legislation.
- Given the status of a statement of general policy under conservation legislation.

The Act, when it comes fully into force in November/December 2010, will establish a new co-management entity called the Waikato River Authority, with a 50:50 Crown-Maaori membership. Its purpose is to:

1. Set the primary direction, through Te Ture Whaimana, to achieve the restoration and protection of the health and wellbeing of the Waikato River for future generations.
2. Promote an integrated, holistic and coordinated approach to the implementation of Te Ture Whaimana and the management of the Waikato River.
3. Fund rehabilitative initiatives for the Waikato River in its role as trustee for the Waikato River Clean-Up Trust (also established under the Act).

Other ways in which co-management is given effect in the provisions of the Act includes:

- An integrated river management plan will be prepared by Waikato-Tainui, relevant departments, local authorities and agencies, acting in a cooperative and coordinated manner.
- Commissioners appointed by the Waikato River Authority will participate in hearing committees and boards of inquiry in respect of applications for resource consents to take, use, dam or divert water in the Waikato River, for point source discharges to the Waikato River and for certain other activities.

[10] Section 3, Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010.

- Joint management agreements will be made between relevant local authorities and Waikato-Tainui over matters relating to the Waikato River and catchment.

To ensure that a comprehensive, consistent and integrated co-management framework could be agreed for the entire Waikato River catchment, by all river iwi associated with it, the other river iwi (Maniapoto, Raukawa, Tuwharetoa and Te Arawa River Iwi) also support the co-management arrangements for the Waikato River in principle, and in co-management deeds, with the Crown. (These are separate from their individual comprehensive negotiations leading to, and pending, formal settlements of their own individual historical Treaty of Waitangi claims.) The Crown signed co-management deeds with Raukawa in December 2009, Te Arawa River Iwi in March 2010 and Tuwharetoa in May 2010. The Office of Treaty Settlements is continuing to negotiate a co-management deed with Maniapoto.

1.2 *Te Ture Whaimana o Te Awa o Waikato – Vision and Strategy for the Waikato River*

Te Ture Whaimana o Te Awa o Waikato[11] is the primary direction-setting document for the Waikato River. It was developed by the Guardians Establishment Committee, a temporary co-management group, comprised of six appointees of the Crown, two appointees of Waikato-Tainui and four appointees of representative bodies of other river iwi (see Appendix 4: Guardians Establishment Committee).

After an extensive consultation period that included listening to the hopes and aspirations of kaumaatua (elders), iwi, local government, industry, interest groups and the many communities along the Waikato River, the Guardians Establishment Committee delivered Te Ture Whaimana – the Vision and Strategy for the Waikato River - to the Crown and Waikato-Tainui at a special hui (meeting) in June 2008.

The overarching vision developed for the Waikato River is as follows:

"Our Vision is for a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come." (See Appendix 3: Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River)

Te Ture Whaimana also outlines a number of objectives for the Waikato River, and strategies to reach those objectives (see Appendix 3: Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River).

1.3 *Purpose and scope of the Study*

The primary purposes of the Waikato River Independent Scoping Study as identified in the Waikato-Tainui Deed of Settlement and included in the Study team's brief, are to:

1 Identify priority actions and associated costs of those actions, necessary to rehabilitate the health and wellbeing of the Waikato River and its tributaries, wetlands and lakes for future generations.

[11] From this reference onwards Te Ture Whaimana o Te Awa o Waikato is referred to as Te Ture Whaimana.

2 Provide background information useful to the establishment and operation of the Waikato River Clean-up Trust.

The Crown and the five river iwi will use the findings to help finalise the amount, scope and key components of the Crown contribution to a clean-up fund to restore and protect the health and wellbeing of the Waikato River. The Study itself does not make final decisions about what actions the Waikato River Authority will fund in its role as trustee of the Waikato River Clean-Up Trust. Deciding which specific actions should be chosen for rehabilitating the Waikato River is solely the responsibility of the Waikato River Authority.

Work on the Waikato River Independent Scoping Study began in May 2009.

To address the scope of the Study, the Study team:

- Reviewed existing evidence on the current state of the Waikato River and the causes of degradation.
- Gathered and analysed maatauranga Maaori (specific Maaori knowledge) about the river, its past and present condition and the causes of degradation through hui, one-on-one interviews and analysis of available literature.
- Identified the aspirations of river iwi and the wider Waikato community for the river.
- Evaluated the benefits, costs and drawbacks of various restoration actions. This evaluation included micro-level and macro-level impacts, environmental impacts and social impacts, how the action could be done, where in the catchment it should occur, who could or should undertake the action, costs (direct, indirect and opportunity costs) of the action, information gaps and recommendations to overcome them and uncertainties and interactions with other actions.
- Developed and analysed three scenarios showing how different 'bundles' of actions could be brought together to reach different outcomes for the health and wellbeing of the Waikato River.
- Recommended the priority actions necessary to restore the health and wellbeing of the Waikato River and its tributaries, wetlands and lakes for future generations.
- Developed a Report Card framework to monitor and communicate the progress of restoration actions. This includes cultural indicators (to be developed by river iwi using maatauranga Maaori) and social indicators of human behaviour such as enthusiasm for, and engagement with, the river.

1.3.1 Area covered

The area covered by the Waikato River Independent Scoping Study includes the Waikato River from Taaheke Hukahuka (Huka Falls) to Te Puuaha o Waikato (Port Waikato) and the whole of the Waipa River catchment. It also includes the tributaries, wetlands and lakes alongside it (see Figure 1.1). Subsequent references to the Waikato River in this document include the entire Waikato River catchment area downstream from Taaheke Hukahuka and excluding the catchment of Lake Taupoo (see Figure 1.1).

1.3.2 Parties involved

The Waikato River Independent Scoping Study has been led by the National Institute of Water & Atmospheric Research Limited (NIWA) and also includes specialists from AgResearch, Beca[12], Diffuse Sources Limited, Enveco, Nimmo-Bell & Company Limited, Market Economics Limited and Tipa and Associates. The multidisciplinary team comprises scientists, social scientists, practitioners in maatauranga Maaori, farming systems specialists, economists, engineers and planners.

The Study has been overseen by the Guardians Establishment Committee and funded by the Ministry for the Environment.

This work is presented in this Report in the following way:

[12] Engineering input was provided by Beca Infrastructure Limited. Planning input was provided by Beca Carter Hollings & Ferner Ltd (BCHF).

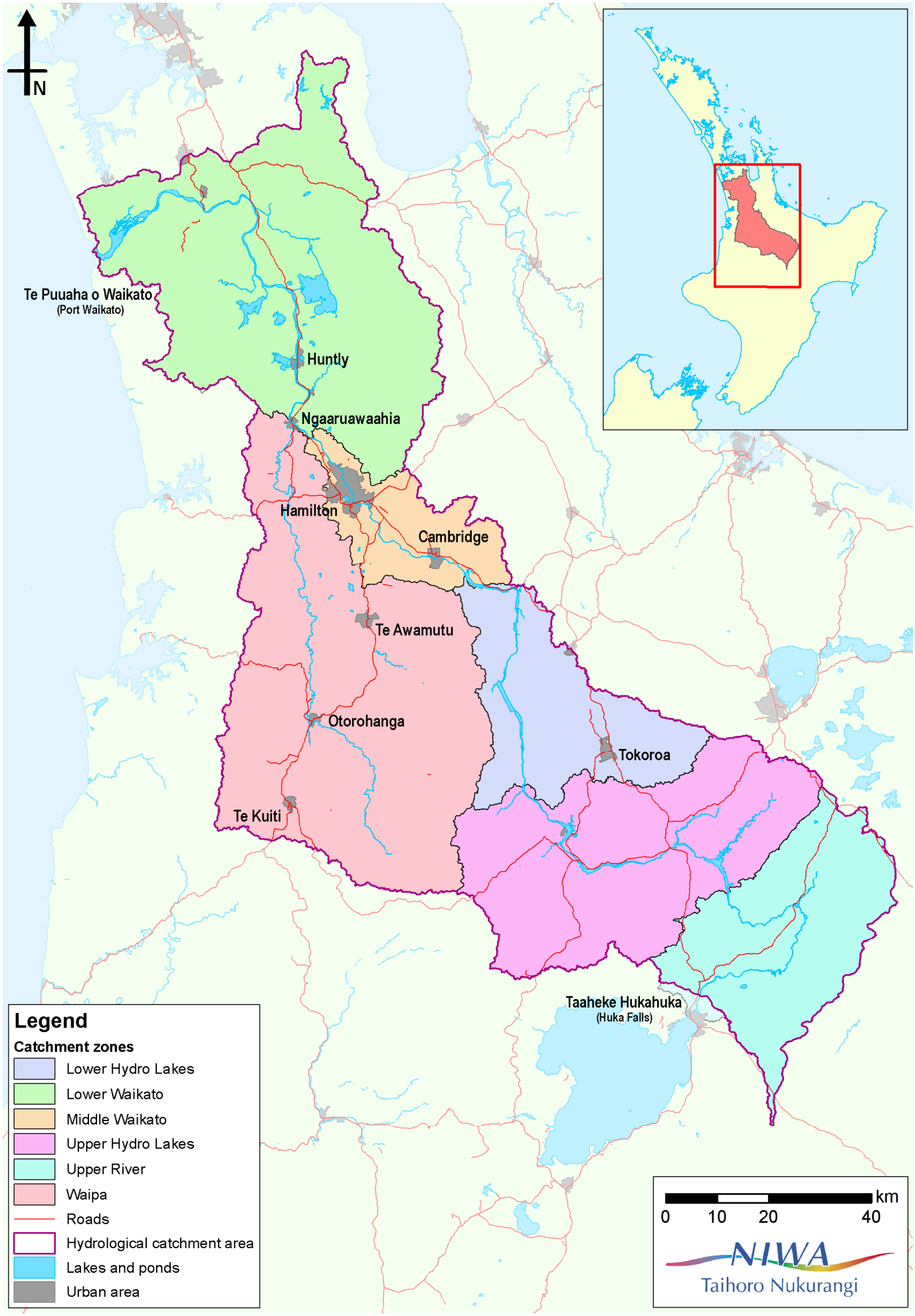


Figure 1.1: A map showing the hydrological catchment area covered by the Waikato River Independent Scoping Study.

2. Study methods

Around the world, there are many studies relating to river restoration[13]. Some are at a catchment-wide scale, some use social science and some incorporate indigenous environmental knowledge. This Study is unusual in that it has all those features. Moreover, its findings will be used by a decision-making body on which indigenous and non-indigenous people have an equal say – globally, that is rare indeed. This unique combination of features requires a unique combination of methods to be applied to the Study.

2.1 Integrating maatauranga Maaori and Western science

2.1.1 What is Western science?

Western science is a term that is widely debated by scientists and academics alike. For the purposes of the Waikato River Independent Scoping Study, Western science is defined as science that uses analytical methods to explore data to determine confidence in the different possible explanations of cause and effect. For the purpose of this Study, Western science includes biophysical, economic and social science analysis. Western science aims to be verifiable, repeatable, objective and quantitative. The Study's specialist group prefer to use the term science, which is more encompassing and includes science developed by all nationalities. From now on in this Report the term science is used instead of Western science.

2.1.2 What is maatauranga Maaori?

Like Western science, there are many competing views about what Maatauranga Maaori is. The Study team reviewed a number of texts (as part of the Maatauranga Maaori literature review – see Section 2.2) to help develop ideas about what maatauranga Maaori was and how it could be applied to this Study (e.g., Harmsworth, 2002; Lyver et al., 2009). For the purposes of this Study maatauranga Maaori is defined as the knowledge, comprehension or understanding of everything tangible or intangible that exists across the universe from a Maaori perspective. It takes many forms including te reo (Maaori language), taonga tuku iho (treasure handed down)

[13] The River Restoration Science Synthesis project in the United States, for example, has compiled a database of over 37,000 restoration projects and one Australian study reviewed 2,247 restoration projects in Victoria (see Appendix 2: Restoration Case Studies).

and maatauranga (traditional environmental knowledge) and knowledge of cultural practices, such as rongoaa (healing and medicines) and mahinga kai (hunting, fishing and cultivation of food) (Harmsworth, 2002)[14].

Generally speaking, there is not one Maaori world view that is shared by all Maaori. Nevertheless, taangata whenua (people of the land) are inextricably linked to their whenua (land) by virtue of their whakapapa (genealogy). This connection is derived from the creation stories of mankind in Maaori cosmology. Many Maaori view themselves as descendants of the gods and consider the mountains, streams, forests and oceans as personifications of the gods and also as their tuaakana (elder siblings).

It is this interconnectedness that lies at the heart of the way Maaori tend to view the world.

"Ko au ko te awa, ko te awa ko au – Waikato Taniwharau" – [I am the river and the river is me – Waikato of a hundred taniwha] (Waikato-Tainui hui, Poohara Marae, 2009)

"Our tupuna awa is part of our life as our tupuna awa is the main blood vein of Waikato-Tainui, which encompasses all lakes, tributaries, puna and groundwater flows." (Submission on Te Ture Whaimana, Kaitumutumu Marae, Huntly, 2009)

This holistic approach is grounded in whakapapa, the very foundation upon which all things are linked back to the beginning of time itself – ultimately to Te Ira Atua (god essence). It is this relationship that explains the way that Maaori view and personify their natural environment. They rely on these natural resources for sustenance. To ensure that these resources are sustainably managed, a system of guardianship and management is devised, known as kaitiakitanga. As kaitiaki (guardians), appropriate karakia (incantations) are offered to ask for permission from the appropriate atua (ancestor with continuing influence, god) and also to acknowledge them once their karakia are answered.

Although it tends to have common threads back to notions of whakapapa and interconnectedness, maatauranga Maaori is not a single, static perspective on the world – just as science is not. It can vary between individuals, whaanau, hapuu and iwi. Maatauranga Maaori is continually evolving through each generation's detailed observations and experiences. It continues to develop and expand in response to the ever changing realities of the contemporary world.

The maatauranga gathered during this Study, therefore, often relates to personal experiences and observations of the Waikato River environs and comparisons with earlier generations. Each generation combines this received knowledge with their observations. Maatauranga Maaori is therefore place-based, dynamic and responsive to ecosystem changes. Thus, maatauranga Maaori is not just the social side or the cultural side of this Study. It has much to say about biophysical aspects of the river as well.

The definition provided above gives the readers of this Report a broad understanding of maatauranga Maaori. The maatauranga Maaori practitioners in the Study team did not define maatauranga Maaori for the people who contributed to the Study – it was for individuals, hapuu, whaanau and iwi to describe, and in effect define, their relationships with the Waikato River.

[14]Aslo see www.natlib.govt.nz/collections/online-exhibitions/Maatauranga-maori.

2.1.3 *Integrating maatauranga Maaori and science*

The integration of traditional environmental knowledge (TEK) (in this case maatauranga Maaori) and science has been the subject of a wide range of international and national studies. (The Study team reviewed more than 25 texts on this issue to help develop ways to ensure both knowledge sets were integrated successfully in this Study. They are included in the maatauranga Maaori bibliography at the end of this Report to assist in future national and international studies where TEK and science are integrated). Some authors of the texts reviewed argued that the two sets of knowledge should not, and cannot, be integrated (e.g., Moller, 2010; Stephenson and Moller, 2009). Some authors argued that Western science is often given a superior status to maatauranga Maaori (e.g., Williams, 2009; Jacobson and Stephens, 2009) while others submit that maatauranga Maaori should be given a higher status than it currently is (e.g., Berkes, 2010).

The Study team does not contend that there is a need for any alternative views offered by maatauranga Maaori or science to be competitive (Williams, 2009). Both maatauranga Maaori and science knowledge systems share similar intellectual processes including the acquisition, classification and management of knowledge. But, as outlined above, they stem from different belief systems. For example:

> *"The Waikato River sustains our lives – our life force. We ask our river to protect us from evil, to bless us in every day life, we have karakia beside our river, it is our life force"* (Submission on Te Ture Whaimana, Te Ruunanga o Ngaati Hikairo, Te Whaea o Waituatua Marae, 2008)
>
> *"The awa is our tupuna awa and is a taonga tuku iho that has been and will continue to be, handed down from generation to generation. The awa is one living body that includes its water, banks and beds and minerals under them in its streams, waterways, tributaries, lakes, aquatic fisheries, vegetation and floodplains as well as its metaphysical being"* (Submission on Te Ture Whaimana, Ngaati Korokii Kahukura Trust, 2008)

The fact that maatauranga Maaori includes sacred and other intangible elements does present challenges for transparent integration. A further complication is that some maatauranga is private in nature (e.g., location of waahi tapu) and therefore cannot be widely disseminated. The Study team had to use a mix of qualitative and quantitative research techniques to gather information depending on what was appropriate to the situation.

Integration does not mean there is a corresponding piece of maatauranga for every science data point or vice versa. Successful integration requires a thorough and thoughtful synthesis, where concepts retain their cultural context. Maatauranga Maaori, the wider Waikato community and science informed the identification of the aspirations for a healthy and well river. These aspirations provided a high level framework for the identification and assessment of restoration actions. Maatauranga Maaori also provided spatially specific knowledge about how taangata whenua interact with their local river system, how it is valued and used and the resources it provides.

2.2 How information was gathered

The Study team collated scientific information using common research techniques, notably reviewing national and international literature, interrogating datasets and using predictive models. Despite evident information gaps, aspects of the Waikato River have been well studied. This Study was also able to draw upon Waikato-specific research, such as social science on engagement with Waikato dairy farmers (Blackett, 2004; Beswell et al., 2005; Beswell et al., 2007), economic analysis of community willingness to pay for restoration in the Karaapiro area (Marsh et al., 2009), long-term multi-disciplinary research into farm-based restoration at Whatawhata (e.g., Quinn et al., 2007; Dodd et al., 2008) and the biophysical Waikato Catchment Model (Rutherford et al., 2001).

The Study team also conducted a significant literature review of maatauranga Maaori, traditional ecological knowledge and related issues. This included (but was not limited to):

1 Literature on maatauranga Maaori concepts and definitions (e.g., Harmsworth, 2002; Royal, 2004;

2 Commentaries on the complexity of integrating of maatauranga Maaori and science and how this could be approached (e.g., Moller, 2010; Agrawal, 2009; Jacobson and Stephens, 2010; Robson et al., 2009; Williams, 2009; Wehi, 2009; Allen et al., 2009; Cram, 2002; Chambers, 2009; Dickison, 2009; Roa et al., 2009).

3 Other science-based case studies that have integrated maatauranga Maaori (e.g., Gaze and Smith, 2009; Moller et al., 2009; Tanner et al., 2005).

4 Texts that assisted the Study team to gather and analyse the maatauranga collected from hui (e.g., Axelrod, 1976; Puginier, 2009; Ritchie, 2003; Novak, 1991; Eden, 1989).

5 Texts providing historical information (from Maaori and non-Maaori observations of the Waikato River) over time (e.g., Mandeno, 1992; More, 1977; Downes, 1917; King, 1983; Dieffenbach, 1843; Collier et al., 2010; Maclean, 1845; Cowan, 1929; Ngata, 1956; Ngata, 1957; Roa and Tuaupiki; McDowall, 1984, Kirk, 1871; Hayes, 1931, Gibbons, 1977; Fenton, 1850, Frost, 1947).

6 Texts on key concepts in Maaori culture (e.g., Barlow, 1991; Orbell, 1985; Ihaka et al., 2000).

7 Studies and reports related to maatauranga Maaori specific to the river iwi and the Waikato River (e.g., iwi management plans such as the Ngati Tuwharetoa Environmental Iwi Management Plan 2002 and the Huakina Development Trust, 1994 and 2007, Tainui region tuna management plan, 2001; Muru-Lanning, 2007, Stancliff et al., 1988; Parkyn, 2007; Ministry for Culture and Heritage, 2006; Mahuta, 2008; Kahotea, 1990; Jones and Biggs, 1995; Fletcher, 2002).

8 Studies related to New Zealand maatauranga Maaori (i.e., not specific to the Waikato River catchment) (e.g., Donnison, 2009; Buck, 1921; Kusabs, 2009; Kusabs, 2005; King, 2077; King, 2008; Hamilton, 1908).

9 Methods to monitor and evaluate the success of restoration programmes that can incorporate maatauranga Maaori and cultural/spiritual values and how they have been applied elsewhere (e.g., Tipa, 1999; 2002; 2003; 2006 a + b; Harmsworth and Tipa 2002; Conrad, 2008, Taranaki District Council, 2007; Pauling 2008, Pauling et al., 2007, Ministry of Culture and Heritage, 2009).

10 Legislation and other legal documents relevant to this Study (e.g., Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010, Waikato-Tainui Deed of Settlement 2008, Agreement in Principle for the Settlement of the Historical Claims of the Affiliate Te Arawa Iwi/Hapu 2005, Whitebait Fisheries Regulations 1994, Raukawa and the Raukawa Settlement Trust and the Sovereign in Right of New Zealand, Deed in Relation to a Co-Management Framework for the Waikato River).

11 National and international studies that consider how health and wellbeing could be defined, particularly in an indigenous context (e.g., Richmond et al., 2005; Curtis, 2004; Airey, 2003; Baskett, 2000; Cox et al., 2003; Durie, 1994 and Durie, 2004; Panelli, 2007; McGregor et al., 2003, Izquierdo, 2005, Gesler and Kearns, 2002).

12 International studies that have used traditional environmental knowledge to develop environmental management plans or programmes for restoration (e.g., Craig 2005 and 2006; Menzies, 2006; Behrendt, 2004; Morgan et al, 2007; BECA, 2000; Berkes, 1999).

The references that formed this literature review are provided in the reference section at the end of this Report[15].

2.2.1 Use of hui and community meetings in this Study

In accordance with the project brief, collecting maatauranga Maaori through hui was an important part of the information-gathering effort in this Study. Hui are a fundamental forum in which Maaori engage with each other and with manuhiri (visitors)[16]. Information from the hui was used to enrich the Study team's understanding gained from the literature and provided many local examples of maatauranga Maaori for inclusion in this Report.

Also embedded in the Study is the recognition that it is dealing with a whole social-ecological system. The current state of the Waikato River's health and wellbeing is due to past behaviours and a new set of behaviours will be required to achieve the vision and strategy set out in Te Ture Whaimana. Indeed, even what people define as a healthy and well river is shaped by how they use and relate to the river today, their past experiences and their broader ancestral, whaanau and community history of interaction with the river. It is, therefore, vital to gather and understand many community perspectives.

In accordance with the project brief, the Study team carried out:

- Two rounds of hui held throughout the Waikato River catchment to capture the maatauranga Maaori of all five river iwi. Over 500 people attended these two rounds of hui and more than 1,000 pages of transcripts were collected.

[15] The Study team notes that an extensive list of references is provided in the reference section at the back of the Report. Not all of these references are referred to directly in the text of the main Report. This is because many of the texts were simply read to develop a broader understanding of issues e.g., more than 25 texts on integrating Maatuaranga Maaori and science were reviewed by the team. They are all provided in the reference section at the back to assist other studies that may grapple with the same issues of integration this Study team has faced but only some are directly referenced in the body of the text itself. The Study team found all references detailed in the reference section at the back of this Report useful to develop their thinking on concepts related to this Study and a rich source of information to understand the historical context for a Study as complex as this. The Study team hopes the literature review will assist similar studies in the future.

[16] It is generally preferable to have an introductory hui to introduce the researchers and the research, and return later to begin to gather maatauranga. Given the short timeframes for this Study, one hui served as both introduction and the first stage of information gathering. The Study team appreciates the willingness of river iwi to engage in this manner.

- Three meetings held in Hamilton to gather community stakeholder views. More than 130 members of the community, industry, councils, farming and voluntary groups attended these meetings. They included representatives from AFFCO New Zealand Limited, AgResearch, Carter Holt Harvey Limited, DairyNZ Limited, the Department of Conservation, Federated Farmers, Fonterra Co-Operative Group Limited, Genesis Energy, Landcare Research, Mighty River Power Limited, National Wetland Trust, Environment Waikato, Hamilton City Council, South Waikato District Council, Franklin District Council, Matamata-Piako District Council, Otorohonga District Council, Rotorua District Council, Waitomo District Council and Waikato District Council.

One disadvantage of any community meeting approach is that the knowledge and views gathered are limited to what those attending choose to express. A robustly designed opinion survey with high response rate would better indicate the representativeness of particular viewpoints and the Waikato River Authority might choose to commission such work in future. For this Study, however, the information gathered from the community meetings supplemented the extensive consultation already done by the Guardians Establishment Committee during the development of Te Ture Whaimana. Many of the same concerns also came through in the analysis of the results of scientific data, maatauranga Maaori and the views of the wider community.

2.2.2 *More detail on the method for gathering maatauranga Maaori*

In conducting hui, the Study team were guided by eight principles for engagement with Maaori: aroha (show sincerity and mutual respect), tikanga (follow tribal rules and customs), kanohi kitea (be a seen face), manaaki taangata (practise reciprocity and generosity), mana (accord dignity and authority), maahaki (exercise humility), tuupatotanga (demonstrate caution) and whakawhanaungatanga (honour relationships). In this Study, an initial hui was held with Waikato-Tainui at Hopuhopu to explore the best ways to gather and record maatauranga Maaori from the river iwi before the full rounds of hui got underway[17].

During the hui, smaller breakout discussions were held to capture the diversity of the knowledge within the whaanau, hapuu or iwi and between different roles (e.g., kaumaatua and rangatahi). Facilitators used a semi-structured open-ended interview format to elicit as much information as possible from the participants.

At the first round of hui, facilitators used aerial photographs and detailed maps of the rohe (area) to stimulate discussion[18]. Participants were encouraged to draw on the maps, identifying significant sites and places where things had changed. This is an effective tool for gathering maatauranga Maaori because the knowledge is often location-specific, and the visual material acts as a 'memory jog', prompting debate and drawing out contributions from more reserved participants.

At each hui, participants were invited to identify absent whaanau members who they believed should also be interviewed. Similar semi-structured open-ended interview techniques were then used in a one-on-one setting. This widened the source of maatauranga. The non-random selection process is appropriate because the maatauranga is held by the whaanau, hapuu or iwi and its members are best placed to guide researchers to authoritative sources.

[17] Maniapoto was unable to participate in the early parts of the Study for the upper Waipa River (including the first round of hui) because the Crown and Maniapoto were still finalising aspects of the co-management arrangements for this area. Later in the Study Maniapoto provided valuable maatauranga Maaori relevant to the upper Waipa River and participated in the second round of hui.

[18] As noted above Maniapoto did not participate in this part of the Study.

The maatauranga Maaori practitioners within the Study team transcribed and collated all recorded koorero (discussion) and maps from the hui and one-on-one interviews. The Study team sorted and grouped the participants' observations (based on maatauranga Maaori) of the current state of the river, the causes and potential responses. The Study team also used concept mapping to represent graphically the 'mental models' of the Waikato River that emerged from the hui. Mental models are formed in people through their personal experiences with the river, including early life learning (in whaanau, hapuu and iwi contexts), exposure to the river environs, their personal imagination and other dimensions of river iwi culture directly associated with the river. The concept maps assume that the behaviour of whaanau and hapuu, and the nature of their relationship with the river, are driven by their knowledge of the current state of the river. The concept maps are a useful way of grouping this knowledge and were used with other established social science techniques (domain, centrality and cluster analytical sorting (Decision Explorer, Version 3.2.3 Analyst, Banxia Software Limited, 2001–2002)) to deduce key areas of concern. The Study team's analysis was then taken back to iwi in the second round of hui to seek confirmation or adjustment to ensure the Study team accurately captured the expressed concerns. These concerns are reflected in the Study's list of aspirations for a healthy and well river (see Section 4) and helped guide the Study team's selection and analysis of actions[19].

2.3 Indicators

The progress of a restoration programme is measured using indicators. The choice of indicators is driven by the desired outcome or aspiration. For example, excluding cattle from streams is an action which should help make streams safe for swimming. An indicator for the success of that action would be the concentration of *E. coli* in downstream water, because *E. coli* indicates the presence of faecal contamination which could make people sick when they swim.

The most novel feature of this Study is that it incorporates indicators from maatauranga Maaori as well as science to measure and evaluate progress towards restoration. Over 60 potential maatauranga Maaori indicators have been identified and roughly the same number of science indicators (these indicators are outlined in Appendix 29: Monitoring and Evaluation and Appendix 30: Report Cards). Many of these require iwi input for further development. This is outlined in more detail in Section 8.

2.3.1 Report Cards

This Study takes a widely used tool for reporting on such indicators – Report Cards – and extends it in new ways. Report Cards are used extensively in New Zealand and elsewhere, but mostly only to monitor water quality and ecological health. Typically, Report Cards 'report' on a group of indicators that describe the state of the environment (e.g., nutrient concentrations) and assign it a 'grading', sometimes simply A, B, C, D, E – much like an old-fashioned school report card.

The South East Queensland Healthy Waterways Partnership, for example, generates annual 'Ecosystem Health Report Card Grades' (A to E) for 19 catchments and 18 estuaries. These score the state of ecosystem health values, key ecological processes and critical habitats[20].

[19] It is the Study team's view that the maatauranga shared at the hui belongs to the specific iwi that provided it. For this reason all the information gathered during this part of the Study has been returned to the individual iwi.

[20] http://www.healthywaterways.org/EcosystemHealthMonitoringProgram/ProductsandPublications/AnnualReportCards.aspx

In this Study, the Report Card framework is used in the following ways:

- To 'score' the current state of the health and wellbeing of the Waikato River, so that scenarios for future action could be compared with the current state (see Section 6).
- To summarise and report predictions of the likely effect of bundles of actions on the future health and wellbeing of the Waikato River, so that it was clear how far those bundles would move the river from its current state towards the desired state (see Sections 6 and 7).
- As a recommended holistic way to measure both progress on, and the success of, restoration actions, to communicate this information, and to engage the community in restoration (see Section 8).

Indicators typically have a quantitative target associated with them – the closer an indicator is to reaching its target, the better the score. There can be Report Cards for different aspects of a complex restoration programme, so the same indicators may appear on more than one Report Card (e.g., *E. coli* levels could appear on Report Cards for safe swimming, human health, and overall water quality).

In combining indicators to obtain an aggregate 'score' of progress, indicators must be appropriately weighted to reflect their relative importance. Interactions between indicators must also be considered. For example, the benefit for whitebait abundance of expanded iinanga (whitebait) habitat can only be achieved after the removal of migration barriers (e.g., perched culverts or tide gates) which prevent iinanga from getting to that habitat.

Maatauranga Maaori is generally specific to an iwi, hapuu or whaanau and some is private in nature. For this reason, the detail of many indicators will need to be developed by the river iwi themselves. This also fosters engagement since river iwi can guide their own monitoring of the health and wellbeing of the river.

2.3.2 Predicting likely outcomes

Section 6 outlines how various bundles of actions (scenarios) were developed and then assessed to determine their likely effects on the health and wellbeing of the Waikato River. Indicators were used to do this.

Where biophysical models are available, the Study team modelled the likely effects of different scenarios. In the area of water quality, this Study used the Waikato Catchment Model and CLUES (Catchment Land Use for Environmental Sustainability) to predict the effects of restoration actions on the following indicators: *E. coli*, total phosphorus, total nitrogen, chlorophyll, clarity and colour. Targets for each of these indicators were selected from published guidelines (e.g., Ministry for the Environment and Ministry of Health, 2003; Ministry for the Environment, 1994; Burns et al., 1999), guideline trigger values[21] and informed by local data (e.g., Hamilton et al., 2010).

Models are not available for many indicators of ecosystem health and for the majority of indicators of community wellbeing. For example, there are no models capable of predicting the effects of restoration on whitebait and tuna abundance, although such models would be very useful especially if they also enabled an assessment to be made of the benefits of pest fish

[21] ANZECC 2000 defines trigger values for chemical physical stressors in terms of 80th or 20th percentile values obtained from an appropriate reference system. This choice is arbitrary, although considered 'reasonably conservative' – section 3.3.2.3 ANZECC Guidelines.

control and improved water quality. Where models do not exist, the Study team selected indicators of a restoration action which the available evidence suggests are most likely to lead to the desired improvements. For whitebait, for instance, such indicators would include:

- Length of spawning habitat restored and protected.
- Area of adult habitat restored and protected.
- Number of barriers to migration between the sea and adult habitat.

It is important to realise that this relies on the assumption that the actions (restoring habitat and removing barriers to migration) will indeed bring about the desired result (an increase in whitebait abundance). This is a reasonable assumption, given the knowledge that both maatauranga Maaori and science bring to bear, but not 100 percent certain.

2.4 Description of water quality models

As noted above, the Study team made extensive use of two biophysical models for water quality: The Waikato Catchment Model and CLUES.

2.4.1 Waikato Catchment Model

The Waikato Catchment Model (WCM) models not only nutrients and suspended sediment but also phytoplankton growth, water clarity and colour. The model assumes steady flow but can be run at a number of different flow regimes. It divides the river into segments about 100–200 metres long and predicts the changes in concentrations that occur from Taupoo to Te Puuaha. For this Study, the WCM was modified so that it also models changes along the Waipa River from its headwaters to near Ngaaruawaahia (the confluence with the Waikato River) and the effects that the Waipa has on the lower Waikato River. Other tributaries are not modelled in detail but their inputs into the Waikato or Waipa River are estimated using information about land use and point source discharges in their sub-catchment (see Appendix 13: Water Quality). Model predictive ability was verified using existing data gathered by NIWA and Environment Waikato (e.g., Environment Waikato's routine water quality monitoring and New Zealand's National Rivers Water Quality Network (NRWQN) which is operated by NIWA).

2.4.2 CLUES

CLUES (Catchment Land Use for Environmental Sustainability) has been developed as a tool for assessing the effects of land use and land use change on water quality at a minimum scale of sub-catchments (about 10 kilometres squared and above). CLUES runs within a GIS (geographical information system) platform (ArcGIS) and has the capability to predict a range of water quality parameters. In this Study it was used to predict concentrations of the microbial health risk indicator – *E. coli*. CLUES models the loss of pollutants from land and transport through the tributary streams to the main stem of the Waikato River (see Appendix 10: Faecal Contamination). Model predictive ability was verified using existing data gathered by NIWA and Environment Waikato.

2.5 Role of expert judgment in this Study

This Study is intended as a platform for decision making. The Waikato River Authority will make major decisions about the management of the Waikato River including encouraging and, where appropriate, funding (in its role as trustee for the Waikato River Clean-Up Trust) actions that will restore the river's health and wellbeing. The Waikato River Authority will have to make these decisions in a world where information is never complete and predictive power (i.e., do x and y will happen) is often low. The dilemma of making decisions where uncertainty is the only certainty is common in river restoration (Darby and Sear, 2008).

As is common practice in other river restoration projects around the world, the Study team took a pragmatic approach and relied on weight of evidence and expert judgement where available information (maatauranga Maaori and/or science) was sparse and would not pass any formal test of its rigor. This is a well established practice. In the area of monitoring, for example, the South East Queensland Healthy Waterways Partnership initially used expert opinion to score many Report Cards whilst monitoring programmes were put in place and information gaps plugged. For example – extensive research has provided many pointers to the likely success factors in improving tuna abundance even though these cannot be proven in a quantitative way. The same is true for lakes restoration. In multi-factorial relationships, years of experience may suggest the right answer long before sufficient data are available to prove it. This is a strength of local knowledge gathered over generations – and is part of what maatauranga Maaori can provide to the Study. That said, expert judgement should be used with care. An adaptive management approach to restoration is prudent because it encourages people to seek out new information and use it to review prior views, actions and priorities.

2.6 Assessing the market costs and benefits of actions

The assessment of the financial costs and benefits of restoration actions was done in two steps using: an Economic Model and an Input-Output Model (also see Appendix 31: Economic Modelling).

2.6.1 Economic Modelling

For the purposes of the economic modelling, the Study team had to assume that costs would be spread, and benefits accrued, within a finite period (the Study team assumed 30 years).

The direct quantifiable capital costs (CAPEX), operating costs (OPEX) and direct benefit were estimated for each action. A discounted cash flow analysis was developed which capitalised the costs of actions (assuming a standard Treasury discount rate of eight percent), totalled them and presented the results in terms of net present value (NPV).

This analysis does NOT include:

- The impacts that expenditure on restoration is likely to have on the regional and national economy. (These impacts are addressed by the Input-Output model.)
- Non-market values (e.g., ecosystem services and cultural/spiritual values). The analysis only includes costs and benefits that can be estimated in dollar terms (e.g., savings in fertiliser costs and income derived from fencing and planting) (see Section 2.7 for more information about non-market values).

- The costs and benefits of the Emissions Trading Scheme (ETS) (e.g., the benefits that might accrue to forestry from carbon credits and the cost implications of methane/nitrous oxide emissions from pastoral farming). This is because it is not possible to make reliable predictions of the price of carbon over the next 30 years and there is uncertainty about how methane/nitrous oxide emissions will be controlled. The 'best guess' at this time is that carbon trading may make the economics of forestry more favourable and the economics of pastoral farming less favourable. Although not included in the formal economic modelling, the Study team does discuss the implication of the ETS where its effects could be significant (e.g., afforestation).

- Costs and benefits beyond the 30 year modelling period. It is recognised that costs and benefits (both monetary and non-monetary) of restoration will extend well beyond 30 years.

  Some benefits of restoration are monetary and extending the analysis beyond 30 years would increase the cost/benefit ratio. For example, the monetary benefits of pine afforestation on marginal hill country will not be fully realised within a 30 year timeframe. Although not included in the formal economic modelling, we do discuss the implications of costs and benefits beyond the 30 years where these are significant.

- Possible changes in factors such as commodity prices, labour prices and productivity gains. Such changes may cause the economic baseline to change over time (e.g., the annual profit from farming). The assumption is made that the net costs of restoration can be added to the economic baseline to determine the economic impacts.

2.6.2 Input-Output Model

The region wide and nationwide effects of the Waikato River clean-up were assessed using Input-Output (IO) analysis. IO analysis is widely applied (Miller and Blair, 2009) and estimates not only the direct costs/benefits, but also the interdependencies between different sectors of the economy and different parts of the country. Alternative models were considered, including computable general equilibrium models, but the IO approach was best suited to this Study.

An existing Multi-Regional Input-Output (MRIO) model for the Waikato was adapted for this Study. It takes, as input data, the net costs estimated by the discounted cash flow analysis (see previous section) and estimates changes in value added[22] and employment[23] (in Modified Employment Counts (MECs)). At the core of the MRIO model is a dataset from 2007 that describes the flows of money or goods among various sectors in three regions – Waikato, North Island excluding Waikato and South Island. Each region has 48 economic sectors with seven primary inputs (wages and salaries, operating surplus, consumption of fixed capital, imports, subsidies, taxes of production and other taxes) and seven final demands (household consumption, central government services, local government services, gross fixed capital formation, exports, net increases in stocks and not-for-profit organisations). Flows are recorded in a matrix or 'IO table' by arrays that summarise the purchases made by each industry and the sales of each industry from, and to all, other industries. Using this table it was possible to

[22] Value added refers to the contribution of the factors of production (e.g., land, labour and capital goods) to raising the value of a product. For a selected product, the value added can be ascertained by the difference in the sale price of the product and the cost of the materials used to produce it.

[23] Employment counts (ECs) are head counts of working people as taken from the Statistics New Zealand Business Frame. Market Economics Limited has created modified employment counts (MECs) based on this data, which unlike standard ECs, include estimates of the numbers of working proprietors for each industry type.

calculate, for the proposed restoration actions, the changes that are likely to occur within the wider economy.

In applying the MRIO model to this Study a series of assumptions were made including:

- Expenditure is funded from loans (5.51 percent over 20 years).
- Farmers fund farm-related expenditure from farm income.
- Local government funds new infrastructure from increased rates.
- Households reduce and redistribute expenditure by increasing local, and decreasing overseas, purchasing.
- Central government funds new infrastructure through budget reallocation.
- The majority of capital expenditure occurs in the first 10 years of the Study although loan repayments continue for 20 years.
- Small structural changes to the lO table were assumed to better reflect the mix of goods and services bought and sold as a result of the restoration actions.

These assumptions affect the detail of the estimated value added and employment figures, but they do not affect the main conclusions of the analysis. Nevertheless, the Study team recommends that the economic analysis be revisited once there is more information available about what actions will be undertaken and who will have the responsibility for funding them.

2.7 Methods for estimating non-market values

The Waikato River provides a range of benefits that are difficult to measure in monetary terms – in economics these are called non-market values. They include positive benefits such as recreation, ecosystem services[24], aesthetics, intrinsic/existence values[25], legacy/bequest values[26], historical and cultural/spiritual values[27]. They also include negative benefits (e.g., intensive land use has significant non-market costs in terms of reduced water quality and quantity). The reason these costs and benefits are not currently included in the formal economy (e.g., in GDP (gross domestic product)) is that there are no markets where they are regularly bought and sold, hence the price that people are prepared to pay for them cannot easily be determined. The total economic value (TEV) incorporates both market and non-market values of a natural resource. TEV is grounded on the use that is made of that resource and currently does not include cultural or spiritual values.

In order to better reflect overall wellbeing, alternative and more holistic measures than GDP are currently being devised – for example, the Genuine Progress Indicator (GPI) that measures net human welfare and includes both positive and negative contributors to human welfare. A GPI has recently been completed for Environment Waikato but it is not yet available[28]. Some refined

[24] Ecosystems provide a range of resources and processes such as drinking-water, waste assimilation and treatment, nutrient and soil cycling, pollination and many others. Collectively these are known as ecosystem services.
[25] Intrinsic/existence values refer to values ascribed by people to something simply because it exists even if they never experience it directly.
[26] Legacy/bequest values refer to the values people ascribe to maintaining something for future generations.
[27] This refers to values from all cultures.
[28] The work was undertaken by the New Zealand Centre for Ecological Economics (NZCEE) and Market Economics Limited (MEL) as part of the SP1 FRST programme.

form of this GPI has the potential to be a useful tool for indicating changes in wellbeing as a result of river restoration, although it is unclear if Maaori values could be adequately included.

Surveys or other field work to gather primary data on non-market values in the Waikato are costly, time consuming and beyond the scope of this Study. However, the Study team reviewed nine previous relevant studies (three of which relate to the Waikato region) on non-market values (see Appendix 32: Non-Market Values). In these studies, non-market values were estimated to be of comparable size to the market costs of restoration. Patterson and Cole (1998) estimated the annual value of the Waikato region's ecosystem services to be (2010) NZ$12.6 billion using global costs analysis data (Constanza et al., 1997). This gives an indication of the total monetary value of the water, wetlands and land in the Waikato but not about the effect degradation has had on that value or the benefits of restoration to that value. Ecosystem services include direct and indirect use values but not passive values including cultural and spiritual values. Schuyt and Brander (2004) showed that in the Whangamarino Swamp passive use values (e.g., preservation) exceeded active use values (e.g., recreation, flood control and fishing) by a factor of 2.7.

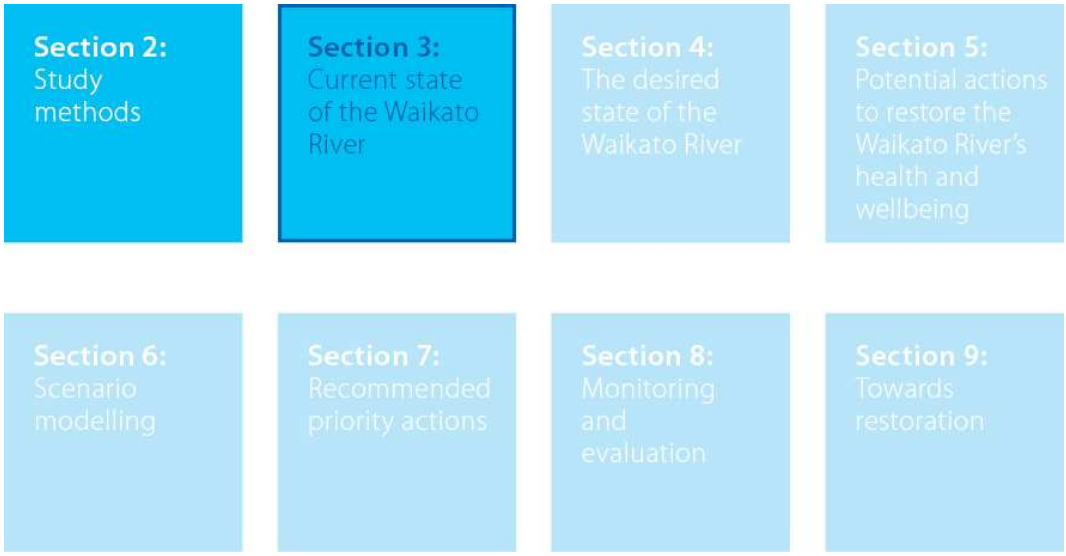
Marsh et al. (2009) surveyed 178 households (2.3 percent) in the Upper Karaapiro catchment and estimated the willingness to pay each year for 10 years to improve swimming, water clarity and ecological health at the expense of jobs in the dairying industry. The average willingness to pay (per household per annum for 10 years) for improvement in quality was:

- Suitability for swimming $161
- Water clarity $65
- Ecological health $145
- Jobs in dairying -$190

Aggregated over 7,802 households in the catchment, this amounts to +$2.9 million per year for water quality improvements and -$1.5 million per year associated with job losses. Over 10 years the present value (PV) after discounting at eight percent is $21.0 million and -$10.9 million. These estimates do not include tourists and other visitors and, therefore, may be conservative (see Appendix 32: Non-Market Values).

The study by Marsh is closely aligned with the objectives of the Waikato River Independent Scoping Study but because of the vast differences in scale and restoration objectives, it would be unwise to transfer its findings directly to this Study. In particular, and of central importance to this Study, none of the studies consider Maaori cultural and spiritual values. Nevertheless, it does mean that the results of the economic analyses discussed in Sections 6 and 7 are likely to significantly underestimate the total benefits to the community of the restoration actions under all scenarios. It also highlights that the costs to the community of not doing anything to clean up the river are likely to be significant but, to date, these costs have been largely ignored by the traditional economic indicators. Future research on non-market values and the Genuine Progress Indicator (GPI) seems warranted, particularly if methods for including Maaori values and the change in values upon restoration can be developed.

3. Current state of the Waikato River



This Section provides an overview of the current state of the Waikato River including its tributaries, lakes and wetlands.

The starting point is that the river is *"seriously degraded along much of its length"*[29]. This is an underpinning motivation for Te Ture Whaimana[30] and this Scoping Study itself.

As noted in Section 1, a primary purpose of this Study is to recommend priority actions or bundles of actions for the rehabilitation of the Waikato River. Some of these actions may be funded through the Waikato River Authority in its role as trustee of the Waikato River Clean-Up Trust. Many other people and organisations are involved in restoration action, including iwi, landowners, community groups, industry and local authorities.

For all these stakeholders, this Section addresses the following questions:

- In what respects is the health and wellbeing of the river degraded; how bad is that degradation; and where does that degradation occur? [The *state* of the river]
- Is the health and wellbeing of the river deteriorating or improving; by how much; and where? [The *trends*]
- What is causing the current state and these trends? [The *pressures*]

If we know the state of the river and the trends, we can identify priority areas for action (in terms of dimensions of health and wellbeing, and locations). If we know the causes – especially the ones related to human activity – we can select actions which address them, and so have a good chance of success.

[29] *"All agree that the Waikato River is seriously degraded along much of its length."* – Co-Chairpersons' foreword to Te Ture Whaimana.

[30] Objective H of Te Ture Whaimana, for example, is: *"The recognition that the Waikato River is degraded and should not be required to absorb further degradation as a result of human activities."*

3.1 Defining health and wellbeing

The focus of Te Ture Whaimana is *"the restoration and protection of the health and wellbeing of the Waikato River".*

River restoration and protection usually focuses on the biophysical *health* of the river – its water quality, biodiversity and ecosystem health. The health of a river is typically measured in biophysical terms – such as nutrient concentrations, faecal contamination and fish abundance. Consequently, river health is seen as affected by physical changes – such as land use, surface and subsurface hydrological changes, contamination from point source and non-point source discharges and declining habitats for animals and plants.

By contrast, in this Study, the *health and wellbeing* of the river has a much broader meaning, one almost synonymous with *mauri*[31]. Previous sections of the Study have noted that Waikato-Tainui regard the river as their awa tupuna (ancestral river). The mauri of all the Waikato river iwi is inextricably linked with the mauri of their awa tupuna[32].

Mauri is often translated as life principle or life force. *"It generates, regenerates, upholds creation and binds the physical and spiritual elements of a resource together"* (Environment Waikato, 1998). As long as the river has the ability to sustain life, the mauri is still said to be active.

A kaumaatua from Ngaati Koroki Kahukura at Poohara Marae told the Study team:

> *"Ko au ko te awa, ko te awa ko au, Waikato Taniwharau, he piko he taniwha, he piko he taniwha" – "I am the river, and the river is me, Waikato of a hundred monsters, at each bend a chief, at each bend a chief"*

This demonstrates how local taangata whenua view their relationship with the awa. If the river is in a degraded state, then it is thought that the people will also suffer and their health and wellbeing will be compromised but if the mauri of the awa is improved then the health and wellbeing of the people will also be enhanced. A leading kuia (female elder) from Waikato-Tainui, Iti Raawiri, when asked what the Waikato River meant to her, replied:

> *"The Waikato River is our tupuna and looks over us throughout our lives. The river feeds us, nurtures us and takes care of us, healing our hurts and protecting us from harm. The river is our lifeline from which we take our name, our identity and our mana."* (Iti Rangihinemutu Rawiri[33])

[31] The Study team reviewed a number of texts discussing how health and wellbeing could be defined, particularly in an indigenous context, in the course of this Study (e.g., Richmond et al., 2005; Curtis, 2004; Airey, 2003; Baskett, 2000; Cox et al., 2003; Durie, 1994 and Durie, 2004; Panelli, 2007; McGregor et al., 2003, Izquierdo, 2005, Gesler and Kearns, 2002).

[32] See, for example, the preamble to the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 (Section 17(f)), where the Crown acknowledged that *"to Waikato-Tainui the Waikato River is a tupuna which has mana and in turn represents the mana and mauri of Waikato-Tainui."*

[33] www.tainui.org.nz

The Waikato Iwi Management Plan elaborates thus:

> *"Each stream or body of water had its own mauri, was guarded by its own taniwha and carried its own mana. Our responsibility is to ensure that these basic entities are maintained intact. When not achievable and on the occasions it was necessary to counter natural forces, tohunga were employed to determine the utu or koha to restore the mana of the offended atua (present in the waterway). This ensured that various development activities could be carried out with harmony and balance, equity and justice according to ancient lore."* (Huakina Development Trust, 2007)

Crucially, then, since the mauri of the iwi is inextricably linked to the awa, the definition used in this Study for health and wellbeing of a river includes people's *economic, social, cultural and spiritual relationships*[34] with it. People need to use the river for spiritual, cultural and recreational purposes, engage in the river's restoration and protection and be actively involved in decision-making processes to make the river healthy and well. This aspiration was expressed strongly by iwi and is an overarching principle of co-management.

Rivers are dynamic systems – the ecosystem health of a river will vary over time (e.g., seasonally) and from place to place (e.g., sub-catchments). People's relationship with the river is also dynamic and multi-faceted, depending on their culture, their spiritual beliefs, their early experiences and family history, their recreational pursuits and many other factors. What this means is that the health and wellbeing of a river cannot be defined by measurement at a single point in time or fixed by a single variable. Spiritual, cultural, recreational, economic and biophysical factors must all be considered.

3.2 People's relationships with the river

Key points:

- The ability of Waikato River iwi to exercise kaitiakitanga (guardianship) according to their tikanga (correct procedure, custom) and kawa (ceremonial rituals, protocol) has been compromised.
- The spiritual relationship iwi and the wider Waikato community have with the Waikato River has been adversely affected by degraded water quality, riparian conditions and loss of access. Iwi feel particularly distressed by human sewage discharges into the river.
- Overall, engagement is patchy. Some people are active in restoration work already. Some people do not use the river because they perceive that it is seriously degraded.
- Attempts at a holistic, integrated catchment management system have only been partially successful, with some key instruments under the Resource Management Act 1991 (RMA) not used effectively.
- Many significant cultural and historic sites have been lost or degraded. The exact number is unknown. Many Maaori place names in the Waikato River catchment are either not in common use or are used incorrectly.

[34] Objectives B, C and D of Te Ture Whaimana all use this phrase.

- The primary causes of degradation are urbanisation and development including electricity generation, flood control and agriculture.
- Access to the Waikato River is good in towns but poor along riverbanks.
- Some recent improvements have been made, e.g., through the Waikato River Trails project.
- The causes of loss of access include private land ownership, flood protection works, flooding of old accessways around hydro dams, weeds and erosion.
- The aesthetic values of the Waikato River have changed markedly since pre-European times. The most significant changes are the shift in riparian vegetation from native species to predominantly willows and grass, lower water clarity, more green-brown colour and the drowning of waterfalls and gorges by the hydro scheme.
- The causes of the loss of pre-European aesthetic values of the Waikato River include development for towns, agriculture, flood protection and electricity generation.
- River and lake restoration projects are improving aesthetics.

3.2.1 Overview and spiritual connections

Both iwi and the wider Waikato community regard the river as important to them. At hui for this study, and in submissions to the Guardians Establishment Committee on Te Ture Whaimana, however, all iwi said they felt the wider community (including industry and local authorities) did not fully recognise the importance of the river to the identity, health and wellbeing of the river iwi.

Kaitiakitanga is a key value for many Maaori. Taangata whenua regard themselves as guardians of their rohe, taonga and resources, responsible for respecting and protecting the whole environment for future generations. Kaitiakitanga relates to spiritual and cultural identity as well as to questions of management and decision-making.

In s8(3) of the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010, for example, the statement of the significance of the Waikato River to Waikato-Tainui includes the following:

"… Our relationship with the Waikato River, and our respect for it, gives rise to our responsibilities to protect te mana o te Awa and to exercise our mana whakahaere in accordance with long established tikanga to ensure the wellbeing of the river. Our relationship with the river and our respect for it lies at the heart of our spiritual and physical wellbeing, and our tribal identity and culture."

Waikato-Tainui and hui participants told the Study team that their cultural and spiritual connection to their awa tupuna has not been lost, but this Study did identify concern that rangatahi may not have the depth of understanding held by previous generations.

For example, in times of distress, the river iwi go to the water at dawn, *"patting the river surface to invoke the ancestors and sprinkling themselves with water facing the rising sun."*[35] One hui participant put it thus:

> *"We hear koorero about mahinga kai [food gathering] and I know that some people still do that, but for the vast majority one of the key issues is the lack of [a] direct relationship with the river 'aa tinana' [physically] so it's always a theoretical thing so for me a sign that restoration is successful is that the vast majority of our people have that relationship in a meaningful way, when they say 'haere ki te wai' [go to the river] when there's…something that needs sorting out then our people know where that is, including our rangatahi…"* (From hui transcript: Poohara Marae, Waikato-Tainui)

In a worldview where the river is a living being, a life force, anything which damages the river also affects the spiritual wellbeing of the people. Thus, almost everything discussed in the rest of this Section has a bearing on the spiritual connection between river iwi and their awa tupuna. Hui participants said their ability to conduct rituals and connect spiritually with the river has been affected by such factors as:

- Past and present inputs of contaminants (particularly disease-carrying organisms) from urban and rural sources resulting in a perception that the river is too polluted to swim in.
- Restricted access to the river and its lakes and wetlands.
- Loss of significant and historic sites and, as a result, the restricted and degraded knowledge associated with these.
- Degradation of plant and food resources.
- Degradation of water quality in areas of intensive land use.
- Loss of wetlands and degradation of shallow lake habitats.

In particular, to many Maaori any discharge of human sewage directly to water is unacceptable, even if it is treated. From the river iwi's perspective, to put any sewage directly into the awa is to defile and dishonour one's own ancestor and to drink water or eat kai from a river where human sewage has been added is to consume a person. While science can define levels of pollutants that will have an adverse effect on the health of people and ecosystems, it is the community that ultimately decides on the values of natural waters.

It is also the case that many members of the wider Waikato community have a strong connection to the Waikato River and see it as part of their cultural identity. This connection has underpinned the reduction in point source discharge of wastes to the Waikato since the 1970s, the existing efforts to restore access (e.g., the Waikato River Trails), environmental care groups (of which there are at least 50, Moira Cursey, Waikato Biodiversity Forum Coordinator. pers. comm.), actions to improve environmental outcomes by individual landowners and actions by the Department of Conservation and local authorities. In other words, participation in restoration action can reflect and reinforce people's connection with the river.

[35] http://www.ew.govt.nz/Tangata-Whenua/Waikato-Te-Awa-a-taonga-treasure/

3.2.2 *Engagement in restoration action*

Today, there is considerable restoration activity in the Waikato catchment, and anecdotally the trend appears to be towards greater engagement. (The Waikato River Authority will need to coordinate actions with these activities to complement and build on existing restoration efforts and avoid duplication of funding or actions already taking place – see Section 7.3.1).

Urban examples include:

- Hamilton City gully restoration (over 500 contacts on Hamilton City Council's database) (Clarkson and McQueen, 2004).
- Mangaokootukutuku Streamcare[36].
- Riparian plantings and fish access enhancement within established reserves such as Donny Park[37].
- Riparian plantings and landscaping in new subdivisions.
- Peat lake restoration at Waiwhakareke Natural Heritage Park[38].

Rural examples include:

- Stream fencing and planting on farms under Environment Waikato's Clean Streams Project (Environment Waikato, 2007) and Project Watershed[39] to meet the requirements of the Dairying and Clean Streams Accord[40 41].
- Other voluntary actions by individual landowners (e.g., Neems, 2010; see Appendix 11: Riparian Aesthetics for details of existing fencing and riparian vegetation).
- Activities by rural care groups (e.g., over 80 biodiversity restoration projects many of which involve fencing and planting riparian wetlands[42]).

[36] http://www.streamcare.org.nz/
[37] http://www.wceet.org.nz/fish-passage-restoration-project/
[38] http://www.waiwhakareke.co.nz/
[39] http://www.ew.govt.nz/News-and-events/Media-releases-archived/Project-Watershed-Works-Identified-For-Whakamaru-Zone/
[40] http://www.mfe.govt.nz/issues/land/rural/dairying-accord-may03.pdf
[41] http://www.maf.govt.nz/mafnet/press/2010/180310-dairy-clean-streams.htm
[42] http://www.waikatobiodiversity.org.nz/community_group_restoration_proj/

Involvement by larger organisations includes:

- Waikato Catchment Ecological Enhancement Trust[43].
- Lower Waikato River Enhancement Society Incorporated[44].
- Fish and Game New Zealand's projects such as the Eastern Whangamarino Restoration Project (Fish and Game New Zealand, 2008) and provision of school curriculum resources[45].
- The Department of Conservation's Arawai Kaakaariki Wetland Restoration project at Whangamarino, Biodiversity Fund projects, input to the Waipa Peat Lake Accord and educational resources for teachers on Waikato Wetlands[46].
- The New Zealand Landcare Trust's[47] educational resources[4849] support of land care groups involved in stream, lake and wetland restoration.
- Ministry for the Environment's support for Waikato Rivercare through the Sustainable Management Fund.
- Projects funded by the Waikato Catchment Ecological Enhancement Trust[50].
- Waipa Peat Lakes and Wetlands Accord[51] led by Environment Waikato[52].
- The National Wetland Trust of New Zealand's[53] activities including plans for a National Wetland Centre at Lake Kopuera, near Rangariri or Lake Serpentine, near Te Awamutu.

Despite this, efforts are patchy and a sense of disengagement, often associated with the perception that the river is degraded, persists.

As for the causes of a sense of disengagement, for Waikato-Tainui, land confiscation in the 1860s severely reduced their association with the land and the awa and breaches of the Treaty of Waitangi by the Crown denied their rights and interests in, and mana whakahaere[54] over, the Waikato River, compromising their ability to ensure the river's health and wellbeing[55].

[43] http://www.wceet.org.nz/
[44] "Waikato Rivercare" focuses on riparian revegetation of the 120 km of river between Hamilton and Port Waikato: http://www.genesisenergy.co.nz/genesis/index.cfm?12D2B5D5-EC25-58FB-B634-0FC54B26C164
[45] http://www.fishandgame.org.nz/Site/Education/default.aspx
[46]http://www.doc.govt.nz/getting-involved/for-teachers/field-trip-resources/fiedl-trips-by-region/waikato/waikato-wetlands/
[47] http://www.landcare.org.nz
[48] http://landcare.org.nz/news-features/wetland-restoration-handbook-launch/
[49] http://www.landcare.org.nz/user-content/2300-silt-trap-fact-sheet.pdf
[50] http://www.wceet.org.nz/funding/
[51] http://www.waipadc.govt.nz/NR/rdonlyres/CBDB25EB-85F8-4121-BC04-9A03DB161152/52360/wetlandsbook.pdf
[52] The Accord is an interagency agreement between Environment Waikato, Department of Conservation, Waipa District Council, Auckland/Waikato Fish and Game Association and Ngaa Iwi Toopu O Waipa. The purpose is to work cooperatively with landowners, iwi and interest groups for the restoration and enhancement of the peat lakes.
[53] http://wetlandtrust.org.nz
[54] Mana whakahaere refers to the authority that Waikato-Tainui and other river tribes have established in respect of the river, over many generations.
[55] See, for example, s17(c) of the Preamble to the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Action 2010, where the Crown acknowledged *"that the Crown's breach of the Treaty of Waitangi denied Waikato-Tainui their rights and interests in, and mana whakahere over, the Waikato River".*

More broadly, the movement of people from rural to urban areas reduced regular contact with natural waterways. The history of pollution due to poorly managed sewage and other point sources from at least 1903 until the 1970–80s (More, 1977) also contributed to urban dwellers and others *"turning their backs on the river"* (Gibbons, 1977).

Today, from the perspective of the iwi and some wider community members who participated in this Study, the main current causes of a lack of engagement are:

- An apparent lack of accessible and comprehensive information on processes, initiatives or actions to restore and protect the health and wellbeing of the Waikato River.
- A lack of capacity to participate in decision making processes and initiatives or actions to restore and protect the health and wellbeing of the Waikato River.
- Limited timeframes to make submissions and other applications on issues to do with the health and wellbeing of the Waikato River.
- Poor relationships between stakeholders e.g., iwi, farmers and councils and the need for improved conflict resolution.

3.2.3. Holistic management and the RMA

Te Ture Whaimana says that an *"integrated, holistic and coordinated approach to management of the natural, physical, cultural and historic resources of the Waikato River"* will be pursued in order to realise the vision of a healthy and well river[56].

Under the RMA, regional councils are responsible for promoting the sustainable management of natural and physical resources in New Zealand. Environment Waikato (the Waikato Regional Council) is responsible for managing land, water, soil, air, coastal and geothermal resources in the Waikato River catchment. Ten local authorities (district and city councils) also have responsibility for managing the effects of the use, development and protection of land, subdivision of land, noise and the effects of activities on the surface of water in rivers and lakes in the catchment (see Figure 3.1). Other agencies including the Department of Conservation, Ministry of Health, Ministry of Fisheries, New Zealand Transport Agency and Fish and Game New Zealand, also have roles which influence the health and wellbeing of the river.

It can be difficult to achieve coordinated planning when functions and strategies operate under different legislation, at different time scales and within different levels of government (see Appendix 28: Impediments). The Study team notes that the relationship the Waikato River Authority has with Environment Waikato and the other ten local authorities will be essential to the successful implementation of the restoration programme. Likewise, without the support of existing (and new) regulatory and planning frameworks and mechanisms, a holistic and coordinated approach to implementing and enforcing restorative actions will not be possible. Environment Waikato and other local authorities and agencies (such as the Department of Conservation and the Ministry of Fisheries) will play a key (and sometimes lead) role in many of the priority actions undertaken (see Table 7.1 and Section 7.3.1).

[56] Objective C, Te Ture Whaimana.

Under the Local Government Act 2002, councils are required to prepare a long-term council community plan (LTCCP) every three years. The LTCCP is guided by 'community outcomes' which are an expression of a community's desired outcomes for social, economic, environmental and cultural wellbeing. Councils consult with their community when developing the LTCCP and, once adopted, the LTCCP can be changed only after further appropriate consultation. The LTCCP outlines details of all of a council's activities and how these activities contribute to the desired community outcomes. It also outlines the council's budget, explaining what the council plans to spend over the next 10 years.

A recent study by Sinclair Knight Merz (2010), however, identified the need for improved links between RMA processes and LTCCPs. Currently, some non-regulatory methods identified in RMA documents never make it into the LTCCP, notably commitment to education and advisory programmes.

An Integrated River Management Plan is a key activity arising from the Waikato–Tainui Raupatu Claims (Waikato River) Settlement Act 2010. It must be prepared within three years of settlement to achieve an integrated approach between Waikato-Tainui, relevant government departments, local authorities and agencies and approved jointly by the Waikato River Authority (in their role as trustee for the Waikato River Clean-Up Trust) and the Ministers of Conservation and Fisheries, Environment Waikato and the other agencies involved. A similar arrangement is part of the Ngati Tuwharetoa, Raukawa and Te Arawa River Iwi Waikato River Bill. Maniapoto have signed an agreement in principle with the Crown to develop a co-management and co-governance agreement for the Waipa River. These negotiations are continuing. Once completed, Maniapoto is likely to be included in the Integrated River Management Plan and associated co-management arrangements.

The purpose of the Integrated River Management Plan is to achieve an integrated approach between the river Iwi and co-management partners for management of aquatic life, habitats and natural resources within the Waikato River. The plan will better coordinate the priority actions the Waikato River Authority decides to fund – e.g., by informing funding criteria and decision making of the Waikato River Authority, RMA decision making and, potentially, other agency activity planning as well.

At the national level, the Study notes that councils feel there is a need for national direction on water quality/quantity issues. The impact of diffuse pollution, especially from agriculture, is generally considered the key issue to be addressed. However, this is potentially difficult to achieve through local regulation, because the three-year electoral cycle can colour local decision making and there may be a lack of policy alignment between councils. The Settlement Act does mitigate this issue by placing statutory obligation on councils to align plans and policies with Te Ture Whaimana and by the powers it provides to the new Waikato River Authority (comprising equal representation of iwi and Crown). The Land and Water Forum is currently reviewing national water policy and is due to report to the Minister for the Environment by September 2010. It is anticipated that this report will consider (and address) establishment of nationally consistent standards, approaches and guidance for the management of freshwater in New Zealand.

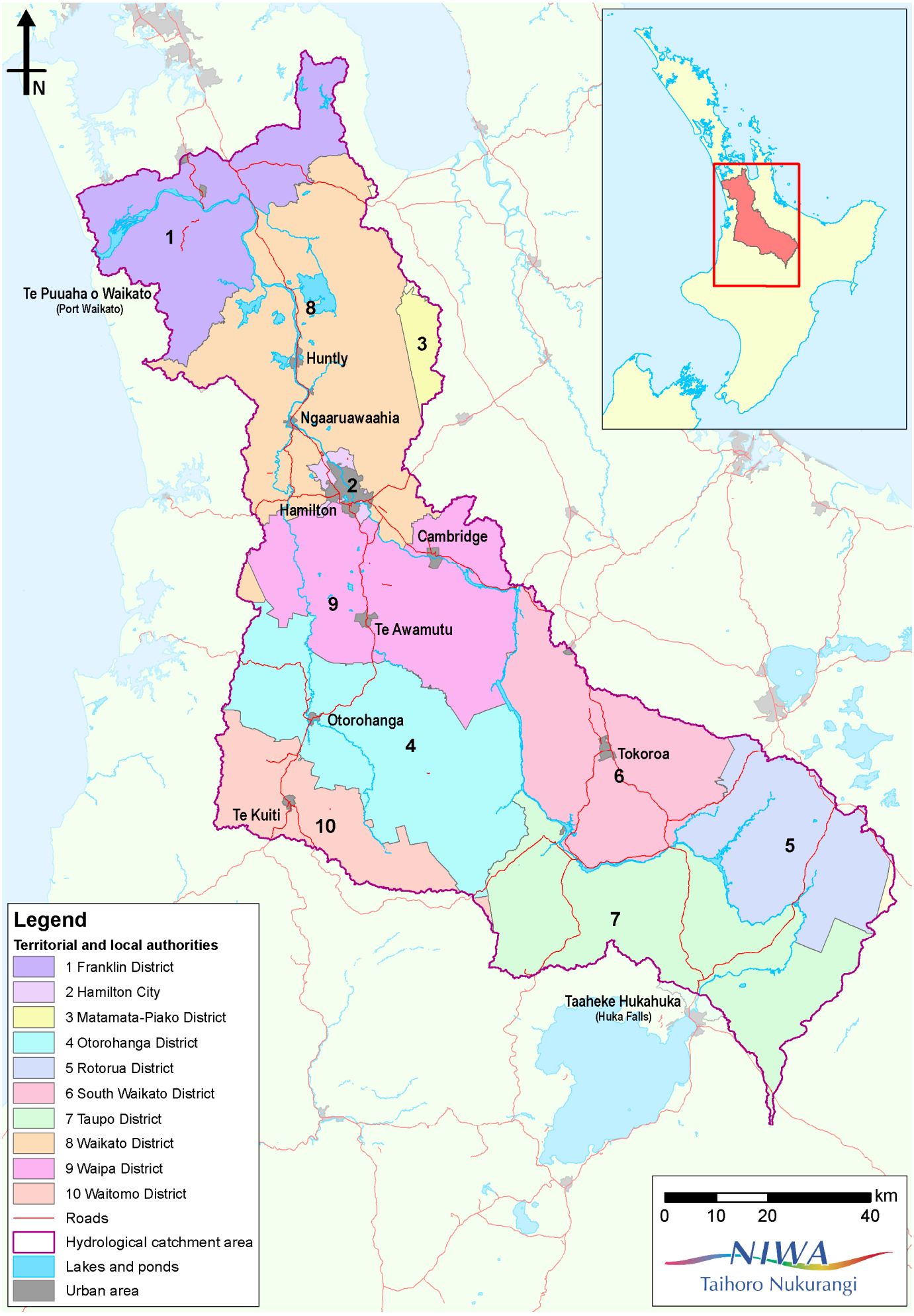


Figure 3.1: Map showing local authority boundaries within the Study area.

3.2.4 Significant and historic sites

There are just under 200 places in the Study area, including paa (traditional settlements), middens, pits and terraces which are publicly listed on the New Zealand Historic Places Trust (NZHPT) Register (see Appendix 26: Significant Sites). Of these, the largest numbers (66) are in the Waipa district, with sizeable numbers also registered in the Waikato district (41) and Hamilton City (40). In addition, Rangiriri was registered as a waahi tapu area in June 2007, but there are no other waahi tapu sites along the Waikato River registered on the NZHPT Register (S. Collins, pers. comm., NZHPT).

During hui for this Study, iwi shared some koorero (speech or narrative) about the location of their waahi tapu (sacred place). Location-specific information is regarded as private, held by the iwi themselves and not available for publication in this Report.

Many significant and historic sites in the Waikato have been lost including waahi tapu, urupaa, historic access points and river crossings, kaainga (home or dwelling), paa, gardens and named river features. The extent of degradation ranges from total destruction and physical loss (e.g., by inundation when the dams were created), to irreversible damage (e.g., ngaawhaa (hot pools) and geysers filled with concrete), restricted or complete denial of access (e.g., waahi tapu on private land) and lack of respect by private landowners.

The exact number of sites which have been lost is unknown. In 1990, of the 24 waahi tapu sites identified in the district scheme for the Hamilton City Council, 20 were listed as 'destroyed' (Kahotea, 1990). Approximately 30 percent of the 146 archaeological sites and landscapes in the Waikato associated with the New Zealand Wars are categorised as 'completely destroyed', 'obliterated', 'dilapidated state' or 'no trace of surface remains' (Prickett and McGovern-Wilson, 2009).

Upstream of Karaapiro, maatauranga focuses on the effect of the hydro scheme, which inundated burial caves, geothermal features (especially at Oraakei Koorako), fishing sites, paa, walkways and islands. At Ohaaki, steam extraction for geothermal power generation is causing subsidence which is flooding occupation sites along the edge of the adjacent Waikato River (Law, 2002).

"If you go upstream from Oraakei Koorako in that stretch of the river are a number of ana [burial caves]. Kei reira tonu ngaa keehua a oo taatou tuupuna maatua [The ghosts of our ancestors are still there]… all of those caves are now underwater as a consequence of the building of the dams… where those caves used to be accessible they are no longer accessible…" (From hui transcript: Maatarae Marae, Te Arawa)

In the lower river, maatauranga focuses more on the effects of urban development, flood control and agriculture.

"Where this Waitaawhiriwhiri paa was there was an ana [burial cave] an ana that was exposed…when they started building the Fairfield Bridge foundation. They came across a cave, and in the cave they found these three perfectly preserved moko [tattooed heads]…our granduncle uplifted those kooiwi [human bones] out of those caves." (From one-on-one interview, conducted with kaumaatua in October 2009)

"And we've got a bloody city over the top of it [our taniwha]. Kino eh [That's bad eh]. Oh well. Oh well koinaa ngaa aahua o mua nee. Engari kei te ora tonu te mauri o te awa me te whenua, noo reira kei te ora tonu ngaa koorero [That was the way things were done before eh. But the spiritual essence of the river and the land is still alive and therefore the history is also still alive too]." (From one-on-one interview, conducted with kaumaatua in October 2009)

The causes of the loss or degradation of significant and historic sites include:

- The hydro dams drowning sites (upstream of Karaapiro) including burial caves, fishing sites, paa, walkways, islands and geothermal features (most notably at Oraakei Koorako).
- Loss of land ownership due to confiscation and sale.
- Sites being developed for agricultural, industrial or urban uses that negate historic values.
- Lack of information on significant and historic sites in planning documents resulting in developments (e.g., channelisation and infrastructure) that negate their values and failure to recognise and commemorate sites (e.g., with historic place names and signage).
- Draining of wetlands and conversion to farmland and urban areas.
- Channelisation and flood control destroying significant sites (e.g., paa, waka landings, swimming and fishing sites) through earthworks and bank erosion.
- Degraded water quality and aesthetics leading to abandonment of sites previously used for a variety of purposes (such as food gathering, waka ama (outrigger canoe) and swimming).

Many of these causes were raised at the hui and are reinforced by previous studies and reports (e.g., Phillips, 1947; Waitangi Tribunal, 1985 and 1993; McCan, 2001; Fletcher and Galvin, 2002; Law, 2002; Te Purongo Maniapoto, 2002; Te Pumatautanga o Te Arawa Trust and the Raukawa Trust Board, 2008; Prickett and McGovern-Wilson, 2009; O'Sullivan and Te Hiko, 2010).

Much of the length of the river and its bank had been named by river iwi but, many of these original Maaori names have been replaced. Even where Maaori names have been preserved they do not always label the correct site any more, especially where features were flooded by the hydro scheme. For example, 'Arapuni' used to be the river crossing point for the people of Poohara Marae. When the area was flooded, the name was moved further south to the village where the power station was constructed. Waitete Stream and Waipapa are other examples of original place names which were later changed to other sites. This is particularly important because Maaori often used place names to memorise and transfer knowledge about local, social, cultural and environmental history from one generation to the next (Reed, 2002; Orbell, 1985; King et al., 2007 and 2008).

3.2.5 Access

The river historically played a major role in transport and communication by providing walking and boat access. As noted above, the river's pre-European character has been substantially altered by hydro-power development, flood protection works, agriculture and urbanisation.

There is no comprehensive, catchment-wide information on the state of access (e.g., length of riverbank serviced by walkways and cycleways) but access tends to be better in towns than in rural areas.

Legal access along riverbanks currently comprises a piecemeal collection of public strips including reserves, roads and other classes of land in Crown, local authority or private ownership[57]. Contrary to common belief, there is no legal entitlement to access to, and along, water margins (the so-called Queen's Chain).

Maatauranga Maaori shared by iwi suggests that access to the river is significantly impeded.

"…the pathway to Arapuni [was] where people used to walk across the river, but that's all changed because of the damming on the river. There used to be a walkway but the dams have made that impossible…because the flows have washed the rocks away and the whole nature of the river has changed." (From hui transcript: Poohara Marae, Waikato-Tainui)

"…access is difficult in a lot of places because of the growth that is there… blackberry or gorse." (From hui transcript: Te Waananga o Aotearoa, Raukawa)

"That is one thing with going down to the water, Tiopipi used to be an easy place to get down, it had a nice sandy [bed]….. But over the years we've noticed that it's not as safe as it used to be. And it's steep, they've got erosion problems..." (From hui transcript: Ngaa Tai E Rua Marae, Waikato-Tainui)

"…A lot of these, some of these are peat lakes as well actually, but because they are also landlocked now with private interests, it's very hard for our people to go in there and use them now, because it's more – other than Lake Kainui, you have to go through some private lands to get to them… people don't even know that they're there…" (From hui transcript: Waahi Marae, Waikato-Tainui)

Maatauranga Maaori gathered through the hui and literature review highlighted the following causes:

- Loss of historic waka landing sites due to channel modification for flood protection.
- Loss of ownership of access rights and riparian land by iwi through confiscation and sale of land.
- Pest plants (e.g., blackberry and aquatic weeds) clogging access to the river and lakes and willows encroaching into river margins.
- Traditional whaanau whitebait fishing sites being permitted to other users.

[57] http://www.qualityplanning.org.nz/plan-topics/esplanade-reserves.php

Environment Waikato's Long-Term Council Community Plan emphasises the importance of improved access to the river and that is reflected in current projects. For example, the Waikato River walk and cycleways now stretch for 11 kilometres within Hamilton City, and the New Zealand Cycle Trail Project has given impetus to cycleway construction through the Waikato River Trails project. In 2009, the Waikato River Trails received $3 million to construct 41 kilometres of track and thereby finish a 100 kilometres long cycle trail along the river and five hydro lakes from Aatiamuri to Horahora[58].

3.2.6 Aesthetics

For Maaori, landscapes are part of a deep, intimate and familial understanding and connection that has developed over many generations (see Section 3.2.1). Mosley (2004) describes the main factors that combine to determine river aesthetics as: landscape setting, riparian vegetation, water colour and clarity, channel character and flow types, visual diversity and the knowledge that the river is in a healthy state.

At about three miles from north of Atiamuri we pass close to the Aniwhaniwha ('Rainbow') Fall and rapids. Just above the cataract the Waikato flows round a sweeping bend, dark, smooth and deep, and impressing one with a profound sense of power. Clouds of spray rise high in the air; and when the sun is shining rainbows arch the falls". (The New Zealand Railways Magazine, 1929)

"…that's where that waterfall was…[it] used to be about 12 feet high and stretched right across the river… well they're all underwater now". (From hui transcript Maatarae Marae, Te Arawa)

To evaluate the current state of *riparian* aesthetics in the Waikato River catchment, the Study team used the Riparian Management Classification (RMC) (Quinn, 2009). This is an established ranking scheme which provides a guide to what type of vegetation most enhances stream aesthetics. Aesthetic values are subjective by definition, but using a recognised classification scheme reduces bias. The values embedded in this scheme were identified through surveys of the public conducted at large rural and urban events (Parkyn et al., 2003; Parkyn and Quinn, 2006; also see Appendix 11: Riparian Aesthetics).

The rankings are shown in Table 3.1, along with example photos from the Waikato region.

[58] http://www.waikatorivertrails.com/

Table 3.1: Riparian Management Classification

Ranking	Description	Example photo
0	Bare ground or covered in blackberry and other invasive weeds.	
1	Pasture with unconstrained livestock access to the stream, no trees.	
2	Fenced pasture grasses without livestock access to the stream; or pasture with livestock access and a 1—2 types of exotic trees (e.g., willows and/or poplars).	
3	Varied exotic dominated vegetation, limited livestock access.	
4	Native shrubs or wetland is dominant vegetation type.	
5	Native forest is dominant vegetation.	

Lengths of streams under each ranking are weighted by the ranking and the RMC score is calculated as a percent of the total weighted stream length. Therefore if all the river and tributary lengths in an area (e.g., upper Waikato) were native forest the RMC score would be 100, and conversely if all were weed infested the score would be zero. Thus, the higher the score, the better the aesthetic state of the river and its banks.

The Study team used a 2007 Environment Waikato survey of riparian vegetation (Storey, 2010) and applied the RMC to the data.

The average RMC rating of *pastoral* streams for each of the four sub-areas ranged from 34 percent in the lower Waikato to 53 percent in the upper Waikato with an average of 43 percent for the whole Waikato River catchment. Overall, average aesthetic scores for streams in all land uses were estimated to range from 42 percent in lower Waikato and middle Waikato to 58 percent in Upper Waikato, with an overall Waikato River catchment average of 50 percent (see Figure 3.2). Figure 3.2 also shows stream lengths with a low rating of 1 decline from the lower Waikato to the upper Waikato while the opposite occurs with stream banks with a rating of 3 (and to a small extent 4–5).

In general, this indicates that people would find the lower and middle Waikato less aesthetically pleasing than the upper Waikato, and that the aesthetics of farmland can be improved by excluding livestock and planting the streambanks.

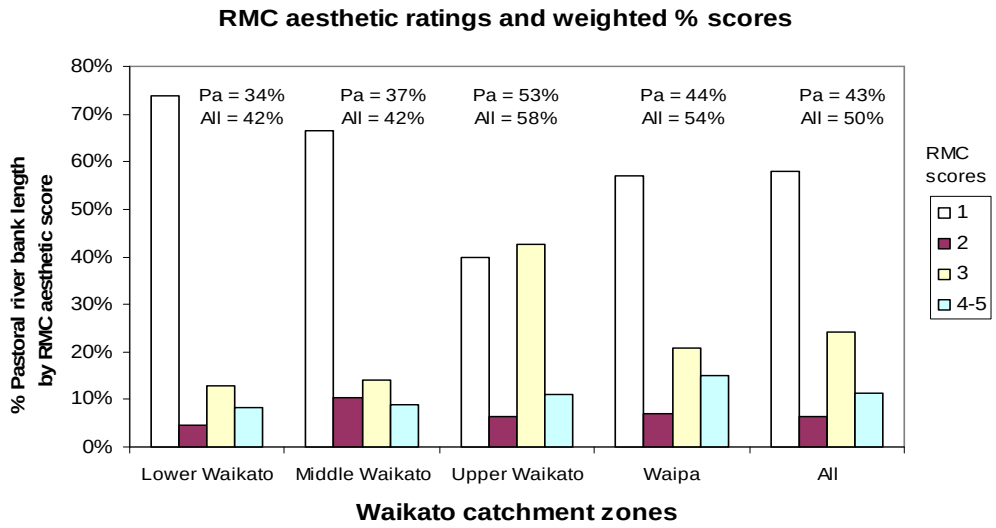


Figure 3.2: RMC aesthetic ratings for pastoral streams in each Waikato catchment zone. These ratings are inferred from Environment Waikato's 2007 survey of riparian vegetation. The percentages show the average scores for pastoral streams (Pa) and the average score for the entire streambank length in each zone. A rating of 100 percent would indicate stream banks are at RMC score 5; a rating of 0 percent would indicate streambanks are at RMC score 0.

The main causes of the current relatively poor aesthetic state of the Waikato River are:

- Deforestation of riparian areas and replacement of native vegetation with pasture grass and/or exotic trees, particularly willows and alders.
- Wetland drainage for pasture, resulting in bland pastoral landscapes.
- Loss of visual diversity in riparian vegetation.
- Livestock access to waterways which causes bank erosion and direct faecal contamination. The livestock also eat riparian and emergent aquatic plants.
- Willow infestation of wetlands.
- Dams 'drowning' waterfalls rapids, geothermal and other natural features.
- Farm run-off and erosion adding fine sediment that reduces water clarity directly.
- Increased nutrient inputs that affect growth of algae and aquatic weeds which reduce water clarity and change water colour.
- Wastewater inputs altering the natural colour of the water.
- Channelisation and flood control resulting in geomorphically simplified, straightened, channels in urban and rural areas.
- Knowledge that there is direct discharge of treated sewage to the river.

Despite the above, river restoration projects are improving aesthetics in some places. In towns, it is increasingly common for councils to use native planting in riparian areas and to promote the use of native plants by individual landowners and community groups[59] involved in 'gully restoration' (Clarkson and McQueen, 2004) and providing cheap plants, planting guides (e.g., Wall and Clarkson, 2001) and workshops. Rural stream aesthetics have also been improving through fencing and planting programmes including Environment Waikato's Clean Streams Project and the Dairying and Clean Streams Accord.

To quantify trends, however, a RMC analysis – or similar exercise — would need to be repeated at regular intervals. Aesthetics take time to change, especially when restoration involves planting large trees which take decades to reach maturity.

3.3 Human health, swimming and boating

Key points:

- Three groups of contaminants potentially affect the safety of drinking-water and kai taken from the river: geothermal chemicals (mercury and arsenic), cyanotoxins (at times of some algal blooms), and faecal contaminants.
- Pathogens (disease-causing organisms) and arsenic may make untreated river water unsafe to drink. Appropriate treatment can solve these problems, but water supplies in some rural areas are insufficiently treated.

[59] e.g., http://www.streamcare.org.nz/

- Heavy metals of geothermal origin may pose a risk to those taking kai from the Upper Waikato River.
- Pathogens associated with faecal contamination may pose a risk to those taking kai, especially foods which are eaten raw (e.g., watercress)
- Faecal contamination makes contact recreation unsafe in some parts of the Waikato River catchment: Bathing water standards for *E. coli* are met in the upper Waikato and hydro dams, but they are not always met in the Waipa, lower Waikato and tributaries.
- Other factors affecting safe recreational use of the river include: low water clarity in the lower Waikato, navigation hazards, conflict between users, and the hydro scheme's flow regime.

3.3.1 Safety of drinking water

Drinking-water is abstracted from the river, tributaries and groundwater in many places, with the largest takes being to supply Hamilton (1 cubic metre per second) and at Tuakau to supplement the Auckland supply (up to 1.7 cubic metres per second) (Brown, 2010).

All surface waters and most groundwaters must be treated to remove particulate matter (e.g., fine sediment, phytoplankton), and disinfected to inactivate pathogens (bacteria, viruses and protozoa) before it is safe to drink. In urban areas, this currently occurs, and drinking water quality is generally high but in rural areas within the Waikato catchment many water supplies are insufficiently treated and could pose human health risks (Eberhart-Phillips et al., 1997; Till and McBride, 2004; Appendix 16: Rural Water Supply).

Some marae obtain their drinking water supplies from springs and there are concerns that these may have become contaminated (e.g., by pesticides and pathogens) but there is a lack of information to allay or confirm these concerns (see Appendix 17: Marae Water Supply).

Geothermal chemicals

Geothermally derived arsenic (As) is a natural input into Lake Taupoo and the upper Waikato River, but a major point source is the Wairaakei geothermal power station. Arsenic concentrations in the river water downstream of Lake Taupoo exceed drinking- water standards. Arsenic is removed effectively by most conventional drinking-water treatment systems (i.e., alum flocculation).

In 2001, a Ministry of Health review found that of the 91 drinking water zones assessed in the Health Waikato region, 19 zones exceeding half the maximum acceptable value (MAV) for arsenic, serving 136,967 people. Eight of these zones – serving 12,985 people – exceeded the MAV (Ministry of Health, 2001). By the time of the most recent review (Ministry of Health, 2010), using 2008–09 data, the larger Waikato drinking supplies had less than the 50 percent arsenic MAV threshold. However, there is no additional information on the concentrations of arsenic in any supplies to communities of less than 500 people, because there is no requirement for monitoring. This means that people living in small rural communities – as well as anyone drinking untreated Waikato River surface water or groundwater from the geothermal region may be at risk.

Nitrate in groundwater

Nitrate concentrations exceeded the New Zealand Drinking Water Standard (11.3 grams NO_3-N per cubic metre) in 16 percent of 110 wells monitored in the Waikato regional network (Environment Waikato, 2008a)[60], but the situation is better amongst 82 community (school) supplies with two percent guideline exceedence[61]. In the Waikato, areas of free-draining soils with intensive land use were most at risk, with 31 percent of groundwater samples from dairy farms exceeding the nitrate drinking standard, compared with just five percent from drystock farms and urban wells (Environment Waikato, 2008a).

Faecal contamination

A recent Ministry of Health report on the status of drinking water supplies for New Zealand in 2008–2009[62] shows that 75 percent of the population in the Waikato region's 199 distribution zones were supplied by systems complying with the Ministry of Health's Drinking Water Standards for *E. coli*.[63] However, only 35 percent of the zones complied; 129 of the 199 zones did not. This reflects a much lower rate of compliance among smaller rural systems — as is typical in other regions in New Zealand. Shallow (<30 m deep) unconfined groundwaters are also most likely to have faecal contamination (Sinton, 2001). At present there is little information on the extent of microbial contamination in individual rural groundwater supplies. However, a study of 40 wells in Matangi (near Hamilton) found five (12.5 percent) were contaminated with faecal coliforms[64].

There is some evidence of contamination of drinking water sources by viruses shed by humans (Williamson et al., 2010). These could arise either from community wastewater treatment plants or from on-site wastewater systems.

Cyanotoxins (from blue-green algal blooms)

Large numbers of cyanobacteria (blue-green algae) occur periodically in the Waikato River catchment, particularly in the hydro lakes and downstream of Lake Karaapiro. For example, in the first few months of 2003, algal blooms were recorded in the Waikato River and public health warnings were issued for drinking-water and recreational use. The combination of high nutrient concentration (the result of inputs from farmland and discharges) and long residence times in the hydro lakes are thought to be the main causes of these blooms.

Cyanobacteria may produce toxins which can, in some conditions, affect public water supplies, as well as causing adverse health effects to recreational water users, stock and other domestic animals (e.g., dogs). It is thought that fish and other kai sources could also accumulate these toxins, and could pose a health risk for people consuming them (see discussion below).

The Ministry for the Environment has developed interim guideline levels for cyanobacteria (Ministry for the Environment, 2009) but further research is required to understand more about the risks to human health. Most water treatment facilities abstracting from the Waikato River

[60] See map at http://www.ew.govt.nz/Environmental-information/Groundwater/Monitoring-groundwater-quality/Nitrate-contamination-of-groundwater/Nitrate-concentrations---map/

[61] http://www.ew.govt.nz/Environmental-information/Environmental-indicators/Inland-water/Groundwater/gw1-report/

[62] http://www.moh.govt.nz/moh.nsf/indexmh/annual-review-drinking-water-quality-nz-2008-09. Details by Health District are given in Table 1 (page 8) of this Ministry of Health report, which was prepared by ESR.

[63] New Zealand Drinking Water Standards 2005, amended in 2008 (http://www.moh.govt.nz/moh.nsf/pagesmh/8534).

[64] http://www.ew.govt.nz/environmental-information/Groundwater/Monitoring-groundwater-quality/Microbial-contamination-of-groundwater/

downstream of Lake Karaapiro (seven of the 10), are required to monitor for cyanotoxin development and implement mitigation or treatment measures if levels exceed acceptable limits. Only three water supplies have installed treatment facilities able to remove cyanotoxins. These are Waikato (which serves Auckland city), Waiora Terrace in Hamilton and Whangamarino (see Appendix 20: Cyanotoxin Treatment).

3.3.2 Safety of kai taken from the river

In a study of non-commercial wild food (NZFSA, 2005), the New Zealand Food Safety Authority concluded that wild food does not generally present a major risk of human exposure to food-borne hazards in New Zealand. However, they also noted that there was a lack of reliable information on harvesting and consumption patterns, along with poor information generally about the sources of food-borne illness, and this prevents an adequate assessment of risk. The report noted that the risks posed by chemical hazards are often difficult to quantify as health effects may only arise over a long period of low exposure. Overall, then, the lack of information on the nature of kai consumption from the Waikato River makes a robust health risk assessment difficult. The Sections below present the available information.

Mercury

Mercury occurs naturally in the Waikato River from geothermal inputs, and levels are raised further by Wairaakei Geothermal Power Station discharges. Concentrations of mercury in river water do not exceed water quality standards for drinking or guidelines for the protection of aquatic life. However, mercury is known to accumulate in river and lake sediments (notably in Lake Ohakurii) and may accumulate in the food chain as methyl mercury (Hickey et al., 1995). High levels of methyl mercury ingested in food can damage the nervous system, with unborn babies being particularly vulnerable. The Australia and New Zealand Food Standards Code prescribes maximum levels for mercury in some foods, including fish[65]. Two separate maximum levels are imposed for fish — a level of 1.0 milligram mercury per kilogram for fish that are known to contain high levels of mercury (such as long-lived or large marine species) and a level of 0.5 milligrams per kilogram for all other species of fish. A limit of 0.5 milligrams per kilogram is also imposed for crustaceans (kooura) and molluscs (kaaeo/kaakahi). The Australia New Zealand Food Standards Code also specifies a standard based on the number of serves (meals) of different fish that can be safely consumed.

In 1993, surveys of fish from the Waikato River found that mercury levels exceeded 0.5 milligrams per kilogram in only 11 of the 285 fish sampled (Mills, 1995). The highest mercury concentrations were found at upstream sites, and generally decreased downstream. This pattern of contamination was consistent with the geothermal sources of mercury in the Upper Waikato, but there were significant differences between species within the same lake. For example, 30 percent of the long-finned tuna exceeded the food safety guideline in Lake Arapuni, while short-finned tuna in the same lake were about half the guideline level at the most. Comparison with accepted daily intake values indicated that some sites *"could conceivably pose some threat to human health"* (Mills, 1995), with the total daily intake (TDI) differing markedly between lakes and fish species. The maximum amounts which should be eaten, according to that study, were:

[65] www.foodstandards.gov.au/consumerinformation/adviceforpregnantwomen/mercuryinfish.cfm

- Brown trout: All sites down to Hamilton, 76 – 150 grams per day.
- Rainbow trout: Lake Ohakurii, 121 g per day; Lake Aatiamuri, 112 grams per day; Lake Karaapiro, 120 grams per day.
- Short-finned tuna: Lake Karaapiro, 118 grams per day.
- Long-finned tuna: 11 grams per day.

An average meal-sized portion is 150 grams. A more cautious approach to consuming fish from the Upper Waikato would be advisable for pregnant women and smaller individuals. This particularly applies to tuna from Lake Ohakurii, which has been introduced to the lake since this survey was undertaken.

Thus, the historical information suggests that most fish in the Waikato River should have mercury concentrations below the maximum acceptable concentration (0.5 milligrams per kilogram), but the higher concentrations in some species and in the Upper Waikato, indicates that only occasional harvest would be recommended.

"I always say eat the little ones [tuna] not the big ones because that sort of stuff bio-accumulates." (From hui transcript: Maatarae Marae, Te Arawa)

Arsenic

In 1993, arsenic levels in fish were low and below health regulation limits at all surveyed sites, and followed a decreasing downstream trend consistent with concentrations in the river water (Mills 1995). Below Hamilton, however, arsenic tissue concentrations increased substantially, at least for mullet and brown trout. The cause for this increase is unknown. There is no data for tuna in the Upper Waikato (above Lake Arapuni), where they have been released since 1993.

Most of the arsenic is carried down the river and discharged to the ocean. However, significant quantities have accumulated in the sediments of Lake Ohakurii and other lakes downstream. Lake Ohakurii has the highest sediment arsenic concentrations of any of the Waikato River lakes, exceeding sediment quality guidelines for ecological protection (ANZECC, 2000) by, on average, eight times. The sediment pore water concentrations of the most toxic form of arsenic (As^{III}) are also known to be elevated (Aggett and Kriegman, 1988). These high levels can potentially result in toxic conditions for both sediment-dwelling organisms (e.g., kooura and kaaeo/kaakahi) and those living in the lake waters, such as tuna, which rely on an abundance of sediment dwelling species.

It is conceivable that if nutrient concentrations in the hydro lakes were to increase and result in greater algal growth and subsequent deoxygenation of bottom waters then arsenic could be mobilised from the lake sediments, and markedly increase downstream concentrations and transport of contaminants.

"So there is natural and unnatural sources of arsenic, boron and all those other elements, so the Wairaakei Stream does have that naturally but then you have these unnatural ones [sources]... and that's why it's not cool to eat watercress out of this area because they pick up that nutrient [these elements] and the crayfish it gets absorbed into the shell..." (From hui transcript: Mookai Marae, Tuwharetoa)

Some species of aquatic plants are 'hyper-accumulators' of water and sediment-derived arsenic. Watercress is among the species which strongly accumulates arsenic (Robinson et al., 2006). A health assessment of watercress from Lake Ohakurii has indicated that regular consumption of 16 grams of fresh watercress per week would exceed the tolerable intake (Robinson et al., 2006). Russell et al. (1999) identified that consumption of watercress at least once per week was reported by 16 percent of Maaori respondents, 13 percent of Pacific Island respondents and one percent of respondents from other ethnic groups. The average serving in these cases was 230 grams. On this basis, people should restrict their consumption of watercress from Lake Ohakurii or geothermally contaminated streams to a small fraction of their total diet. However, while watercress occurs in some locations in the upper Waikato and hydro lakes, it is not abundant there. Collection is more likely from tributary streams, most of which are not contaminated with arsenic although there may be some streams impacted by natural geothermal springs. The health risk is, therefore, probably minimised by the low availability and suitability of river sites for regular collection of watercress.

Cyanobacteria

Cyanobacteria, or blue-green algae, produce toxins at times during bloom conditions.

Their toxins, known as microcystins, have been shown to accumulate in rainbow trout liver and muscle tissue and in freshwater mussels (kaaeo/kaakahi) in studies in Lakes Rotoiti and Rotoehu (Wood et al., 2006). The concentrations of microcystins slowly declined in both trout and mussels after the algal bloom ended.

The tolerable daily intake (TDI) limit of microcystins for human consumption recommended by the World Health Organisation (WHO) is 0.04 micrograms per kilogram per day. Woods et al. undertook a human health risk assessment for rainbow trout consumption and determined that a 70 kilogram person can safely eat a 300 gram serving of rainbow trout every 3.6 days. This calculation used a muscle tissue concentration of 35 micrograms per kilogram (the highest concentration recorded, Lake Rotoehu, April 2004). If 70 kilogram humans eat rainbow trout at less than this rate, or in smaller portions, they will consume concentrations of microcystins below the WHO guidelines, and there is a low risk of adverse health effects. This TDI is a recommended limit for a healthy adult; children, the elderly and sensitive individuals may be at a higher risk. The concentrations of microcystins are significantly higher in rainbow trout liver, indicating substantially higher health risks if livers are consumed.

Kaaeo/kaakahi can accumulate much higher concentrations of microcystins in their tissue (Wood et al. (2006) found up to 65 micrograms per kilogram). This suggests that a proportionately lower quantity of kaaeo/kaakahi could be safely consumed than for trout.

There is no information on the accumulation of microcystins in tuna tissue.

Microbial contamination

Pathogens attached to uncooked food sources from the awa (e.g., watercress eaten as uncooked salad) also pose a health risk (Donnison et al., 2009, 2010). Donnison et al.'s study found that watercress, sourced using Maaori collection protocols, from unfenced small (1–1.5 metres wide) streams on a sheep-beef and a dairy farm typically had *E. coli* levels rated as marginal or unsatisfactory according to NZ guidelines for 'ready to eat' food (FSANZ, 2001). These streams' waters had average *E. coli* levels of 461 and 710 *E. coli* per 100 millilitres, respectively, which are typical of unfenced headwater tributary streams on pastoral farms in the Waikato (Wilcock et al., 2006). In contrast, more than 90 percent of unwashed watercress samples sourced from a bush reserve were 'satisfactory', as were 50 percent of samples from a

fenced stream in a scenic reserve, where the average water column *E. coli* was 56 per 100 millilitres. Triple washing in tap water only improved the quality of the watercress from the dairy stream to 'marginal' (Donnison et al., 2009). These findings indicate that actions proposed later in this report to exclude livestock from streams will reduce the health risk associated with eating watercress from pastoral streams.

The filtering action of kaaeo/kaakahi mussels results in bioaccumulation of pathogenic organisms (Donnison and Ross, 1999) and some of these pathogens can survive standard steaming and marinating (e.g., Abad et al., 1997; Hewitt and Greening, 2004; 2006), although boiling is expected to be effective. Sites comply with the guidelines for recreational shellfish gathering waters if the median faecal coliform content (that includes *E. coli*) of samples taken over a shellfish-gathering season does not exceed a count of 14 per 100 millilitres, and not more then 10 percent of the samples exceed a count of 43 per 100 millilitres (Ministry for the Environment/Ministry of Health, 2003). These requirements for very low levels of faecal indicator organisms are based on consumption of raw shellfish, whereas kaaeo/kaakahi are typically cooked well before eating (Paul, 1996), removing the risk of pathogenic illness.

There is little data on the prevalence of microbial contaminants of fish (Turner et al., 2005). However, it is unlikely that freshwater microbial contamination poses a health risk via fin-fish consumption because tuna and trout are gutted and then cooked or smoked at temperatures that kill pathogens. Whitebait are cooked without gut removal, but the risk of illness eating whitebait is considered low because they are caught on their way into river systems from the sea and are typically cooked at high temperature by frying. The actions proposed later in this report to reduce livestock inputs to streams and for sewage treatment are expected to further lower this risk.

3.3.3 Risk of disease from contact recreation

Water quality, where contact recreation activities occur (swimming, skiing, paddling, kayaking), needs to be such that accidental ingestion does not result in illness. It is impractical to measure the level of pathogens in the water routinely. Instead, levels of "indicator bacteria" are monitored that provide an indication on the likely number of pathogens. For freshwaters the indicator micro-organism used is *Escherichia coli* (*E. coli*) which is found in the gut of humans, farm animals and wildlife, and is a convenient indicator of faecal pollution and associated health risks. The safe swimming *E. coli* level set in Environment Waikato's Regional Plan is a median concentration of 126 *E. coli* per 100 ml of water with a maximum concentration of 550 *E. coli* per 100 millilitres of water during the swimming season (defined in the Regional Plan as 1 December to 31 March, in dry weather conditions).[66]

[66] The current guidelines (Ministry for the Environment/Ministry of Health, 2003) no longer contain a median limit (126 *E. coli* per 100 millilitres), but Environment Waikato's Regional Plan does. The Plan's standard was based on earlier editions of the Ministry for the Environment/Ministry of Health guidelines which did contain that median limit.

Environment Waikato data show the proportion of sites from different parts of the river that met the Regional Plan *E. coli* levels between 2002 and 2006. These are:

- Upper Waikato main stem above Karaapiro 100 percent
- Lower Waikato main stem below Karaapiro 90 percent
- Taupoo tributaries 74 percent
- Upper Waikato tributaries 57 percent
- Lower Waikato tributaries 35 percent
- Waipa River 55 percent

As these data suggest, there is a pattern of increasing values downstream and of higher levels in the Waipa River than in the upper Waikato River.

In the context of the 77 sites in the National River Water Quality Network, two sites on the Waipa (Otewa and Whatawhata) are amongst the most polluted in the country for *E. coli* (ranked 74th and 75th respectively, using median levels for 2005–2008) (Davies-Colley and Ballantine, 2010). The Waikato River at Reid's farm just below Taupoo, by contrast, was the cleanest in the network for *E. coli*.

The major sources of *E. coli* in the Waikato River catchment tributaries are farm animals, although domestic sewage discharges cause local contamination in the river and tributaries. Wild birds contribute significantly in some lakes, and may contribute significant proportions of *E. coli* in rivers during low flow conditions. In years past it was commonly held that human faecal material would pose a much larger health risk compared with animal faecal material of the same volume and 'age'. While this may be true in respect of wildlife, the conventional wisdom has changed in recent times. In particular, faecal wastes from farmed animals may pose rather similar risks to similar volumes of human wastes. A relatively high proportion of New Zealand's reported instances of notifiable diseases are 'zoonoses' (illnesses caused by microorganisms passed from animals to humans). Given the relatively large volumes of animal wastes in the Waikato, this health risk (via exposure to drinking-water or recreational water contaminated with animal faecal material) can no longer be discounted.

3.3.4 Duck itch (swimmer's itch)

People who swim regularly in the Waikato River can experience duck or swimmer's itch. This skin rash is caused by parasitic flatworm larvae associated with a snail commonly found in weed beds in the waters of Waikato River catchment. The larvae burrow into the exposed skin of swimmers and divers, causing a rash which, while unpleasant, has no long lasting effects[67].

"Pollution is a huge factor in Hamilton, sometimes our kids will swim in the rivers and come out with rashes and it happens at Tuurangawaewae as well and this is not even swimming in the river this is taking part of waka taua and things like that and they'll get splashed and sometimes their arms will come up with rashes because of the exposure to the river." (From hui transcript: Poohara Marae, Waikato-Tainui)

[67] http://dermnetnz.org/arthropods/swimmers-itch.html

3.3.5 Other issues for safe swimming and boating

In addition to human health issues discussed above, some other factors affect safe recreational use of the river.

- Low water clarity in the lower river diminishes swimming safety (see Section 3.4.3).
- Congestion can compromise safe and enjoyable swimming and boating in some parts of the river, especially the hydro lakes and lower Waikato (Environment Waikato, 2008).
- There are many natural hazards to navigation and safe swimming, such as strong currents, rapidly varying water levels, logs, and sandbanks. Dense beds of aquatic weeds occur in the hydro lakes and are controlled for recreational purposes in two areas of Lake Karaapiro.
- The hydro scheme operating regime produces fluctuating flows and water levels around the dams. Mighty River Power is required under its resource consent to liaise with users over flows below Karaapiro for major events.

3.4 Water quality

Key points:

- Water quality varies systematically across the catchment. In general, water quality is good in the upper Waikato main stem but poor in the Waipa, the lower Waikato, tributaries and shallow lakes.
- Trend data generally show that water quality is declining.
- Point source inputs of pollutants have been reduced significantly since the 1970s but continue to degrade water quality in a few locations.
- Diffuse sources now comprise the majority of nutrient and sediment inputs to the Waikato River.
- High nutrient concentrations cause algal blooms, low water clarity and colour changes in the Waikato River.
- High suspended sediment concentrations cause low water clarity in and below the Waipa, and in some shallow lakes.
- Arsenic and mercury concentrations are elevated in the upper Waikato as a result of geothermal inputs, both natural and due to geothermal power station discharge.
- Pesticides have been found in groundwater at low levels.
- The potential effects of landfill leachate on water quality are poorly understood.

3.4.1 Overview of the state of water quality

The quality of the river water varies considerably across the catchment. For a national comparison, the Ministry for the Environment's league tables[68] using data from 2007 are illustrative. These rank the 77 sites in NIWA's National River Water Quality Network. The sites are typical of the larger rivers in New Zealand, of which the Waikato is one.

For nutrients, the Ministry combined nitrate, total nitrogen, dissolved reactive phosphorus and total phosphorus. Where 1=best and 77=worst, the measuring sites in the Waikato River catchment ranked as follows:

Waikato at Reid's Farm (near Taupoo)	6
Waipa at Otewa (upper Waipa)	56
Waikato at Hamilton Traffic Bridge	60
Waikato at Rangiriri (lower Waikato)	70
Waipa at Whatawhata (lower Waipa)	74

The following figures (3.3–3.6) show how the river becomes laden with nutrients (phosphorus and nitrogen) and pathogens (*E. coli*) as it flows downstream. The water clarity in the main stem drops, the phytoplankton chlorophyll concentration rises, and the colour changes from blue in Lake Taupoo to yellow-brown at Te Puuaha, especially after it receives the sediment load from the Waipa. These changes are further described in the following sections (3.4.2 and 3.4.3) and in the relevant appendices (particularly Appendix 13: Water Quality).

[68] http://www.mfe.govt.nz/environmental-reporting/freshwater/river/league-table/river-water-quality-league-tables.html

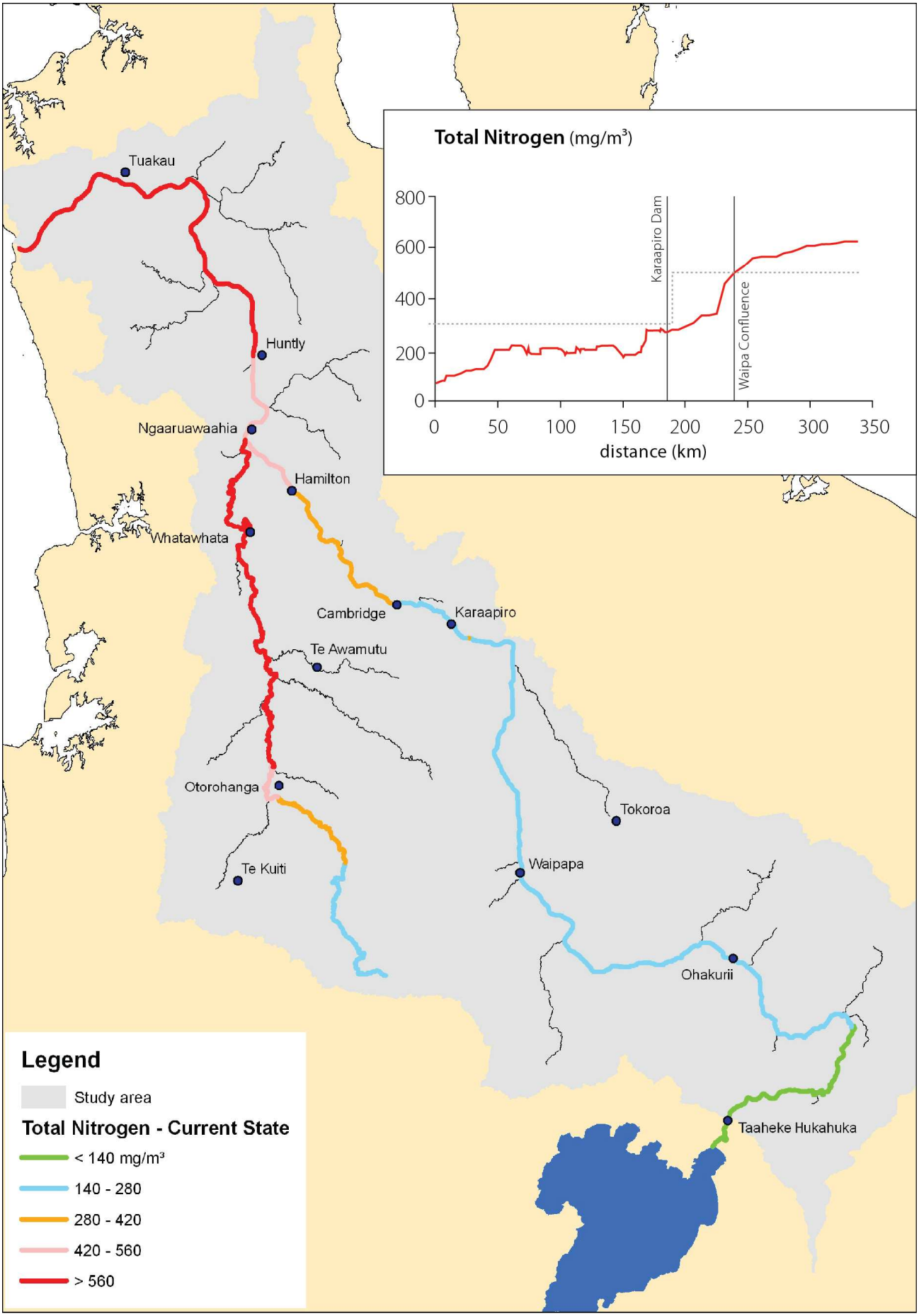


Figure 3.3: Map of total nitrogen showing spatial variations across the catchment and graphs showing details of changes down the main stem of the Waikato River at base flow using NIWA and Environment Waikato monitoring data and the Waikato Catchment Model (Section 2.4.1). The dotted lines across the graph are targets based on ANZECC guidelines, Environment Waikato classifications and expert opinion of the Study team (see Section 4 for further discussion).

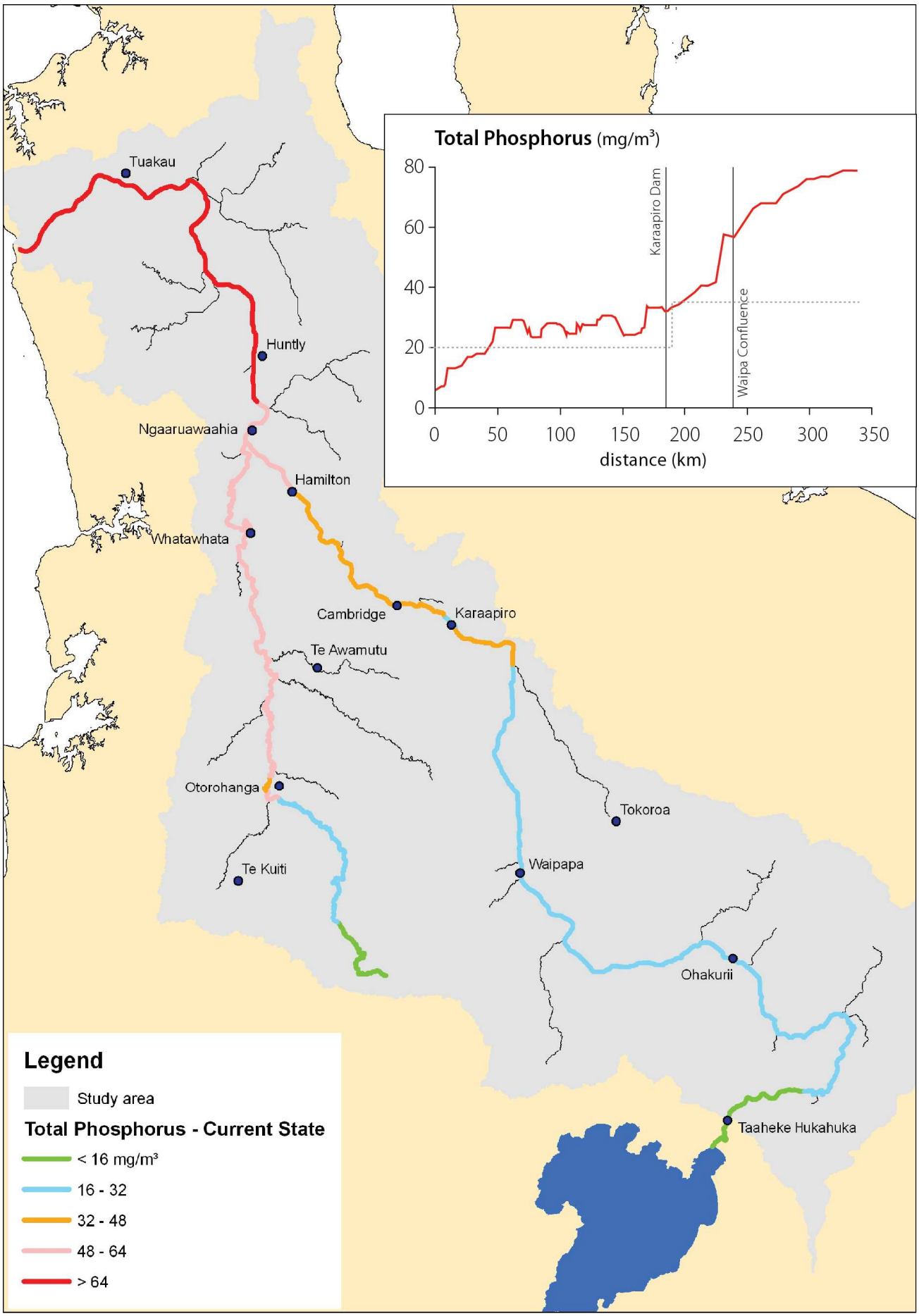


Figure 3.4: Map of total phosphorus showing spatial variations across the catchment and graph showing details of changes down the main stem of the Waikato River at base flow using NIWA and Environment Waikato monitoring data and the Waikato Catchment Model (Section 2.4.1). The dotted lines across the graph are targets based on ANZECC guidelines, Environment Waikato classifications and expert opinion of the Study team (see Section 4 for further discussion).

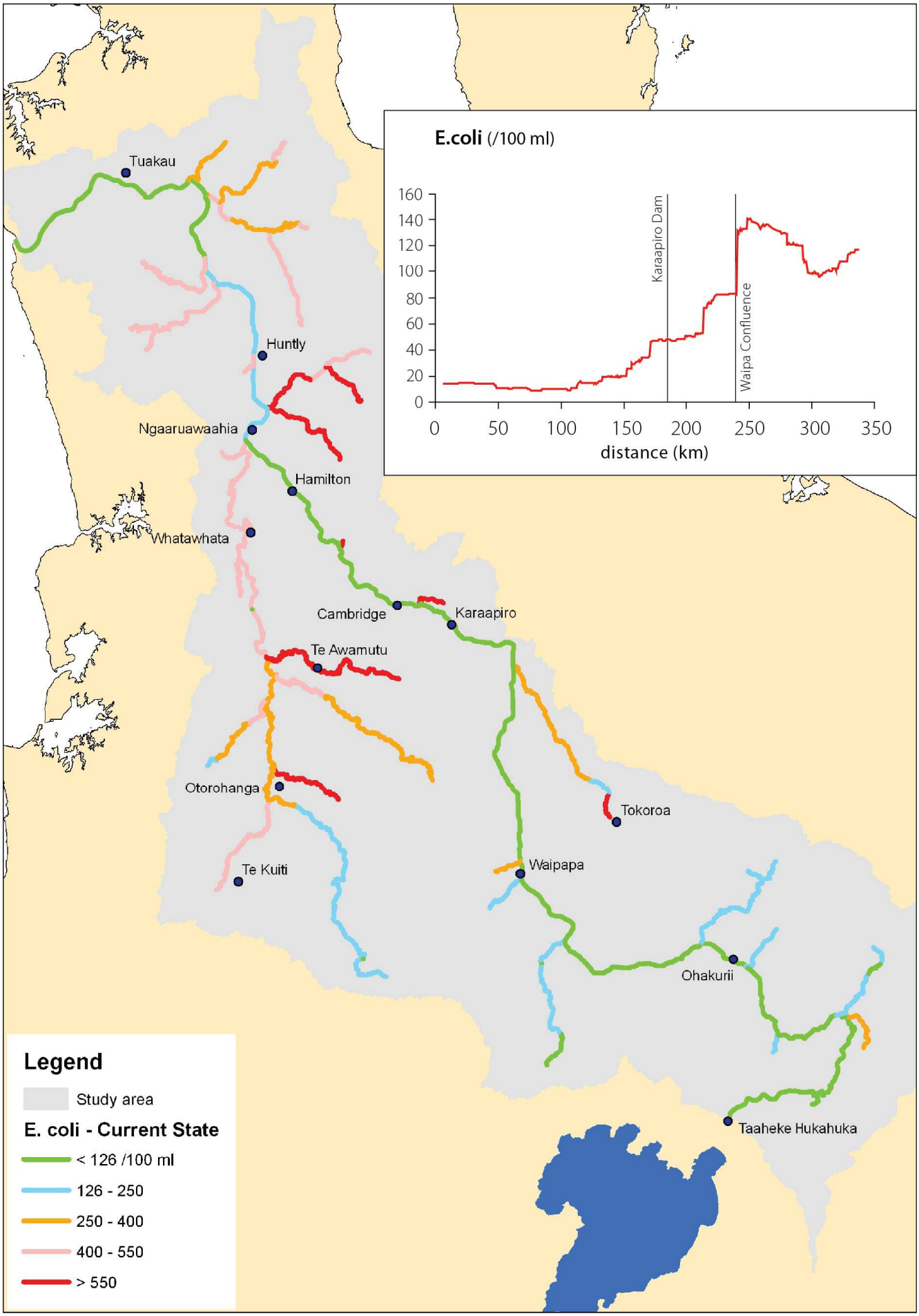


Figure 3.5: Map showing the predicted distribution of *E. coli* concentrations across the Waikato catchment using monitoring data from NIWA and Environment Waikato and the CLUES model (Section 2.4.2). River sections in green meet the Environment Waikato Regional Plan level for contact recreation of 126 *E. coli* per 100 millilitres.

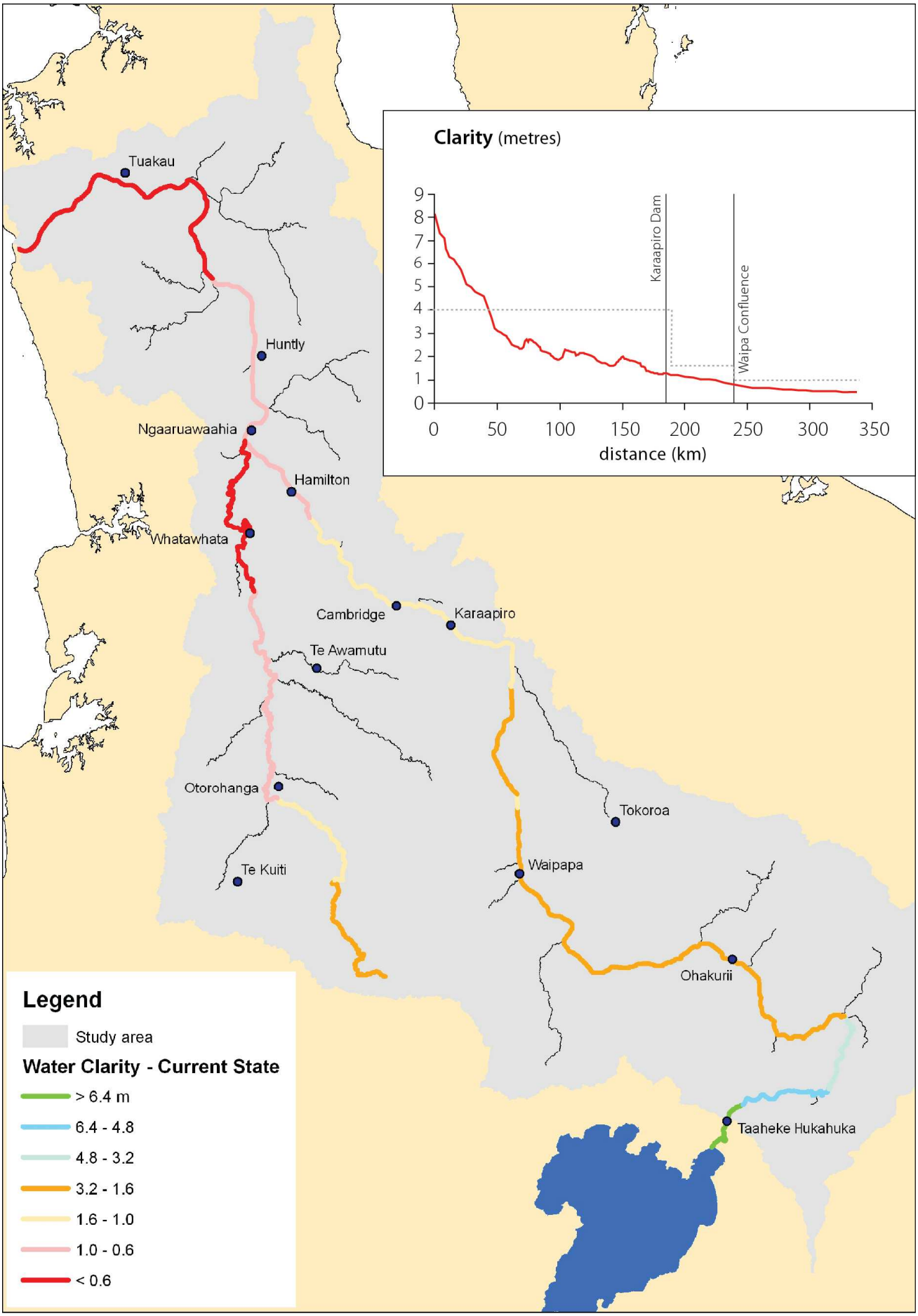


Figure 3.6: Map of water clarity showing spatial variations across the catchment and graph showing details of changes down the main stem of the Waikato River at base flow using NIWA and Environment Waikato monitoring data and the Waikato Catchment Model (Section 2.4.1). The dotted lines across the graph are targets based on Environment Waikato and Ministry for the Environment guidance, and expert opinion of the Study team (see Section 4 for further discussion).

3.4.2 Point source and diffuse contaminants: trends and causes

Significant improvements in waste treatment have occurred in the Waikato River catchment since the 1970s and this has resulted in measurable improvements in some aspects of water quality, such as total ammonia and Biochemical Oxygen Demand (Vant, 2010). Nevertheless, there are still 30 large point source discharges of treated sewage and industrial waste into the main stem of the Waikato River and 1,600 discharges (many quite small) into tributaries[69]. These often have detectable effects on water quality and ecological health. With 13 point-source discharges to the main stem contributing 9 percent of the nitrogen load and 18 percent of the phosphorus load (Vant, 2010) to the river, point source discharges remain significant.

Nonetheless, the predominant pollution load is from diffuse run-off from farms. (See Appendix 13: Water Quality). There is clear scientific evidence that sediment, nutrients and pathogens in runoff from farmland degrade water quality in the Waikato River (See Appendix 9: Farms). The Environment Waikato Regional Plan concludes that "*the cumulative effects of non-point source discharges have a significant adverse effect on the water quality of many water bodies in the Waikato Region."* Nutrient concentrations are significantly higher in catchments with large numbers of farm animals (notably dairy cows) than in catchments that are forested or have low animal numbers (Environment Waikato, 2008).

Four of the five sites in the Waikato River catchment which are part of the National River Water Quality Network show statistically significant increasing trends in nitrogen and/or phosphorus between 1989 and 2008 (see Table 3.2). This can be attributed to increased farm intensification in the catchment (see Appendix 13: Water Quality).

Table 3.2: Trends in nutrient levels in the Waikato River and national comparisons, 1989–2007.

Site	Total nitrogen			Total phosphorus		
	Average (mg per m3)	Trend	Rank	Average (mg per m3)	Trend	Rank
Waikato at Reids Farm (upper Waikato)	66	↗↗	8	5	↗↗	4
Waikato at Hamilton Traffic Bridge	384	↗	49	36	↗↗	60
Waikato at Rangiriri (lower Waikato)	635	–	60	67	–	71
Waipa at Otewa (upper Waipa)	408	↗↗	52	39	–	52
Waipa at Whatawhata (lower Waipa)	1033	↗	73	81	↗	72

Arrows indicate the direction of statistically significant trends; double arrows indicate trends greater than one percent per year. Rank is amongst the 77 National Water Quality Monitoring sites (1 = best, 77 = worst). Source: NIWA

[69] http://www.ew.govt.nz/Environmental-information/Rivers-lakes-and-wetlands/healthyrivers/Waikato-River/Wastewater-discharges/

The highest nitrogen concentrations in the lower Waipa means that the nitrogen load carried by the Waikato River nearly doubles at their confluence at Ngaaruawaahia.

Nutrient levels tend to be higher in the Waikato shallow lakes than in the river. Average concentrations range from around 20 milligrams per cubic metre for total phosphorus and 1000 milligrams per cubic metre for total nitrogen in the less impacted lakes (e.g., Serpentine East and Rotomanuka) to around 600 milligrams per cubic metre for total phosphorus and 3000–5000 milligrams per cubic metre for total nitrogen in Mangahia and Koromatua (Hamilton et al., 2010). Many of these lakes are surrounded by developed farmland and as a result receive elevated inputs of nutrients (see Appendix 12: Shallow Lakes).

3.4.3 Colour and clarity: Trends and causes

It appears that the colour of the Waikato always changed as the river flowed to the sea, from blue in the upper Waikato to green-brown in the lower Waikato.

> *"The Waipa River, at its mouth, has the speed of a half to one mile per hour, while the Waikato runs at four to five miles per hour….the temperature and colour of the water in both rivers were likewise remarkably different. The Waikato showed 68 Fahr. and its water light green and clear while that of the Waipa showed the dark brown colour of peat water and a temperature 70 Fahr."* (von Hochstetter, 1867)

These days, by the time the river has reached the Narrows, just above Hamilton, clarity has declined to an average of 1.5 metres (see Figure 3.6) and the water has a green hue.

The river's clarity ranking amongst the 77 major river sites in the National River Water Quality Network changes from second near the Taupoo outlet to 65th at Rangiriri while the lower Waipa site is 74th, the third lowest ranking river in New Zealand (see Table 3.3). Typical clarity in Waikato lakes (apart from the hydro lakes) is around 2 metres at best (e.g., Rotomanuka and Serpentine North) but often below 0.5 metres, with the worst lakes averaging only 0.1 metres (e.g., Rotokawau, Kimihia) (Hamilton et al., 2010).

The water clarity of most of the shallow lakes in the lower catchment has declined markedly since European settlement. For example, botanist Thomas Kirk was able to identify plants that occurred at two metre depths in Lake Whangapee when he visited in 1869 (Kirk 1871), whereas today the average clarity is 0.35 metres.

The Waikato river iwi have adapted a method for estimating fish abundance (by counting the number that pass over a white board) as an indicator of water clarity. They report having to hold the white Ariari board (a board used during whitebaiting) increasingly close to the water surface as decades pass (maatauranga Maaori shared at Tuakau hui).

These observations are backed up by monitoring data from sites in the catchment (see Table 3.3).

Table 3.3: Trends in water clarity in the Waikato River and national comparisons, 1989–2007

Site	Average (metres)	Trend	Rank
Waikato at Reid's Farm (upper Waikato)	8.0	↘	2
Waikato at Hamilton Traffic Bridge	1.1	–	54
Waikato at Rangiriri (lower Waikato)	0.67	↗	65
Waipa at Otewa (upper Waipa)	1.3	–	43
Waipa at Whatawhata (lower Waipa)	0.60	↘↘	74

Arrows indicate the direction of statistically significant trends (down = worsening clarity, up = improvement); double arrows indicate trends greater than one percent per year. Rank is for 2007 data, amongst the 77 National Water Quality Monitoring sites (1 = best, 77 = worst). Source: NIWA

The causes of the observed decline in water clarity and changes in water colour in the Waikato River are the combination of point source waste discharges and diffuse source run-off of sediment (direct effect) and nutrients (indirect effect through promotion of algal growth). Some of this is natural, but it is exacerbated by human activity (e.g., clearance of vegetation destabilising hillsides in erosion prone areas, such as those in the Waipa catchments), increasing flood flows and stream bank erosion.

Many shallow lakes have lost the rooted plants that used to stabilise their beds, so that wind disturbance can readily resuspend fine sediment (Reeves et al., 2002). Water clarity and colour are both affected by the concentrations of three constituents: fine suspended sediment, phytoplankton chlorophyll and dissolved colour (also termed yellow substance). Fine sediment (clay-sized) makes a much larger contribution to the loss of water clarity than coarser sediment (silt and fine sand) and settles much more slowly. Yellow substance occurs naturally in peat soils and, together with high iron concentrations, imparts the characteristic brown colour to peat lakes on the Lower Waikato floodplain and to several tributaries that drain peat land (e.g., Mangawara, Whangamarino). Yellow substance also enters the river from the Kinleith Pulp and Paper Mill discharge. Although recent improvements in waste treatment have reduced colour inputs they have not entirely eliminated them (See Appendix 19: Kinleith Discharge).

Sediment

There are several different 'stores' of sediment in the Waikato River catchment that move at different times (notably during rain events) and can cause problems in the Waikato River (Hicks et al., 2001) including poor water clarity, mud deposition and sandbanks. The main sources of sedimentation are landslides, erosion of banks and beds in the tributaries, animal tracks, raceways and roads, cattle damage to banks along the tributaries and riparian areas, drains and waste discharges.

Around 40 percent of the Waikato River catchment has the potential to erode (Environment Waikato, 2008). One area especially prone to erosion is the hills of the upper Waipa due to their soft mudstone geology. Sixty seven percent of the sediment load in the lower Waikato River comes from the Waipa River basin (see Figure 3.7) (Hicks and Hill, 2010). Landslides and streambank erosion are the dominant process of sediment generation in the Waipa, with these processes more dominant in pasture landscapes.

The large input of sediment from the Waipa to the Waikato River is evident in the photo above (courtesy Environment Waikato), and in Figure 3.7 below. Figure 3.7 also demonstrates that significant sediment settles behind the dams, lowering sediment loads downstream.

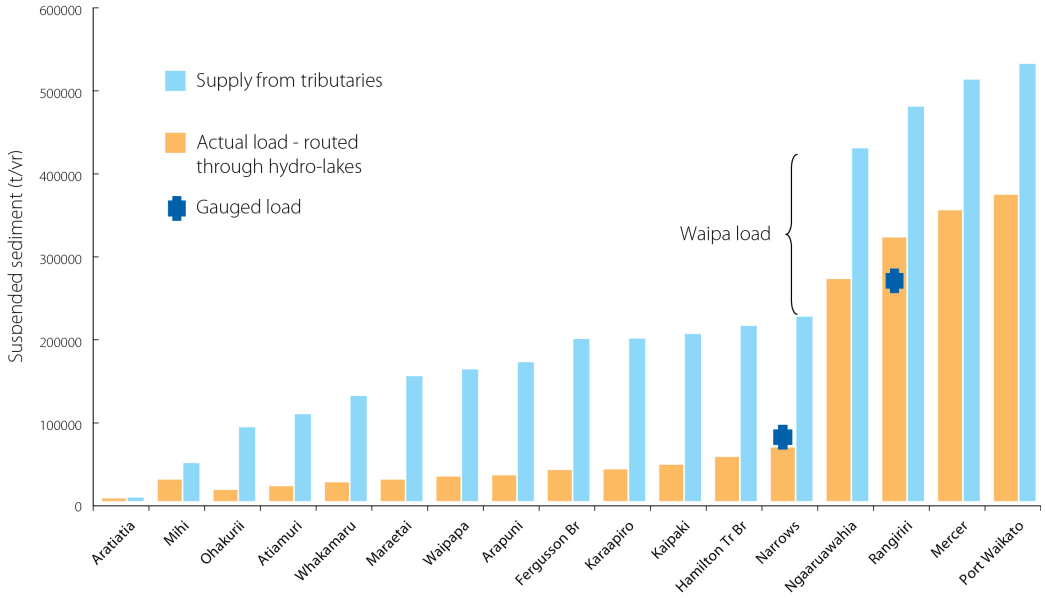


Figure 3.7: Downstream cumulative average annual supplies of suspended sediment to the Waikato main stem and the estimated downstream cumulative load allowing for hydro lake sedimentation. The blue bar shows the sediment that comes into the river system from tributaries. The orange bars show the actual sediment measured in the river at various points. The difference is lost (i.e., settled in the river system). The figure also shows that significant sediment settles in the hydro lakes behind the dams. The measured (gauged) load at Hamilton Traffic Bridge and Rangiriri are also shown. Source: NIWA and Hicks and Hill, 2010 (also see Appendix 23: Hydro Dams).

Bank erosion is a source of suspended sediment and turbidity in tributary streams, although there are, to date, no reliable estimates of what proportion of the turbidity and suspended sediment measured in the Waikato River tributaries originates from bank erosion compared with other sources. Research has shown that livestock access can damage streambanks, accelerating bank erosion and the loss of sediment to the stream system. Surveys indicate that the majority of the Waikato River bank between Lake Taupoo and Te Puuaha o Waikato is stable but there are localised areas of erosion (normally on the outside of sharp bends) amounting to three percent of the total riverbank length (McConchie, 2001). Environment Waikato monitors streambank stability in four Waikato River areas and has found 14–33 percent of the surveyed streambank length to be unstable (Grant et al., 2010).

Point-sources of sediment include mines and quarries, gravel extraction from streams, urban storm water, and earthworks associated with residential sub-divisions and roading. Local authorities impose conditions on these activities to control sediment release. Modelling indicates that they make a relatively small contribution to the suspended sediment loads in the Waikato River, although they may cause localised problems in small tributaries.

Phytoplankton

High concentrations of phytoplankton (microscopic, floating aquatic plants) occur in the hydro lakes and lower Waikato during summer low flows and in the shallow lakes on the lower Waikato floodplain in summer (Hamilton et al., 2010) (see Figure 3.8). Normal phytoplankton in the hydro lakes includes diatoms and green algae that reduce water clarity and impart a green colour to the water but are otherwise benign. Occasionally, however, cyanobacteria (blue-green) blooms have occurred in the hydro lakes and lower Waikato River. The cause of high phytoplankton concentrations and algal blooms in the hydro lakes is the combination of high nutrient concentrations in the lake waters and the relatively long residence time of the water in the lakes that allows phytoplankton time to grow. The high nutrient concentrations are caused by runoff from farms and waste discharges.

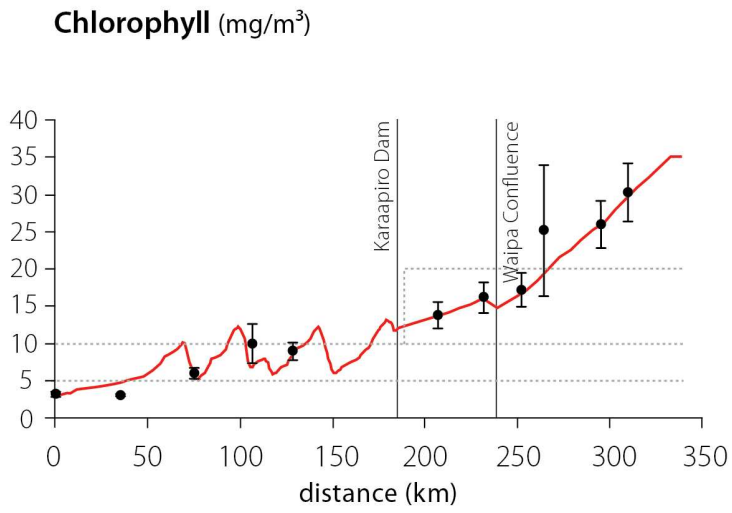


Figure 3.8: Variation with distance downstream of planktonic chlorophyll, at base flow in the Waikato River. Black circles are observed data (mean ± 95 percent confidence interval) (Source: NIWA and Environment Waikato monitoring). The dotted lines across the graph are targets based on ANZECC guidelines and expert opinion of the Study team (see Section 4 for further discussion). The solid line is as predicted by the Waikato Catchment Model (see 2.4.1).

Most of the shallow lakes have lost their submerged aquatic plants (weed beds) and have become very turbid (Hamilton et al., 2010). In these lakes, phytoplankton has little competition for nutrients and can grow to very high concentrations. Lakes with submerged aquatic plants tend to be clearer and to have fewer problems with phytoplankton blooms (see Appendix 12: Shallow Lakes).

3.4.4 Toxic compounds

There are a number of compounds found in the Waikato River that are potentially toxic including heavy metals and hydrogen sulphide from natural geothermal features of the river, industrial dioxins and resin acids, agricultural chemicals (including pesticides, herbicides and animal drenches) and a new group of chemicals collectively called 'chemicals of potential environmental concern'. In addition, there is the potential for toxic leachate from landfill sites, toxins released by cyanobacteria and contaminants from urban run-off.

As noted earlier in this Section, natural geothermal features in the upper reaches of the Waikato River cause high concentrations of arsenic and mercury in that area, which are increased by discharges from the Wairaakei Geothermal Power Station. In recent years there has been an ongoing programme to reduce mercury and arsenic concentrations in the power station's discharge. The Wairaakei Geothermal Power Station is also a source of hydrogen sulphide which is short-lived once it mixes with river water but is highly toxic to fish and is implicated as a possible reason for low fish biodiversity immediately downstream from the power station. Recently granted consents require a significant reduction in the quantity of hydrogen sulphide discharged to the Waikato River.

Industrial dioxins and resin acids, together with dissolved colour, are discharged by the Kinleith Pulp and Paper Mill into Lake Maraetai. In recent years there have been significant reductions in the amounts of dioxin and resin acid discharged and the risks posed by the discharge are now deemed to be fairly low (see Appendix 19: Kinleith Discharge). Nevertheless, recent consents granted to the mill require ongoing monitoring including assessing the risks of eating fish caught in Lake Maraetai (Depree et al., 2008).

In many areas there is also a risk of toxicity due to nitrate increases in groundwater because of increased nitrate leaching from:

- The doubling of dairy stocking rates over the last 40 years[70].
- Increased amounts of dairy wastewater discharged onto land (to approximately 460,000 cubic metres per day).
- Increased use of nitrogen fertiliser.

Large quantities of pesticides are used in the Waikato River catchment[71]. Between June 1997 and June 1998, 336 tonnes of herbicide, 25 tonnes of insecticide and 284 tonnes of fungicide were used in the Waikato catchment area (Holland and Rahman, 1999). Most pesticides break down at the surface or in shallow soil, but some mobile and persistent chemicals reach groundwater. A recent survey[72] showed that:

[70] http://www.mfe.govt.nz/environmental-reporting/land/use/pastoral.html
[71] http://www.ew.govt.nz/environmental-information/Groundwater/Monitoring-groundwater-quality/Pesticide-contamination-of-groundwater/#Heading1
[72] http://www.ew.govt.nz/Environmental-information/Environmental-indicators/Inland-water/Groundwater/gw2-keypoints/

- Pesticides are contaminating some ground waters.
- Concentrations of most pesticides are well below drinking-water guidelines.
- Pesticides are more likely to be found in vulnerable, shallow, unconfined aquifers where use of relatively mobile and persistent pesticide chemicals is high.
- Most pesticide contamination is because of poor management practices and historic use. For example, there are now thought to be over 50,000 contaminated sheep dip sites in New Zealand from historic use – with an unknown number in the Waikato region[73].

Chemicals of potential environmental concern include chemicals from cosmetics, cleaning agents, paints, human hormones and modern pesticides. Although modern pesticides are not as persistent as the chemicals they have replaced, their use is widespread and increasing. This issue is likely to require further research in the future.

At hui for this Study, several iwi expressed concerns about the possibility of leachate from landfills contaminating groundwater and streams in the Waikato River catchment. Landfills are acknowledged as potential contaminated sites by Environment Waikato, and a process is underway to register and test suspect sites[74] (see Appendix 22: Landfills). The Environment Waikato register lists 3,400 sites potentially (from activites such as timber treatment, sheep dipping, gas works, petrol stations, and scap yards) identified using the Ministry for the Environment's Hazardous Activities and Industries List (HAIL)[75]. To date 107 sites have been confirmed as contaminated and are being remediated. Procedures are in place to identify and manage other potentially contaminated sites. Their effect on waterways has not been quantified but is likely to be minor.

Stormwater-derived urban contaminants (such as road and roof run-off of heavy metals, hydrocarbons, silt and faecal microbes) can degrade water and aquatic habitat in urban streams. Based on the available information, it is likely that stormwater does contaminate some urban streams in the catchment. By contrast, impacts in large water bodies, such as the Waikato River at Hamilton and Cambridge, are likely to be localised and small (see Appendix 18: Urban Stormwater).

3.5 *Fisheries, kai and taonga species*

Key points:

- The tuna (eel) fishery in the Waikato has declined by about 75 percent in the past two decades.
- There is evidence of a decline in the whitebait fishery.
- The piiharau (lamprey) fishery no longer exists in the Waikato River main stem but a remnant fishery exists in the Waipa River.

[73] http://www.ew.govt.nz/Policy-and-plans/Regional-Policy-Statement/Regional-Policy-Statement-Review/RPSdiscussiondocument/2-Community-well-being/27-Hazardous-substances-and-contaminated-land/

[74] http://www.ew.govt.nz/environmental-information/Hazardous-substances-and-contaminated-sites/Contaminated-sites/

[75] Ministry for the Environment (2004). Contaminated Land Management Guidelines Schedule A: Hazardous Activities and Industries List (HAIL). Ministry for the Environment, Wellington, New Zealand.

- Kooura (freshwater crayfish) and kaaeo (freshwater mussels) are no longer common in the lower Waikato River, the Waipa River and the shallow lakes.
- Watercress is now only collected in certain places in the Waikato River catchment.
- Harekeke (flax), kuta (rush) and other plants used for traditional, cultural purposes such as weaving and medicine are now much less abundant.
- The causes include: loss of habitat, barriers to migration, competition and predation by pest species, poor water quality and overharvesting.

The Waikato River supports 19 species of native fish and 13 species of introduced fish some of which are fished recreationally and commercially and provide an important traditional source of kai for the five river iwi. In addition, estuarine fish migrate into the Waikato River and its tributaries, including mullet and flounder (Environment Waikato, 1998).

It is well documented that fish were abundant in the Waikato River until the 1950s. For instance:

> *"Along this river, the Maori [sic], for an aboriginal race, led an ideal existence. Fish such as eels, whitebait, mullet, kahawai and herrings were plentiful for miles up the river past the tidal influence..."* (Frost, 1947)
>
> *"The Waikato [River] with its tributaries north of the Huka Falls…were particularly noted for their eels and for their many eel weirs (pa-tuna)."* (Andersen, 1942)

Other important kai species including watercress, kooura and kaaeo (freshwater mussels) also appear to have declined in abundance. For iwi, this adversely affects their ability to provide these kai sources at important gatherings including hui, tangihanga (funerals) and poukai (annual visitation aligned to the Kiingitanga)[76] – which is part of their tradition and culture.

This decline and its effects were acknowledged by the Crown in the Preamble to the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010, as follows:

> *"that the pollution, degradation and development of the Waikato River, its lakes, streams and wetlands have caused the decline of once rich fisheries that, for generations, had sustained the people's way of life and their ability to meet obligations of manaakitanga, and this is a further source of distress"*

There are many reasons for the decline in abundance of fish, other kai and taonga species, but the most significant is degradation of habitat. A recent study noted that, in terms of fish habitat, *"the Waikato is … one of the most impacted rivers in New Zealand due to extent of loss of forest and wetlands, industrial discharges, volume of commercial harvest, presence of high numbers of introduced fish and barriers to native fish passage"* (Collier et al., 2010).

The sub-sections below provide further detail on the state and trends in abundance, then Table 3.4 summarises the causes of decline for key species.

[76] Annual visitation - a gathering instituted by Kiingi Taawhiao to feed the widowed, bereaved and the destitute to align to the Kiingitanga.

3.5.1 Whitebait

The estimated total whitebait catch from the Waikato River in 2000 was three tonnes, compared with about 10 tonnes per year in the 1980s. This is significantly lower than the estimated average 46 tonnes per year caught between 1931 and 1950 (Baker and James, 2010).

Whitebait in the Waikato comprises two main species – iinanga and banded kookopu (with smaller numbers of giant kookopu). They are primarily found in the lower Waikato and Waipa (Figures 3.10 and 3.11). Whitebait are diadromous (i.e., spend part of their life cycle in the sea and part in fresh water). Young whitebait move into the river each year in spring. Iinanga move up into vegetated streams, shallow lakes and wetlands where they live as adults before moving out in the autumn to tidal areas of streams and rivers to spawn on riparian vegetation at high tides. Banded kookopu are a climbing species and move further up into headwater streams where adults spawn amongst riparian vegetation, with their larvae washed out to sea in floods.

The total length of stream habitat for *adult* iinanga in the Waikato River is close to 800 kilometres. Approximately 320 kilometres (40 percent of the total iinanga habitat) occurs in catchments below the confluence of the Mangatawhiri River and the Waikato River. This is prime habitat for iinanga because it is close to the river mouth. Around 24 percent of the total iinanga habitat in the Waikato River catchment (192 kilometres) is potentially affected by flood protection works or inaccessible due to road culverts preventing migration. An estimated 180 road culverts and 5,000 farm culverts are impassable to iinanga, and 4,000 farm culverts are impassable to banded kookopu. In addition, the 23 tidegates at Aka Aka near Te Puuaha o Waikato may be impassable to iinanga.

Historically there was around 30 kilometres of prime iinanga spawning habitat in the Waikato River catchment but much of this has been lost as a consequence of changes in riparian vegetation related to farming practices (see Appendix 6: Whitebait). Degradation has mainly been caused by livestock grazing, vegetation removal and stock trampling eggs. Currently, there is only an estimated 10.5 kilometres of prime iinanga *spawning* habitat in the catchment.

Causes of decline of whitebait are presented in Table 3.4, with more information presented in Appendix 6: Whitebait and Appendix 7: Fisheries Management.

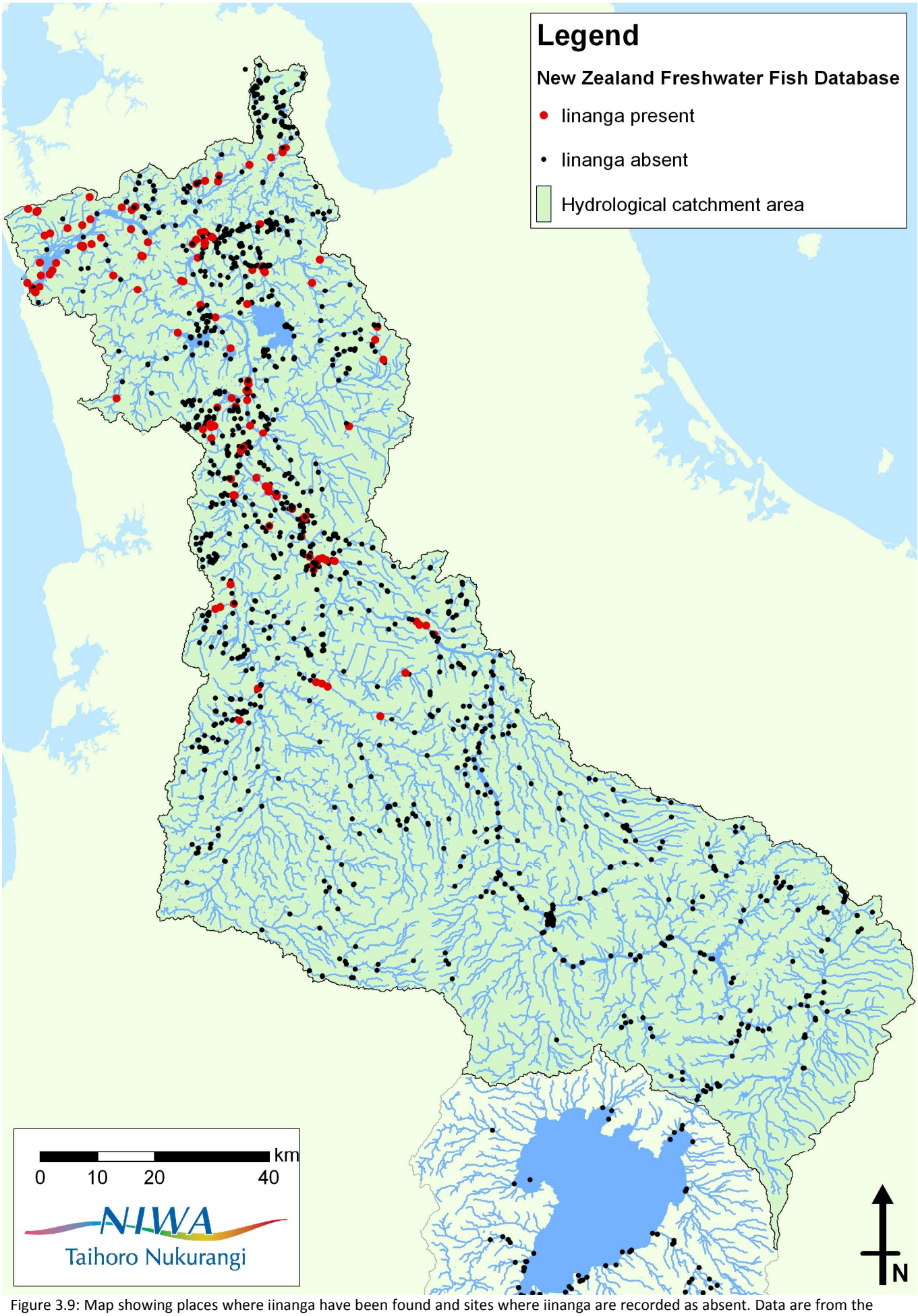


Figure 3.9: Map showing places where iinanga have been found and sites where iinanga are recorded as absent. Data are from the New Zealand Freshwater Fish Database and cover the past 50 years. The long time period means locations should be regarded as indicative only.

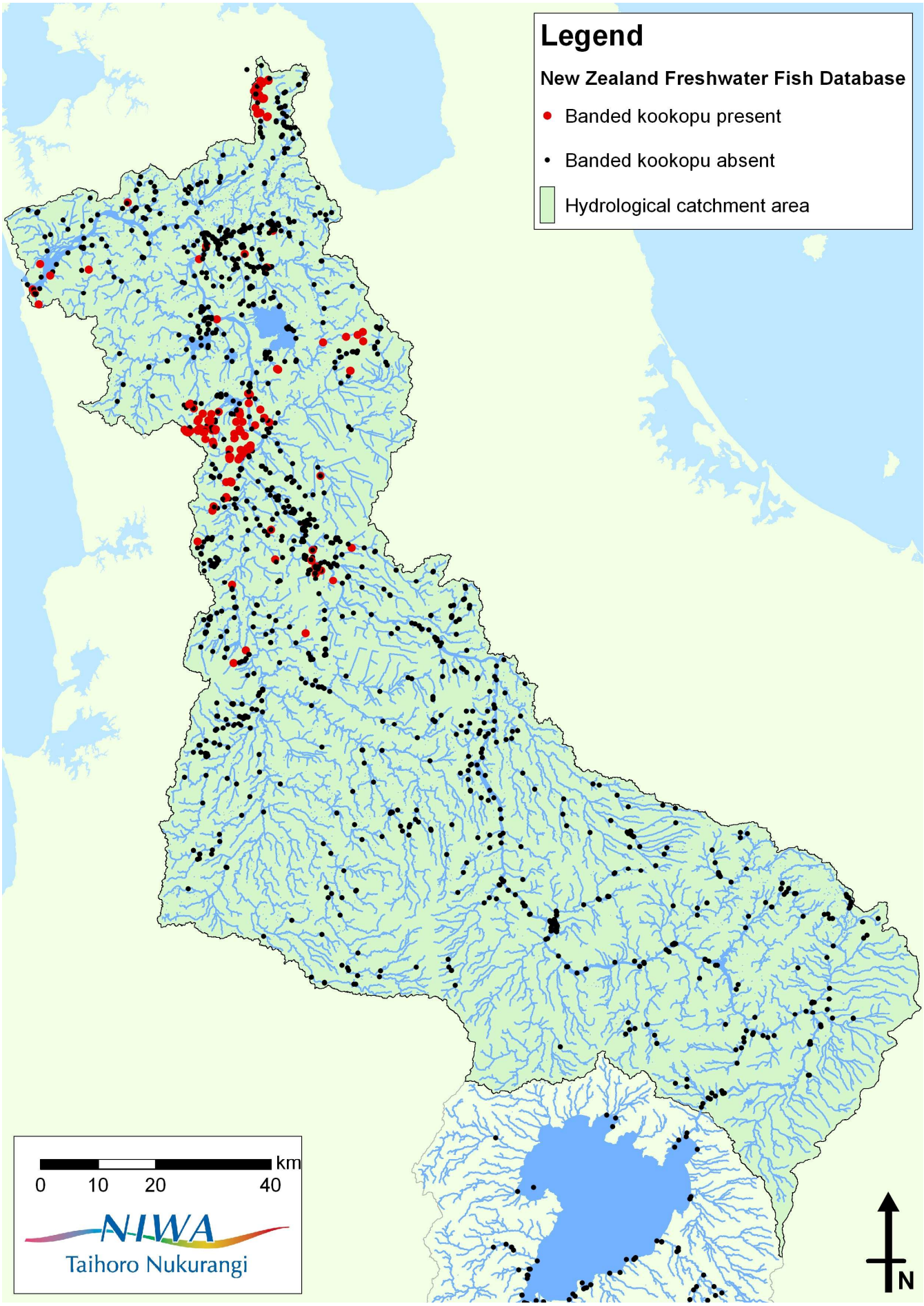


Figure 3.10: Map showing locations where banded kookopu have been found and sites where banded kookopu are recorded as absent. Data are from the New Zealand Freshwater Fish Database and cover the past 50 years. The long time period means locations should be regarded as indicative only.

3.5.2 Tuna

The Waikato River supports New Zealand's most productive tuna fishery but the abundance of edible-sized tuna has declined in the past two decades. The current annual commercial catch of tuna from the Waikato River is about 100 tonnes, which is roughly 75 percent less than the estimated annual catch in 1980 (see Appendix 5: Tuna). There are two main species – the shortfin and the longfin tuna. Adults of both species migrate to the sea in autumn to breed in the central Pacific Ocean, with young migrants (glass eels) returning to rivers in spring to early summer. Glass eel recruitment to the Lower Waikato appears to have reduced in the last 30 years (Jellyman et al., 2009), but the river is still the largest source of glass eels in New Zealand.

Longfins are more sensitive to water quality and habitat degradation (Beentjes et al., 1997) and tend to occur further upstream than shortfins, which have proved more resilient to pastoral development (see Figures 3.11 and 3.12). Migratory tuna are good climbers, but the lower hydro lakes have proved impossible barriers to migration. To address this, a large-scale trap and transfer programme has run from the base of the Karaapiro Dam to upstream reservoirs since 1992. Commercial tuna fishing in the North Island has been regulated by the Ministry of Fisheries under the Quota Management System since 2004.

For more detail on tuna, see Appendix 5: Tuna. For discussion of the management of this fishery, see Appendix 7: Fisheries Management.

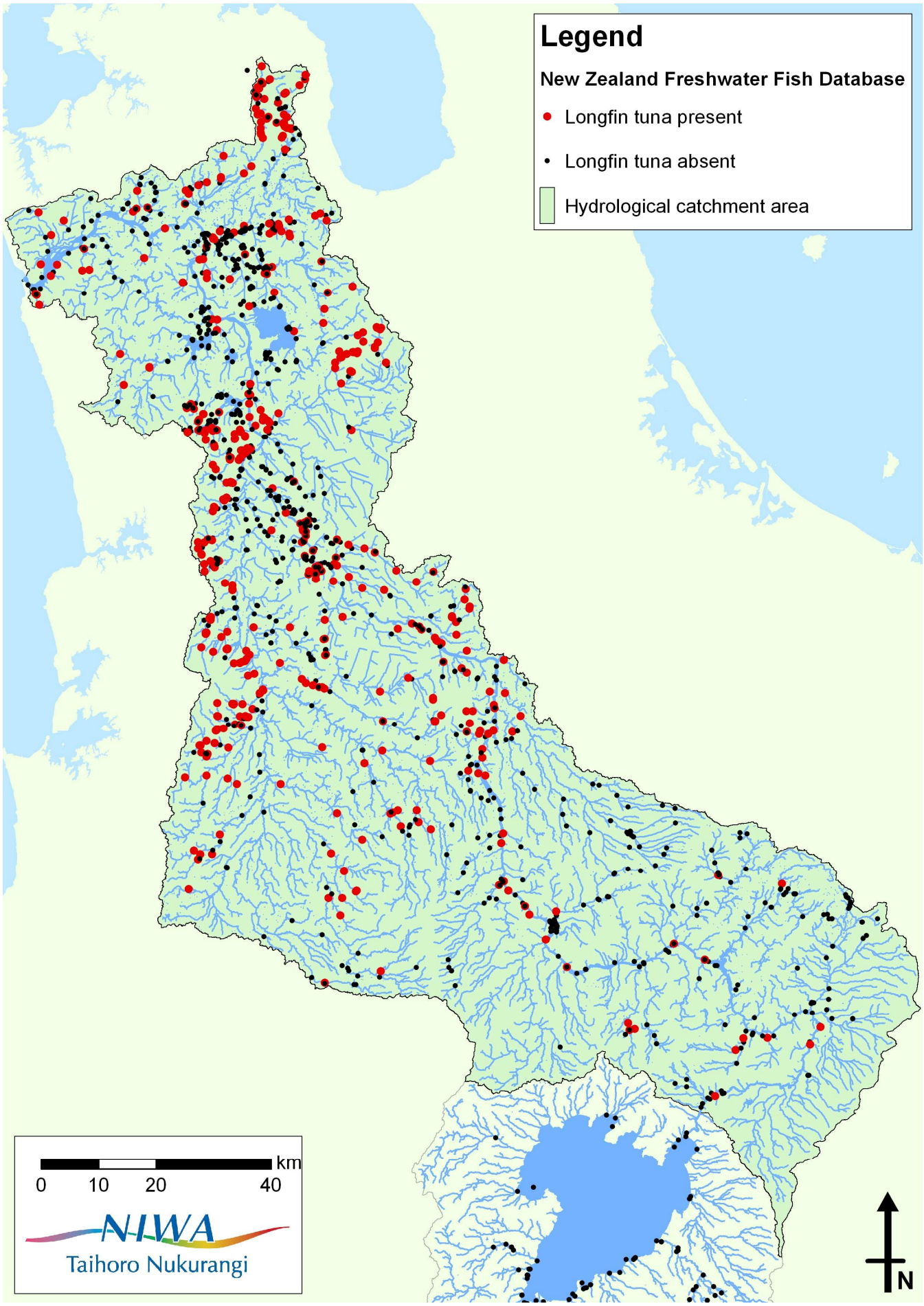


Figure 3.11: Map showing locations where longfin tuna have been found and sites where longfin tuna are recorded as absent. Data are from the New Zealand Freshwater Fish Database and cover the past 50 years. The long time period means locations should be regarded as indicative only.

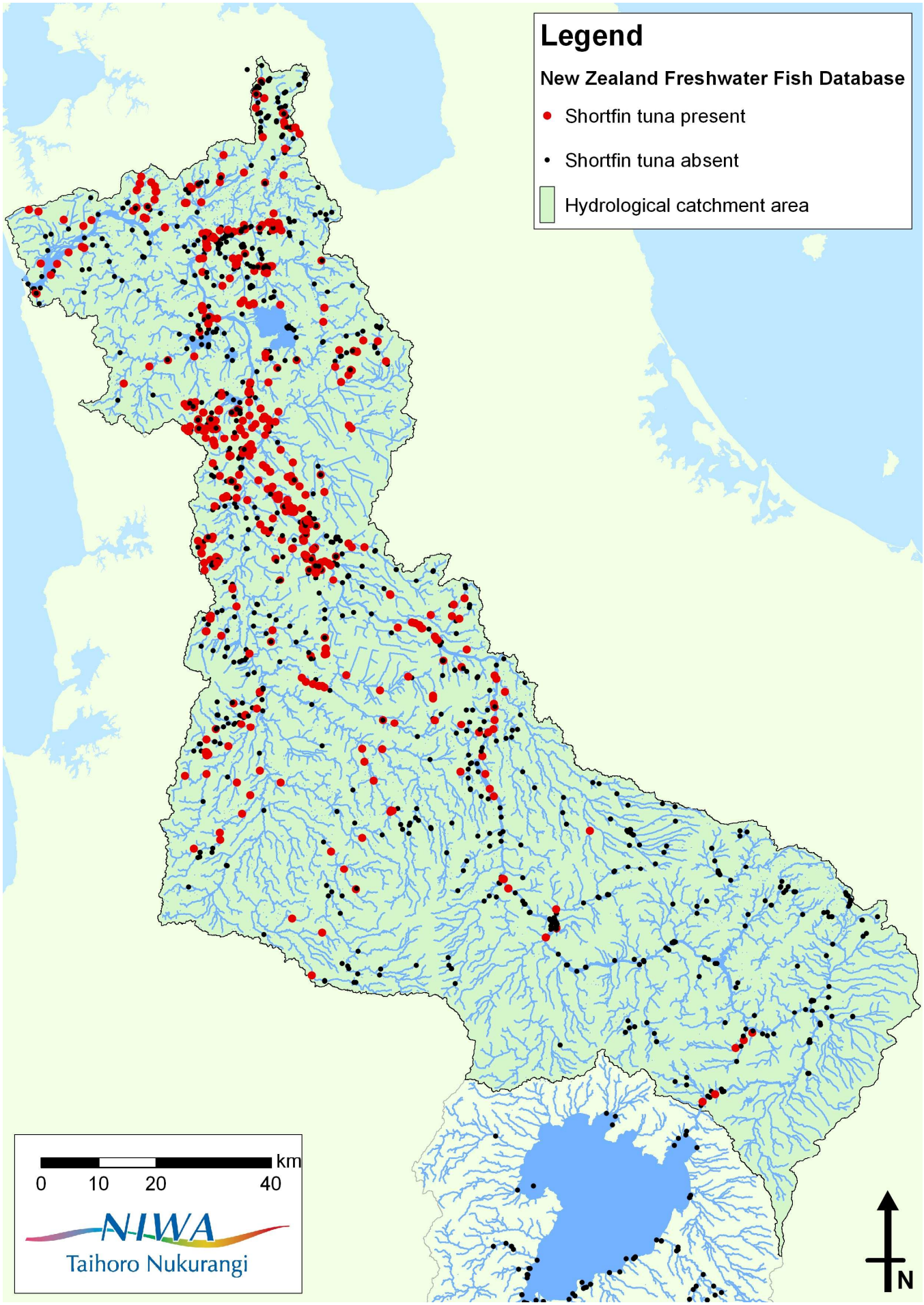


Figure 3.12: Map showing locations where shortfin tuna have been found and sites where shortfin tuna are recorded as absent. Data are from the New Zealand Freshwater Fish Database and cover the past 50 years. The long time period means locations should be regarded as indicative only.

3.5.3 Other fish species

Other important fish species, used for commercial and recreational fishing and as a traditional source of kai, and found in the Waikato River catchment are also important to iwi and the wider Waikato community. They include piiharau, poorohe (smelt), aua (yellow eyed mullet), trout and paatiki (flounder). Not much is currently known about these species in the Waikato River and whether they are declining in numbers, but the effects of reduced water quality and loss of habitat will almost certainly have an impact on their populations (Appendix 8: Fisheries Research outlines information gaps).

3.5.4 Kooura

Kooura can be found throughout the Waikato River catchment and were once common in tributary streams, the main stem of the Waikato River, the hydro lakes and shallow lakes. They are an important traditional kai species and, at hui for this Study, all five river iwi noted a major decline in their abundance. Little is currently known about the causes of their decline but they are regarded as a keystone species in the catchment because they break down and recycle detritus in the water. Healthy numbers of kooura would indicate good water quality and health.

3.5.5 Kaaeo/kaakahi

Until recently kaaeo/kaakahi were found in abundance throughout the Waikato River catchment and were also a traditional source of kai for the five river iwi. Now they are rare, a concern that is recognised nationally (Hitchmough et al., 2005). Freshwater mussels are a keystone species because, as filter feeders, they purify the water, consume fine organic sediment and help to stabilise the sediment. No freshwater mussels have been found in the Waikato shallow lakes since the ecological collapse of the weed beds.

3.5.6 Watercress

Watercress is an important introduced aquatic plant that was abundant in the Waikato River catchment and harvested regularly by the five river iwi as a highly valued kai source. During hui for this Study, nearly all the iwi remarked on the major decline in the abundance and quality of watercress in their rohe (tribal boundary). Iwi were also concerned about reduced access to watercress gathering sites because of private ownership. Issues associated with contamination of watercress are covered in section 3.3.2.

3.5.7 Other plant species

The massive loss of Waikato wetlands (Hughes, 1981) has reduced plant biodiversity (Clarkson et al., 2007) and the availability of many plant species used by Maaori for crafts, art, carving, food and medicine, including harakeke (flax) and raupoo (bullrush)[77].

> *"Harakeke and bullrush, raupoo…I'll tell you what's missing ... the ngaawhaa, that's all gone and Whangamarino,* [is] *very limited. It used to be plentiful."* (From hui transcript: Ngaa Tai E Rua Marae, Waikato-Tainui)

[77] http://www.teara.govt.nz/waikato-region/8

3.5.8 Birds

The Waikato River and associated streams, wetlands, lakes and estuary support a diverse bird community of national significance. This comprises a mix of species that only breed in New Zealand (e.g., New Zealand dabchick and New Zealand scaup), native species that breed here and elsewhere (e.g., little black shag) and introduced species (e.g., mallard ducks and Canada goose). Six rare and endangered species found in the Waikato River catchment are: grey duck, Australasian bittern, New Zealand dabchick, northern New Zealand dotterel, North Island fernbird and the spotless crake (Sagar, 2010).

Extensive wetland drainage to produce farmland has greatly reduced important habitats of some of these species. In the upper Waikato, high variability in water levels due to power generation (see Appendix 23: Hydro Dams) has affected waterfowl numbers above Lake Ohakurii.

The development of the hydro lakes drowned riverine rapid habitats to the detriment of some bird species but has provided abundant lake habitat for a wide variety of many other water birds. Most birds on hydro lakes occur where riparian vegetation provides shelter, although Canada geese and mallard ducks can favour pasture areas with gentle slopes (Sagar, 2010). Lakes with large areas of macrophyte beds (aquatic plants that grow in or near water and are either emergent, submergent, or floating) in shallow water support abundant and diverse bird populations, so the collapse of macrophytes in many of the shallow lakes has reduced their capacity to support bird-life.

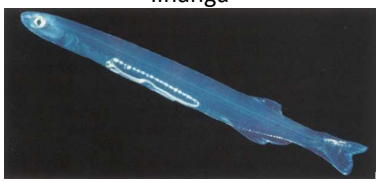
Riparian forest, where it still occurs, provides habitat and stepping stones/corridors linking isolated forest fragments for iconic birds such as tui, korimako (bellbird) and ruru (morepork). Restoration of gully vegetation in Hamilton City is a key part of endeavours, led by Environment Waikato and Landcare Research, to enhance urban populations of tui (Wall and Clarkson, 2001).

3.5.9 Bats

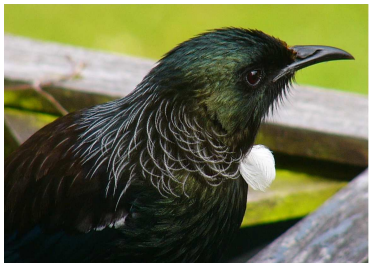
New Zealand's two species of bats represent the only mammals that were present before human colonisation. The long-tailed bat occurs along the Waikato River, including within Hamilton City. It uses the river and gullies, and appears to remain within 200 metres of the river. Bats use a variety of native and introduced trees for roosting and nesting, but studies have shown a preference for native forest over mixed native/exotic stands (Sagar, 2010)[78].

[78] Bat densities and ecology are the subject of a current University of Waikato PhD study.

Table 3.4: Summary of causes of the decline of some kai and taonga species in the Waikato River catchment

Species	*Importance*	*Causes of their declining abundance*
Tuna 	Traditional food source, commercial fishery	• Loss of wetland and lowland lake habitat. • Barriers to upstream migration of juvenile tuna and downstream migration of adult spawners (e.g., the hydro dams, stop banks, tide gates and culverts). • Loss of stream habitat. • Increased competition for food because of pest fish (e.g., koi carp). • Poor fisheries management and over fishing. (Appendix 5: Tuna)
Whitebait Iinanga  ***Kooaro***  ***Kookopu*** 	Traditional food source, recreational fishery	• Loss of floodplain connectivity. • Loss of wetlands. • Poor riparian conditions. • Livestock access and degraded habitat at spawning areas (in the Waikato River and other West Coast rivers that support recruitment). • Migration barriers such as culverts, pump stations, dams and floodgates reducing access. • Shallow lake degradation (from silt, loss of macrophytes and pest fish). • Lowland stream habitat degradation (from channelisation and excessive macrophytes). • Poor fishery management. • Competition/predation by pest fish (including trout). • Low clarity of the Waipa River reducing upstream migration. (Appendix 6: Whitebait)

Species	Importance	Causes of their declining abundance
Kooura 	Traditional food source, possible keystone indicator species	• Habitat modification and forest clearance. • Impacts of pest aquatic plants. • Poor water quality, particularly increased fine sediments. • Sedimentation. • Predation by pest fish (including trout). (Parkyn and Collier, 2004; Parkyn and Kusabs, 2007; Kusabs and Quinn, unpublished data)
Kaaeo, kaakahi 	Traditional food source	• Deoxygenation. • Increased fine sediment mobility. • Reduced numbers of kooaro (climbing galaxias) – a prime fish host of mussel larvae. • Pest fish feeding disturbance of lake and streambeds. (James et al., 1998; Phillips et al., 2007; Burlakova and Karatayev, 2007)
Watercress 	Traditional food source	• Exclusion by more invasive plants such as water celery, musk, reed sweet grass, alligator weed and, in some places, blackberry. • Water levels and flows affected by the operating regimes of the hydro dams. • Drainage of swamps and wetlands. • Farm stock access to stream banks. • Point source and non-point source discharges (both natural and as a result of human activity). • Arsenic from the geothermal areas in the Waikato River catchment. • Over-harvesting. (Robinson et al., 2006; Donnison et al., 2009)

Species	Importance	Causes of their declining abundance
Birds 	Taonga species	• Loss of wetlands. • Riparian deforestation. • Water level fluctuations associated with hydro-peaking and hydro generation. • Loss of macrophytes in shallow lakes due to combined pressures of high nutrient and/or sediment levels and pest fish. (Sagar, 2010)
Bats 	Taonga species	• Riparian deforestation. • Predators such as possums, cats, rats and stoats. • Disturbance of roosts. (Sagar, 2010) (Photo courtesy of the Department of Conservation)

3.6 Ecological integrity

Ecological integrity concerns the state of the combined ecosystems of the Waikato catchment, their connections and the degree to which ecosystems have been altered from the natural state. Undisturbed ecosystems have high ecological integrity that declines generally with the degree of modification. The Waikato River, its lakes, wetlands and tributaries have provided a rich habitat for native fish, bird and plant species for centuries, but the ecological integrity of the catchment has been adversely affected by settlement, urbanisation and development and is now in a poor state.

Key points:

- Wetland habitat in the Waikato River catchment has been reduced by 90 percent since pre-European times because of drainage.
- Half of the 32,000 hectares of floodplain in the Lower Waikato has been protected by stop banks, which in turn has markedly reduced natural floodplain habitat.
- Connectivity within the Waikato River catchment has been altered by stop banks, culverts, floodgates and pumping stations.
- Dams disrupt the movement of fish, water and sediment, and allow phytoplankton to proliferate.
- Invasive plants and pest fish cause widespread adverse effects.
- Most of the rivers, streams and lakes have been adversely affected by nutrient inputs from diffuse pollution sources and many are 'eutrophic' (have excess nutrients and are prone to algal blooms).

3.6.1 Degradation of shallow lakes

Perhaps the area in which the poor ecological health of the river is most clearly seen is in its many lakes (see Figure 3.13). Some of the lakes occur in peat soils and early naturalists described the peat lakes as peat-stained but clear (Kirk, 1871). Farming has increased nutrient and sediment inputs and many peat lakes are now turbid, with high nutrient concentrations and periodic blue-green algae blooms.

Several shallow riverine lakes (so called because they are close to and well connected with the Waikato River) have been created during the last few thousand years. Until the 1980s, most of these lakes were clear and contained abundant submerged plants including natives. Several have recently 'flipped' to having few submerged plants, low water clarity, high nutrient concentrations and cyanobacteria 'blooms' (Hamilton et al., 2010).

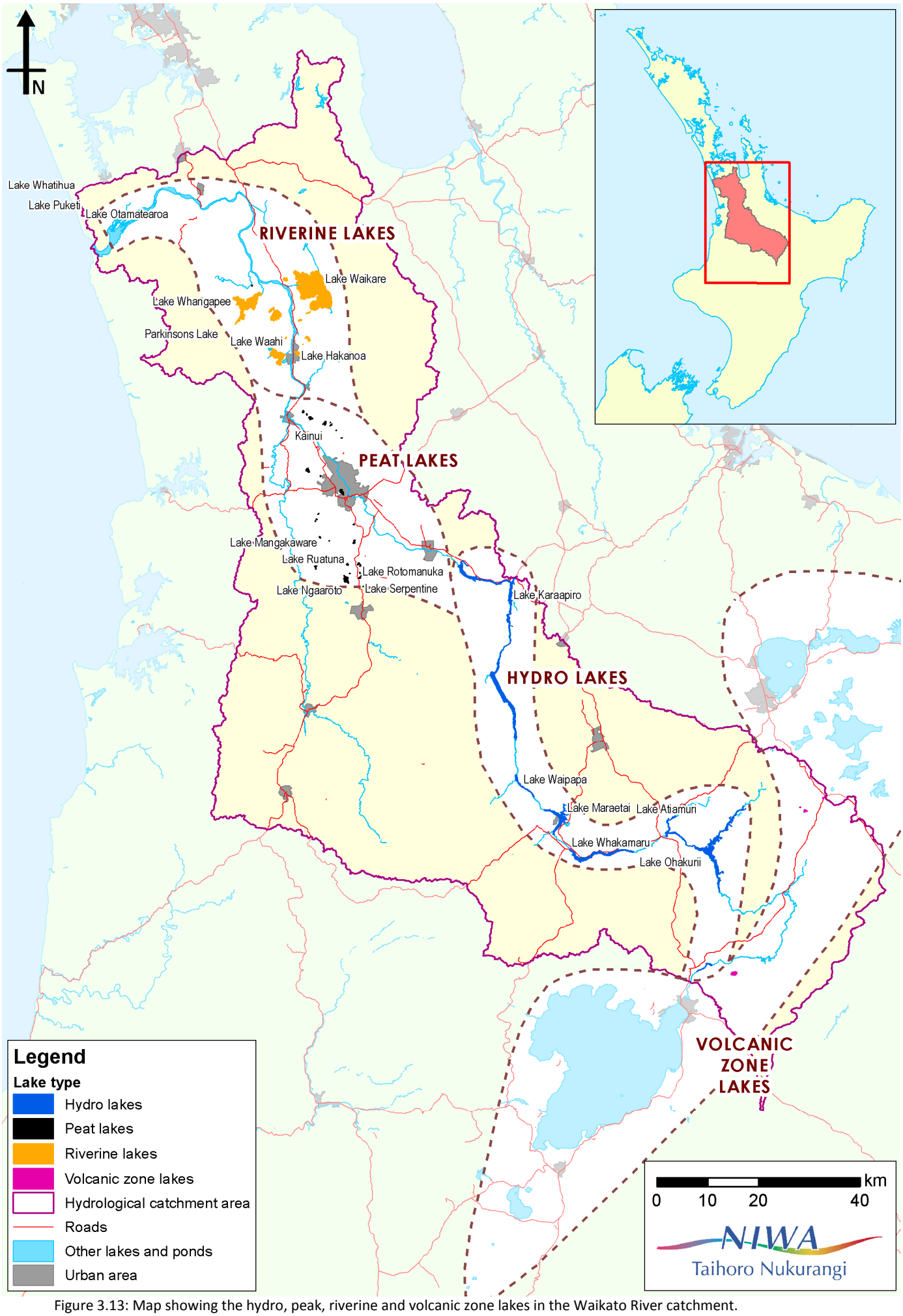


Figure 3.13: Map showing the hydro, peak, riverine and volcanic zone lakes in the Waikato River catchment.

The water level of Waikare, the largest Lower Waikato lake (34 square kilometres), was lowered by one metre in 1965 as part of the Lower Waikato Flood Protection Scheme (Brown, 2010). Diversion of water into Lake Waikare reduced river flood peaks within the diverted water being returned later to the main stem via Whangamarino wetland. This flood protection role limits the lake's ecological values, traditional uses and prospects for restoration (Reeves et al., 2002).

"…These were all river running lakes, which were connected to the river, but now with all the drainage… there's no real natural connection with these lakes to the river. They are pretty much all landlocked, and they pretty much all get fed through the run-off from these areas…" (From hui transcript: Waahi Marae, Waikato-Tainui)

"And every summer Waahi is off limits for swimming, the heat does something… next minute you get algae in the water." (From hui transcript: Waahi Marae, Waikato-Tainui)

As Table 3.5 indicates, the hydro lakes are moderately degraded, but the shallow lakes of the lower river are the most adversely affected, and have low ecological integrity.

Table 3.5: Summary of water quality in three categories of Waikato lakes, 2002–2006

Attribute – measure	*Hydro lakes Group 1[a]*	*Shallow lakes Group 2[a]*	*Shallow lakes Group 3[a]*
Recreation – clarity			
Nutrients – total nitrogen			
Nutrients – total phosphorus	**b**		**c**
Phytoplankton – chlorophyll *a*			

Red indicates that the mean values in that group of lakes fall below the Environment Waikato 'satisfactory' guideline. Yellow indicates that the means fall between the 'satisfactory' and 'excellent' guidelines. Source: Environment Waikato.

a. Group 1–Ohakurii, Whakamaru, Waipapa. Group 2–Rotomanuka, Rotoroa. Group 3–Waahi, Ngaaroto, Whangapee, Hakanoa, Waikare, Kainui. Other shallow lakes are not routinely monitored for water quality.
b. Cyanobacteria blooms occur occasionally in the hydro lakes and lower River.
c. Cyanobacteria blooms occur regularly in these lakes.

Similarly, Table 3.6 assesses the health of the aquatic plant populations in the lakes using the LakeSPI (Lake Submerged Plant Index) method (Edwards et al., 2009). In this analysis, the lakes are subdivided into hydro lakes, peat lakes and riverine lakes. Lakes that have been degraded and now have negligible lake edge vegetation or less than 10 percent submerged vegetation are the most common category. All the riverine lakes fall into this category. Only two of the peat lakes were found to have a high LakeSPI score (green), the number would have been greater before catchment development.

Table 3.6: Summary of macrophyte health index (LakeSPI) values in Waikato lakes

Attribute – Measure	*Hydro lakes*	*Peat Lakes*	*Riverine Lakes*
Number of lakes	*8*	*21*	*9*
LakeSPI >90%		2	
LakeSPI >50%		2	
LakeSPI >25%	1	1	
LakeSPI >10%	7		
Negligible vegetation		16	9

Red indicates severe, yellow moderate and green little degradation. Source: Edwards et al., 2009.

Overall, the health and wellbeing of most Waikato shallow lakes is now substantially degraded. Causes of this degradation include:

- High loads of diffuse contaminant inputs of nutrients, sediment and bacteria from run-off and livestock access to the lakes.
- Internal regeneration of nutrients from sediment re-suspension (by wind action or pest fish) and/or release of nutrients as a result of low oxygen events at the lakebed.
- High abundance of pest fish (e.g., koi carp and catfish), and/or aquatic weeds (willow, alligator weed, oxygen weed, hornwort).
- Reduced water depth due to drainage and/or reduced flushing due to water control structure and artificial regimes such as the Lower Waikato Flood Control Scheme.
- Past development of large exotic weed beds that create deoxygenation events and a switch to turbid, nutrient-enriched conditions.
- Removal of vegetation filtering potential in the catchment through drainage of wetlands around lake margins, agricultural development and grazing access.

(See Appendix 12: Shallow Lakes)

3.6.2 Wetland and floodplain habitats

The river iwi regard wetlands and river floodplains as an integral part of their awa tupuna, sometimes referring to them as the kidneys since they absorb and cleanse the water during floods. Wetlands are important sources of food (such as fish, waterfowl and edible plants) and cultural materials (such as kuta (great spike rush), harakeke, and tootara (species of podocarp tree endemic to New Zealand). European settlers began draining 'swamps' in the 1860s. Today, wetland area has been reduced by about 90 percent (Baird, 2010)[79]. The value of wetlands is now recognised and many are being protected, though there are claims that wetland decline is still occurring (Baird, 2010).

To protect low-lying farmland from flooding, an extensive infrastructure of stop banks, floodgates and pumping stations have been built up, especially in the lower Waikato and Waipa catchments. Whereas fish previously moved freely between the main stem of the Waikato River and the floodplains, wetlands, shallow lakes and tributaries, this is no longer possible.

[79] http://www.teara.govt.nz/waikato-region/8

"*…put the land into farms aye, drained all the swamps and rivers, and re-directed the rivers for irrigation and changed the whole contour of the land, chopped the flax down and the cows could get to the river.*" (From hui transcript: Te Waananga o Aotearoa, Raukawa)

"*… they want to straighten the river so it won't flood, then they put the stop banks in along there as well for the diversion and it's taken away some of the food resources of the native species because of the habitats…*" (From hui transcript: Waahi Marae, Waikato-Tainui)

3.6.3 Pest plants and fish

Submerged exotic aquatic plants, including the 'oxygen weeds' (*Elodea, Lagarosiphon* and *Egeria*), generally grow taller and out-compete native species. Scientific studies have shown that invasion by weeds (especially *Egeria*) has contributed to the loss of native charophyte (a macro-algae) meadows from many shallow Waikato lakes (Champion and Clayton, 2010). Other problems caused by aquatic weeds include: deoxygenation of lake bottom waters, wetlands being degraded, watercress beds being overrun, sand banks on the Waikato delta being colonised, hydro-power station intakes get blocked, access to swimming sites on the hydro and shallow lakes being restricted and rowing events at Lake Karaapiro being affected.

Despite this, invasive weeds can still provide important functions where they have taken over from native species including: providing habitat, shelter, food, bank and bed stability and improving water quality by trapping sediment, reducing turbidity and absorbing nutrient and contaminants. Unfortunately, their excessive growth frequently negates these benefits.

Pest plants also occur along the riverbanks. Since the early 1900s, willows have been planted along waterways to reduce bank erosion or have colonised naturally from plantings on hill slopes. While their extensive root mass does increase bank stability, some willow species 'choke' the channel and aggravate flooding problems. They often form monocultures that shade out more desirable species, including native trees and shrubs. This degrades streambank aesthetics and reduces the abundance of native plants collected by iwi. Other pest plants in the riparian zone include blackberry and gorse.

"*I know along the Waipa there's kahikatea stands, pockets and there's still old pockets of kahikatea but there's heaps of willows constricting the Waipa… the flooding there is terrible…*" (From hui transcript: Waahi Marae, Waikato-Tainui)

"And we've got alligator weed there which we're trying to contain so it doesn't go up the river…we've been trying to hold it back since 1995." (From hui transcript: Ngaa Tai E Rua Marae, Waikato-Tainui)

Currently, the worst pest fish in the river is koi carp. This large bottom-feeding fish was introduced into the catchment in the late 1960s and had become well established by the early 1980s. They compete for food with native species and contribute to poor water clarity because their feeding disturbs the bed sediments. Catfish and goldfish have similar effects.

"*…And the biggest killer of the lake [Waahi] is koi carp*." (From hui transcript: Waahi Marae, Waikato Tainui)

"*…because all the weed's gone, it's gone to that koi carp. It's killing everything on the river*." (From hui transcript: Ngaa Tai E Rua Marae, Waikato-Tainui)

Environment Waikato (2008) describes pest fish as *"one of the greatest threats to the health of waterways."* It rates the risk of pest fish spreading through illegal introductions or accidental transfers as *"considerable"* and notes that, for example, *"koi carp do not appear to be established above Lake Karaapiro Dam – they would threaten water quality upstream considerably if they did so."*

3.6.4 Macroinvertebrates

Macroinvertebrates (e.g., insects, snails, crustacean, and worms) are commonly used as bioindicators of aquatic environmental health (e.g., Boothroyd and Stark, 2000). The Macroinvertebrate Community Index (MCI) is used widely for this purpose in New Zealand (Boothroyd and Stark, 2000) and has been applied as one of three key macroinvertebrate indices in Environment Waikato's regional ecological monitoring of streams programme on wadeable streams since 1994 (Collier, 2005, 2010). Results from this monitoring show a clear pattern of lower macroinvertebrate metrics where there are high levels of development (primarily agricultural) (Collier 2010). In 2005–2008, average MCI at reference (undeveloped) catchments was 133, compared with 114 (15 percent lower) at where 10–50 percent of the upstream catchment was modified and 85 (36 percent lower than reference) where more than 90 percent of the upstream catchment was modified. Urban streams in Hamilton typically had lower ecological condition than those in other developed catchments, although a few supported high numbers of sensitive invertebrate taxa (Collier, 2010).

3.7 Water supply

Key points:

- There is now competition for water supplies for consumption, irrigation, power generation and ecosystem health.
- The largest single consumptive take is drinking-water for Auckland and this demand is likely to increase.
- The largest non-consumptive use is for hydro-power.

Water supply from the Waikato River system is allocated to more than 30 towns in the catchment (Chapman, 1996) as well as providing 10 percent of Auckland's water requirements.

Brown (2010) gave a detailed description of the allocation of the Waikato River's water that can be summarised as follows:

Non-consumptive water use: The total amount of water allocated in the Waikato catchment for non-consumptive use exceeds 2,900 cubic metres per second of which 97 percent is non-consumptive flow through the eight hydro power stations, and cooling water returned to the river at Wairaakei and Huntly geothermal and coal-fired power stations. Non-consumptive water use is nearly 700 percent the mean flow at Mercer. In other words *"each drop of water is used more than seven times before flowing out to sea*" (Brown, 2010).

Consumptive use: Consumptive use is much lower, approximately 13 cubic metres per second which is equivalent to about 3 percent of mean flow at Mercer. Consumptive use is made up of municipal water supply, irrigation supply and other purposes.

The largest individual abstraction is Auckland's Waikato River take at Tuakau (up to 1.7 m^3 per second) and this is likely to increase in the future. Auckland also takes water from two northern sub-catchments of the river, the Mangatangi and Mangatawhiri. Hamilton's water supply is the next largest at 1.0 cubic metres per second. Other sizeable domestic takes are for Taupoo and Cambridge.

Irrigation water is primarily used for agriculture and horticulture where rainfall water supplies are not sufficient. Historically the Waikato River catchment has relied primarily on natural irrigation. Farms in the Waikato River catchment *"most likely to convert to pasture irrigation are those where rainfall and soil characteristics limit the amount of grass growth and the installation of operation of an irrigation system is economically viable"* (Brown, 2004). The first irrigation consent was granted in 1970 and since then demand for irrigation water has increased markedly, particularly for pasture irrigation since 1996. There are currently 49 square kilometres of pastoral land consented for irrigation by surface water and 12 square kilometres for horticulture. In 2008, total consented rates of take for pastoral and horticultural land in the catchment were 2.4 cubic metres per second and 0.5 cubic metres per second, respectively.

Water use 'permitted' under the Waikato Regional Plan and the Resource Management Act 1991 (RMA) is largely for animal drinking water, dairy-shed operations, domestic needs, and small businesses. The total amount of water calculated to be taken in this category is about 1.5 cubic metres per second.

The total consumptive water use for industry is about 2.9 cubic metres per second. This includes the approximately 30 water takes for quarrying and mining purposes, totalling 1.7 cubic metres per second mostly between Mercer and the mouth; Glenbrook steel mill abstraction of about 0.5 cubic metres per second in the reach downstream of Mercer and the seven takes for food processing with a gross take of about 0.8 cubic metres per second – the two largest being the Te Raapa dairy factory and the AFFCO freezing works at Horotiu.

Water supply and allocation has been the subject of much recent controversy and debate in the Waikato community. According to Environment Waikato: *"in recent times the method by which surface and groundwater is allocated in the region has come under increasing scrutiny and sometimes criticism from both political and technical perspectives….Certainly in recent times, a number of issues have arisen that have stretched the organisation's ability to respond proactively and appropriately to the demands being placed upon the region's water supply."*[80]

Environment Waikato (2008b) also noted: *"The Ministry for Agriculture and Forestry and Ministry for the Environment recently projected a 202 percent increase in demand for irrigation water by 2010 in the Waikato Region (an increase of 9,100 hectares over the present 4,500 hectares of irrigated land). In addition, there is also an increasing demand for water for community supplies, industry and stock water supplies. More and more frequently issues of resource scarcity and the equity and fairness of the present allocation strategies are being questioned in consent hearings and before the Environment Court."*

Faced by increasing competition amongst water users and likely future growth in demand for water supply, Environment Waikato proposed a variation to the Waikato Regional Plan (Variation 6). This gives priority to municipal and domestic water supplies. Variation 6 attracted more than 150 submissions, especially from industries concerned at being given lower priority.

[80] http://www.ew.govt.nz/policy-and-plans/Water-allocation-variation/

"I accept that the taking of water for domestic and municipal supply must have top priority but also as a farmer I cannot accept that water for stock drinking requirements has a lesser priority." (Primary Submission: RVP6-60.1, on the Waikato Regional Plan: Variation 6)

"Diverted water plays a significant role in facilitating the operation of the cooling water system at Huntly Power Station, and it is inequitable and contrary to sound resource management practice to have it potentially allocated to other parties." (Primary Submission: RPV6-52.2, on the Waikato Regional Plan: Variation 6)

"*That's where there's a fundamental difference… where most of the [iwi] views around the water are [grounded] around the spiritual [and] cultural and use of the water for kai. But everyone else uses the water for other things and it's their other things that impact on us*." (From hui transcript: Waahi Marae, Waikato-Tainui)

Variation 6 is currently under Appeal to the Environment Court.

3.8 Economic health and wellbeing

Key points:

- The Waikato River and its tributaries play a pivotal role in supporting regional economic activity.
- Some nationally significant industries are reliant on the Waikato River, including dairying, energy, mining and forestry.

Waikato had a regional gross domestic product of $15.6 billion in 2007, representing nine percent of New Zealand's gross domestic product[81]. This was proportionate to the region's population (nine percent of the New Zealand total).

The Waikato River and its tributaries play a pivotal role in supporting economic activity in the region. Table 3.7 lists major industries in the Waikato and high level economic data on the contribution they make to the economy. Some industries have direct impacts on the Waikato River (e.g., they abstract water for irrigation or industrial processing, or they discharge wastes to the river and rely upon it for dilution and assimilation). Some industries that do not abstract water or discharge wastes have indirect impacts (e.g., nutrients and sediment enter the river from non-irrigated grazing land). Those industries that derive some or all of their benefits, either directly or indirectly, from the Waikato River are shaded in grey. Some industries are significant from a national as well as a regional perspective — dairying, energy, mining and forestry are the major ones, with meat production also important.

[81] http://www.ew.govt.nz/Environmental-information/About-the-Waikato-region/Our-economy/

Table 3.7: Major industries in the Waikato regional economy (2007) [82]

	Sector	GRP		Employment	
		$m	%	MEC[83]	%
1	Dairying	1,412	9.0	11,664	5.9
2	Business services	1,243	8.0	20,306	10.3
3	Real estate	931	6.0	3,294	1.7
4	Construction	836	5.4	17,240	8.7
5	Wholesale trade	826	5.3	8,474	4.3
6	Retail trade	815	5.2	24,087	12.2
7	Health and community services	810	5.2	17,874	9.1
8	Owner-occupied dwellings	808	5.2	-	-
9	Education	662	4.2	14,510	7.4
10	Dairy product manufacturing	569	3.6	2,732	1.4
11	Electricity generation and supply	469	3.0	779	0.4
14	Meat and meat product manufacturing	325	2.1	3,768	1.9
15	Livestock and cropping farming	318	2.0	4,872	2.5
19	Wood and wood product manufacturing	243	1.6	3,385	1.7
21	Cultural and recreational services	236	1.5	5,561	2.8
22	Mining and quarrying	220	1.4	1,201	0.6
26	Services agriculture, hunting and trapping	160	1.0	3,080	1.6
27	Forestry and logging	153	1.0	1,470	0.7
28	Horticulture and fruit growing	141	0.9	2,838	1.4
29	Other farming	141	0.9	1,669	0.8
31	Paper and paper product manufacturing	109	0.7	534	0.3
45	Fishing[84]	23	0.1	271	0.1
46	Water supply[85]	19	0.1	124	0.1
	Total regional GRP	***15,606***	***100%***	***197,099***	***100%***

Source: Environment Waikato

Waikato's dairy sector accounts for one third of national dairy production (Environment Waikato, 2006). Dairying (both total area farm size and stocking intensity) increased markedly between 1998 and 2006 (Environment Waikato, 2008). Over the last decade approximately 25,000 hectares of pine forest has been converted to dairy farms in the headwaters of the Waikato between Taupoo and Aatiamuri. Cows per hectare have doubled in the last 30 years. This intensification and expansion has been associated with the trends in increasing river nitrogen concentration discussed in Section 3.4.

[82] Economic information specific to the Waikato River catchment as opposed to the Waikato region is not currently available.

[83] Modified employment count is the sum of full-time equivalent employees plus working proprietors Environment Waikato (2009a) Memorandum to the Environment Committee – 2009 Waikato economic model. www.ew.govt.nz (accessed 24.08.09)

[84] This includes a significant commercial tuna fishery.

[85] This includes potable water abstracted for use in Auckland.

Mighty River Power operates the Waikato River hydro system (See Appendix 23: Hydro Dams) with installed capacity of 994 MW. The eight dams and nine power stations (with two at Maraetai) provide about 13 percent of the national electricity supply and up to 25 percent of daily peak supply[86], which is strategically located closer to the centres of peak electricity demand than other major hydro-electric power sources (in the South Island). The Waikato hydro system also provides key ancillary services to the functioning of the New Zealand power supply, including frequency control, power reserves (to cover interruptions in supply elsewhere in the system), voltage support for the central and upper North Island and black start capacity (where power stations are able to restore operations without relying on external energy sources).

The Waikato River is not only a source of hydro electricity, but provides cooling water for Genesis Energy's coal and natural gas-fired power station at Huntly, and receives some water from geothermal power stations in the upper Waikato (see Figure 3.14)

The Huntly power station is New Zealand's largest thermal power station, employing around 280 people and providing up to 20 percent of the country's electricity requirements.[87]

[86] T.J. Truesdale evidence, Mighty River Power Resource consent hearing.
[87] www.genesis.co.nz

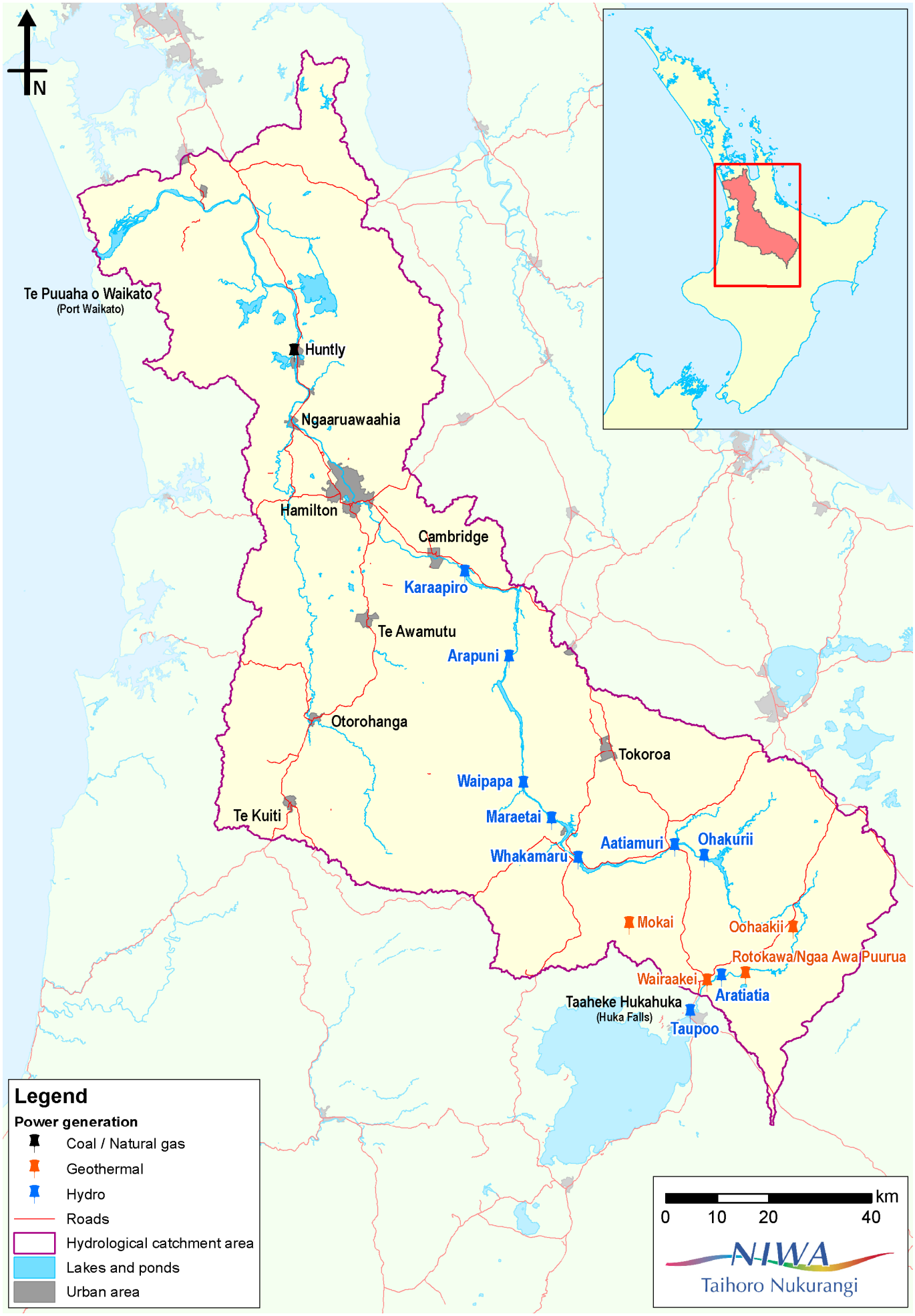


Figure 3.14: Location of major electricity generation within the Waikato catchment.

The Waikato River is important for international and domestic tourism. Tourists engage in on-river activities (e.g., jet boating, scenic cruises, kayaking, fishing, hunting, duck shooting) and/or off-river activities (e.g., walking and cycling along the river banks, visiting historic or scenic sites (e.g., Huka Falls, Oraakei Koorako, Aratiatia Rapids) and attending events (e.g., rowing regatta on Lake Karaapiro). Data on the specific economic contribution of tourism to the Waikato region are not readily available because tourism products and services cut across standard industry definitions (e.g., retail, hospitality, cultural and recreational services and transport) and are embedded within existing economic measures such as GRP. However, we do know that just fewer than one million tourists undertook nature-based activities in the Waikato in 2008[88]. In 2005–06 approximately 10,000 tourists participated in a Maaori cultural experience in the Waikato with about 80 percent being international tourists[89]. Maaori cultural activities associated with the River (e.g., festivals at Ngaaruawaahia) attract domestic and international visitors to the region.

3.9 Summary of the current state of the Waikato River

In summary, then, there is clear evidence in maatauranga Maaori and science that the river is degraded along much of its length. That fact is widely recognised, for example in Te Ture Whaimana, the Waikato-Tainui settlement and the commissioning of this Study.

In biophysical terms (measured by such factors as nutrient levels, faecal contamination, chlorophyll levels, water colour and clarity), the river is in a better state near its source and deteriorates as it flows to the sea. The river's largest tributary, the Waipa, has particularly high loads of sediment, nutrients and pathogens.

All major sections of the river have been modified to some extent by human activity, and the causes of degradation include:

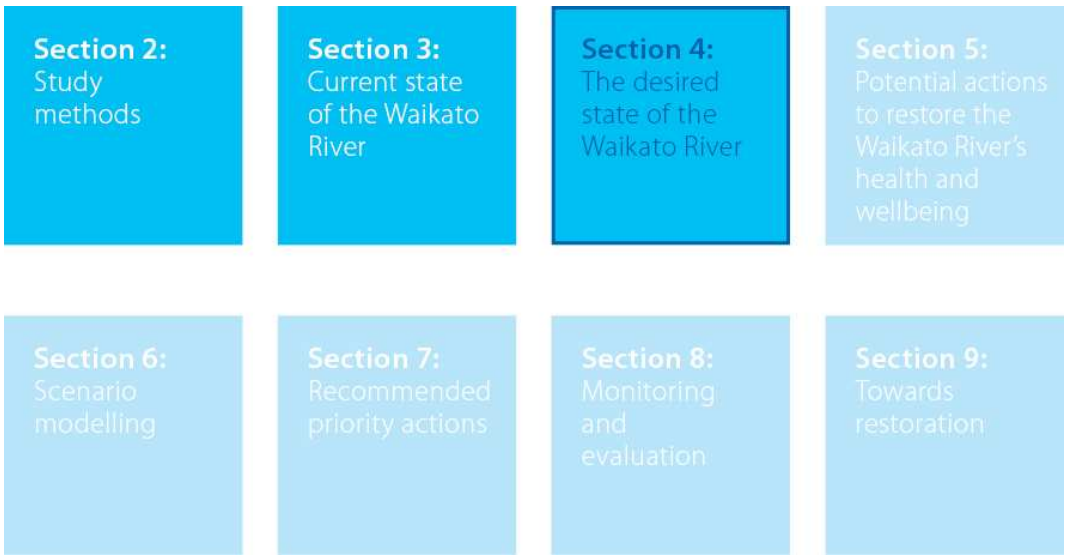
- Agricultural intensification, especially diffuse run-off of nutrients and faecal contamination from farms.
- Point-source pollution, especially from wastewater treatment, industrial discharge, and geothermal sources (natural and power generation).
- Land confiscations, private ownership and urbanisation.
- Hydro power, flood control and other public works which have degraded culturally and historically significant sites, reduced access, threatened the connectivity of the awa and created barriers to passage of taonga kai species.
- Destruction of habitat for key species, especially through loss of wetlands.
- Past limits on iwi and public participation in decision making and engagement with the river.

Although many indicators (e.g., of water quality) are continuing to deteriorate, there are numerous river restoration projects underway and co-management itself is a ground-breaking development. Many people are demonstrating a strong desire to engage in restoration action. Section 4 outlines their aspirations for the health and wellbeing of the river.

[88] Ministry of Tourism, (2009). Tourism sector profile – Nature-based tourism, www.tourismresearch.govt.nz (accessed 20.08.09)

[89] Ministry of Tourism, (2008). Tourism sector profile – Maaori cultural tourism, www.tourismresearch.govt.nz (accessed 20.08.09)

4. The desired state of the Waikato River



4.1 Introduction

The primary direction-setting document for the Waikato River is Te Ture Whaimana - the Vision and Strategy for the Waikato River - developed by the Guardians Establishment Committee following consultation with iwi and with the wider Waikato community. It provides an overarching vision as follows:

"Our Vision is for a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come."

Te Ture Whaimana also outlines 13 objectives and 12 strategies to achieve those objectives (see Appendix 3: Te Ture Whaimana – the Vision and Strategy for the Waikato River).

4.1.1 Identifying aspirations

As discussed in Section 3, the Waikato River is degraded along much of its length. As a result engagement with the river has become patchy, there is a risk that spiritual relationships with the river have been weakened and aesthetic values have changed detrimentally. Pollution from point and diffuse sources has resulted in health risks from faecal matter, elevated nutrient concentrations and algal blooms. It is now unsafe to take unlimited quantities of kai from parts of the river without the risk of illness, traditional fisheries have declined, food sources have been lost and wetland and lake habitat reduced, degraded or changed dramatically. Before actions are developed it is essential to have clear aspirations that need to be met to achieve restoration of the health and wellbeing of the river.

In fulfilling the project brief, the Study team sets out in Section 4 the aspirations people hold for the river that, if met, would achieve the objectives and address the strategies in Te Ture Whaimana. Feedback from hui, public open days, community meetings, calls for submissions and technical reviews were synthesised and then confirmed at a second round of hui. From this analysis 15 aspirations were developed by the Study team (see Table 4.1). These aspirations affirm and support the objectives and strategies set out in Te Ture Whaimana (see Figure 4.1 and Tables 4.2 and 4.3).

The aspirations developed in this Study do not replace or usurp the objectives or strategies set out in Te Ture Whaimana. Throughout the Study, the Study team has given careful consideration to the vision, objectives and strategies set out in Te Ture Whaimana. The Study team has made sure that the aspirations developed were, indeed, consistent with Te Ture Whaimana and supported the successful achievement of the objectives it sets out (as required by the project brief for the Study). Table 4.2 shows the linkage between the aspirations of iwi and the wider Waikato community for a healthy and well river and the 13 objectives outlined in Te Ture Whaimana.

The aspirations also support some of the strategies set out in Te Ture Whaimana (see Table 4.3) and in some cases the Study itself also achieves many of the strategies set out in Te Ture Whaimana (e.g., Strategy 2 – *"Establish what the current health status of the Waikato River is by utilising maatauranga Maaori and latest scientific methods*" is achieved in Section 3 of this Study, Strategy 3 – *"Develop targets for improving the health and wellbeing of the Waikato River by utilising maatauranga Maaori and latest scientific methods"* is achieved in this Section of the Study.)

The aspirations were evolved to help the Study team appropriately reflect and consolidate the views of iwi and the wider Waikato community from the consultation process and other literature reviewed to develop a solid basis for establishing more specific targets and actions required to restore the Waikato River to a desired state. 'Desired state' describes the state that would be achieved when all of the aspirations had been met and the objectives and strategies in Te Ture Whaimana had been achieved (i.e., what is desired by iwi and the wider community for the health and wellbeing of the Waikato River).

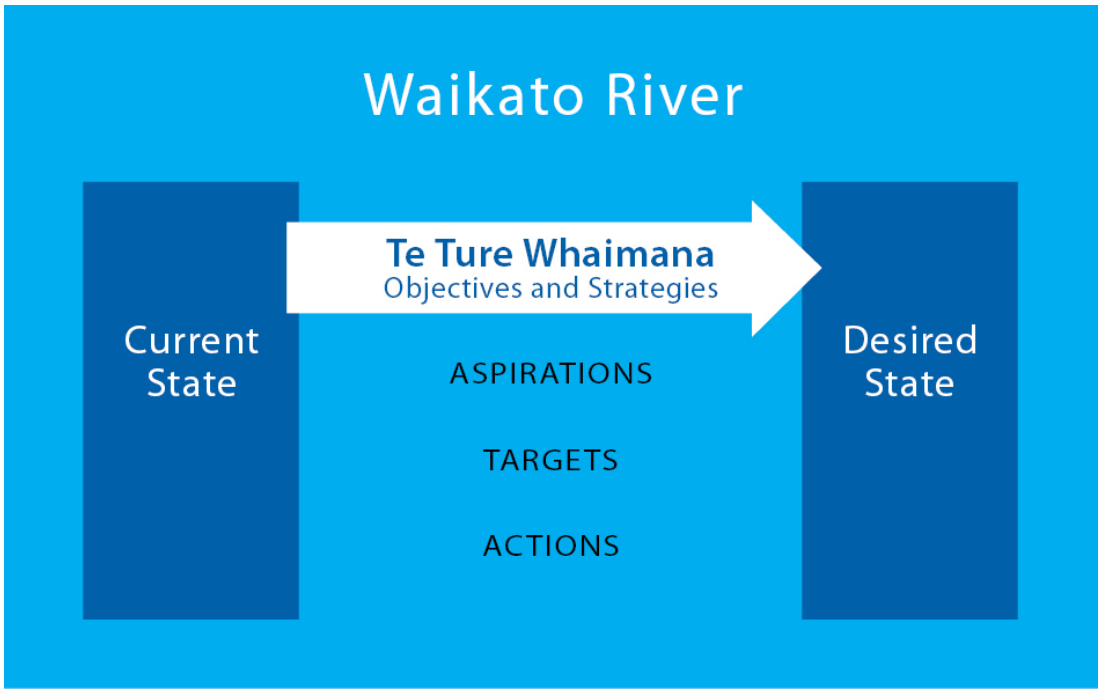


Figure 4.1: Flow chart of process and steps for going from the current state to desired state.

For each aspiration a list of bullet points has been provided, setting out *targets* that would indicate that the desired state has been achieved (see Strategy 3, Te Ture Whaimana in Table 4.3). Once the targets were set these then helped to guide the Study team on potential actions to restore the health and wellbeing of the Waikato River (i.e., what needs to be done (action) to achieve the targets set and, therefore, meet the desired state for the Waikato River) (see Strategy 4, Te Ture Whaimana in Table 4.3).

For some aspirations, such as those related to water quality, there are accepted guidelines while other aspirations are more about seeing trends towards a restored system or changes in the way people interact. Specific indicators and targets for each aspiration were developed using maatauranga Maaori and the latest available scientific information and are provided later in this Report (see Section 8 and Appendix 30: Report Cards).

Table 4.1: Aspirations for a healthy and well Waikato River

	Aspirations for a healthy and well Waikato River, including its lakes, wetlands and tributaries
1	That management of the Waikato River to protect its health and wellbeing is conducted in a holistic, integrated way.
2	That people feel engaged with the Waikato River, and processes, initiatives or actions to restore and protect its health and wellbeing.
3	That the spiritual values of the Waikato are restored and protected.
4	That significant and historic sites along the Waikato River are restored and protected.
5	That greater access to the Waikato River will improve people's use and enjoyment.
6	That the recreational value of the Waikato River is improved.
7	That the aesthetic and landscape value of the Waikato River is improved.
8	That the risk of illness from contact with the Waikato River for recreation or as a source of food or water supplies is minimised.
9	That the water quality of the Waikato River is improved.
10	That the abundance of fish and other kai in the Waikato River is restored and protected.
11	That the abundance of treasured plant and animal species (including cultural materials) in the Waikato River is restored and protected.
12	That the ecological integrity of the Waikato River is restored and protected.
13	That the people of the Waikato have a secure supply of water from the Waikato River.
14	That actions chosen to restore and protect the health and wellbeing of the Waikato River are considered in the context of their effect on the prosperity of the local community.
15	That actions chosen to restore and protect the health and wellbeing of the Waikato River are considered in the context of their effect on the region's and New Zealand's economic prosperity.

Table 4.2: How the objectives outlined in Te Ture Whaimana relate to the aspirations for a healthy and well Waikato River.

Objectives outlined in Te Ture Whaimana – the Vision and Strategy for the Waikato River[90]		*Meeting the following aspirations will achieve this objective*
A.	The restoration and protection of the health and wellbeing of the Waikato River.	All
B.	The restoration and protection of the relationship of Waikato-Tainui with the Waikato River, including their economic, social, cultural and spiritual relationships.	All
C.	The restoration and protection of the relationship of Waikato River iwi according to their tikanga and kawa, with the Waikato River, including their economic, social, cultural and spiritual relationships.	All
D.	The restoration and protection of relationships of the Waikato Region's communities, with the Waikato River, including their economic, social, cultural, and spiritual relationships.	All
E.	The integrated, holistic and coordinated approach to management of the natural, physical, cultural and historic resources of the Waikato River.	1, 5, 6, 8, 9, 10, 12, 13, 14, 15
F.	The adoption of a precautionary approach towards decisions that may result in significant adverse effects on the Waikato River, and in particular those effects that threaten serious or irreversible damage to the Waikato River.	1, 8, 9, 12
G.	The recognition and avoidance of adverse cumulative effects, and potential cumulative effects, of activities undertaken both on the Waikato River and within its catchments on the health and wellbeing of the Waikato River.	1, 8, 9, 12, 13
H.	The recognition that the Waikato River is degraded and should not be required to absorb further degradation as a result of human activities.	1, 3, 7, 8, 9, 12
I.	The protection and enhancement of significant sites, fisheries, flora and fauna.	4, 7, 10, 11, 12
J.	The recognition that the strategic importance of the Waikato River to New Zealand's social, cultural, environmental and economic wellbeing is subject to the restoration and protection of the health and wellbeing of the Waikato River.	8, 12, 13, 15
K.	The restoration of the water quality within the Waikato River so that it is safe for people to swim in and take food from over its entire length.	1, 5, 6, 8, 9, 11
L.	The promotion of improved access to the Waikato River to better enable sporting, recreational and cultural opportunities.	4, 5, 6, 9, 10
M.	The application to the above of both maatauranga Maaori and latest available scientific methods.	All

[90] See Appendix 3: Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River.

Table 4.3: How the strategies outlined in Te Ture Whaimana relate to the aspirations for a healthy and well Waikato River.

	Strategies outlined in Te Ture Whaimana – the Vision and Strategy for the Waikato River[91]	*Meeting the following aspirations will achieve this strategy*
1	Ensure that the highest level of recognition is given to the restoration and protection of the Waikato River.	All
2	Establish what the current health status of the Waikato River is by utilising maatauranga Maaori and latest available scientific methods.	(This is achieved by Section 3 of this Study)
3	Develop targets for improving the health and wellbeing of the Waikato River by utilising maatauranga Maaori and latest available scientific methods.	(This is achieved by Section 4 of this Study - targets developed are guided by all the aspirations)
4	Develop and implement a programme of action to achieve the targets for improving the health and wellbeing of the Waikato River.	(This is assisted by this Study and has been guided by all the aspirations)
5	Develop and share local, national and international expertise, including indigenous expertise, on rivers and activities within their catchments that may be applied to the restoration and protection of the health and wellbeing of the Waikato River.	1,2
6	Recognise and protect waahi tapu and sites of significance to Waikato-Tainui and other river iwi (where they so decide) to promote their cultural, spiritual and historic relationship with the Waikato River.	4
7	Recognise and protect appropriate sites associated with the Waikato River that are of significance to the Waikato regional community.	4
8	Actively promote and foster public knowledge of the health and wellbeing of the Waikato River among all sectors of the Waikato regional community.	1,2
9	Encourage and foster a whole-of-river approach to the restoration and protection of the Waikato River, including the development, recognition and promotion of best practice methods for restoring and protecting the health and wellbeing of the Waikato River.	1,2
10	Establish new, and enhance existing, relationships between Waikato-Tainui, other Waikato River iwi (where they so decide) and stakeholders with an interest in advancing, restoring and protecting the health and wellbeing of the Waikato River.	1,2
11	Ensure that cumulative adverse effects on the Waikato River of activities are appropriately managed in statutory planning documents at the time of their review.	1
12	Ensure appropriate public access to the Waikato River while protecting and enhancing the health and wellbeing of the Waikato River.	5

[91] See Appendix 3: Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River.

4.1.2 Introduction to aspirations from a maatauranga Maaori perspective

For Maaori, whakapapa is fundamental. To understand Maaori aspirations for the health and wellbeing of the Waikato River, readers must start with whakapapa.

The two ancestral waka of Tainui and Te Arawa share many traditional narratives (Winitana, 2005). In these, Hani-a-te-waewae-i-kimi-atu (male element) was instructed to procreate with Puna-ha-rau (female element). They spun around and around each other until they collided joining together and procreated, producing not only the multitudes of fish in the ocean and all things terrestrial, but also the rivers. Consequently whakapapa is the genealogical descent of all living things from the gods to the present time, and such an understanding underpins the Maaori worldview.

Under this way of thinking or maatauranga Maaori, the Waikato River is seen as the blood line that connects the two waka together metaphorically. Hui participants of the Study said that this blood line flows continuously from Tongariro into Lake Taupoo over Taaheke Hukahuka, including the many tributaries, lakes and wetlands out past Te Puuaha o Waikato, well into the open ocean. Similarly, the river iwi often refer to the tributaries as the veins and the lakes and wetlands as the kidneys of the river.

The meaning of whakapapa is to lay one thing upon another as, for example, to lay one generation upon another. Everything has whakapapa: birds, fish, animals, trees and every other living thing. Soil, rocks and mountains all have whakapapa. The river itself has whakapapa.

It is through whakapapa that kinship ties between the animate and inanimate (or the physical world and the spiritual world) are linked. The mana or power of a chief represents that intrinsic connection to the gods. Whakapapa is one of the most prized forms of knowledge and great efforts are made to preserve it. All the people in a community are expected to know who their immediate ancestors are, and to pass this information on to their children so that they too may develop pride and a sense of belonging through understanding the roots of their heritage.

The fundamental value of whakapapa, therefore, connects the people to their environment and the sustenance they derive from this relationship is like a bond between mother and child. Consequently, whakapapa generates a deep and abiding respect for the awa. Many Maaori view the Waikato River metaphorically speaking as a beloved elder or their awa tupuna (ancestral river) and consider that people, Ngaa Aitanga a Tiki, are teina (younger sibling) to the Waikato River - a river which has mana and mauri (life force) in its own right.

For Maaori, spirituality includes knowledge that while everyone is an individual, all are part of a larger living life force sometimes referred to as mauri. This is to be respected and protected. In hui, the river iwi told the Study team that this spiritual connection with the awa has not been lost, even though it is degraded. For example, if people feel there is a mate Maaori (spiritual sickness) experienced by their mokopuna (grandchildren), they still take them to the river to conduct karakia and then riiringi them (sprinkle them with water). What is strongly felt is a desire to start taking action, and especially to engage and teach their rangatahi, lest the pressures of modern life and the degraded state of the river result in these spiritual practices losing meaning.

Maaori aspirations for the river are also bound up with such concepts as manaakitanga (hospitality), kaitiakitanga (guardianship) and rangatiratanga (sovereignty). The river iwi speak of being connected with, and by, the river - being responsible as kaitaiki to protect te Mana o te Awa. The associated concept of tuurangawaewae (a place to stand) is also fundamental to Maaori identity. Tuurangawaewae is where kinships are able to be formed, a place to stand and where they are empowered to make decisions for the benefit of future generations.

When you live in one place for many generations, an understanding and connection develops, resulting in the accumulation of a deep, intimate and familial knowledge of landscape, waters, sites and species. Many of New Zealand's long-standing farming families express similar sentiments. Such knowledge means that degradation of the river is not an impersonal happening but a source of personal distress. Similarly, aspirations to restore the river are felt to be matters of personal restoration and reconstruction.

Thus, there is a deeply held aspiration to exercise control and authority on behalf of the awa — to care for it as you would any elder or a tuaakana (elder brother or sister). In this sense, engagement in restoration activities, directing monitoring programmes in the rohe and participating in co-management are all both a means to an end, and an end in themselves (for more information on these concepts see Huakina Development Trust, 2007).

4.2 Engagement and people's relationship with the river

4.2.1 Holistic management

Maaori take a holistic view of the world and this is reflected in Te Ture Whaimana and its objectives - "*The integrated, holistic and coordinated approach to management of the natural, physical, cultural and historic resources of the Waikato River*".

A lack of coordinated planning and integrated management of the region's resources has been a major impediment to a holistic approach to sustainable management. The river iwi and the wider Waikato community identified a number of problems that have arisen because of shortcomings in the current management of the Waikato River. Thus an aspiration for the future is "*that management of the Waikato River to protect its health and wellbeing is conducted in a holistic, integrated way."* It will be essential that this includes a whole-of-river approach that recognises and protects the health and wellbeing of the Waikato River (Strategy 9 — Te Ture Whaimana) and that cumulative adverse effects are appropriately managed in statutory planning documents at the time of their review (Strategy 11 – Te Ture Whaimana) (also see Strategies 5, 8 and 10). Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, F, G, H, K, M (see Table 4.2).

The aspirations and objectives would be met under the following desired state:

- All statutory plans and policies recognise and provide for cultural, spiritual, social and economic relationships of the five river iwi and the wider Waikato community with the Waikato River.
- An integrated management plan for the Waikato River has been implemented that encompasses physical, chemical, biological, social, economic, cultural and historic matters.
- Statutory plans and policies have been reviewed to ensure they take account of, and manage, cumulative adverse effects and adopt the "*precautionary principle*" when faced with uncertainty[92].
- Co-management agreements have been established between iwi and local authorities and stakeholders.

[92] The *"precautionary principle"* involves acting to avoid serious or irreversible potential harm, despite lack of scientific certainty as to the likelihood, magnitude, or causation of that harm (www.pprinciple.net).

- Industry-led accords have been established to enhance and coordinate best practice activities that lead to the restoration and protection of the health and wellbeing of the Waikato River.

- Actions to restore the Waikato River are coordinated through the development and implementation of management plans.

The desired state above should be considered in conjunction with those outlined in other aspirations in this section.

4.2.2 Engagement

There was a strong aspiration that the river iwi and the Waikato community be actively involved in the restoration and protection of the health and wellbeing of the Waikato River so *"that people feel engaged with the Waikato River, and processes, initiatives or actions to restore and protect its health and wellbeing"*. Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, M (see Table 4.2) as well as Strategy 8 in Te Ture Whaimana — that all sectors of the Waikato regional community are engaged in the health and wellbeing of the Waikato River (also see Strategies 9 and 10).

Many participants at the hui and stakeholder meetings expressed a desire to become more involved in decision making and in implementing actions to restore, monitor and protect the health and wellbeing of the Waikato River. This represents an ideal context for helping to re-connect whaanau and hapuu (especially tamariki and rangatahi) with the river and in turn helps restore the wellbeing of communities.

> *"We hear koorero about the mahinga kai and I know that some people still do that, but for the vast majority one of the key issues is the lack of direct relationship with the river 'aa tinana' so it's always a theoretical thing… for me a sign that restoration is successful is that the vast majority of our people have that relationship in a meaningful way, when they say 'haere ki te wai' when there's some sort of whakarite or something that needs sorting out then our people know where that is, including our rangatahi if there is kai [to be gathered]".* (From hui transcript: Poohara Marae, Waikato-Tainui)

Community engagement is desirable in on-the-ground restoration, monitoring and in policy and decision making. The latter involves members of the community with the necessary skills and commitment becoming involved in local and regional statutory and non-statutory planning processes. The involvement of such spokespeople helps restore the wellbeing of the whole community by giving the community a voice and an opportunity to influence decision making. Iwi also expressed their desire to be involved in monitoring the health and wellbeing of the Waikato River.

The aspiration and objectives in the Te Ture Whaimana would be met if the following desired state was achieved:

Capacity

- There are sufficient trained commissioners with the ability to understand iwi views and have input into decision making at the Environment Court.
- A centralised Waikato River public education centre and waananga/visitor centre in each iwi region provides information on the Waikato River and management to enhance its health and wellbeing.
- Every year waananga/workshops are conducted for each of the five river iwi on restoration methods including riparian fencing and planting, monitoring and traditional fisheries.
- Financial support and resources are provided to one or more coordinators working with iwi and community groups to facilitate better integration of community-based restoration and monitoring initiatives.
- Culturally appropriate monitoring tools (e.g., feeding into an overall Cultural Health Index) are established and, along with suitable equipment, are available and used by iwi. A centralised database and auditing system for monitoring data is provided.
- Partnerships are active between the Waikato River Authority, industry, government departments, local authorities, non-governmental organisations, community groups and international organisations to help restore and protect the Waikato River.

Education

- Knowledge (maatauranga Maaori and science) gained from research, good practice and existing relationships with the Waikato River is being effectively transferred and used.
- The unique relationship that the five river iwi have with the Waikato River is understood and recognised within the wider Waikato community and regional organisations.
- Important information and skill gaps (including maatauranga Maori) that have hindered restoration activities in the past have been filled through research and post-graduate training.
- Cross-curriculum resources (primary and secondary school levels) are available and teachers have the required skills and knowledge to provide education on restoration of the health and wellbeing of the Waikato River.
- Marae-based training courses and resources centred on restoration (e.g., plant nurseries, pest fish control, fencing and planting and weed control) are available and support restoration actions.

Publicity

There is a need for good publicity and communication within the Waikato catchment about the issues facing the Waikato River, who is doing what on restoration, successes and setbacks. Participants at hui and meetings expressed the view that currently it is very difficult to obtain technical reports, monitoring data and other technical information in a timely fashion. Others

felt there were insufficient professionally written and balanced 'issues and options' reports and articles. What they would like to see is:

- Improved communication and publicity initiatives implemented to promote greater public knowledge and understanding of the health and wellbeing of the Waikato River.
- That public understanding, perceptions and engagement in the restoration of the Waikato River has increased through dissemination of information using a variety of media.
- Role model groups and individuals involved with improving the health and wellbeing of the Waikato are being recognised.

4.2.3 Spiritual connection

The degradation of the river poses an especially severe threat to the five river iwi, as it has the potential to deprive them of their resource base and their identity. Both iwi and the wider Waikato community stated their dissatisfaction at being unable to influence decision making about the Waikato River and how this adversely affects their wellbeing. Maaori have expressed the view that their spiritual values and aspirations (e.g., in relation to sewage discharge) are often ignored at consent hearings.

There are concerns that traditional motivations, maatauranga Maaori, learning/teaching opportunities, cultural practices and processes are slowly being eroded as a result of the degradation of the health and wellbeing of the Waikato River. The aspiration for iwi and the community is *"that the spiritual values of the Waikato River are restored and protected".* Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, H, M (see Table 4.2).

These would be met if:

- The relationships of iwi, their culture and traditions with the Waikato River which are taonga to them, and integral to their tribal identities, are recognised and provided for.
- The relationships of the wider Waikato community, their culture and traditions with the Waikato River are recognised and provided for.
- All statutory plans recognise and provide for iwi and wider Waikato community economic, social, cultural and spiritual relationships with the Waikato River.

The desired state above should be considered in conjunction with those outlined in Section 4.2.1 (Holistic management) and 4.2.2 (Engagement).

4.2.4 Significant and historic sites

It is a very high priority for all river iwi that there is recognition and protection of significant sites including waahi tapu (sacred area) areas and sites of significance, and where supported by whaanau, hapuu and iwi, promoting a greater understanding of their significance and their historical associations with the river. The wider Waikato community expressed their interest in the greater understanding of historical associations, and in some cases, restoration (e.g., paa (traditional settlement sites)). This is supported by Te Ture Whaimana (Strategies 6 and 7).

Maaori and the wider community have an aspiration "*that significant and historic sites along the Waikato River are restored and protected".* This will lead to greater promotion of cultural, spiritual and historic relationships with the river by iwi and the wider community. Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, I, L, M (see Table 4.2) as well as Strategy 6 and 7. The aspiration and objectives would be met if the following desired state was achieved:

- Significant sites have been identified, and priority sites protected and/or restored where possible.
- The community understands the historical and cultural associations of sites with the river.
- Management plans for waahi tapu and significant sites have been completed and implemented that cover restoration, a strategy for reinstituting place names, identification/mapping, signage, publicity, access and education.

In order to maintain the integrity of these sites it is vital that each iwi (with input from whaanau and hapuu) retain control over how their significant and historic sites are identified, addressed and managed (see Appendix 26: Significant Sites).

4.2.5 Access

During this study, the river iwi shared a lot of information about historic and significant cultural sites where access is now difficult or denied. Iwi made it clear that some sites are culturally sensitive and should remain hidden, while others could be made accessible to the wider Waikato community so that their history and importance are shared. Decisions about where in each rohe it is appropriate to improve access, and where it is not, need to be made in consultation with the five river iwi. However there is an overall aspiration encompassing the river in general "*that greater access to the Waikato River will improve people's use and enjoyment".* Ensuring appropriate public access to the Waikato River while protecting and enhancing its wellbeing is a strategy in Te Ture Whaimana (Strategy 12).

Meeting the aspiration of greater access to the Waikato River will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, K, L, M (see Table 4.2). These would be met if the following desired state was achieved:

- Access along the banks of the Waikato River and its tributaries has been improved and, thereby, uses for recreational purposes such as walking, cycling and boating have increased.
- Access to significant and historic sites, collection sites for kai and cultural materials and to other sites of cultural significance (where the five river iwi so decide) has been improved.

4.2.6 Aesthetics

Comments made during the consultation hui and workshops with the Guardians Establishment Committee also emphasised the importance to Maaori of the aesthetics of the main stem of the Waikato between the Taupoo outlet and the sea. Several factors combine to determine river aesthetics, including landscape setting, riparian vegetation, water colour and clarity, channel character and flow types, visual diversity, the knowledge that the river is in a healthy state

(Mosley, 2004). However riparian vegetation is arguably one of the largest, manageable, influences on river aesthetics.

Meeting the aspiration *"that the aesthetic and landscape value of the Waikato River is improved"* will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, H, I, M (see Table 4.2). This aspiration and the objectives in Te Ture Whaimana would be met if the following desired state was achieved:

- Appropriate native forest, shrub or wetland vegetation occurs along streams and rivers used for fishing, boating, swimming or walking and around restored shallow lakes.
- Terrestrial weed species are no longer dominant along streams, rivers and lakes used for fishing, boating, swimming or walking.
- Clarity and colour of the Waikato River and its tributaries meets water quality guidelines.

4.3 Human health, swimming and boating

An ultimate measure of meeting the vision of Te Ture Whaimana is that "*the river will be safe for people to swim in and take food from over its entire length*".

Drinking-water needs to be of sufficient quality that it can be consumed or used without risk of immediate or long-term harm. Similarly, where contact recreation activities occur (e.g., swimming, skiing, paddling and kayaking) water quality needs to be such that accidental ingestion of small quantities of the water does not result in illness and that contact with the water does not lead to conditions like skin rashes. There are also concerns about the contamination of kai from heavy metals (such as arsenic and mercury) and other contaminants discharged to the river.

Mercury (Hg) levels in several hydro lakes is of major concern because of the potential for bioaccumulation in kai (especially fish) and potential toxicity to human consumers.

The river iwi do not approve of discharge to waterways of effluent from wastewater treatment plants (WWTPs) and see land disposal as the only acceptable option for wastewater. This is because they, and many other Maaori, have a strong cultural belief that wastes should be cleansed through contact with land before returning to water bodies.

4.3.1 Swimming and boating

Iwi and the wider community have a clear aspiration "*that the recreational value of the Waikato River is improved".*

At annual regatta and special ceremonial hui, waka taua (war canoes) are seen as an expression of tribal mana and pride, a practice that yet again reconnects the iwi with its awa tupuna. Both male and female rangatahi (youths) are given an opportunity to reconnect too by holding waka tiiwai (canoe with attached sides) and waka ama (outrigger canoe) canoeing competitions. These activities are important in instilling a strong sense of responsibility and care. When kaumaatua conduct karakia to bless the proceedings for all kaihoe (paddlers) tangible, spiritual links between the river and its people are reconnected and are felt by one and all.

Iwi have areas set aside for bathing, swimming and for blessing. Hui participants said swimming for Maaori differs to that of others. When they return to their traditional swimming holes again

it is about reconnecting themselves to their awa tupuna – a very different perspective from just going in to have a dip.

Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, K, L, M (see Table 4.2).

This aspiration and the objectives would be met if the following desired state was achieved:

- People are able to swim safely in the Waikato River and its major tributaries everywhere except in zones designated for other users (e.g., near hydro-power station outlets, where priority is given to power boats and when priority is given to sporting events).
- Power boating and related activities are able to occur safely in designated areas of the Waikato River.
- Water quality is improved so that, as a minimum, at summer low flows guidelines to minimise the risk of disease are met (see next part of this section).
- An effective strategic plan is available (the Strategic Access, Boating and Swimming Plan) which identifies the facilities required (including signage and historic landing sites), sets and enforces zones, identifies hazards and outlines regulations covering water safety, boating (including waka ama and waka taua) and swimming.
- The abundance of aquatic weeds in swimming areas has been reduced, thereby, reducing the risk of swimmers being affected by 'duck itch'.

In rivers, water quality varies with flow and the targets apply under base-flow conditions during the swimming season. The desired state of aquatic weeds to meet ecological aspirations for the Waikato River is discussed under Ecological Integrity in Section 4.6. Meeting these will also help to meet swimming and boating aspirations.

4.3.2 Risk of disease from contact recreation, food or water supply

The pattern of faecal contamination gets dramatically worse as the river moves towards the Lower Waikato with the major source being farm animals and local contamination from sewage discharge and birds. As discussed above, being able to swim in, and take food from the entire Waikato River is an overall measure of the success of the restoration programme. A more specific aspiration that developed during this Study is "*that the risk of illness from contact with the Waikato River for recreation or as a source of food or water supply is minimised".*

Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, F, G, H, J, K, M (see Table 4.2). The aspiration and objectives would be met if the following desired state was achieved:

- Kai can be safely taken throughout the river and individuals remain in good health by managing their consumption levels in areas affected by natural inputs of contaminants.
- Water quality in the Waikato River has improved significantly so that water quality guidelines for contact recreation and food gathering are met including the median concentration of *E. coli* and chlorophyll *a* levels, and that the numbers of potentially toxic cyanobacteria do not exceed the Ministry for the Environment (2009) interim amber alert guideline.

- The community understands the "*food basket*" contamination risks in areas affected by natural geothermal inputs.
- Geothermal wastes from power stations pose no risk to human health.
- No risk to human health is posed by the potential release of arsenic and mercury from lake sediments.

4.4 Water quality

Contaminants from farms in the Waikato River catchment are seen as a major issue affecting the health and wellbeing of the Waikato River by both iwi and the wider Waikato community. Intensive agriculture is known to input significant amounts of nutrients (particularly nitrogen (N) and phosphorus (P)), faecal bacteria and sediment to waterways. Many of the aspirations for restoration of the Waikato River, its tributaries and lakes rely on improved water quality thus an overarching aspiration is "*that the water quality of the Waikato River is improved".*

Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, F, G, H, K, L, M (see Table 4.2).

Unlike many of the other aspirations there are existing accepted guidelines and indices for water quality in rivers and lakes that provide the basis for setting more specific indicators of desired state to meet this aspiration. Some general targets are provided below followed by a brief explanation on the rationale for choosing those particular targets. More specific targets are provided in Appendix 30: Report Cards and Appendix 13: Water Quality.

To restore or maintain the mesotrophic (having a moderate amount of dissolved nutrients) conditions in the hydro lakes and to reduce the risk of algal blooms elsewhere the following targets have been set:

Phosphorus and nitrogen	*TP mg/m³*	*TN mg/m³*
Upper Waikato	≤20	≤300
Middle and Lower Waikato	≤35	≤500
Waipa River	≤35	≤500
Shallow lakes	≤35	≤500

Chlorophyll a

- Hydro lakes – mean during summer base flow – no higher than 5 milligrams per cubic metre.
- Karaapiro to Ngaaruawaahia and the Waipa River – mean during summer base flow – no higher than 10 milligrams per cubic metre.
- Lower Waikato River – mean during summer base flow – no higher than 20 milligrams per cubic metre.
- Shallow lakes – mean summer – no higher than 15 milligrams per cubic metre.

Water clarity at base flow

- Taupoo to Karaapiro – not less than 4 metres.
- Karaapiro to Waipa confluence – not less than 1.6 metres.
- Waipa above Otorohanga – not less than 1.6 metres.
- Waipa below Otorohanga – not less than 1.0 metre.
- Lower Waikato – not less than 1.0 metre.
- Shallow lakes – not less than 1.0 metre except where they are heavily peat stained.
- Tributaries draining pasture – not less than 1.6 metres.

Colour change[93]

- Taupoo to Lake Ohakurii – no more than five Munsell units from level predicted by the Waikato Catchment Model for the 1920s (i.e., before the hydro dams and significant catchment development).
- Below Lake Ohakurii and Waipa – no more than 10 Munsell units from level predicted by the Waikato Catchment Model for the 1920's (i.e., before the hydro dams and significant catchment development).

Dissolved oxygen

- Waikato and Waipa main stem, major tributaries and headwater streams – greater than 80 percent of saturation.
- Lowland streams – not less than 6 grams per cubic metre.

Rationale for the water quality targets

Phosphorus and nitrogen

Phosphorus and nitrogen are both plant nutrients that affect phytoplankton chlorophyll in the hydro lakes and lower Waikato. They also affect the growth of aquatic plants, although macrophyte abundance is also affected by water clarity, water depth, the stability of the lake or river bed water flows. ANZECC (2000) guideline 'trigger values'[94] for total phosphorus (TP) concentration in slightly-moderately disturbed ecosystems are: 10 milligrams per cubic metre in Australian lakes, 50-65 milligrams per cubic metre in Australian rivers and 26-33 milligrams per cubic metres in New Zealand rivers. Burns et al. (2000) state that high quality (mesotrophic) lakes have phosphorus levels in the range 10-20 milligrams per cubic metre. Environment Waikato categorises water with TP concentrations below 10 and 40 milligrams per cubic metre

[93] From estimated colour in 1920 (Rutherford et al., 2001)

[94] ANZECC (2000) defines trigger values for chemical physical stressors in terms of 80th or 20th percentile values obtained from an appropriate reference system. This choice is arbitrary, although considered 'reasonably conservative' – section 3.3.2.3 ANZECC Guidelines.

as 'excellent' and 'satisfactory' respectively[95]. The risk of phytoplankton dominance by Cyanobacteria (also known as "blue-green algae"), that are particularly problematic due to toxin and scum formation when they bloom, is low when phosphorus levels are below 35 milligrams per cubic metre (Downing et al. 2001). Consequently, a target of not more than 20 milligrams per cubic metre has been set for the more pristine waters in the upper Waikato and not more than 35 milligrams per cubic metres for middle and lower Waikato, shallow lakes and Waipa River.

ANZECC (2000) guideline trigger values for total nitrogen (TN) concentrations in slightly-moderately impaired waters are: 350 milligrams per cubic metre in Australian lakes, 500-1200 milligrams per cubic metre in Australian rivers, and 295-614 milligrams per cubic metre in New Zealand rivers. Burns et al., (2009) state that in mesotrophic lakes nitrogen concentrations are 200-300 milligrams per cubic metre while Environment Waikato classify water with nitrogen concentrations below 100 and 500 milligrams per cubic metre as 'excellent' and 'satisfactory' respectively. The risk of phytoplankton dominance by Cyanobacteria is low when nitrogen levels are below 700 milligrams per cubic metre (Downing et al. 2001). Decisions were also informed by information on nutrients, clarity and chlorophyll *a* in shallow lakes in Hamilton et al. (2010). Targets have, therefore, been set at not more than 300 milligrams per cubic metre in the upper Waikato and not more than 500 milligrams per cubic metre in the middle and lower Waikato, the shallow lakes and the Waipa River.

Chlorophyll a

Chlorophyll is a recognised measure of algal biomass and an internationally accepted index of river and lake health. Phytoplankton concentrations are lower in the Waikato hydro lakes and the Lower Waikato River than in lakes elsewhere in New Zealand with similar nutrient concentrations because of the high flow rates passing through them (McBride and Pridmore, 1984). Burns et al. (2009) state that lakes characterised by clear water and few algal blooms (termed mesotrophic) have chlorophyll concentrations that range from two to five milligrams per cubic metre while ANZECC guideline 'trigger values' for slightly-moderately disturbed ecosystems range from three to five milligrams per cubic metre. A chlorophyll concentration of 15 per cubic metre denotes the boundary between eutrophic and supertrophic lakes (the latter often have excessive algal growth under suitable climate conditions) in Environment Waikato's adaptation of Burns et al.'s (2000) trophic state classification[96]. Another consideration is the risk of phytoplankton dominance by cyanobacteria. This is low when chlorophyll levels are below 10 milligrams per cubic metre, medium at 20 milligrams per cubic metre and high above 50 milligrams per cubic metre (Downing et al., 2001). Finally, Ministry for the Environment (1992) provides a chlorophyll guideline of 20 milligrams per cubic metre to avoid filter clogging problems in drinking water treatment plants.

Consequently, a chlorophyll target of less than five milligrams per cubic metre is recommended in the hydro lakes (compared with current values of 10 milligrams per cubic metre) to significantly improve water quality and ensure the lakes support very healthy ecosystems. Chlorophyll concentrations near Hamilton were in the range 10-20 milligrams chlorophyll per cubic metre during the 2002 algal bloom in the Waikato River (Environment Waikato monitoring data), but monitoring results (Environment Waikato, 2009) indicate no further increase in cyanobacteria cell counts between Hamilton and Tuakau, despite a 75 percent increase in chlorophyll. This indicates that phytoplankton growth downstream of Hamilton was

[95] Based on the 75th and 25th percentile values of the 77 New Zealand National River Water Quality Network sites from Smith and Maasdam, 1994.

[96] http://www.ew.govt.nz/environmental-information/Rivers-lakes-and-wetlands/Learn-about-our-lakes/Water-quality-glossary/#Heading4

mainly non-cyanobacterial species (e.g., diatoms and green algae) so that a higher chlorophyll target is acceptable in the Lower Waikato without adding to the risk of problems associated with cyanobacteria dominance. Therefore, the chlorophyll target is less than 10 milligrams per cubic metre in the Waipa and between Karaapiro and Ngaaruawaahia to minimise the risk of cyanobacteria blooms. The target in the lower Waikato River is 20 milligrams chlorophyll per cubic metre to manage the risks of algal blooms and filter clogging.

The shallow lakes in the Lower Waikato have high nutrient and chlorophyll concentrations (see Section 3.6.1 and Appendix 12: Shallow Lakes) because they occur in intensively farmed catchments and are poorly flushed. It is not known what the historic or naturally occurring concentrations of nutrient and chlorophyll were in these lakes. Recent levels of chlorophyll in the shallow lakes varied between 11 milligrams per cubic metre (Serpentine South) to 360 milligrams per cubic metre in Lake Koromatua. Based on Environment Waikato's upper limit for eutrophic lakes, a target of no higher than 15 milligrams per cubic metre has been set for the shallow lakes.

Water clarity

Water clarity varies markedly with location and it is not sensible to have a single target value for the whole Waikato River catchment. Water clarity also decreases significantly with increasing flow rate and the targets set only apply at base flow. Environment Waikato classify water clarity as excellent when clarity exceeds four metres, unsatisfactory when clarity is less than 1.6 metres and satisfactory when it lies in the range 1.6-four metres. Rutherford et al., (2001) estimates that at base flow in the 1920s (i.e., before the hydro dams and significant catchment development) clarity at Waipapa in the upper reaches of the Waikato River was three to four metres and in the Waipa River and lower Waikato was c. 1 metre. Consequently, it is recommended that greater than four metres be the base flow target above Karaapiro, greater than one metre in the lower Waikato and Waipa and greater than 1.6 metres between Karaapiro and Ngaaruawaahia and in the upper Waipa above Otorohonga.

Colour

There is wide natural variability in water colour within the catchment – clear, blue water at Taupoo, greenish water in the lakes, yellow-brown waters in the Lower Waikato River and red-brown in the peat-stained tributaries and lakes. Ministry for the Environment (1994) guidelines recommend that colour not be altered by more than five or 10 Munsell units. These guidelines are aimed primarily at managing point source discharges in relation to the Resource Management Act 1991 requirement (s70 and s107) that there shall be "*no conspicuous change in colour or clarity*" as a result of discharge of contaminants. Application of these guidelines is difficult when managing colour in response to diffuse inputs because there is not normally a readily available baseline against which to measure change. However, the Waikato Catchment Model (Rutherford, 2001) provides predictions of Munsell colour in the 1920s (when there was a low level of development and no hydro dams) that provide a baseline against which targets can be set. The Study team recommends that the targets for colour change be based on the Ministry for the Environment 1994 guidelines (five Munsell units for high value waters and 10 Munsell units for other waters) and compared to those predicted for the 1920s at base flow (Rutherford et al., 2001). The natural colour of the Waipa River is unknown but, because its geology is dominated by erosion-prone mudstones and siltstones, it is likely to have been less blue and more yellow-brown than the Waikato. Rutherford et al., (2001) predicted Waipa colour in the 1920s to be 34 Munsell units and this is a realistic target.

Dissolved oxygen

Dissolved oxygen (DO) is a fundamental measure of aquatic ecosystem health. The Resource Management Act 1991 requires greater than 80 percent dissolved oxygen saturation for waters in managed aquatic ecosystems, where fishing or fish spawning takes place or where shellfish are gathered. Daily minimum DO levels in lowland streams with moderate to high levels of macrophytes are unlikely to meet these standards during summer (Wilcock et al., 1998). Laboratory lethal tolerance tests (LT50s = 50 percent lethal levels after 48 hours exposure) for a range of New Zealand species found LT50s between 0.5 and 2.6 grams per cubic metre, with shortfin tuna most tolerant and iinanga whitebait the most sensitive (Landman et al., 2005). This Study concluded that the United States Environmental Protection Agency (1986) DO guideline for general protection of salmon and trout of 5 g m^3 at 15 °C (c. 50 percent DO saturation) may be slightly low for protection of iinanga. Consequently it is proposed that an instantaneous DO target of greater than 6 grams per cubic metre be applied.

4.5 Fisheries, kai and taonga species

For the river iwi (and for Maaori in general), kai is much, much more than just something you eat. Being able to put their own taonga kai on the table in reasonable amounts in the proper season when guests arrive (even unexpectedly), would be one sign that the health and wellbeing of the river is restored.

"Yeah an indicator for whitebait coming back to normal would be when we can feed our marae at poukai". (From hui transcript: Ngaa Tai E Rua Marae, Waikato-Tainui)

At the core of this aspiration is manaakitanga.

Manaakitanga means to care or be responsible for the mana of a person or visiting group. This includes uplifting their spiritual, mental and physical wellbeing. Manuhiri (guests) that are hosted by local taangata whenua assess their host's ability to uphold this very important value. The prestige of rangatira and their hapuu is dependent on their generosity in providing all the above factors (i.e., uplifting the spiritual, mental and physical wellbeing of manuhiri). It is often said after a hui that "*it is not necessarily what has been said that matters but how they have been looked after that really counts*". As an example, when local delicacies have been placed on the table for their visitors, such as tuna, piiharau, iinanga or kooura, the reputation of the local people as excellent hosts is reinforced. Koorero (narrative) around who gathered the kai, its size, taste and abundance is shared with pride. If taangata whenua cannot provide the kai for which they are renowned – including if they have to buy it commercially – they may feel whakamaa (be ashamed, shy, bashful or embarrassed). These days, the shame tends to be felt most acutely by the elders, and by those rangatahi who have been raised in the old ways.

At hui held for this Study at Waahi Paa and Ngaa Tai E Rua Marae, for example, kaumaatua spoke of watching tuna rolling in a huge knot coming down the river. Those with special skills could hook a big, fat tuna without unravelling the ball. Scenes such as these were viewed as tohu (signs, indicators) illustrating the health of the fishery (and signalling that the tuna are ready to migrate). Such tales of a bountiful river are based on direct observation by people still alive today and to return to these times (to see such events again) is a strongly held aspiration.

This is also about upholding te Mana o te Awa. Those with kaitiakitanga want to be able to show the river in the best light, remembering that many see it as their awa tupuna. For non-Maaori,

an analogy might be with presenting respected family members to outsiders i.e., you seek to portray their dignity and beauty, not their weak points.

Another aspect of the notion of the river as a tupuna is that when eating their local kai, taangata whenua are eating the same food that their ancestors ate. It is a reaffirmation of identity and whakapapa. All river iwi aspire to have their rangatahi understanding and practising this more.

4.5.1 Taonga species

Taonga species of special importance to iwi include tuna, whitebait, watercress, kooura, kaaeo and a variety of plants (e.g., harakeke (flax)). Most of these species have declined in abundance and now have limited distribution. A clear aspiration that came out of the hui was "*that the abundance of treasured plant and animal species (including cultural materials) in the Waikato River is restored and protected".*

Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, I, K, M (see Table 4.2). The aspiration and objectives would be met if the following desired state was achieved:

- Conditions favourable to taonga species have been restored in key locations through actions to restore the tuna and whitebait fisheries, riparian vegetation, water quality and flow regimes.
- The abundance of kooura and kaaeo has increased to the point where they can sustain a traditional fishery.
- Taonga species have been re-established in selected streams.
- Plant species that have traditional significance to iwi (e.g., raaranga (weaving), whakairo (carving) and rongoaa (medicine)) have been replanted as part of riparian and wetland restoration and included in best practice guidelines.
- Plant species that have particular value as habitat and food resources for taonga species (e.g., kowhai for tui) have been replanted as part of riparian and wetland restoration.

It is not recommended that individual targets should be set for each individual plant or species on the list of significant plant and animal species mentioned during the hui and community consultation meetings (e.g., x number of kowhai planted along the riverbank or x number or biomass of kooura in the Waikato catchment (see Appendix 30: Report Cards). In some cases there is not enough information available on specific species to identify the cause of the decline and hence to recommend restoration actions. Instead targets have been set for the restoration of taonga species generally (as well as some specific species such as kooura and kaaeo) that have traditional significance to iwi or a particular value as a habitat or food resource for taonga species. In many cases actions taken to restore other aspects of health and wellbeing will have significant co-benefits for taonga species. For example, it is recommended that riparian planting include taonga riparian plant species and the restoration of riparian vegetation will enhance instream habitat conditions for aquatic taonga species, and actions to restore shallow lakes and the tuna and whitebait fisheries will also assist kooura and kaaeo populations.

4.5.2 Tuna, whitebait and kai

Iwi have clearly articulated a strong aspiration "*that the abundance of fish and other kai in the Waikato River is restored and protected".* This aspiration is supported by the wider community as well. Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, I, L, M (see Table 4.2). The aspiration and objectives would be met if the following desired state was achieved:

- The availability and accessibility of kai species, including fish, have been restored to levels that allow marae to provide manuhiri with the specialty foods from within their rohe for which they are traditionally renowned.
- Iwi links with the river are restored such that they are able to maintain and pass on to rangatahi the kawa (ceremonial rituals and protocol) and tikanga (customs) associated with conserving, gathering and offering kai to visitors.

The aspirations and objectives noted above would also be met if the following desired states for tuna and whitebait were achieved:

Tuna

- A tuna management plan has been developed and implemented.
- Suitable habitat for tuna in the Waikato River catchment has doubled and barriers to the upstream migration of tuna have been removed where practical.
- The number of adult tuna that return to the sea for spawning has increased and there has been an increase in abundance of tuna for iwi fishers.

Whitebait

- Suitable habitat for adult whitebait and spawning habitat has been protected and increased and barriers to whitebait migration have been removed where practical.
- The impact of pest fish on juvenile whitebait has been reduced.
- The number of banded kookopu in the whitebait run has increased.
- There has been an increase in abundance of whitebait for fishers.
- All aspects of the whitebait fishery are part of an integrated management plan and come under the control of a single regulatory agency including the licensing of fishers, the construction and permitting of whitebait stands, regulations covering fishing methods and any raahui and restrictions that may need to be imposed.

It is difficult to set targets for the numbers or biomass of tuna and whitebait in the Waikato River because (a) it is impracticable to measure abundance and (b) abundance is affected by things outside the control of the Waikato River Authority (e.g., loss at sea, management of other rivers in New Zealand and Australia). Instead, it is recommended that targets (see Appendix 30: Report Cards) be focused on restoration and protection of habitat areas, removal of barriers to migration, revision of fishing regulations and increasing the customary take of tuna available to iwi.

4.6 Ecological integrity

There is general consensus among iwi, the wider community and scientists that the ecological integrity of the Waikato River, its tributaries and lakes has been adversely affected by developments in the region and is now in a poor state. Losses of wetlands, degradation of shallow lakes and invasions by exotic pest species have contributed significantly to this degradation which impacts on economic, cultural and ecological values. A key aspiration that has come out of hui and feedback is "*that the ecological integrity of the Waikato River is restored and protected".* Aspirations to restore fisheries and kai (see Section 4.5.2), taonga species (see Section 4.5.1) and riparian vegetation (see Section 4.2.6) also contribute to ecological integrity.

The notion of connectivity is fundamental to iwi aspirations for the river. Historically, Maaori regarded water as an "*undivided entity [which] included lakes, lagoons, rivers, swamps, their associated beds and the adjoining land*[97]".

The Deed of Settlement quotes the late kaumaatua Kamira Henry Haggie[98]*:*

> *"The River is a being, a mother, complete and whole body comprising the water, the bed and the banks from its source to the sea. The life of the River and thus of the tribe is in its intactness – no limb struck from its body or the head separate from the heart."*

This helps explain, for example, why many hui participants were adamant that the dams should be removed (see Section 7.2.2 for more discussion on this issue). Along with an understanding that the dams are a hindrance to the migration of many kai and taonga species, Maaori have a strong aspiration that the river becomes whole again.

Meeting this aspiration helps to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, F, G, H, I, J, M (see Table 4.2). This aspiration and the objectives would be met if the following desired state was achieved:

- The abundance and, therefore, impact of pest fish has been significantly reduced.
- Where possible, invasive aquatic weeds have been replaced with native aquatic plants thus improving the submerged plant index (LakeSPI). Where replacement is impractical, invasive aquatic plants have been controlled below nuisance levels with environmentally friendly control strategies.
- Restoration has been achieved to at least mesotrophic conditions for different types of lakes that are of high priority (i.e., representative dune lakes, peat lakes and large riverine lakes).
- Macroinvertebrate communities have been restored to near predicted reference levels. (e.g., MCI[99] values are within 20 percent of predicted reference) throughout the catchment.
- There has been no further deterioration in water quality and biodiversity or loss of aquatic and riparian habitats in the Waikato River catchment.

[97] www.waimaori.maori.nz
[98] Her Majesty the Queen in right of New Zealand and Waikato-Tainui (2009). Deed of Settlement in relation to the Waikato River — Section 2.45.
[99] MCI = Macroinvertebrate Community Index used.

4.7 Water supply and economic wellbeing

4.7.1 Water supply

The wider community have identified that water takes may have adverse effects on the Waikato River and that it is important that water is used wisely. However, as stated by Environment Waikato (2008), *"in recent times the method by which surface and groundwater is allocated in the region has come under increasing scrutiny and sometimes criticism from both political and technical perspectives"*. The Ministry of Agriculture and Forestry and Ministry for the Environment recently projected a 202 percent increase in demand for irrigation water by 2010 in the Waikato region (an increase of 9,100 hectares over the present 4,500 hectares of irrigated land) (Hegarty et al., 2001). In addition, there is also an increasing demand for water for community supplies, industry and stock water supplies. More and more frequently issues of resource scarcity and the equity and fairness of the present allocation strategies are being questioned in consent hearings and before the Environment Court.

The marae is the centrepiece of Maaori community life. The recognition and protection of drinking-water supplies for marae (including reliability and safety) was identified as an issue by all river iwi. While the day to day population of marae may be relatively small, there will be times (e.g., for important gatherings such as hui or tangi) where large groups may gather. During these times, the water supply and other sanitary services come under pressure. It is important to iwi to be able to provide safe drinking-water from the Waikato River at all times as part of their traditional hospitality activities. Statistics New Zealand and Ministry for Culture and Heritage (2003) report that 25 percent of people living in the Waikato River catchment visited a marae over the 12 month period studied.

"That the people of the Waikato have a secure supply of water from the Waikato River" will be essential if the competing demands for iwi and the wider community are to be met. Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, G, J, M (see Table 4.2). This aspiration and the objectives would be met if water is allocated, abstracted and managed in such a way that:

- Decisions are made in a holistic and integrated framework.
- Ecological values are not compromised.
- Water-take plans are optimised for efficient water use.
- Water quality targets are met.
- Drinking-water quality and, therefore, public health is not compromised.
- Taangata whenua values have been considered in all water supply consents.

4.7.2 Prosperity of local communities

Restoration of the health and wellbeing of the Waikato River is essential for the river to continue to provide input into New Zealand's social, cultural, environmental and economic wellbeing. Submissions on Te Ture Whaimana and hui and consultation meetings in this Study show that there is broad and strong support for restoration actions to begin as soon as possible before the river becomes more degraded. However, input from iwi and the wider Waikato community at hui and the consultation meetings shows there is also a perceived conflict

between people's desire to restore the Waikato River while at the same time maintaining or increasing their prosperity. In other words, recommended priority actions must be considered in the context of their economic impact on prosperity (local, regional or national).

At hui and consultation meetings for this Study iwi and the community expressed the view that the actions the Waikato River Authority chooses to restore the river should not have a significant or undue adverse effect on the prosperity of the local communities in the Waikato River catchment. This does not mean that no negative economic effect can be caused by actions to restore or protect the Waikato River.

People's willingness to pay is a good measure of the balance between maintaining their present and future prosperity with the aspirations they might hold for a healthy and well Waikato River. Surveys of residents in the Waikato region have clearly demonstrated that they do not consider it is okay to sacrifice environmental quality for economic growth (Gravitas, 2006). There have been few case studies where this balance has been explored but several are included in Appendix 32: Non-Market Values. One case dealing with water quality in part of the upper Waikato catchment suggests that people are prepared to pay up to a certain level but if this resulted in a loss of jobs the level was reduced by 50 percent. A more extensive willingness to pay survey specifically related to achieving the aspirations held for a healthy and well Waikato River as described in this study would fill an important information gap.

During the development of priority actions the Study team has grappled with these issues – the trade off between some negative economic impacts (at a local, regional and national level) and the effectiveness of restoration actions. In the end the Study team has chosen the priority actions it thinks are most cost-effective (i.e., achieve the targets for restoration but at the same time minimise any undue adverse economic effects – see Section 6 and 7).

The views of the community on the economic impacts of actions chosen were strongly articulated to the Study team at hui and consultation meetings. But the Study team is cognisant that the intent and vision of Te Ture Whaimana is that restoration comes first and foremost, even if some economic impact is felt.

Therefore, to ensure that iwi and community's concerns about maintaining prosperous local communities are adequately reflected but are not in conflict with the intent and vision of Te Ture Whaimana the aspiration is to ensure *"that actions chosen to restore and protect the health and wellbeing of the Waikato River are considered in the context of their effect on the prosperity of the local community."*

Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, M (see Table 4.2).

In broad terms the aspiration and objectives will be met if:

- A restoration programme is implemented which delivers a healthy and safe Waikato River and which considers the present and future prosperity of local communities.

4.7.3 New Zealand's economic prosperity

The co-management deeds with iwi and Te Ture Whaimana highlight that both the Crown and iwi recognise the strategic importance of the Waikato River to New Zealand's social, cultural, environmental and economic wellbeing and, therefore, the need for restoration and protection of its health and wellbeing. The Waikato River is New Zealand's largest river and catchment. It supports significant industries that contribute to New Zealand's economy (e.g., dairying, energy, mining and forestry, see Section 3.8) and a significant proportion of New Zealand's population including a large iwi base.

If the Waikato River is not restored and protected the awa tupuna, which is a taonga of national significance, will be irreversibly damaged and will not be able to provide input into New Zealand's social, cultural, environmental and economic wellbeing in the way that it currently does. For example – if water quality in the Waikato River falls too low it will not be able to sustain drinking water supplies to more than 30 towns in the catchment or provide 10 percent of Auckland's water requirements, if fish species disappear a rich source of food will be lost or if water quality and aesthetics along the river banks becomes too degraded recreational and tourism values in the river will be destroyed.

This is made clear by Objective J in Te Ture Whaimana – *"The recognition that the strategic importance of the Waikato River to New Zealand's social, cultural, environmental and economic wellbeing is subject to the restoration and protection of the health and wellbeing of the Waikato River."* Only a healthy and well Waikato River will support New Zealand's social, cultural, environmental and economic wellbeing. Conversely, if actions are not taken now and the river continues to degrade, the Waikato River will not be able to provide the significant input it makes to the nation's social, cultural, environmental and economic wellbeing in the same way it has done in the past and continues to do today.

Just as iwi and the wider community expressed concern that restoration actions did not unduly adversely affect local prosperity, it was clearly articulated to the Study team that actions chosen to restore and protect the health and wellbeing of the Waikato River do not have an undue adverse effect on the region's economic prosperity. Likewise, some participants expressed concern about the impact on the nation's economic prosperity. In other words, there is broad and strong support for actions to restore and protect the Waikato River but iwi and the wider community are of the view:

"that actions chosen to restore and protect the health and wellbeing of the Waikato River are considered in the context of their effect on the region's and New Zealand's economic prosperity."

It should be noted that the aspirations for prosperity (locally, regionally and nationally) are not aspirations for growth at all costs. In effect, people are asking that they do not "*go backwards*" economically in such a way that restorative actions cannot be supported or justified against the restorative benefits they would provide.

Meeting this aspiration will help to achieve the following objectives outlined in Te Ture Whaimana: A, B, C, D, E, M, J (see Table 4.2).

This aspiration and the objectives would be met if the following desired state was achieved:

- Government recognises the Waikato River as a taonga of national significance and that it is afforded a special status as such.
- Restoration actions consider the present and future sustainable economic prosperity of the Waikato region and New Zealand.

4.8 Concluding comments for desired state

Te Ture Whaimana clearly acknowledges that the river is important to all the people of the region. It summarises the desired state of the river in the following way:

"… the ultimate measure of this Vision and Strategy will be that the Waikato River will be safe for people to swim in and take food from over its entire length."

The Waikato-Tainui Deed of Settlement says *"respect for te Mana o te Awa (the spiritual authority, protective power and prestige of the Waikato River) is at the heart of the relationship between the tribe and their ancestral River"*[100]. The recognition of this principle is expressed as an aspiration[101]. One answer to the question *"How will we know when the river is healthy and well?"* is: *"When te Mana o te Awa is respected and upheld at the highest level".*

Te Ture Whaimana notes that the current state of the river compromises the ability of river iwi to exercise kaitiakitanga or conduct their tikanga and kawa in an acceptable manner. Kaitiakitanga is an overarching value which places upon those whose ancestors were looked upon as guardians of a place to be responsible for its continued protection for future generations.

Thus, another answer to the question *"How will we know when the river is healthy and well?"* is: *"When whaanau, hapuu and iwi are able to uphold their inherent rights and responsibilities to exercise kaitiakitanga once more, including the ability to access adequate numbers of taonga kai so they are able to have that taonga grace their tables at important hui on their marae".*

But, likewise, the Waikato River cannot be regarded as healthy and well until the desired state for the Waikato River set out by iwi and the wider community is fully met. That means that all of the aspirations have been met and the objectives and strategies in Te Ture Whaimana have been achieved (i.e., what is desired by everyone, collectively as whole community, for the health and wellbeing of the Waikato River has come to fruition).

The aspirations outlined above provide a sound basis and guidance for developing actions in a holistic way to restore the health and wellbeing of the Waikato River that meets everyone's aspirations together. Potential actions to meet these targets are outlined and analysed further in Section 5.

[100] Her Majesty the Queen in right of New Zealand and Waikato-Tainui (2009). Deed of Settlement in relation to the Waikato River —Section 2.42.

[101] Her Majesty the Queen in right of New Zealand and Waikato-Tainui (2009). Deed of Settlement in relation to the Waikato River —Section 2.61.

5. Potential actions to restore the Waikato River's health and wellbeing

5.1 Introduction

Section 4 describes the aspirations that are held for the river. The current state of the river (as described in Section 3) falls short of meeting these aspirations and there is a need for action to bridge this gap. The call for action to restore the health and wellbeing of the river is a core element of the redress sought in the Waikato-Tainui Deed of Settlement (and co-management arrangements of other river iwi). The focus of that action is given further direction by the objectives outlined in Te Ture Whaimana prepared by the Guardians Establishment Committee.

The aspirations held for the health and wellbeing of the river are broad in scope encompassing social, cultural, economic and environmental dimensions. Not surprisingly, the suite of potential actions to 'bridge the gap' and meet these aspirations are therefore many and varied across these dimensions. This Section summarises those potential restorative actions, including the benefits and co-benefits that will accrue, where the actions should be carried out, how much they cost, and any risks or unintended consequences associated with implementation. The Study team has drawn upon maatauranga Maaori, biophysical and social science, and economics to describe the actions. Where appropriate, references to the relevant appendices that provide more detail and rationale are also given.

Experience in the Waikato (Dodd et al., 2008; Wilcock et al., 2009), elsewhere in New Zealand (Fenemor et al., 2008; Quinn et al., 2010) and overseas (e.g., Ison and Watson, 2007) indicates that achieving restoration goals requires an appropriate mix of actions to enhance engagement, knowledge sharing (maatauranga Maaori, social, economic and biophysical sciences, practical experience), monitoring to allow adaptive management, supporting governance structures (institutions and policies) and financial incentives or resources (see Figure 5.1).

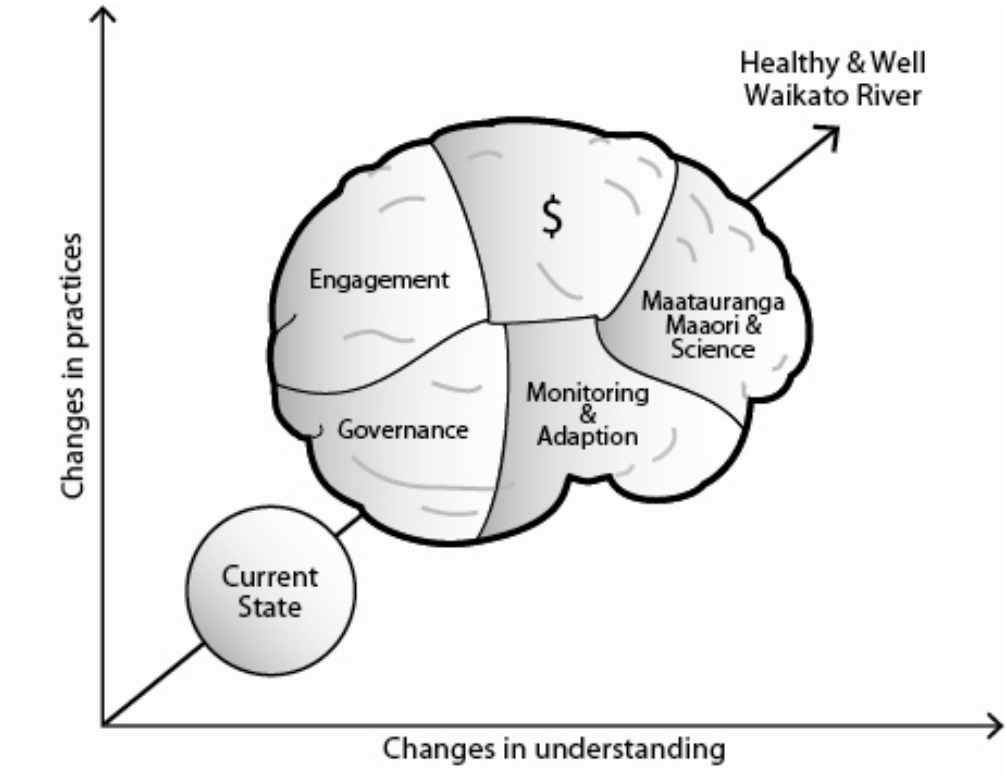


Figure 5.1: Key elements required for change in practices to restore ecosystem health and wellbeing (adapted after Ison and Watson, 2007).

Although actions are described individually in this Section, many actions are linked directly (e.g., riparian planting and fencing) or indirectly (e.g., actions to increase engagement are needed to achieve adoption of riparian management actions) to one another. Similarly, several actions often contribute to meeting individual restoration targets and single actions often contribute to multiple targets. An example, showing this complexity, is provided in Figure 5.2 where the interacting effects of farm-related direct restoration actions on river habitat and water quality have flow-on effects to swimming, aesthetics and fisheries aspirations. These complex interactions are dealt with in Section 6 where the Study team has evaluated the cumulative benefits of implementing 'bundles of actions' in three scenarios in meeting the aspirations held for the river.

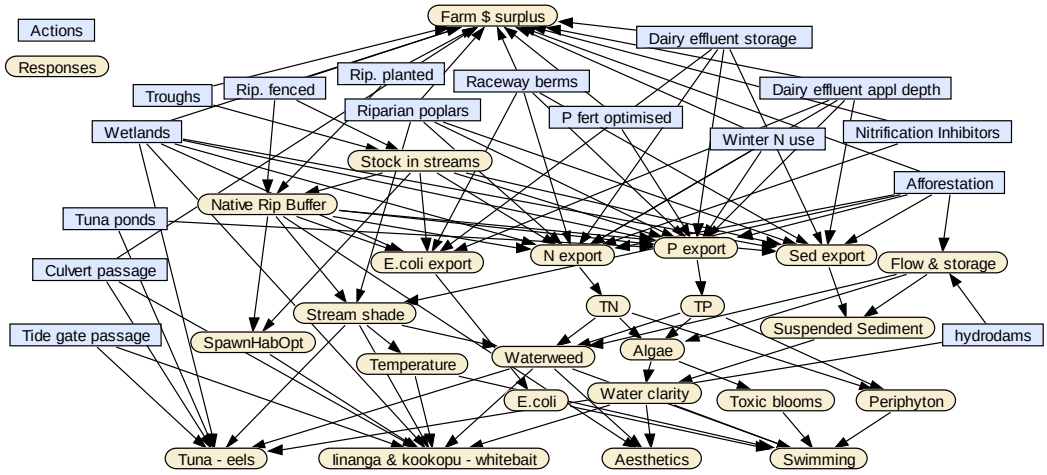


Figure 5.2: Linkage diagram showing the complexity of interactions between direct farm restoration actions (blue boxes), and responses (yellow ellipses) of habitat and water quality, and flow-on swimming, aesthetics, tuna and whitebait aspiration responses.

5.2 Description of potential actions

5.2.1 Holism

Restoration success is enhanced by taking a holistic approach at all phases of action (e.g., Fenemor et al., 2008 and Dodd et al., 2008). This applies to spatial scale (from individual farms, towns and industrial sites through subcatchments to the whole Waikato catchment), to socio-economic issues (education, politics, economy, spiritual) and to governance. Holistic governance seeks to ensure that decision making integrates the cumulative impacts of all activities in the catchment, is based upon a shared understanding across the community of issues, options and available information, includes robust mechanisms for resolving conflict and balancing competing demands (e.g., between development and restoration) and ensures equity in decision making (viz., a sharing of costs and benefits). In order to ensure a holistic, integrated approach to restoration is achieved it is essential that maatauranga Maaori and science knowledge (biophysical, social and economic) are woven together throughout the actions outlined in this Report. The actions discussed here focus on achieving holism in management (see Table 5.1).

Section 3 notes that holistic management of the catchment has not always been possible in the past. The Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 provides several drivers for more integrated governance because other statutory planning processes must be consistent with Te Ture Whaimana.

An initial step towards delivering on the promise of holism afforded by the Settlement Act, could be for the new Waikato River Authority to review rules, consents, plans and decision-making. This review would identify and implement ways to work with councils to overcome statutory impediments to integrated management. This review and subsequent actions should cover ways to improve:

- Application of the precautionary principle as a policy driver for the management of natural resources in the face of uncertainty.
- Management of cumulative effects and multiple stressors (e.g., sediment, nutrients and invasive species).

- Integrated consideration of physical, chemical, biological, social, economic, cultural and historic matters.

To address the lack of national-level direction, the Authority could also lobby central government for effective national policies, guidelines and standards.

The new co-governance structure requires more iwi commissioners available to sit on Resource Management Act (RMA) hearing panels, and therefore increases demands on iwi members capable of effective involvement in RMA and co-management processes. Training of additional RMA commissioners, and marae-based workshops on RMA processes for iwi, could help build capability.

Restoration success will be enhanced by cooperative relationships between all those involved. Goodwill and commitment are essential, of course, but effective co-management agreements can provide structure between iwi and local authorities, and between the Authority and key farming, forestry, tourism, industry and hydro-power industry groups (e.g., DairyNZ, AFFCO, Federated Farmers) and with key non-governmental organisations involved with land and water issues (e.g., Fish & Game New Zealand, Forest & Bird, New Zealand Landcare Trust).

The costs of actions to enhance holistic management are summarised in Table 5.1 below.

Table 5.1: Estimated total costs (capital and operational) for some key actions to enhance holism in management of the Waikato River

Action	*Cost ($M)*
Review rules, consents and decision making	4
Review plans to improve management of cumulative effects and multiple stressors and enhance the application of the precautionary principle	4
Lobby central government for effective national policies, guidelines and standards, and promote industry collaboration	0.6
Train iwi RMA commissioners and provide marae-based workshops on RMA processes for iwi	1.5
Co-management agreements and seed funds for restoration with industry and other non-governmental groups	2

5.2.2 Engagement

Effective engagement with the awa and each other amongst iwi, the community, key industries and government is essential for successful restoration. Without this, or worse with antagonistic relationships amongst key stakeholders, progress is unlikely to occur (Boon, 1998).

In Section 3, the Study team identified the sources of disengagement, including land confiscation, loss and degradation of sites of cultural and historical significance and a history of pollution contributing to people "*turning their backs on the river*" (Gibbons, 1977).

Restoring the health and wellbeing of the river will require increased engagement with the awa, and changes in many people's understanding, perceptions and social norms that drive improved behaviours (e.g., Rhodes et al., 2002; Parminter et al., 2006; Ison and Watson, 2007). Achieving this requires an integrated approach to engage different audiences (youth, urban dwellers, farmers, industries, managers, different ethnicities) early in the restoration process. It should link with, and build on, the existing efforts and resources provided through:

- Schools/kura, e.g., there are over 100 Waikato schools involved in the Enviroschools[102].
- Local government, e.g., Environment Waikato's 2002 Clean Streams Guide; Hamilton City Council's Gully Restoration Guide (Wall and Clarkson, 2001).
- Industry, e.g., DairyNZ's Farm Enviro Walk[103] and related projects to engage farmers in environmental action[104].
- Non-governmental organisations, e.g., New Zealand Landcare Trust's guide for silt traps on peat lake tributaries (Berry and Dresser, 2010[105]).
- Crown Research Institutes, e.g., NIWA's guide on wetland treatment of tile drainage (Tanner et al., 2010) and restoration tools[106].

The actions identified to enhance engagement focus on sharing knowledge, gaining new knowledge and building the capacity of the community to contribute to and/or support the restoration of the river's health and wellbeing. They emphasise building on existing activities and structures, where possible, in order to harness local knowledge and enthusiasm, get maximum benefit for the investment, and avoid duplication of effort. There is considerable scope for the Waikato River Authority to vary the resources put into engagement actions. It would be appropriate, therefore, for the Waikato River Authority to develop a strategic engagement/public outreach plan to ensure that any actions it funds are coordinated and well-targeted. In Table 5.2 we present a range covering adequate to high resourcing.

5.2.2.1 School curricula

Primary and secondary schools' curricula provide a key mechanism to build the cross-community capacity of the next generation for restoration, and to also educate students' parents/caregivers and wider whaanau (Connor et al., 2006). An action would be to develop new curriculum material for kura kaupapa, primary and secondary schools on restoration of the Waikato River, and provide associated professional development for teachers. This material could include biophysical science, social science, economics and (where appropriate) kawa, tikanga and karakia associated with the Waikato River. The University of Waikato's online science hub provides a useful model of delivery of new curriculum material and could be easily adapted for use in bringing alive for students the science and maatauranga Maaori of Waikato River restoration. The Royal Society of New Zealand's Teacher Fellowships provide a source of funding and motivated practising teachers to engage in the development of suitable curriculum-appropriate resources (e.g., these fellowships have supported the development of StreamSense[107] and EnviromentWatch[108] school resource kits). These resources need to build on and link to the existing Enviroschools/Kura Taiao programme and the EMAP waterways programme[109] that aim to influence student's awareness, knowledge, attitudes and skills and to build a network of schools/kura committed to environmental learning, action and creating sustainable communities.

[102] http://www.ew.govt.nz/for-schools/Waikato-Enviroschools-newsletters
[103] http://www.dairynz.co.nz/page/pageid/2145839052/Farm_Enviro_Walk
[104] http://www.dairynz.co.nz/news/pageid/2145838957
[105] http://www.landcare.org.nz/user-content/2300-silt-trap-fact-sheet.pdf
[106] http://www.niwa.co.nz/our-science/freshwater/research-projects/all/restoration-of-aquatic-ecosystems
[107] http://www.ew.govt.nz/for-schools/Resources-for-teachers/Classroom-units/Stream-sense/
[108] http://www.niwa.co.nz/education-and-training/schools/resources/envwatch
[109] www.emap.rsnz.org

5.2.2.2 Community group coordination and facilitation

Investment in coordination and knowledge-sharing between community-based restoration groups can leverage disproportionate benefits in terms of local restoration action and improved engagement. The Waikato Biodiversity Forum[110], for example, has a biodiversity coordinator who acts as a link and support person for over 50 care groups within the Waikato region. Funding assistance could be provided from additional coordinators/facilitators across the catchment, along with support for annual community group meetings.

5.2.2.3 Community-based monitoring and Cultural Health Index

Community-based environmental monitoring programmes assist individuals, community groups and organisations to actively participate in the restoration of their environment (e.g., Fraser et al., 2006; Jollands and Harmsworth, 2006). They can also facilitate networks, knowledge and training, and provide support required by communities to monitor, track and respond to issues of common concern. A Cultural Health Index (CHI) provides a particularly relevant monitoring tool for iwi. Section 8 of this Report provides advice and guidance on establishment of a monitoring programme, and a CHI is discussed in more detail there (see also Appendix 29: Monitoring and Evaluation). River iwi will need to identify the range of cultural indices that they want to see developed that are consistent with their values and aspirations. It is also important to note that so far the CHI has only been applied to streams (Tipa and Teirney 2003, 2006a, b). Thus research and development is required to extend the CHI to lakes, adapt the existing CHI to river iwi aspirations and provide a centralised database for sharing findings, as appropriate.

The actions proposed to support the CHI, and community and iwi-based monitoring are:

1 Extend and adapt the existing CHI to the Waikato River, its lakes and iwi aspirations.

2 Support on-going iwi-based monitoring using the CHI and other tools.

3 Develop and maintain a repository of equipment for environmental monitoring that can be borrowed by volunteer monitors to meet Report Card assessments required for funded projects and general state monitoring at a variety of scales.

4 Develop a database for storing environmental monitoring and background data for use by each iwi and provide regular database training and/or a centralised managed database.

5.2.2.4 Raising awareness and building social capacity and cohesion

Modern mass media are particularly useful for raising awareness of issues and potential solutions (Rogers, 1983; Harrison et al., 1996). However, their effectiveness in changing environmental behaviour is unclear (Harrison et al., 1996), although linking them to the removal of barriers to behaviour change is suggested to improve this (McKenzie-Mohr, 2000). This suggests that the most effective approach would be to develop a package of measures which uses mass media and mass events for awareness raising (including strengthening the communities' connection with the river), along with more targeted/specialist communication channels to impart information and to build social capacity and cohesion. Potential actions include:

[110] http://www.waikatobiodiversity.org.nz/

- **Mass media** items on issues and solutions, e.g., commissioned articles, dedicated magazine or electronic paanui, television documentaries.

- Targeted **training materials**, e.g., 'how to' handbooks that fill gaps in existing resources on riparian, wetland and gully restoration (including plants that provide cultural services such as kai, craft and medicines), monitoring (e.g., kooura monitoring using tau kooura), and involvement in statutory planning processes.

- Conducting **marae-based waananga/workshops** on restoration topics (e.g., riparian plant nurseries, plant establishment and management, pest fish management, monitoring and data management and wetlands treatment) and other components to strengthen spiritual links with the river (e.g., enhancing spiritual values associated with the river through waananga or workshops on tikanga, kawa etc).

- Establishing centralised **waananga/visitor education centres** to engage Waikato people and tourists on the history, issues and actions to restore the river.

- Sponsoring **new awards** for river, lake, riparian and wetlands activities that improve health and wellbeing to complement existing awards such as the Ballance Farm Environment Awards[111]. These awards encourage role models and places where land owners and managers can see and discuss examples of good environmental practice.

- Supporting a biannual **River Festival** (similar to the Brisbane River*festival*[112]) including an international conference, cultural events, water sports and entertainment.

- Supporting marae-based enterprises that support restoration (e.g., native plant nurseries).

5.2.2.5 Building monitoring and research capacity to address key information gaps and support adaptive management

The Study has identified several informations gaps relating to the ecology of the Waikato River and its lakes (e.g., ecology of taonga species, such as piiharau), restoration technologies (e.g., tuna aquaculture; pest fish control), monitoring (e.g., methods for assessing total abundance of whitebait and tuna; a cultural plant species index for riparian areas and wetlands) and social issues (e.g., design of social marketing to engage different stakeholders in restoration action). There is also a need to expand on current monitoring by Environment Waikato, local authorities and dischargers, and the new CHI monitoring programme (see Section 5.2.2.3) to support adaptive management. This will involve additional targeted monitoring to evaluate responses to restoration actions of the biophysical systems (e.g., nutrient leaching rates, pathogen retention in wetlands and riparian buffers, stream hydrology) and social systems (e.g., changes in people's understanding, attitudes and practices). Actions which help to address these gaps and expand the professional skill base available to support restoration action, include:

- Lobbying the new Ministry of Science and Innovation to fund research on the Waikato River from Vote Research, Science and Technology.

[111] http://www.ew.govt.nz/news-and-events/Ballance-Farm-Environment-Awards/

[112] The River*festival* has been running since 1998. In 2009, it merged with the Brisbane Festival: http://brisbanefestival.com.au

- Supporting a research position that builds international networks and coordinate targeted research and post-graduate students, such as the application of maatauranga Maaori in the development of tools and/or scientific research on restoration of taonga species, managing pest fish and weeds, restoring habitats and catchment mitigation tools.

- Supporting additional monitoring of the effectiveness of restoration actions to inform adaptive management.

Table 5.2: Estimated costs (capital and operational) for key actions to enhance engagement

Action	*Cost ($M)*
Strategic engagement/public outreach plan, leading to such actions as:	
Develop resource material on the Waikato River and its restoration for school curricula and teacher professional development	7
Support community group meetings and coordinators/facilitators	5
Extend and adapt the existing Cultural Health Index to the Waikato River and its lakes, and support ongoing iwi-based monitoring using the Cultural Health Index and other tools	13
Maintain a repository of equipment for environmental monitoring by volunteer monitors	1
Develop and maintain a database for environmental monitoring and background data by each iwi and regular training	3
Mass media information and targeted training materials (e.g., 'how to' handbooks, monitoring courses)	11
Marae-based waananga/workshops on restoration topics	15
Waananga/visitor education centres to engage public on the history, issues and actions to restore the river	16
Sponsoring new awards for activities that improve the health and wellbeing of the awa to complement existing awards	4
Supporting a biannual River Festival	4.5
Supporting marae-based enterprises that support restoration (e.g., native plant nurseries)	14
Supporting research to fill information gaps	30
Supporting monitoring of restoration actions to inform adaptive management	46

5.2.3 Significant and historic sites

In Section 3, the Study team described the loss and degradation of significant and historic sites, and the causes.

Some damage cannot be undone, e.g., ngaawhaa filled with concrete. More tractable issues relate to concern that further degradation may occur, and that knowledge of these sites may fade over time. Thus, proposed actions focus on ensuring there is adequate recognition and protection of waahi tapu and historic sites in district plans while securing sensitive site information in a hidden file.

The Study team recommends development and implementation of a holistic, catchment-wide strategic plan for significant and historic sites. These plans would cover identification/mapping/GIS layers, restoration, signage, publicity, access and education and would require ongoing input and prioritisation as implementation of restoration progresses. In order to maintain the integrity of significant sites, however, it is vital that each river iwi (with input from whaanau and hapuu) or wider community organisation retain control over how their own significant sites are identified, addressed and managed.

With regard to the loss or dislocation of place names, restoration can and should be sought through the New Zealand Geographic Board (as the statutory body which assigns, approves, alters or discontinues the use of names for geographic features).

The costs of these actions are summarised in Table 5.3 below.

Table 5.3: Estimated costs (capital and operational) for key actions to restore significant and historic sites

Action	*Cost ($M)*
Catchment-wide strategic plan for significant and historic sites, leading to actions such as:	
Develop significant site management plans by each river iwi	2
Develop appropriate signage, registered naming and support site restoration actions	2

5.2.4 Access

In Section 3, the Study team noted that access to the Waikato River is patchy with legal access to a piecemeal collection of strips. The main impediments to access in general (including access to sites of historical and cultural significance) appear to be private land ownership, lack of facilities, and pest plants. To date, however, there has not been a comprehensive, catchment-wide assessment to quantify the extent and deficiencies in access. It is currently not known, for example, precisely how much of the Waikato main stem and the Waipa are accessible by footpaths and cycleways. Furthermore, the interests of public access sometimes clash with other interests such as public safety, landowner interests (e.g., not to have stock disturbed), ecological fragility and iwi desire to preserve some waahi tapu by keeping knowledge of their location private.

A logical first step, therefore, is to develop a strategic access plan for the region, identifying where access needs to be enhanced or restricted, including any legal constraints and how to overcome them.

Where access is impeded by private ownership or lease, a range of mechanisms are available to obtain and enhance access to the river and its margins. These include:

- Esplanade reserves, esplanade strips, access strips (when land is subdivided)[113].
- Marginal strips.
- Reserves.
- Non-statutory approaches to securing access, e.g., Te Araroa (creating a walkway from Cape Reinga to Bluff)[114].
- Direct purchase of land for this purpose.

The strategic access plan would identify which mechanisms are more appropriate in which circumstances. It would also indicate what facilities were needed, including:

- Footpaths and cycleways.
- Boat ramps and facilities.
- New reserves.
- Private and/or public access to waahi tapu sites.

[113] http://www.qualityplanning.org.nz/plan-topics/esplanade-reserves.php
[114] http://www.teararoa.org.nz/

- Improved riparian vegetation (action here has many co-benefits, including better aesthetics, filtering run-off, reduced bank erosion and improved habitat for kai and taonga species).

As an indication of what may be required, this Study scoped the need for boat ramps for waka ama/waka taua. The lower Waikato lakes are likely to require improved boat access but in the upper Waikato, existing boat access may suffice. A preliminary engineering assessment is that most locations on the Waipa River are unsuitable for installing a boat ramp, and in these areas money may be better spent on improving access in other ways, such as creating reserves next to the river. For the purposes of costings, we have developed a generic guideline cost for new boat ramps of $460,000 per ramp. This is based on the 2009 costs for the Hamilton City Council replacement boat ramp at the Delta, and includes an estimate for a 1,000 square metres parking area. No allowance is made for any additional costs such as land purchase, road access, toilets, washwater or other general amenities, since these are location-dependent and will vary widely. Upkeep and maintenance of a ramp are assumed to be the responsibility of the local council, and to be minor over the first 30 year period. This cost is indicative only of the scale of investment required. During the development of a comprehensive strategic plan, locations and costings would need to be thoroughly canvassed, beyond the level of a scoping study.

The creation of new walkways and cycleways should mesh with, and leverage off, existing activities[115]. An estimate has been made here of additional investment which would at least accelerate some initiatives. Specific decisions (and finer costings) should be driven by the strategic access plan.

The costs of these actions are summarised in Table 5.4 below.

Table 5.4: Estimated costs (capital and operational) for some key actions to improve access. These actions are listed for costing purposes and would be refined during plan development

Action	*Cost ($M)*
Strategic Access Plan - leading to actions such as:	1.5
Creating 16 new boat ramps for waka ama/waka taua	7.4
Creating 4 new reserves	13
Extending footpaths and cycleways	21

5.2.5 Spiritual values

Many of the restoration actions described will help restore spiritual values, notably those actions that address the aspirations for fisheries and kai, taonga species, ecological integrity, access, significant sites, holism and water quality. Actions to promote learning on kawa, tikanga and karakia are also included in actions around engagement e.g., waananga/workshops to teach and train people in tikanga and kawa (see Section 5.2.2.4).

[115] E.g., Environment Waikato's Walking and Cycling Strategy: http://www.ew.govt.nz/Policy-and-plan/Walking-and-cycling-strategy-for-the-Waikato-region/

5.2.6 Recreational values

In Section 3, the Study team described the current state of the Waikato River with regard to recreational use.

Many of the key issues for safe contact recreation are fundamental water quality problems: faecal pollution, blue-green algal blooms and low water clarity. The Waipa, the lower Waikato, tributaries and the shallow lakes are the most affected. As outlined in Section 3, the main causes of poor water quality in the Waikato relate to increased run-off due to land use change and farming, so actions need to address these causes.

For example, to reduce faecal bacteria going into the water, actions which the Study team found were very cost-effective on dairy farms are single-wire fencing to keep cattle out of streams, improved effluent management, and installation of berms on raceways to prevent run-off directly entering the stream. Single-wire fencing is also very cost-effective on sheep and beef farms (see Appendix 9: Farms). The Study team costed a suite of actions, of which these are just examples. They are listed in Section 5.2.9: Water Quality and Section 5.2.12: Ecological Integrity.

In order to improve access, and reduce hazards, for swimming and boating one possible action is to actively manage aquatic weeds and snags at key boat ramps and popular swimming holes. The problem of 'duck or swimmer's itch' is caused by flatworm larvae associated with a snail commonly found amongst submerged aquatic plants in the river, so managing weeds is also expected to reduce this problem. The question of building new boat ramps and other actions to improve access to the river for recreational use are discussed under 'access' in this section.

With regard to the hazards of rapid changes in flow and water level just below the hydro dams, we note that hydro-peaking issues were analysed when the hydro dams were re-consented. Nonetheless, further work with Mighty River Power on managing flows below dams may improve conditions for recreational users at a minor cost.

As noted in Section 3, regulations already exist to address competition amongst river users in some places. Additional enforcement may be needed by the relevant local authorities. Actions discussed earlier in this chapter to increase engagement with and access to the river may, on the one hand, increase congestion while, on the other hand, possibly fostering a greater sense of care for the river.

The costs of actions to assist with recreational use of the river are summarised in Table 5.5 below.

Table 5.5: Estimated costs (capital and operational) for some key actions to improve recreational use of the Waikato River, lakes and tributaries

Action	*Cost ($M)*
Reduce faecal contamination	See 'water quality' and 'ecological integrity'
Reduce risks of algal blooms	
Improve colour and clarity	
Manage hydro-peaking below dams	Minor cost
Manage aquatic weeds and snags at boat ramps and swimming points within the Waikato/Waipa main stem (cost estimate to manage ~40 sites)	1.6

5.2.7 Aesthetics

In Section 3, the Study team noted that several factors contribute to river and lake aesthetics, including landscape setting, riparian vegetation, water colour and clarity, channel character and flow types, visual diversity, the knowledge that the river is in a healthy state (Mosley, 2004). Consequently, a wide range of actions proposed to manage water quality, ecological integrity and farm contaminants also contribute to restoration of aesthetics. Actions to improve water clarity, colour and reduce algal blooms are covered under water quality.

Riparian vegetation is one of the largest manageable influences on river aesthetics and this is the focus of the actions proposed here. Proposed actions to enhance riparian aesthetics focus on establishing locally appropriate native riparian vegetation (i.e., wetland grasses, shrubs or forest appropriate to the site) within 10 metre wide fenced buffers on streams with riparian pasture grasses or willows. This will increase the Riparian Management Classification (RMC) aesthetic scores from one or two (pasture) to four or five (native vegetation).

The vegetation near the water's edge has the strongest influence on aesthetics and once a solid band of riparian vegetation has been established along the banks, additional width improves the aesthetics by a diminishing amount. Buffer width recommendations reflect a balance between establishment and opportunity costs (see Appendix 9: Farms and Appendix 11: Riparian Aesthetics) and requirements to create a relatively self-sustaining riparian forest for aesthetic benefits. Weed invasion decreases and self-seedling increases with buffer width (Parkyn et al., 2000; Reeves et al., 2006). Parkyn et al. (2000) suggest a buffer width of about 10 metres allows for indigenous vegetation succession and should result in a relatively low-maintenance riparian buffer strip, whereas five to six metre wide buffers will require maintenance to keep weed-free. Note however that five metre wide buffers along small headwater streams tend to merge over the channel creating a similar forest environment to a 10 metre wide buffer on a larger stream that creates canopy gap between the forests on each of its banks.

Landowners can earn Kyoto compliant carbon credits if the total minimum width of the riparian forest is 30 metres (i.e., 15 metres on either bank of small-medium streams) and other requirements are met (area and ultimate forest height). This may influence decisions on buffer width because carbon credits can offset planting and opportunity costs.

Efforts are prioritised first on main stem (sixth and seventh order) reaches of the Waikato and Waipa Rivers (where some work is already underway), then on fifth order reaches, then on third and fourth order reaches[116]. This priority reflects the greater recreational use of the main stems (e.g., for boating, rowing, waka ama and walkways) and the increasing river length (and therefore cost) as smaller streams are included (see Table 5.6). Actions on first and second order streams were not costed for river aesthetic restoration because these are small streams on farmland with little public recreational use.

The proposed actions are predicted to increase the average riparian score (based on the RMC results weighted by stream length and order) for Waikato pastoral streams. Fencing and planting grass/willow areas on third to seventh order streams is expected to increase the weighted average score from 43 percent to 74 percent (see Appendix 11: Riparian Aesthetics for more detail).

[116] Stream order is a measure of the relative size of streams. A stream with no tributaries (headwater stream) is considered a first order stream. A segment downstream of the confluence of two first order streams is a second order stream and so on. Stream sizes in the Waikato River catchment range from the smallest, first order, to the largest, seventh order i.e., the main stem of the Waikato River (see Appendix 11: Riparian Aesthetics).

These aesthetic–targeted actions have co-benefits for water quality and ecological integrity. In practice, riparian restoration for aesthetic enhancement would be part of, and/or an extension to, the package of riparian fencing and planting for controlling the farm contaminant effects, so that the costs would be shared across these actions. This is allowed for in the analysis of costs and benefits of scenarios in Section 6.

The costs of these actions are summarised in Table 5.6 below.

Table 5.6: Estimated costs (capital and operational, excluding opportunity costs) for recommended actions to improve aesthetics through riparian management

Action	*Cost ($M)*
Plant 10 m native vegetation buffers on areas which have 5 m buffers and fences on larger (5^{th}, 6^{th} and 7^{th} order) reaches of Waikato and Waipa. (For cost of fencing and creating the 5 m buffers see actions for dairy farms in Section 5.2.9)	12
Fence and plant 10 m native vegetation buffers on areas currently with riparian pasture and/or willows on all streams and rivers used for public recreation (3^{rd} to 7^{th} order)	66
Plant 10 m buffers and enhance walkways on urban streams	3

5.2.8 Human health

In Section 3 the Study team concluded that water and food quality did not meet Te Ture Whaimana objective that the Waikato River is safe for people to swim in and take food from over its entire length, and there were risks associated with some untreated drinking-water supplies. The problems are caused by pathogens and nitrate, heavy metals of geothermal origin and blue-green algal blooms. The solutions to these issues are met at the local to catchment-wide scale.

The actions for human health include reducing the direct and indirect inputs of farm animal faecal material by fencing streams, creating riparian buffers, addressing surface run-off from high source areas and reducing the risk of contamination of surface waters from effluent irrigation systems. This will greatly reduce pathogen inputs, but will not completely eliminate them because of feral animals and waterfowl, fencing and irrigation failures, and contaminated run-off from pastures during large storm events. More regular cleaning of septic tanks would ensure better effluent quality for the 40 percent of the existing systems which are cleaned less than once every two to three years, and reduce the risk of human viruses in drinking-water supplies.

While Maaori have an aspiration to drink untreated water directly from the river, this is not realistic, given the difficulty of eliminating risk of faecal contamination and this country's high reported rate of zoonoses (Till and McBride, 2004)[117]. Additional risks are posed by arsenic in the Waikato River, some of which occurs naturally. While municipalities can treat drinking-water to remove pathogens and arsenic, smaller community supplies may not have the appropriate treatment. With the marae as the centrepiece of Maaori community life, a reliable and safe marae water supply was identified as a priority by the five river iwi. There will be times (e.g., hui and tangi) where large groups may gather, and the water supply and other sanitary services come under pressure. An important action, therefore, is to ensure safe drinking-water at all times by installing small water treatment plants at marae considered to be at risk.

To address the increasing frequency of cyanobacteria ‘blooms’ in the Waikato River and the associated threats to human (and animal) health, a key action is to reduce nutrient inputs from farms. This is also an important action in shallow lakes, where such blooms occur quite

[117] New Zealand has a rather high reported zoonoses rate—illnesses caused by pathogens derived from animals (cattle, sheep) that are infectious to humans.

frequently. The actions to reduce nutrient inputs are described under 'water quality', although it should be noted that there will be time lags before algal blooms start to reduce as a result. The Study team assessed the cost of implementing cyanotoxin treatment facilities at 12 of the 14 water takes identified from the Register of Community Drinking-Water Supplies and the Resource Consents for the Waikato area (see Appendix 20: Cyanotoxin Treatment). (The two other takes, Wairaakei Resort and New Zealand Prawns Limited, are just downstream of Taaheke Hukahuka where the risk of algal blooms is considered small).

Some of the farm management actions to reduce nitrogen losses and leaching will benefit groundwater quality by arresting the trend for increasing nitrate levels. However, local factors may still mean some groundwater exceeds water quality standards for nitrate, so these water supplies still need to be tested and treated if necessary.

Overall, with regard to drinking water systems (especially in rural areas), it is important to note that the solutions will vary widely depending on the nature of current treatment and the current water source. Detailed technical investigations would be required on a site-by-site basis to produce definitive costings.

Section 3 points out that mercury and arsenic inputs may limit the safe consumption of kai from the river. Actions include reducing inputs of mercury and arsenic to the river through treatment of effluent from geothermal power generation and/or re-injection, and this should occur under existing consent conditions. However, some inputs are natural, and there is also a legacy of accumulated contaminants in the sediments and food chain thus the risks cannot be eliminated completely. The Australia New Zealand Food Standards Code addresses consumption in the wider community, mainly of marine species, but it does not address the desire of Maaori for safe – and presumably more frequent – consumption of a wide variety of kai species, including older and larger fish and freshwater mussels. There is a major information gap, because relatively little is known about mercury (and arsenic) in food species from the river. An initial action, therefore, is to determine the health risk from a 'food basket' of these widely-used kai species, by surveying arsenic and mercury levels in food and determining patterns of consumption. This can be linked to a similar study in Rotorua and Temuka (Phillips, 2008). This information could be used to develop a food advisory on kai species for different parts of the river and for different consumers (pregnant women, children and adults).

The legacy of accumulated arsenic in hydro lake sediments from natural and geothermal inputs means there is a risk that arsenic may be mobilised off the lakebed at Ohakurii. This could occur if high nutrient inputs cause bottom-water deoxygenation. This poses a risk for drinking-water supplies, increased accumulation in watercress, as well as ecosystem health. There are a range of potential actions available here. At least, the risk that these contaminants will escape from the sediments should be assessed. Laboratory and field trials of techniques for sediment immobilisation could be conducted. These trials and the risk assessment could be a precursor to 'capping' the lake sediments to prevent release, if the risks were sufficiently high and it proved technically feasible.

Sediment capping would have the co-benefit of preventing nutrient release from the lakebed. Conversely, other actions to reduce nutrient input (especially from farming activities in the upper Waikato) may reduce the risk of contaminant mobilisation in any event.

The costs of these actions are summarised in Table 5.7 below. For a full explanation of actions and their costs, see Appendices 10, 12, 17 and 21: Faecal Contamination, Shallow Lakes, Marae Water Supply and Toxic Contaminants.

Table 5.7: Estimated costs (capital and operational) for some key restoration actions for human health

Action	Cost ($M)
Assess and manage the risk of arsenic and mercury in the 'food basket'	0.1
Drinking-water treatment at marae	23.1
Cyanotoxin treatment of drinking-water	6
More frequent septic tank cleaning	18.3
Investigate arsenic mobilisation risk at Lake Ohakurii, including lab and field trials	0.7
Sediment 'capping' at Lake Ohakurii	7.1
UV treatment of sewage	4

5.2.9 Water quality

In Section 3 the Study team described current water quality and concluded that a major influence on that quality was increased pollutant run-off as a result of land use change and farming activities. Degraded water quality is a key concern, its current state falling short of the water quality aspirations held for the river (see Section 4), and having negative flow-on effects for other aspirations. Actions that restore water quality are likely to be a key element in meeting the overall vision of a healthy and well river.

Restoration actions for water quality need to primarily focus on lowering the transfer of contaminants from farmland to tributary streams of the river – "*fix the veins that feed the awa and you will fix the awa itself".* There is sufficent scientific evidence to show the water quality benefits of implementing various practices on the farm and within riparian margins to either reduce the mobilisation of contaminants in the first place or to intercept those contaminants before they reach the waterways. Several of the key studies that provide this evidence have been carried out in the region, including the Toenepi dairy catchment study near Morrinsville (Monaghan et al., 2009; Wilcock et al., 2007) and sheep and beef hill country studies at Scotsmans Valley (Smith, 1989) in the Waipa catchment (Donnison et al., 2004; Quinn et al., 2007; Hicks and Hill, 2010). This scientific understanding has been encapsulated into various computer models that allow predictions to be made of the water quality benefits and costs (including any effects on farm profitability) of implementing different sets of restoration actions. In Appendix 9: Farms we describe the use of two of these models, *Overseer* and *Farmax*, for eight farm types representative of existing dairy and sheep/beef farms in the Waikato. The restoration actions included in this modelling were: excluding stock from streams, creating riparian buffers to intercept contaminants, better use of soil tests to optimise phosphorus fertiliser application rates, not applying nitrogen fertiliser to saturated soils in winter, the use of nitrification inhibitors to reduce nitrogen transfer to waters, creation of soakage areas to treat storm run-off from critical source areas (e.g., raceways), improved dairy shed effluent management, the use of constructed wetlands to remove contaminants from run-off seepage and farm drains, herd shelters to contain contaminants during wet periods and afforestation of marginal hill country farms.

Analysing the output of the models identified some of the key sources of contaminants discharged to water from farmland in the Waikato River catchment (see Figure 5.3) and provides key information for the targeting of restoration actions. For nitrogen, the modelling predicts that dairy farms generate about 70 percent of the 18,500 tonnes of nitrogen transferred annually from farmland to streams, with much of this contribution coming from dairy farms located on free-draining soils. In the case of the 1,200 tonnes of phosphorus transferred annually, there is a more equal contribution to farmland discharges. Because of their relatively large areal extent and location in more hilly and erosion-prone land (e.g., within

the Waipa catchment), sheep-beef farms are estimated to generate the largest proportion of the 320,000 tonnes of sediment discharged from farmland each year.

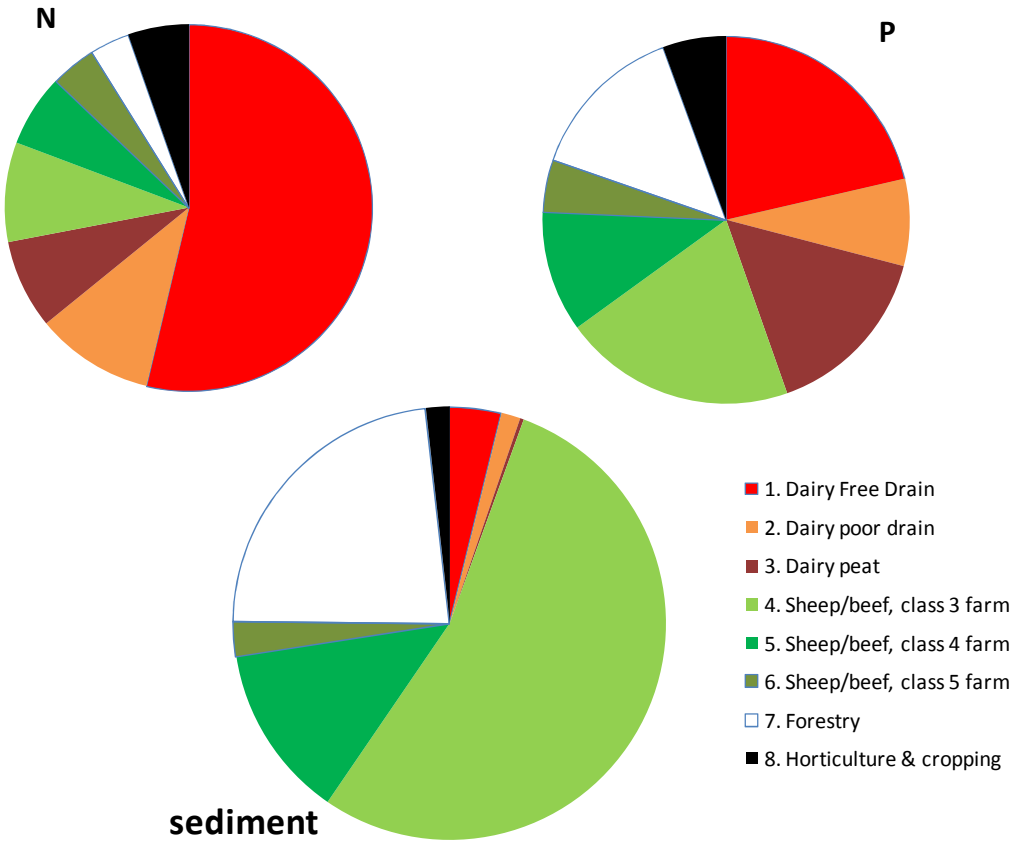


Figure 5.3: Estimates of the key sources of contaminants discharged from farms within the Waikato River catchment.

To reduce nitrogen pollution, restorative actions should generally be targeted to dairy farms, with the most cost-effective actions being:

- Improved management of farm dairy shed effluent (greater pond storage and larger irrigation areas to limit nitrate leaching during wet seasons).
- The use of nitrification inhibitors to reduce nitrate leaching from pastures.
- Not applying nitrogen fertiliser to saturated soils in winter.
- Single-wire fencing along streams to prevent direct inputs of nitrogen from cows.
- Establishing end-of-drain and stream-side wetlands to remove nitrate from emergent groundwater.
- Establishing 5 metre wide planted riparian buffers on each side of the stream (total forest width = 10 metres).

To reduce phosphorus pollution, restorative actions should generally be targeted to the following most cost-effective actions:

- Reducing phosphorus fertiliser inputs to economically-optimal levels on the horticultural and dairy farms (this represents a net saving to the farmer).
- Single-wire fencing to exclude cows from streams on all dairy farms.
- Installing berms to direct farm track run-off away from streams.
- Single-wire fencing to exclude cattle from streams on all sheep-beef farms.

The most cost-effective measures (kilograms removed per dollar spent) for reducing sediment pollution included:

- Cattle exclusion from streams in sheep-beef farms.
- Improved soil management techniques on farms used for market gardening.
- Leaving buffers around streams when harvesting forests.
- Retiring and afforesting steep hill country pasture currently used for sheep and beef grazing.

Fencing for full stock exclusion and planting along streams on sheep-beef farms had some added benefit but at high cost.

For faecal bacteria pollution, limited information means it is difficult to make direct comparisons of cost-effectiveness but the Study team was able to conclude that cost-effective actions include:

- Single-wire fencing to exclude stock (dairy, sheep and beef farms).
- Improved farm shed effluent management (dairy farms) (see also Collins et al., 2007; Wilcock et al., 2009).
- Installation of berms on laneways to prevent run-off directly entering streams (dairy farms).
- Additional riparian protection (sheep and beef farms).

The models were used to derive separate cost-abatement information for each contaminant for the progressive implementation of restoration actions within the catchment (see Appendix 9: Farms). An example is shown in Figure 5.4.

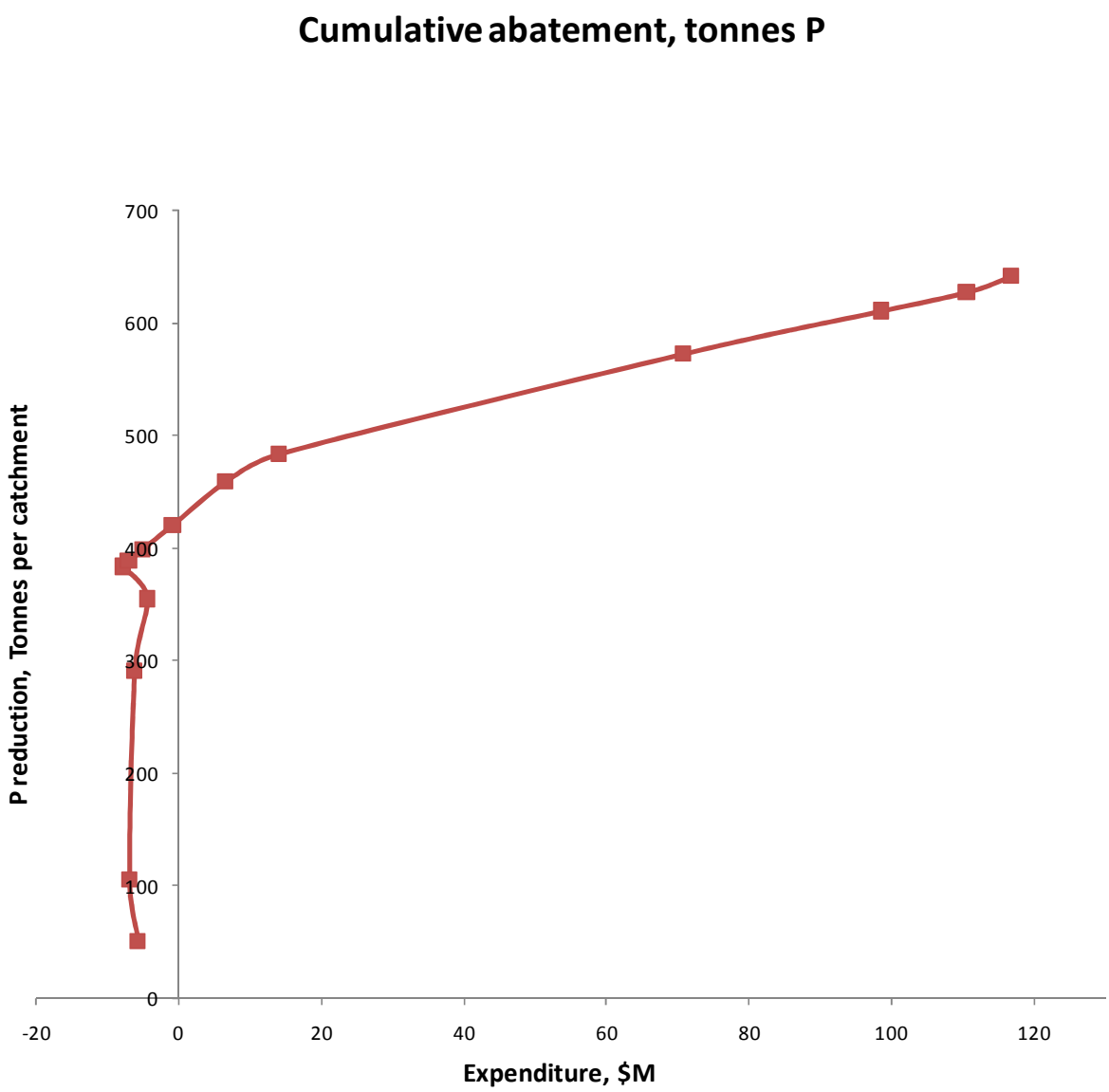


Figure 5.4: Cumulative phosphorus abatement curve for farms within the Waikato River catchment. Some actions increase the farm cash surplus, so show as negative expenditure.

The modelling shows that restoration actions within the catchment are able to reduce the transfer from farms to waterways by 50 to 60 percent for nitrogen and phosphorus and about 35 percent for sediment. Many of the actions evaluated have the positive effect of reducing losses of more than one contaminant (co-benefits) but for the purposes of the analysis here these co-benefits are not considered – in Section 6, when we combine actions to address all scenarios, we incorporate co-benefits in our analysis and avoid 'double counting' of costs.

It will take varying lengths of time for actions to show benefits, particularly in groundwater. Nitrification inhibitors reduce nitrate leaching (Di and Cameron, 2004) and this will eventually result in lower groundwater nitrate concentrations as the existing groundwater is diluted by younger, less contaminated groundwater. The response time will therefore be influenced by groundwater residence time, which varies markedly within the Waikato catchment. Groundwater residence time in the aquifer at eight bore locations within recharge zones in the Reporoa Basin, was between 11 years to 73 years (Piper, 2005), whereas in Waipa hill country, at Whatawhata, groundwater residence time is about nine years (Stewart et al., 2007). At Toenepi, near Morrinsville, groundwater age varies with season (Stenger et al., 2009). Groundwater that emerges as baseflow during winter is very young (age ca. one year), when shallow groundwater flows laterally through subsurface drains and well-drained allophanic and granular soils. However baseflow is a few decades old during summer when deeper groundwaters supply the streamflow (Stenger et al., 2009).

The restoration actions proposed require changed behaviours and buy-in from farmers so that uptake is improved. Some of the actions are already familiar to many farmers: matching phosphorus fertiliser levels to requirements from soil tests, single-wire fencing to exclude cows from waterways as part of the Dairying and Clean Streams Accord. Implementation of these on-farm restoration actions will need to be tailored to each farm and resources to advise and guide actions may be limiting. Coordination between the various extension agencies will be the key to ensuring efficient delivery of that advice.

The proposed action to change the land use from sheep-beef grazing to forestry on the steepest marginal farming land, where erosion is greatest, requires further analysis before adaption. However, there is local evidence from the Whatawhata Integrated Catchment Management study in the Waipa Catchment that such an approach can enhance the long-term economic and environmental sustainability if the financial transformation hurdle can be overcome (Dodd et al., 2008a,b,c,d). A detailed analysis of the farm ecosystem by a stakeholder group came to the conclusion that enhancing overall sustainability required a better match of land use to land capability for this rolling steep-hill farm. The plan to achieve this, implemented in 2001, involved:

- Afforestation of 160 hectares (mostly in pine on Land Use Capability Class VI and VII[118]) of the 296 hectares hill catchment farm.
- Riparian management of the remaining 20 kilometres of stream network.
- Restoration/extension of five hectares of native forest.
- Intensification of the remaining pastoral component (on better pastoral land) to a high fecundity ewe flock and bull beef finishing.

This had a net cost of $260,000 in the first year, with total establishment costs of approximately $600,000 over 10 years for establishing the land use changes. The changes improved the financial return on the area remaining in pasture, and water quality and biodiversity (Dodd et al., 2008; Quinn et al., 2007, 2009).

[118] Lynn et al., 2009

Sheep and beef farming of steep pastoral land has low profitability (see Appendix 9: Farms) and conversion to pine forestry has generally been shown to increase the profitability of the farm system in the long-term (Knowles et al., 1991). However, the increase in returns from the pastoral area at Whatawhata were not sufficient to offset the debt servicing (at 8 percent per year) on the $0.6 million cost of the capital input during the 30 year period until the revenue from the forest was realised. The study catchment is unusually steep, and the economics would be more favourable on a typical hill farm with a more normal mix of land classes (Dodd et al., 2008c). The current opportunity for 'carbon forestry' may provide a new means of overcoming this financial transformation hurdle (West et al., 2009; Pratt et al., 2010). Indeed, the ability to earn carbon credits appears to be encouraging some hill farmers to plant their steep gullies as carbon forests[119]. Alternatively, the financial hurdle could be addressed by joint-venture capital investment or government incentives. The Ministry of Agriculture and Forestry's afforestation grants scheme[120] and the East Coast Forestry Project are examples of government incentives, with the latter having seen 40,000 hectares of erodible East Coast pastoral land planted in pine in the last 16 years.

The most appropriate land for retirement and afforestation is steep dry stock farmland. Much of this is hill country in the Waipa, especially given the highly erodible nature of soils in that area and the very high sediment load in the Waipa River. Figure 5.5 shows land use in the Waikato catchment, with sheep and beef pasture coloured a pale green. In a small number locations engineering works are required to stabilise major earthflows (deep-seated landslides) and river bends that are eroding badly. For the purposes of costing, the Study team has estimated the likely cost at $15 million but detailed site investigations would be required to refine these costs.

[119] http://www.stuff.co.nz/waikato-times/farming/3961071/new-ideas-tried-to-raise-meat-yield
[120] http://www.maf.govt.nz/climatechange/forestry/initiatives/ags/

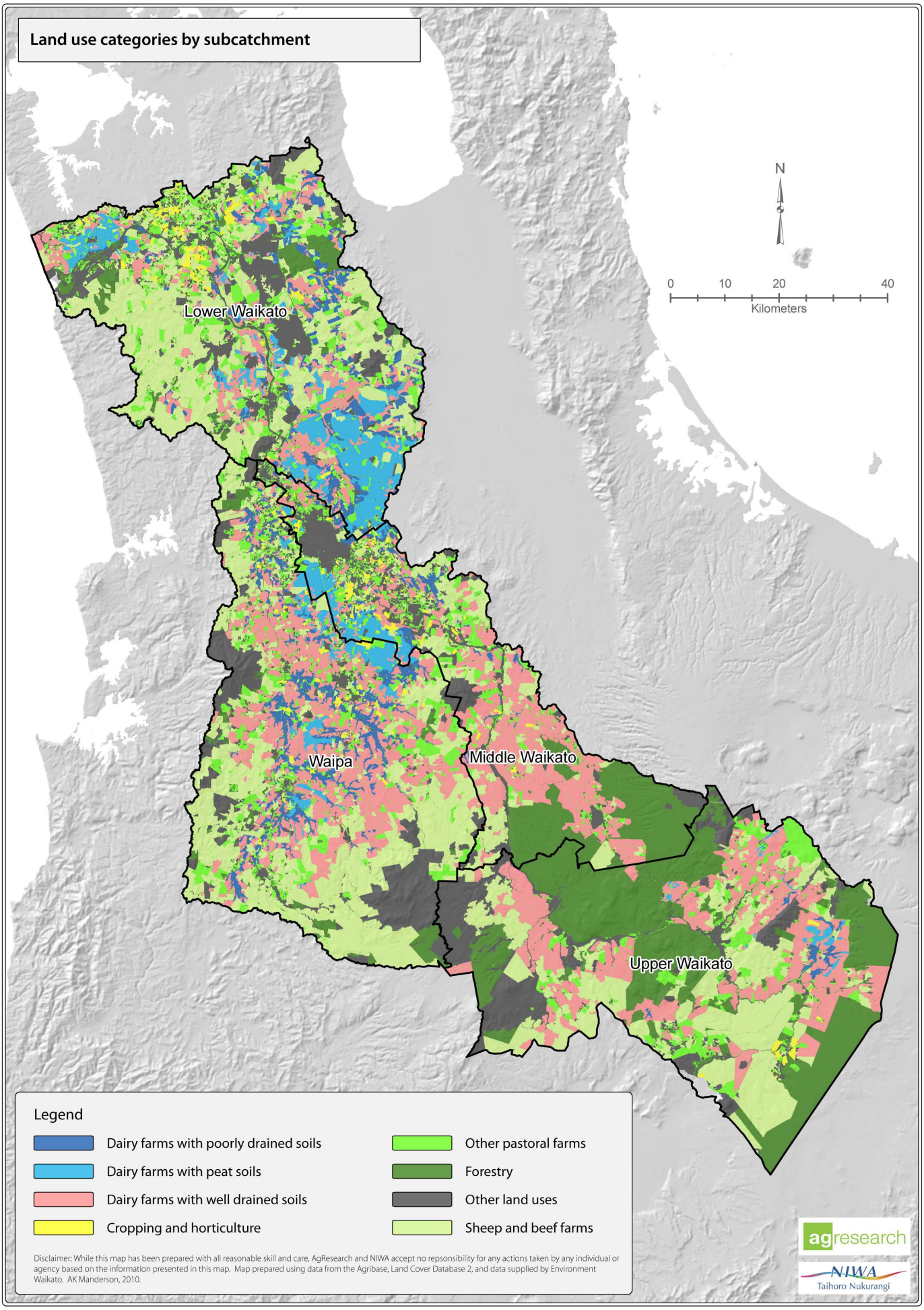


Figure 5.5: Land use in the Waikato catchment

Although diffuse run-off from farms is currently the major source of pollution in the Waikato, Section 3 notes the adverse effect of point source discharges of treated sewage and industrial water. In particular, Hamilton city sewage and the AFFCO freezing works at Horotiu each have resource consent to discharge 100 kilograms of total phosphorus per day. The Te Raapa dairy factory has a consented load of 25 kilograms per day. These three make a significant contribution to the amount of phosphorus in the Lower Waikato. Hamilton City Council is investigating options to remove phosphorus from the final effluent of the Pukete wastewater treatment plant over the next five years, and this action is included in the analysis. Action to further reduce nutrient inputs from these sources is likely to become more pressing as restoration action on farms takes effect and the relative proportion of input due to point sources rises.

Wastewater treatment plants are required by consents to achieve minimum effluent standards for *E. coli*. However, in Section 4 the Study team notes that Maaori have an additional requirement that there be no direct inputs of human sewage to water[121] to preserve the mauri of their tupuna. Land disposal can be achieved in many ways with the most common in New Zealand being either Slow Rate Irrigation (SRI) to pasture or forest, discharge via a wetland or discharge to a Rapid Infiltration Basin (RIB). It is difficult to estimate a cost for land disposal of all treated municipal effluent throughout the catchment. One reason is that a standard suitable for meeting cultural aspirations is not clearly defined. Current consents in the Waikato, which appear to have been agreed with iwi, range between slow rate irrigation to pasture through to discharge into rock-lined channels. It is not clear which technologies fully meet Maaori requirements and further consultation will be required with iwi. A second reason is that site-specific investigations are required to determine the technical feasibility (e.g., RIB may not be feasible in areas with high water tables) and cost (e.g., land for SRI may be very expensive near Hamilton). The Study team was able to access feasibility studies for land disposal at only three locations – Hamilton City (bankside wetland) and two small rural communities (wetlands or irrigation). Total costs for these three sites were $35 million and this figure was included in the economic and scenario modelling described in Section 6. Subsequent analysis of land, wetland and infiltration basin disposal was undertaken as described in Appendix 14: Wastewater Management. The total cost for land disposal or infiltration basins (Option B in Appendix 14, Table 6) was $1,080 million, and the total cost for wetland was $124 million (Option A in Appendix 14, Table 6).

Like municipal wastewater, marae wastewater solutions need to be determined on a case-by-case basis, but the intermittent and widely fluctuating nature of wastewater generation in the marae situation poses particular challenges. Some technologies do not perform well under such loading conditions, as noted in a study for Poohatuiri Marae, near Waitomo (de Vos and Headley, 2006). Detailed technical investigations would be required to identify the needs and appropriate options for each marae.

Other potential actions costed in this Study to address point source discharges were: reduction of the colour in the discharge from the Kinleith Pulp and Paper Mill (see Appendix 19: Kinleith Discharge), and retrofitting environmentally sensitive design and treatment to older urban stormwater systems (see Appendix 18: Urban Stormwater).

The costs of these actions are summarised in Table 5.8 below.

[121] This aspiration is not exclusive to Maaori. In the Gravitas Public Awareness Survey, 2006, for Environment Waikato, 78 percent of Asian/Indian respondents agreed that discharges of treated human sewage are a major source of pollution in the waterways, compared with 62 percent of Maaori respondents and 55 percent of respondents with Maaori ancestry.

Table 5.8: Estimated costs (capital and operational) for some key restoration actions for water quality

Action	Cost ($M)
Dairy farms	
Improved nutrient management	11
Improved effluent management	36
Run-off diversion	5
Creation of wetlands over one percent of catchment	45
E-fence and plant 5 metre buffers on all streams	263
Use of nitrification inhibitors	138
Improved management of cropping land	-20*
Herd shelters (keeping cattle inside in winter)	1,090
Dry stock farms	
Fence (single e-wire) and plant poplars on 1st and 2nd order streams	93
Fence (8-wire post and batten) and plant 10 m native buffer on 3rd order and larger streams (This action is costed in Section 5.2.7: Aesthetics)	(66)
Retire and afforest 68,000 hectares of steep hill country pasture	91**
Earthflow remediation	15
Forestry	
Leave uncut forest buffers on streams	225
Point source discharge	
Land disposal of treated human sewage	365***
Colour removal from Kinleith pulp and paper mill	195
Retrofitting urban stormwater controls	1,000

* Negative cost represents a cash surplus.

**After harvesting the first rotation (in Year 36) there is a net cash surplus of $937 million. Note that carbon credits are not included in these costings, only timber harvesting.

*** Engineering feasibility and, hence, costs have high uncertainty.

5.2.10 Fisheries and kai

In Section 3 the Study team described the current state of the tuna and whitebait fisheries, including the causes of their degraded state – declines in suitable habitat, barriers to the upstream migration of juveniles and the downstream migration of adults, and over-fishing. Restorative actions need to be focused on addressing all of these causes if they are to have long-term success in meeting the aspiration for fisheries and kai.

Tuna

For the tuna fishery, increases in suitable adult habitat can be achieved through improving the quality of existing habitat in streams and farm drains and establishing entirely new habitat through creating ponds and wetlands. These restorative actions should be focused in the lower Waikato downstream of the Karaapiro Dam, the major migratory barrier, as this is where habitat is most constraining on numbers. In the lower Waikato, there are approximately 1,600 km of drains and streams where suitable habitat could be created through weed control and riparian shading. A further 700 hectares of habitat could be established through the creation (or, in some cases, re-creation) of wetlands and ponds in low-lying areas and gullies. This combination of activities is estimated to create sufficient new habitat to support an additional 100 to 150 tonnes of tuna, approximately equal to the current commercial catch and ten times

the estimated current traditional harvest. The realisation of this benefit is dependent on other actions (see below) being implemented so that the new habitat becomes fully occupied.

Restoration of the tuna fishery upstream of Karaapiro Dam will require continued capture and transfer of juveniles (elvers) over all the dams up to and including Ohakurii. Currently, approximately two million elvers are captured and transferred every year but catch rate data suggest that the proportion of these reaching a size suitable as kai is low. Given the effort in elver capture, raising survivability holds the key to accelerating the restorative benefit derived from that effort. If the problem lies with survivability of elvers soon after transfer then effectiveness of upstream transfer could be improved considerably by the aquaculture of elvers to sub-adults prior to release. Such a capture – aquaculture – release approach has been practised in Europe and Australia but apparently with limited success so a thorough analysis of the approach would need to be done before this action was implemented. Suitable habitat is not currently a factor limiting the tuna population upstream of the dams indicating that major benefits could accrue to the upper Waikato fishery in the long-term, particularly if recruitment of elvers into the Waikato River were to increase and allow capture – aquaculture – release rates to increase.

Improving recruitment of elvers into the river will require that sufficient adults leave the river to spawn at sea. Efforts in Europe to restore tuna fisheries seek to ensure the downstream migration to the sea of 40 percent of the adult spawners that would have migrated prior to human influences and the Study has adopted that target here. Downstream migration barriers include the hydro dams and the pumps in flood protection schemes in the lower Waikato. Capture and downstream transfer (preferably with installation of protective measures at the intakes) although labour intensive, would seem to be the only practical action available at hydro dams. The replacement of existing pump systems with fish-friendly pumps (such as is practised in the Netherlands) in the flood protection works would allow downstream migration in the lower Waikato. There is strong evidence, obtained from hui and historical records (see Appendix 5: Tuna), that elver recruitment into the Waikato River has declined significantly over the last 50 years, mirroring the decline seen in tuna fisheries elsewhere. Although other factors are likely to play a part, on a numbers basis the assumption is made that to increase elver recruitment into the river more fish need to reach sexual maturity and migrate to spawning grounds at sea. As other actions are implemented through time and the tuna population rises the importance of increased downstream migration to maintain a self-sustaining and increased population will rise.

Complementary to the above actions, there are changes to the harvest size limits that would assist in restoring the tuna fishery. Under the current situation of low recruitment, increasing the minimum harvest size from 220 grams to 450 grams would increase the production obtained from each recruit. Reducing the upper size limit from four kilograms to two kilograms would provide more adults reaching sexual maturity and migrating downstream. Such actions would lead to an immediate and significant reduction in harvest for traditional and commercial purposes for several years until tuna achieve the larger harvest size. To further boost downstream migrants and consequently increase recruitment, Lake Whangapee (if restored) could be made a reserve free of any traditional, recreational or commercial tuna harvest. Our estimates indicate that such an action would provide a significant fraction of the downstream migrants needed to meet the 40 percent target referred to above (see Appendix 5: Tuna). In the longer term, and in conjunction with the other actions, such measures will lead to a larger fishery.

Because of the inter-dependencies between the actions described above, there will be an early need to develop a tuna management plan that has stakeholder buy-in and understanding. This plan will need to outline a logical sequence of actions so that restorative actions are effective. For example, there is little point in creating new tuna habitat in a stream when barriers to elver

migration remain downstream of that habitat. In the tuna management plan, it would seem appropriate to draw on the Maaori tradition of raahui.

Maatauranga Maaori indicates that raahui was used to protect tuna in the Waikato:

"Tuna were plentiful in Lake Waahi and Hakanoa when Maaori settlers first came to this area. In order to conserve the tuna supplies from both lakes, a rest period between fishing seasons was proclaimed by the local chief. He signified this by driving a pou-rahui (flax stick) into the ground. At the end of the rest period he heralded the start of a new fishing season by lowering the pou-rahui to ground level in front of the assembled people. In time, however, the groups living on the east and west banks quarrelled over the size of their respective eel catches. Friction developed and there was threat of bloodshed. The chief gathered his people together and said, "this quarrelling must cease. Behold I have driven the pou-rahui into the ground. When I cease speaking I shall lower it. From this day when our pou-rahui is lowered we will dance a haka of joy to show that we are all free from our bond not to fish for tuna. To commemorate this event the eastern lake shall be named Hakanoa. From today all eels taken from both lakes shall be divided evenly between our two groups and to record this, the western lake, shall be called Waahi." [122]

Because of these events, the Maaori name given to the Huntly area was Raahui Pokeka.

The costs of these actions are summarised in Table 5.9 below. For a full explanation of actions and their costs see Appendix 5: Tuna.

Table 5.9: Estimated costs (capital and operational) for some key restoration actions for tuna

Action	*Cost ($M)*
Develop and implement a management plan	15
Upstream elver transfer	6.7
Aquaculture of elvers to sub-adults, then release	17.3
Create farm ponds and wetlands in the Lower Waikato	177
Install and maintain fish-friendly flood control pumps	96.5
Install and maintain intake screens and bypasses at the hydro dams	600

Based on an analysis of relative gain (dollars per tonne of tuna restored) three actions stand out: development of a management plan (with harvest rules), upstream elver transfer, and aquaculture (see Appendix 5: Tuna for details).

Tuna are a long-lived species and it will take time before the benefits of restorative actions are seen. Year-to-year variability in elver recruitment and catch will continue and long-term trend data will be needed to discern the effectiveness of the restoration.

Whitebait

Restoration of the whitebait fishery will require an increase in the number of adults able to spawn as well as an improvement in the survival of the eggs that are produced. This could be achieved by the re-instatement of migration pathways, improvements to the habitat of the

[122] http://www.naumaiplace.com/site/waahi-paa/home/page/27/marae-history/#Namarua

juveniles and adults, and protection and enhancement of spawning areas. There would also be benefits in reducing the effects of pest fish, although effective methods of achieving this need to be investigated. Placing the whitebait fishery under a single regulatory authority could also be considered as a means of better managing harvest.

Actions required to restore the whitebait fishery are similar to those proposed to enhance the tuna fishery but will require strategies that recognise the differing needs of the main species harvested (mostly iinanga but also kookopu). No restoration of the upper Waikato kookopu fishery is recommended as the abundance of trout and smelt in Lake Taupoo and the hydro reservoirs would most likely negate attempts at restoration.

Iinanga is essentially a lowland species and to increase numbers the fencing and riparian planting of 450 kilometre of stream is proposed. Improving habitat and water quality of shallow lakes would further increase the number of adults able to be sustained. To take full advantage of existing and restored habitat, upstream passage for juveniles must also be restored but in a manner that does not allow passage of pest fish. Migration barriers such as tide gates, floodgates and poorly constructed culverts will need replacement or retrofitting with fish-friendly structures. Here, an initial target of 23 gates and over 100 road and farm culverts is proposed. Alongside habitat and migration pathways restoration, 11 kilometres of bankside iinanga spawning habitat within the estuary will need restoration. A further 0.8 kilometres of re-created iinanga spawning habitat is also proposed.

A GIS modelling analysis of potential habitat for adult kookopu has shown that restoration of a closed tree canopy over about 60 kilometres of small, elevated streams in the hills of the lower Waikato would increase high quality habitat by about 20 percent. Fencing and riparian planting of small streams currently running through open pasture would provide further improvements. To ensure passage of juvenile kookopu to these habitats, in addition to actions proposed for iinanga, some 3,000 farm culverts will need to be replaced or retrofitted.

The costs of potential restoration actions are summarised in Table 5.10 below. For a full explanation of actions and their costs see Appendix 6: Whitebait. Relative costs of the actions vary markedly as do gains, and no single action stands out as being more desirable, although removal of floodgates for iinanga in the Aka Aka/Otaua region is clearly the most expensive action possible. Inter-relationships between actions are strong and little gain can be acheived by restoring adult habitat of iinanga or kookopu without also ensuring free passage for migrants. Consequently, a staged catchment-by-catchment restoration programme is proposed alongside a gradual improvement of iinanga spawning habitat.

Table 5.10: Estimated total costs (capital and operational) for some key restoration actions for whitebait

Action	*Cost ($M)*
Restore and protect iinanga spawning habitat	5.9
Restore kookopu habitat in hill country streams	9.9
Replace or retrofit road culverts that are barriers to iinanga and kookopu	4.7
Modify farm culverts that are barriers to iinanga and kookopu	30.3
Install 'fish-friendly' tide gates to restore iinanga habitat	6.9
Restore iinanga habitat in streams and drains by fencing, planting and mechanical weed control	44.3
Remove flood control structures for iinanga in the Aka Aka/Otaua region	220.2
Re-introduce giant kookopu into restored urban streams	0.2
Create a single whitebait management agency	7.5

Benefits of restorative actions proposed will not be immediate as habitat restoration, notably the development of bankside vegetation will take at least a decade to show results. As for tuna, year-to-year variability in whitebait recruitment and catch will continue and long-term trend data will be needed to discern the effectiveness of the restoration.

5.2.11 Other taonga species

In addition to tuna and whitebait, there is a strong desire to restore the abundance of other taonga species, both plants and animals (see Section 4).

Important traditional fisheries requiring restoration are piiharau, kaaeo/kaakahi and kooura but there is currently insufficent information about the habitat requirements of these species and the causes of their decline (see Section 3) to be confident in recommending restoration actions solely targeted towards them. Evidence suggests that restorative actions for whitebait involving removal of migration barriers and restoration of headwater stream habitat would have co-benefits for piiharau, particularly in tributaries of the Waipa where remnant populations currently exist. For kaaeo or kaakahi, the freshwater mussel, actions to improve water quality and the abundance of fish may enhance their abundance. Previous research has indicated a relationship between water quality and kaaeo/kaakahi abundance but it is uncertain whether this is a cause-effect relationship. It is known that an early larval life stage of kaaeo/kaakahi is parasitic on fish and therefore restoring fish abundance may be an important requirement for the restoration of kaaeo/kaakahi. Actions to restore water quality and stream habitat that involve riparian fencing and planting are likely to have co-benefits for kooura abundance.

The planting of riparian margins with species of particular significance to Maaori is a key restorative action. Enhanced riparian management is a 'cross-cutting' action that is required to address several of the aspirations held and it will be important to ensure that when this action is implemented the specific needs of cultural practice are incorporated into planting plans.

Many actions to address other aspirations will be carried out and will consider taonga species enhancement in their justifications and implementation. For example, including taonga plant species and species that provide food for taonga bird species in riparian planting lists. There are, however, two specific actions – conduct research on piiharau, kaaeo/kaakahi and kooura that increases understanding of the ecology of these species such that actions for their restoration and protection can be better defined (see Appendix 8: Fisheries Research) and progressively re-introduce these taonga species as suitable habitats become available and restorative actions are perfected. Current mechanisms for funding of research should be used.

Table 5.11: Estimated total costs (capital and operational) for some two key restoration actions for taonga species

Action	Cost ($M)
Re-introduce taonga species	3.5
Supporting research on taonga species (This action is costed in Section 5.2.2.5)	(30)

5.2.12 Ecological integrity

Ecological integrity of the river will be enhanced by the package of actions described in this chapter, such as actions to reforest riparian areas (see 5.2.7, 5.2.9), improve connectivity for migratory fish (see 5.2.10) and reduce contaminant inputs (see 5.2.8, 5.2.9). These will be complemented by actions to further enhance ecological integrity involving restoration of a subset of Waikato shallow lakes, most of which are in a degraded state (Neilson, 2008).

The goals of shallow lakes restoration are:

- Improved water clarity and indicator bacteria (limited by waterfowl) to meet bathing standards in fine weather.
- Lake nutrient and chlorophyll concentrations meeting mesotrophic condition or better.
- Significant improvement of lake aesthetics on margins (planting, diversity, wetlands) and in water quality (colour and clarity).
- Significantly expand habitat that suits New Zealand native biodiversity for aquatic plants, terrestrial plants and aquatic biota.
- Restore native macrophytes in lake margins and bottom, which will contribute to iinanga habitat.
- Significantly expand the tuna fishery.

The restoration activities and their results will contribute to many other aspirations for a healthy and well Waikato River (including access, engagement, and recreational value). They will assist the river iwi to exercise manaakitanga and kaitiakitanga, and reinforces values such as respect and whaanau.

It is possible to restore the ecological health of the lakes to varying degrees, and the costs of restoration will not be identical for any two lakes. Table 5.12 presents cost estimates for bundles of actions at medium and high restoration levels. The medium-level actions are considered highly likely to achieve improvements, with the aim of restoring lakes to a known prior water quality (e.g., 1950s for dune lakes), whereas the high-level actions are expected to deliver more substantial and faster improvements (see Appendix 12: Shallow Lakes).

For the smaller lakes, the Study team has costed restoration of two dune lakes and four peat lakes. These could then serve as models for restoration of other lakes of that type.

Costs are also presented here for restoring two large riverine lakes that previously had very high values (Waahi and Whangapee) and the largest hydro lake (Ohakurii). The largest Waikato lake, Waikare, is not included in these costings because evidence (Reeves et al., 2002) indicates that Waikare's use for flood flow storage in the Lower Waikato Flood Scheme limits the prospects for restoration relative to Waahi and Whangapee (see Appendix 12: Shallow Lakes). Environment Waikato is currently working with local landowners, iwi, community groups and other agencies to improve the health of Lake Waikare. They are also working with landowners in the Matahuru catchment to protect streams flowing into the lake, which will help in reducing the amount of sediment reaching the lake. These actions are designed to reduce the likelihood of further degradation and bring about some improvement but are not a full restoration plan.

The actions in Table 5.12 build on those for farm contaminants and aesthetics. More detailed rationale and the costs of individual actions are provided in Appendix 12: Shallow Lakes.

Table 5.12: Summary of Waikato lake restoration actions for medium and high levels of restoration actions and estimated costs

Lake type	*Medium level*	*High level*
2 Dune lakes (e.g., Otamatearoa, Parkinson, Taharoa, Puketii, Rotoroa, Whatihua)	10 m planted buffers around lakes, herbicide control of submerged weeds, public access and amenities, monitor using LakeSPI.	50 m planted buffers around lakes, grass carp control of weeds, public access and amenities, monitor using TLI and LakeSPI.
	Total cost = $2M	Total cost = $2.8M
4 Peat lakes (e.g. Serpentine, Rotomaanuka, Ruatuna, Ngaaroto, Mangakaware, Kaituna, Kainui)	50 m planted buffers around lakes, infiltration filters and ring drains to bypass peak flows. Intensive netting of pest fish. Access provided. Monitor using LakeSPI. One lake with 10 m willow control needed. Two lakes with weirs.	50 m planted buffers around lake. Infiltration filter and ring drain to bypass peak flows. Sediment capping (Aqua-P). Raise water table with outlet bund. Pest fish eradication using Rotenone and add selective fish pass to prevent upstream passage of pest fish but allow tuna passage. Public access and amenities. Monitor using TLI and LakeSPI. One lake constructed wetland. One lake with 10 m willow control needed. Two lakes with weirs.
	Total cost = $19M	Total cost = $39M
Whirinaki Arm, Lake Ohakurii	10 m planted buffer on main stem as part of aesthetics, 1 percent catchment area constructed wetland Whirinaki Arm, aquatic weed control using herbicide Whirinaki Arm, monitor using LakeSPI.	Planting 10 m buffer on main stem as part of aesthetics, 3 percent constructed wetland, aquatic weed control using herbicide, sediment capping whole lake (also costed under Human Health), monitor using TLI and LakeSPI.
	Total cost = $27M	Total cost = $36M
2 large riverine lakes, Waahi and Whangapee	10 m planted buffer around lake. Intensive netting for control of pest fish. Poison willow from shoreline. Plant native emergent vegetation along portion of shoreline. Public access and amenities. Monitor using LakeSPI.	50 m planted buffers around lakes. Constructed wetland three percent of catchment area. Dredge top layer of sediment. Intensive netting for control of pest fish. Poison all willow and replant. Plant native emergent vegetation and submerged vegetation. Grass carp control of aquatic weeds. Wave barriers. Public access and amenities. Monitor using TLI and LakeSPI.
	Waahi = $12M; Whangapee = $23M	Waahi = $37M; Whangapee = $112M

TLI = Trophic Lake index; LakeSPI = Lake Submerged Plant Indicators[123].

[123] http://lakespi.niwa.co.nz/index.do

5.2.13 Secure water supply

Reliable and continued ability to take and use water is a key aspiration. Actions to meet this aspiration need to focus on ensuring efficient and equitable allocation whilst not compromising other aspirations held for the river (e.g., spiritual values, aesthetics, water quality and ecological integrity). While the Waikato has not generally been regarded as a 'water-short' region there are emerging issues of growing and competing demand for the resource (see Section 3). These issues have prompted Environment Waikato to develop a variation to its Regional Plan, known as Variation 6, that is "*designed to proactively future proof the water allocation system in the region, and allow for more efficient and equitable distribution of water use rights*" (Environment Waikato press release 31 October 2008). Variation 6 is currently under Appeal to the Environment Court.

The principles, objectives and proposed rules in Variation 6 are largely aligned with the aspirations held for restoring a 'healthy and well' river. These include considering the implications of water take on taangata whenua values, ecology, assimilative capacity, water supply, hydro-electric power generation, holistic management, and cumulative effects. Priority is given to meeting the drinking-water requirements of people and animals, to ensuring no reduction in the ability to derive energy from the hydro dams and to maintaining existing use rights. It could be argued that establishing these priorities has subjugated other uses for the water to a 'scrap over what is left'. In particular, there seems to be a lack of recognition of the status of taangata whenua and the priority that should be accorded to Maaori aspirations for the awa. This appears at odds with the Waikato-Tainui Raupatu Claims Settlement Bill and the Deeds of Settlement with other river iwi.

Given that Variation 6 addresses many of the water take issues identified in this Study, there is no need for additional costing of actions here. Instead, we recommend the Waikato River Authority ensures that:

- Policies and rules included in the final version of the revised Regional Plan are consistent with the restoration objectives in Te Ture Whaimana.
- Implementation of these policies and rules (e.g., through consents for water take) remain consistent with the restoration objectives in the Te Ture Whaimana, including giving status and recognition in decision making to the special relationships hapuu and iwi have with the river.
- Implementation of these policies and rules when setting environmental and allocable flows takes into account the potential effects of other restoration actions, in particular changes in flow regime as a result of afforestation of pasture.

5.3 Concluding comments for potential actions

The potential individual actions outlined above and in the relevant appendices need to be evaluated from a broader perspective – that is, combination of actions best able to address the objectives of Te Ture Whaimana and the aspirations held for the river (Section 4) and, therefore, meet the desired state.

In this Section the Study team has shown that single actions often influence more than one aspiration and actions can have interdependencies (e.g., restoring fish habitat is only worthwhile if migration barriers have been removed). There is a need to 'bundle' actions and predict their cumulative benefits. In Section 6 the Study team describes the restoration benefits of three different 'bundles of actions' and, from that, a list of recommended priority actions is derived (Section 7).

6. Scenario modelling

6.1 Introduction

In Section 5 the Study team described potential actions that could be implemented to meet each of the aspirations that together define a healthy and well Waikato River – that is, actions that aim to 'bridge the gap' between the current state (Section 3) and the desired state (Section 4). Section 5.1 describes the complexity inherent in the analysis we are undertaking – each aspiration requires more than one action, single actions often influence more than one aspiration (either positively or negatively), and actions can have interdependencies as can aspirations. These complex interactions are dealt with in this Section, where the Study team has used scenario modelling to predict the cumulative benefits of implementing three different 'bundles of actions' (i.e., scenarios) and whether they achieve the full suite of aspirations held for the river. In Section 7 the findings of this scenario modelling are used to recommend a set of priority actions to meet Te Ture Whaimana – the Vision and Strategy for the Waikato River.

In addition to predicting benefits, the scenario modelling also estimates the extra investment required (from whatever source) and the economic effects of each scenario. This economic modelling is an integral part of our analysis, as the vision for the river seeks to achieve a healthy river that sustains both abundant life and prosperous communities – these two aspects to the vision are reflected in the aspirations held for the river and need to be considered together when evaluating restoration options. Scenario modelling can show the extent to which these two aspects are met or are in conflict and therefore assist the Waikato River Authority in its decision making.

In estimating the benefits and costs of restoration actions the current environmental pressures and economic settings were used as the baseline – that is, the Study team chose not to make any prediction of changes to these baselines through time. The Study team recognises that such changes may well occur and significantly alter both the predicted benefits and cost. For example, increased environmental pressure (e.g., expansion and intensification of dairy farming) could reduce or even negate the benefits that are derived from restoration actions. The Waikato River Authority will need to exert its influence on regional policies and plans to ensure that objectives of Te Ture Whaimana are given full effect: adoption of the precautionary approach towards decisions that may result in significant adverse effects, the avoidance of

adverse cumulative effects and recognition that the river should not be required to absorb further degradation as a result of human activities.

6.2 Description of the three scenarios

The three scenarios modelled were:

Scenario 1:

The current state of the Waikato River represents the result of past actions and inactions – it does not represent what could be achieved if current statutory and non-statutory instruments are fully implemented and given time to take effect. This scenario sought to answer the question: *"Will we meet the aspirations held for a healthy and well river if we apply current practices to meet existing rules in the regional plan and industry codes of practice?"* Addressing this question is important as it seeks to establish what future progress can be made towards restoring the river at the current level of investment and activity. The shortfall between this scenario (taken as zero extra cost, with costs assumed to lie where they currently fall) and that required for a healthy and well river, represents the extra investment required to achieve the objectives of Te Ture Whaimana.

Scenario 2:

This scenario includes all the restoration actions of Scenario 1 plus evaluates the benefits which would accrue from applying a package of those restoration actions that were individually shown in Section 5 (and associated appendices) to have the greatest benefits, a high probability of success (i.e., implementation risk is low) and, preferably, a high benefit to cost ratio compared with other actions to address the same aspiration. The purpose of running this scenario was to determine whether such an 'optimised' package of restoration actions delivered the benefits required to achieve the objectives of Te Ture Whaimana.

Scenario 3:

This scenario includes all the restoration actions of Scenario 2 plus those additional actions shown in Section 5 that promise further benefit but were not well-proven and/or had low benefit to cost ratios. These additional actions are therefore regarded as 'actions of necessity', only being recommended if the analysis was to show that they were required to meet the aspirations held for a healthy and well river.

6.2.1 What actions are in each scenario?

Table 6.1 lists all the actions which form part of each scenario. These actions are described in Section 5 and detailed in the appendices referred to in the Table.

Table 6.2 then identifies which aspirations are addressed by various actions in each scenario.

Many of the actions outlined in Section 5 have 'degrees' of implementation, and the Waikato River Authority will have to decide how much is enough (not too little, not too much) to meet Te Ture Whaimana. The Study team recommends that for many actions the Authority adopt an 'adaptive management' approach, often said to have been used by Maaori in pre-European times, where actions are implemented incrementally. The scenarios approach is a useful way to illustrate this. For example, each scenario (1, 2 and 3) implements the engagement actions more fully than the previous scenario, requiring larger investment in return for greater benefits. In Section 7 the Study team outlines its recommended bundle of priority actions and discusses the use of adaptive management.

Table 6.1: Potential actions to meet the aspirations held for a healthy and well Waikato River and the links to Te Ture Whaimana
S1 = Scenario 1, S2 = Scenario 2, S3 = Scenario 3

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
a. Dairy farm systems (Appendix 9: Farms)	
S1: Optimise P fertiliser to soil test results; enlarge effluent irrigation areas; provide 1 month effluent storage; reduce effluent application depth, add berms on farm lanes to direct run-off away from streams and fully exclude cows from streams[124]. **S2:** S1 + Nitrification inhibitors; wetlands installed on 1 percent of farm area; 5 metre wide native planted buffers on streams. **S3:** S2 + winter herd shelters	Likely benefits: • Economic optimum reduces P loss and improves farm profit. Improved effluent management reduces effluent run-off risk (nutrients, sediment, pathogens) and enhances farm utilisation of nutrients and animal health. • Berms and stock exclusion prevents direct inputs of faeces and urine and streambank damage. • Inhibitors reduce nitrate loss and boost pasture growth. • Wetlands and vegetated riparian buffers reduce nutrient, sediment and pathogen loss to streams and improve stream habitat and biodiversity. • Winter herd shelters reduce nutrient, sediment and pathogen loss and enhance pasture production by protecting soil health. Aspirations addressed: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 Te Ture Whaimana objectives addressed: : A, D, E, G, H, K, M
b. Sheep-beef farm systems (Appendix 9: Farms)	
S1: Provide trough water and shade away from streams and exclude all stock from iinanga spawning areas and priority lake margins[125]. **S2:** Fence cattle out of streams and plant poplars on each side of streams. **S3:** Pine afforestation of 60 percent of pasture on SB3 and 25 percent of pasture on SB4 farms[126] and fence (8-wire post and batten) and plant 15 metre native buffers.	Likely benefits: • Reduces slightly the direct inputs of livestock excreta and streambank damage and enhances iinanga spawning success and lake margin vegetation. • Reduces diffuse run-off, stream temperature and enhances stream habitat • Reduces erosion, direct and indirect contaminant input, streambank damage and water temperature. • Improves stream clarity and sequesters carbon. Aspirations addressed: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 Te Ture Whaimana objectives addressed: A, D, E, G, H, K, M

[124] This is a slight extension of the requirements of the Dairying and Clean Streams Accord.
[125] Waikato Regional Plan Section Rule 4.3.5.3-6 requires livestock exclusion from iinanga spawning on large rivers and priority lakes.
[126] Farm classes follow Meat and Wool New Zealand Limited (2010) – see Appendix 9 – Farms for class defintions.

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
c. Urban stormwater (Appendix 18: Urban Stormwater)	
S1: Encourage local authorities to require infiltration of storm water wherever practicable and to continue application of Sustainable Urban Design Systems (SUDS) in new urban developments. Collaborate with local authorities to educate public to reduce contaminant inputs and enhance on-site storm water treatment (e.g., rain gardens). **S2**: 10 m wide native restored riparian buffers and walkways where particularly lacking in rural towns, enhance access for 'climbing' native fish species and restore giant kookopu to suitable habitat. **S3**: Comprehensive urban storm water treatment retrofits.	Likely benefits: • Reduces run-off and contaminants, enhances baseflow and stream habitat. • Enhances recreation, stream habitat, terrestrial and aquatic biodiversity (e.g., plants, birds, stream invertebrates and fish), and whitebait and tuna production. Aspirations addressed: 5, 6, 7, 8, 9, 10, 11, 12, 14, 15 Te Ture Whaimana objectives addressed: A, D, E, F, G, H, K, L, M
d. Riparian aesthetics (Appendix 11: Riparian Aesthetics)	
S1: Fence and plant 10 metre buffers on unfenced pasture grass/willow areas on the main stem of the Waikato and Waipa Rivers (6th and 7th order reaches). **S2:** As above on 5th, 6th and 7th order streams. **S3:** As above on 3rd to 7th order streams.	Likely benefits: • Enhances river aesthetics, with increasing benefit as extended to smaller streams. • Co-benefits for reducing contaminant inputs, streambank stability, shade (temperature and instream plant control), native fish habitat, terrestrial biodiversity, cultural materials, recreation/access, flood peak control and stock shelter. Aspirations addressed: 2, 3, 5, 6, 7, 10, 11, 12 Te Ture Whaimana objectives addressed: A, B, C, D, E, H, I, J, L, M
e. Colour and clarity (Appendices 9 and 19: Farms and Kinleith Discharge)	
S1: See farm systems S1 and keep a watching brief on Kinleith consents as they continue to improve effluent treatment. **S2:** See above S1 and Farming systems S2.	Likely benefits: • Reduces nutrients for algal growth, direct input of yellow-brown organic matter and fine sediment. • Improves clarity due to reduce streambank and hill slope erosion.

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
S3: See above S1 and Farming systems S3.	Aspirations addressed: 6, 7, 9, 10, 11, 12, 15 Te Ture Whaimana objectives addressed: A, B, C, D, E, G, H, I, K, L, M
f. Geothermal contaminants (Appendix 21: Toxic Contaminants)	
S1: Keep a watching brief on Wairakei consents as they continue to improve effluent treatment and lobby for re-injection of all geothermal wastes. **S2:** Laboratory and field trials of sediment immobilisation for Arsenic (As) and Mercury (Hg) control in the hydro lakes and conduct risk assessment and management of the 'food basket' in areas affected by natural geothermal inputs. **S3:** Apply As and Hg controls to Lake Ohakurii bed.	Likely benefits: • Reduces input of mercury, arsenic, sulphides and heat and in-river legacy sources of mercury and arsenic. • Reduces risk of human intake to levels that cause harm. Aspirations addressed: 6, 8, 10, 11, 12, 13 Te Ture Whaimana objectives addressed: A, C, D, E, F, G, H, K, M
g. Marae drinking-water (Appendix 17: Marae Water Supply)	
S1: N/A **S2:** Identify where marae water is unsatisfactory and supply point of entry treatment plants for 10 marae. **S3:** Supply point of entry treatment plants for 67 marae.	Likely benefits: • Reduce health risks and enhance hospitality. Aspirations addressed: 8, 9, 13 Te Ture Whaimana objectives addressed: B, C
h. Sewage discharge to land/wetlands (Appendix 14: Wastewater Management)	
S1: N/A. **S2:** Land/wetland disposal at 3 sites where it is known to be technically feasible. **S3:** As above.	Likely benefits: • Meets cultural needs. • Reduces nutrient input. Aspirations addressed: 3, 6, 8, 9, 14 Te Ture Whaimana objectives addressed: A, B, C, E, H, K, M
i. Pathogens (Appendices 9, 10 and 14: Farms, Faecal Contamination and Wastewater Management)	
S1: See Farming systems S1. **S2:** See Farming systems S2, plus upgrade septic tank	Likely benefits: • Reduces direct and run-off input of animal faecal material and input of human pathogens to both groundwater and surface waters.

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
cleaning frequency. **S3:** Upgrade septic tank cleaning frequency, plus Farming systems S3 and sewage discharge to land/wetlands S3.	Aspirations addressed: 3, 6, 8, 9, 13 Te Ture Whaimana objectives addressed: A, B, C, D, E, F, G, H, J, K, L, M
j. Access, boating and recreation (Appendix 25: Boat Ramps)	
S1: Footpaths from marae adjacent to river/lake. **S2:** Development of strategic plan; access to river/lakes from marae and develop 16 boat ramps at marae; identifying sites to enhance or restrict access; extend foot/cyclepaths on the banks of the Waikato and Waipa River main stems. **S3:** Implement access plan (as in S2), private access to some waahi tapu sites and develop four new public reserves. Identify and address legal constraints.	Likely benefits: • Enhances access for Maaori to river and lakes, public access to the river and tourism. • Protects culturally sensitive sites and reduces use conflicts. • Enhances waka ama, waka taua and general boating. Aspirations addressed: 2, 5, 6 Te Ture Whaimana objectives addressed: A, B, C, D, E, I, J, L
k. Physical hazards (Appendix 23: Hydro Dams)	
S1: Lobby Mighty River Power to enhance signage and advertising on hydro peaking and continue to manage hydro peaking to reduce impacts on river-based events. Lobby Environment Waikato to manage snags at boat ramps and swimming points and control aquatic weeds in hydro lakes boat lanes and rowing lanes. **S2:** Control aquatic weeds at selected major swim/boat sites. **S3:** Control aquatic weeds at all common swim/boat sites.	Likely benefits: • Enhances water safety. Aspirations addressed: 5, 6 Te Ture Whaimana objectives addressed: J, L
l. Significant sites (Appendix 26: Significant Sites)	
S1: Identify key waahi tapu and recent historic sites in district plans and put sensitive sites in a hidden file.	Likely benefits: • Reduces risk of conflicts based on lack of information and understanding.

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
S2: Develop a strategic plan on waahi tapu and historic sites covering restoration, identification/mapping/GIS layers to councils, signage, publicity, access and education. **S3:** Support development of appropriate signage and undertake key site restoration. Update strategic plan with place names to be appropriately documented and confirmed through New Zealand Geographic Board.	• Protects sensitive cultural knowledge. • Prioritises restoration and protection. • Enhances cultural knowledge, identity, tourism and protection and restoration of key sites. Aspirations addressed: 3, 4, 5 Te Ture Whaimana objectives addressed: A, B, C, D, E, I, J, L
m. Whitebait (Appendices 6, 9 and 12: Whitebait, Farms and Shallow Lakes)	
S1: See Farming systems S1 + plant (and fence) 5.5 kilometre length of spawning habitat along Waikato River bank and 0.8 kilometre of side streams. Encourage farmers to plant appropriate vegetation on streambanks fenced under the Dairying and Clean Streams Accord along prime potential iinanga habitat on lowland streams and on banded kookopu habitat in upland headwater streams and to remove all significant road and farm track culvert barriers. **S2:** Install iinanga-friendly flood and tide gates on 23 sites in the Aka Aka/Otaua and add a further 4 kilometres of new spawning habitat in embankments. In conjunction with farming systems S2, plant 450 km of streambank of lowland drains with low-lying vegetation and another 60 kilometres of potentially optimal banded kookopu habitat with shade trees; manage aquatic weeds in 900 kilometres of drains; provide fish passage at 1,500 culverts. Customary take is increased and fishery placed under single regulatory authority. Research is conducted on pest fish impacts. **S3:** As with S2 except remove all 23 tide gates in the Aka Aka Otaua region. In conjunction with Farming systems S3, plant appropriate riparian vegetation on dry stock farms to	Likely benefits: • Enhances whitebait spawning success. Note that stock exclusion from key whitebait spawning areas is required by Environment Waikato Regional Plan. Enhances and creates wetland spawning and rearing areas and also increases habitat for tuna, other native fish, birds and wetland plants. Riparian shading reduces drain clearing and flooding. Aspirations addressed: 10, 11, 12, 14 Te Ture Whaimana objectives addressed: A, B, C, D, E, F, G, I, J, L, M

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
enhance banded kookopu habitat. Also see dune lakes, peat lakes, Lakes Waahi and Whangapee S3.	
n. Tuna (Appendices 5 and 12: Tuna and Shallow lakes)	
S1: Elver transfers from below Karaapiro and release in hydro dams and lobby Environment Waikato/farmers to remove all significant road and farm track culvert barriers. **S2:** On-grow elvers to juvenile tuna before release in the hydro dams. Install 65 tuna-friendly pumping stations and screening and transfer of adult migrant tuna downstream at Karaapiro dam. Create 700 hectares of adult wetland habitat as ponds (0.2-5 hectares). Adopt tuna size no-take limit to protect spawners in lower river. Create tuna reserves (e.g., in restored Lake Whangapee) and ban fishing in greater than third order streams. Prepare tuna management plan. **S3**: Install screening and transfer adult migrant tuna downstream at 2 Waikato hydro intakes. Also see Dune lakes, peat lakes, Lakes Waahi and Whangapee S3.	Likely benefits: • Enhances recruitment to access restricted areas and habitat created by dams. • Increases survival of tuna released in hydro dams. • Increases tuna habitat and production. • Provides elver and tuna access past all the perched culverts restricting access to potential stream habitat. • Improves escapement for spawning of mature tuna and contributes to maintaining recruitment. Aspirations addressed: 10, 11, 12, 14 Te Ture Whaimana objectives addressed: A, B, C, D, E, F, G, I, J, L, M
o. Dune lakes, peat lakes, Lakes Waahi and Whangapee (Appendices 9 and 12: Farms and Shallow Lakes)	
S1: See farming systems (e.g., cows excluded). **S2:** Extend farming systems S2 to a 10 metre planted buffer around lakes (50 metres in peat lakes) and control of submerged weeds using appropriate herbicide. Treat peat lake inflows using infiltration filters and ring drains to bypass peak inflows and install control weirs/bunds at outlets of peat lakes to raise lake water level. Plant native emergent vegetation along portion of shoreline of large riverine lakes. Provide public access and amenities. **S3:** Extend S2 (above) and farming systems S3 to a 50	Likely benefits: • Excludes direct access by dairy cows reducing browsing on vegetation, nutrient and pathogen inputs and lake margin damage. • Reduces contaminant inputs in run-off and seepage and enhances biodiversity, and protects marginal vegetation. • Enhances whitebait and tuna fisheries. • Improves access and recreational use. Removes weeds, improving native vegetation, biodiversity and recreation. • Enhances peat lake sustainability. • Reduced lake internal phosphorus loads, algal blooms, enhancing water clarity. • Monitoring supports adaptive management.

Potential actions	Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River
metre planted buffer around lakes. Use grass carp to control aquatic weeds in dune lakes. In peat lakes, eradicate pest fish using Rotenone and add selective fish pass to prevent upstream passage of pest fish but allow tuna passage. Construct treatment wetlands at lake inflows to peat and riverine lakes. Immobilise phosphorus in peat lake sediments. Dredge top layer of sediment and build wave barriers in large riverine lakes.	Aspirations addressed: 3, 4, 5, 6, 7, 9, 10, 11, 12, 14 Te Ture Whaimana objectives addressed: A, B, C, D, E, F, G, I, J, K, L, M
p. Lake Ohakurii (Appendices 9 and 12: Farms and Shallow lakes)	
S1: See farming systems (e.g., cows excluded) and river riparian aesthetics. **S2**: Extend farming systems S2 to a 10 metre planted buffer around the Lake Whirinaki Arm and install constructed wetlands on inflows to Arm. Control aquatic weeds using herbicide. Immobilise phosphorus in Whirinaki Arm sediments. **S3:** See farming systems S3 and S2 above + construct wetlands on inflows to whole lake and treat Lake Ohakurii sediments to immobilise phosphorus.	Likely benefits: • Excludes direct access by dairy cows reducing browsing on vegetation, nutrient and pathogen inputs and lake margin damage. • Reduces contaminant inputs in run-off and seepage and enhances biodiversity, and protects marginal vegetation. • Reduces lake external and internal nutrient loads, reducing algal blooms, and enhancing water clarity. • Enhances aesthetics. • Phosphorus immobilisation has a co-benefit of arsenic immobilisation. Aspirations addressed: 4, 5, 6, 7, 9, 10, 11, 12, 14 Te Ture Whaimana objectives addressed: A, B, C, D, E, F, G, I, J, K, L, M
q. Water allocation (Appendix 15: Water Allocation)	
S1: The Waikato River Authority keeps a watching brief on the policies and rules included in the final version of the revised Regional Plan Variation to ensure they are consistent with the restoration objectives in Te Ture Whaimana, including giving status to the rights of taangata whenua. **S2:** Ensure water takes consider the impacts of land use and riparian actions undertaken under S2 on environmental and allocable flows. **S3:** Ensure water takes also consider the impacts of land	Likely benefits: • The proposed Variation 6 for water allocation appears to address most of the requirements for sustainable flow necessary for successful restoration actions. • Taking land use changes and riparian management into account will protect environmental flows and assimilative capacity. • Using water quality targets for assessing assimilative capacity implications will meet water quality aspirations. Aspirations addressed: 6, 11, 12, 13, 14, 15 Te Ture Whaimana objectives addressed: A, B, C, D, E, F, G, J

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
use and riparian actions undertaken under S3 on environmental and allocable flows.	
r. Waikato hydro peaking (Appendix 23: Hydro dams)	
S1: The Waikato River Authority keeps a watching brief on results of ongoing monitoring of potential impacts required under Mighty River Power's consents. **S2:** As above. **S3:** As above.	Likely benefits: • Mighty River Power's consents require monitoring of effects of hydro peaking and reporting to Environment Waikato. Aspirations addressed: 5, 6, 11, 12, 14, 15 Te Ture Whaimana objectives addressed: A, B, C, D, E, F, G
s. Engagement - Schools (Appendix 27: Engagement)	
S1: Develop links with existing programmes. **S2:** Collaborate with Ministry of Education, University of Waikato Science hub, Royal Society Environmental Monitoring and Action Project and the teachers' fellowship programme, Environment Waikato educators and Enviroschools to prepare curriculum materials on the Waikato River and its rehabilitation for primary and secondary schools. **S3:** S2 + develop a supplementary activity to add to curriculum resource pack every year and annual 1-day professional development workshops for teachers.	Likely benefits: • Provides students with improved understanding of the Waikato River and their role in restoration of its health and wellbeing. • Engages students in monitoring and sharing information between schools in catchment. • Builds additional capacity and awareness amongst educators and engages the community on issues and their role in restoring the health and wellbeing of the Waikato River. Aspirations addressed: 2, 3, 4 Te Ture Whaimana objectives addressed: A, B, C, D, J
t. Engagement - Capacity and education (Appendix 27: Engagement)	
S1: Develop links with existing programmes (e.g., DairyNZ, Environment Waikato). **S2:** Commission 'issues and options' articles on key aspects of the Waikato River Independent Scoping Study and publish in a variety of media. Commission appropriate level	Likely benefits: • Providing easily accessible and simple tools for restoration will improve the communities' ability to contribute to restoration of the Waikato River. • Updates will help engage the wider community on Waikato River Authority activities and progress and showcase success. • Media programmes will raise national awareness of strategic importance of the Waikato

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
'how to' handbooks on activities that enhance Te Ture Whaimana, such as riparian management (including plants that provide cultural services such as kai, craft and medicines), wetland restoration and creation, hot-spot contaminant source management on farms and in urban areas, monitoring and assessment methods (e.g., kooura monitoring using tau-kooura). Promote handbooks in two annual marae-based waananga/workshops on Te Ture Whaimana topics. Support a biannual river festival including international research conference (like Brisbane River Festival), cultural events, water sports and entertainment. **S3:** See above + produce a Waikato River quarterly magazine, distributed throughout the catchment (hard copy and ePaanui). Collaborate with a television production company to create annual 30 minute television documentaries on the Waikato River. Establish iwi-based restoration training (in partnership with NZQA) and employment development initiatives (e.g., native plant nurseries, koi carp removal programme).	River to New Zealand and increase engagement with restoration actions. • Handbooks and training workshops will support up-skilling for new employment opportunities associated with rehabilitation and accelerate protection and enhancement of significant sites, fisheries, flora and fauna. Aspirations addressed: 1, 2, 3, 4 Te Ture Whaimana objectives addressed: A, B, C, D, I, J, K, L, M
u. Engagement - Research capacity (Appendix 27: Engagement)	
S1: Develop a signed agreement between the Waikato River Authority and University of Waikato, NIWA and the Waikato-Tainui College for Research and Development to encourage targeted research programmes. Waikato River Authority to lobby the Ministry of Science and Innovation to support research on Waikato River. **S2:** Support 3 post-graduate students in targeted research studies that include the application of maatauranga Maaori in the development of tools and/or scientific research on restoration of taonga species, habitats and catchment mitigation tools; establish international networks.	Likely benefits: • Reduces knowledge gaps in fisheries research, and improves partnerships between iwi and research organisations. • Accelerates restoration outcomes through the application of new tools and greatly increased capacity. • Recognition of strategic importance of the Waikato River to New Zealand. • Increased research capacity developed through international networks. Aspirations addressed: 1, 2, 9, 10, 11 Te Ture Whaimana objectives addressed: A, J, M

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
S3: See above S2 + support a Waikato River Research Chair to coordinate all research in catchment, and supervise 5-7 supported post-graduate students.	
v. Engagement - Waananga/visitor centres (Appendix 27: Engagement)	
S1: N/A **S2:** Establish a centralised waananga/visitor education centre to engage Waikato people and tourists on the history, issues and actions to restore the river. **S3:** Expand to establish one waananga per river iwi.	Likely benefits: • Provides a focus for education and outreach to build linkages and enthusiasm to accelerate actions towards Waikato River cleanup. Aspirations addressed: 1, 2, 3, 4 Te Ture Whaimana objectives addressed: A, B, C, D, H, I, J
w. Engagement - Co-management protocols, joint decision making panels	
S1: N/A **S2:** Train two persons per river iwi as Resource Management Act consent hearings commissioners. **S3:** Resource Management Act workshops run by commissioners for group training with river iwi every two years.	Likely benefits: • Increased capacity for Maaori contribution to key decision making processes. Aspirations addressed: 1, 2, 3 Te Ture Whaimana objectives addressed: A, B, C, E, G I, M
x. Engagement - Community group coordination and collaboration (Appendix 27: Engagement)	
S1: N/A. **S2:** Improve coordination of community groups focused on Waikato River restoration and protection (e.g., land care and stream care groups) by supporting coordinator and gap filling to achieve better integration of efforts across catchment. Support community meetings in support of joint restoration initiatives (4 x 1 per region/yr). **S3:** See above S2 + provide seed funds to facilitate	Likely benefits: • Enhance river restoration progress through information sharing, joint learning, cross-cultural volunteer action and community assessment of outcomes. Aspirations addressed: 1, 2, 3 Te Ture Whaimana objectives addressed: A, B, C, D, E, I

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
collaborative community-led projects.	
y. Engagement - Industry collaborations (Appendix 27: Engagement)	
S1: Build partnerships with e.g., DairyNZ, MeatNZ, Fonterra, Federated Farmers, AFFCO, Kinleith Pulp and Paper Mill, Fish & Game NZ and Forest & Bird to coordinate activities that enhance Te Ture Whaimana. **S2:** Develop a joint accord with key primary industries. **S3:** Support 2 industry Vision and Strategy awards and provide seed money for 50:50 partnerships with industry for restoration projects.	Likely benefits: • Enhance progress through collaboration, positive relationships and education using existing extension networks. Aspirations addressed: 1, 2, 9, 14, 15 Te Ture Whaimana objectives addressed: A, B, C, D, E, I
z. Engagement - Restoration awards (Appendix 27: Engagement)	
S1: N/A **S2:** Sponsor new awards for river, lake, riparian and wetland activities that improve health and wellbeing to complement the Farm Environment Awards trust activities, Maaori Farming awards etc. Present one award for the whole Waikato River, at biannual River Festival. **S3:** Expand S2 to support four restoration awards per region every two years.	Likely benefits: • Enhance progress through positive role models, publicity and education. Aspirations addressed: 1, 2, 9, 12 Vision and Strategy objectives addressed: A, B, C, D, E, I
aa. Monitoring (Appendix 29: Monitoring and evaluation)	
S1: N/A **S2:** Develop 'cultural' indicators (e.g., Cultural Health Indices) and implement cultural indicator monitoring programmes. Develop and maintain a repository of environmental monitoring equipment that can be used by volunteer monitors to contribute to Report Card assessments. Develop a database for storing	Likely benefits: • Improved coordination of data. • Improved analysis. • Increased ability to view whole of catchment issues. • Provides excellent platform for whole of catchment management. • Enhances kaitiakitanga and adaptive management of restoration activities. Aspirations addressed: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 Te Ture Whaimana objectives addressed: A, B, C, D, E, G, J, M

Potential actions	*Likely benefits and the links to aspirations and Te Ture Whaimana for the Waikato River*
environmental monitoring and background data for use by each iwi. **S3:** Create a centralised database, coordinated by a dedicated person managing and supporting it (IP agreements to be made, contribute material over web based support structures).	
bb. Holistic management (Appendix 28: Impediments)	
S1: N/A **S2:** Plans, policies, rules and decision making take into account cultural, spiritual, social and economic relationships of river iwi and wider community with the Waikato River; adopt the precautionary principle; and take into account cumulative effects including multiple stressors. Decision making is guided by effective national policy and guidelines. An integrated statutory management plan for the Waikato River has been implemented that encompasses physical, chemical, biological, social, economic, cultural and historic matters, at regional, sub-catchment and farm scales. Co-management agreements have been established between river iwi and local authorities. The methods used by local authorities are standardised. Actions to restore the Waikato are being coordinated through the development and implementation of non-statutory management plans. **S3:** See S2 above.	Likely benefits: • Whole of catchment approach will consider the effectiveness of current policy instruments in contributing to the health and wellbeing of the Waikato River. • Aims to provide clear lines of responsibility, improved communication, coordination and accountability for holistic, integrated catchment management. • Application of the precautionary principle will ensure its use is based on a clear understanding of best practice models in the Waikato River context. • Future proofing against restoration being undermined by cumulative impacts, through integration of predictive models, economics, maatauranga Maaori and policy. Aspirations addressed: 1, 2, 3, 9, 12, 13 Te Ture Whaimana objectives addressed: A, B, C, D, E, F, G, H, I, K, M

Table 6.2: Actions (a–bb) included in Scenarios 1, 2 and 3 and the aspirations (1–15) they address.

	Aspirations															
Actions	***1. Holism***	***2. Engagement***	***3.Spiritual values***	***4.Significant sites***	***5. Access***	***6.Swimming and boating***	***7. Aesthetics***	***8.Human health***	***9. Water quality***	***10a.Tuna***	***10b. Whitebait***	***11.Taonga species***	***12.Ecological integrity***	***13.Water supply***	***14.Prosperous local***	***15.Regional and national economic***
a. Dairy farm systems						1,2,3	2,3	1,2,3	1,2,3	2,3	1,2,3	2,3	1,2,3	2,3	1,2,3	1,2,3
b. Sheep-beef farm systems						1,2,3	2,3	1,2,3	1,2,3	3	1,2,3	3	2,3	3	1,2,3	1,2,3
c. Urban stormwater					1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2,3	1,2,3	1,2,3	1,2,3		1,2,3	1,2,3
d. Riparian aesthetics		1,2,3	1,2,3		1,2,3	1,2,3	1,2,3			2,3		1,2,3	1,2,3			
e. Colour and clarity			1,2,3			1,2,3	1,2,3		1,2,3		1,2,3	1,2,3	2,3			1,2,3
f. Geothermal contaminants						1,2,3		1,2,3		1,2,3		1,2,3	2,3	1,2,3		1,2,3
g. Marae drinking-water								1,2,3	1,2,3					1,2,3		
h. Sewage discharge to land/wetlands			2,3			2,3		2,3	2,3						2,3	
i. Pathogens			3			2,3		1,2,3	1,2,3					1,2,3		
j. Access/boating/recreation		1,2,3			1,2,3	1,2,3										
k. Physical hazards					1,2,3	1,2,3										
l. Significant sites			1,2,3	1,2,3	1,2,3											
m. Whitebait			2,3								1,2,3	1,2,3	1,2,3		1,2,3	

Actions	*1. Holism*	*2. Engagement*	*3.Spiritual values*	*4.Significant sites*	*5. Access*	*6.Swimming and boating*	*7. Aesthetics*	*8.Human health*	*9. Water quality*	*10a.Tuna*	*10b. Whitebait*	*11.Taonga species*	*12.Ecological integrity*	*13.Water supply*	*14.Prosperous local*	*15.Regional and national economic*
n. Tuna			2,3							1,2,3		1,2,3	1,2,3		1,2,3	2,3
o. Dune lakes, peat lakes, Lake Waahi and Whangapee			1,2,3	1,2,3	2,3	2,3	2,3		2,3	2,3	2,3	2,3	2,3		1,2,3	
p. Lake Ohakurii				1,2,3	2,3	2,3	2,3		2,3	2,3	2,3	2,3	2,3		1,2,3	
q. Water allocation			1,2,3			2,3						1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
r. Waikato hydro peaking					1,2,3	1,2,3						1,2,3	1,2,3		1,2,3	1,2,3
s. Schools		1,2,3	1,2,3	1,2,3												
t. Capacity and education	1,2,3	1,2,3	1,2,3	1,2,3												
u. Research capacity	1,2,3	1,2,3							1,2,3	1,2,3	1,2,3	1,2,3				
v. Waananga/visitor centres	1,2,3	1,2,3	1,2,3	1,2,3												
w. Co-management protocols, joint decision making panels	1,2,3	1,2,3	1,2,3													
x. Community group coordination and collaboration	1,2,3	1,2,3	1,2,3													
y. Industry collaborations	1,2,3	1,2,3							1,2,3						1,2,3	1,2,3
z. Restoration awards	1,2,3	1,2,3							1,2,3				1,2,3			
aa. Monitoring	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3			
bb. Holistic management	1,2,3	1,2,3	1,2,3						1,2,3				1,2,3	1,2,3		

6.3 How the benefits of each scenario were assessed

The Study team has developed a prototype scenario modelling framework which allows the benefits of actions to be compared and combined into a single score for each aspiration. The main reason for developing the framework was to provide a flexible, systematic and repeatable way of estimating and combining scores for the array of potential actions.

The prototype modelling framework uses an Excel spreadsheet which is easy to modify and transfer. This can be provided to the Guardians Establishment Committee as an output of the project on request. The Study team recommends that the Waikato River Authority, Waikato River Clean-Up Trust and stakeholders use a common framework, based on this prototype, which will help:

- Decide which actions to fund by comparing benefits.
- Track the progress of restoration using Report Cards (see Section 8).

The modelling framework contains two steps: score individual restoration actions and then combine actions to score aspirations. The rationale for the scores for each individual action and how they combine for each aspiration are contained within the relevant appendices.

Step one - score actions

Step one involves estimating a summary score for the benefits that would be derived from each individual restoration action by:

1. Listing each of the possible actions (e.g., restore or protect whitebait spawning habitat, remove barriers to whitebait migration etc.).
2. Identifying one or more indicators for each action (e.g., length of spawning habitat that is restored or protected).
3. Setting a target for the state (e.g., 21 kilometres of habitat is potentially available but this would require protection/restoration of 10.5 kilometres of degraded spawning habitat).
4. Setting the minimum possible state (e.g., 0 kilometres of habitat).
5. Identifying the current state (e.g., 10.5 kilometres of habitat is currently protected and of high quality).
6. Selecting a formula which converts the current state into a score (A, B, C, D or E). The default formula is a linear relationship in which the target state scores an A and the minimum state scores an E. Hence the current state of 10.5 kilometres scores a C for the target of 21 kilometres and the minimum of 0 kilometres.

The same steps are followed to score the predicted state for a possible restoration action. For example, a proposed action is to fence and replant 4 kilometres of riverbank that is potential whitebait spawning habitat currently damaged because cattle have access to it. This action would increase the state to 14.5 kilometres (existing 10.5 kilometres plus restored 4 kilometres) which scores a B.

For the water quality aspiration, the catchment models CLUES and WCM were used to predict the effects of restoration actions on the following indicators of water quality: *E. coli*, total phosphorus, total nitrogen, chlorophyll, clarity and colour. Targets for each of these indicators were selected from published guidelines as described in Section 4.

Catchment modelling was required to determine:

- Spatial patterns (e.g., sediment, nutrient and colour inputs vary throughout the catchment).
- Cumulative effects (e.g., inputs accumulate down the river).
- Transformations (e.g., settling in the hydro dams).
- Biophysical interactions (e.g., sediment, nutrient and colour all affect water quality but to different degrees in different parts of the catchment).

Model predictions were compared with the extensive monitoring dataset available for the Waikato River collected by Environment Waikato and NIWA to ensure that transformations (e.g., settling in the hydro lakes) and attenuation (e.g., nutrient removal) were quantified properly, and to account for sources (e.g., bank erosion) that could not be determined a priority. Details of the water quality modelling are given in Appendix 13: Water Quality.

Step two – combine action scores to score aspirations

Step two considers all the actions that affect a particular aspiration. For example, the aspiration for 'fisheries and kai' is affected by all the actions that:

- Improve the abundance of whitebait and tuna.
- Increase the customary catch available to river iwi that enables them to supply guests with the specialty foods for which they are renowned.
- Recognise the cultural connection between hapuu and the river through actions to manage, conserve and gather kai.

The modelling framework allows a summary score for each aspiration (e.g., 'fisheries and kai') to be estimated by:

- Identifying which indicators best quantify progress towards the aspiration.
- Assigning weightings to these indicators which account for some indicators being more important than others.
- Combining the weighted scores into a single score for each aspiration.

For the purpose of assessing scenarios, the key question is to what degree the aspiration will be achieved by the set of actions proposed. In situations where actions contribute equally and independently, the model simply averages the scores of the contributing actions. In situations where some actions are more important than others, then they are weighted accordingly. If the actions are not independent of one another, then the dependency is explicitly recognised in the model.

For some aspirations, quantitative computer models were used to predict the effect of restoration actions and to 'score' the changes against widely accepted guidelines (for example, models such as *Overseer*, CLUES and WCM were used for the water quality aspiration). For other aspirations, equivalent quantitative models linking actions with response are either inappropriate or do not exist – for example, predicting changes in people's level of engagement and associated attitudes and behaviours. In these situations, the findings from international and New Zealand restoration projects were drawn upon (also see Appendix 2: Restoration Case

Studies). A consistent finding from these projects is the importance of actions that increase people's engagement with the restoration programme – actions involving education, the free flow of information and demonstrations of good practice. Such actions are included in Table 6.1 and the Study team is confident that these actions, if implemented properly, will engage people and change attitudes and behaviours in a positive way. The Study team scored these actions relative to the degree to which they are implemented in any particular scenario. The Study team acknowledges that this method of scoring is somewhat subjective and introduces uncertainty into the analysis but contend it is justifiable as the Study team needs to evaluate the effect of actions on all aspirations if it is to know whether a healthy and well river will be achieved.

6.4 Assessing the economics of the scenarios

The direct quantifiable costs and benefits associated with each of the actions included in Scenarios 2 and 3 are estimated using an economic model. As explained in Section 6.2, Scenario 1 is not costed because the Study team's brief is to establish what *extra* costs would be involved in meeting Te Ture Whaimana. In accordance with the project brief, capital costs (CAPEX), operating costs (OPEX) and direct benefit are estimated in each of 30 years for each action by the economic specialists in the Study team.

The region-wide and nation-wide effects of the Waikato River clean-up are assessed using Input-Output (IO) analysis. This takes, as input data, the net costs estimated by the Economic Model, and estimated changes in 'value added'[127] and employment[128] as a result.

An overview of the economic methods used in this Study is provided in Section 2. Details of the analysis are given in Appendices 31 and 32: Economic Modelling and Non-Market Values.

As noted in Section 2, in relevant studies from the existing literature, non-market values were estimated to be of comparable size to the market costs of restoration (see also Appendix 32: Non-Market Values). Furthermore, the benefits estimated by the nine studies reviewed almost certainly underestimate the true non-market benefits of restoration for two reasons. First, they omit some values that are important in the Waikato (e.g., fisheries). Second, they include 'ecosystem services' that help support communities but they do not consider cultural and spiritual values that are an important part of community wellbeing.

While it would be unwise to transfer the findings directly to this Study, given vast differences in scale and restoration objectives, the key message is that the economic analysis presented here is likely to significantly underestimate the total benefit to the community of the restoration actions under all scenarios.

Consequently, the total benefits (including 'ecosystem services' and the benefits to community wellbeing) are likely to be higher than the direct costs of restoration a bundle of the most cost-effective actions – those actions where the Study team considers this to be the case are the priority actions identified in Section 7. It is also important to remember the community bears the costs of not doing anything to clean up the river and these costs are likely to be significant.

[127] 'Value Added' refers to the contribution of the factors of production (e.g., land, labour and capital goods) to raising the value of a product. For a selected product, the 'Value Added' can be ascertained by the difference in the sale price of the product and the cost of the materials used to produce it.

[128] 'Employment Counts' (ECs) are head counts of working people as taken from Statistics New Zealand Business Frame. In this Study, we use 'Modified Employment Counts' (MECs), developed by Market Economics Limited based on these data. Unlike standard ECs, MECs include estimates of the numbers of working proprietors for each industry type.

6.5 Results of the scenario modelling

6.5.1 Scenario 1:

Scenario 1 is estimated to deliver some benefit for all aspirations but does not go very far towards meeting the objectives of Te Ture Whaimana (Figure 6.1). These actions either have already been undertaken or are likely to be undertaken as a result of statutory processes (e.g., consent conditions) or non-statutory initiatives including industry-led initiatives (e.g., the Dairying and Clean Streams Accord).

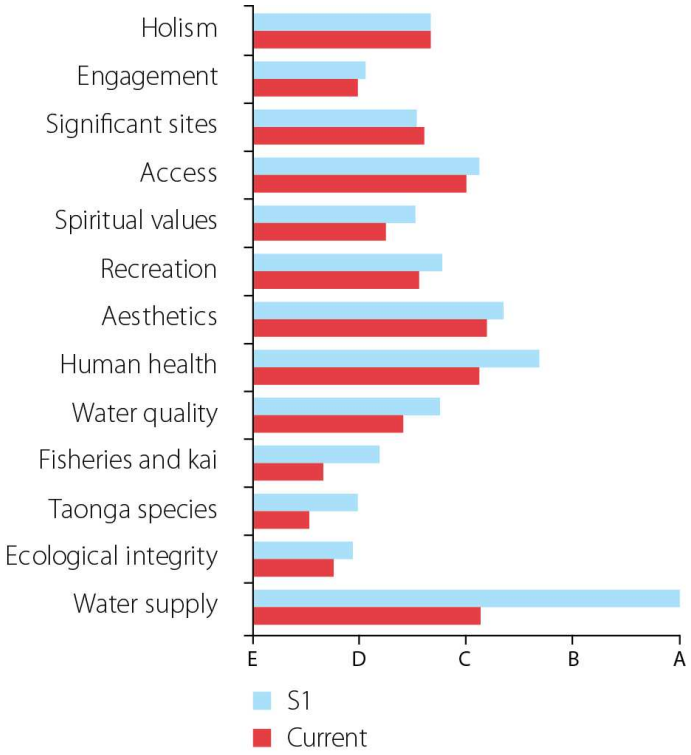


Figure 6.1: Progress towards meeting aspirations for the health and wellbeing of the Waikato River: comparison between Scenario 1 (light blue) and the current situation (red). Benefits are relative to prescribed targets scaled from A to E.

Full implementation of Scenario 1 would see the following outcomes:

- A small increase in engagement of the community (both Maaori and non-Maaori) as the co-management requirements of the Deed of Settlement has improved consultative processes and raised awareness of river issues. Key waahi tapu and recent historic sites have been identified. However, without significant 'good news' stories about the river, many still feel disengaged. River iwi concerns remain largely unaddressed and Te Mana o Te Awa has not been restored.

- Water is allocated efficiently as a result of successful implementation of Environment Waikato's proposed Variation 6. Maaori values (te Mana o te Awa) are appropriately respected and given priority through allocation processes.

- Water quality in the main stem of the Waikato River is slightly better than at present but nitrogen, phosphorus and toxic algae blooms continue to exceed guidelines in the lower Waikato and may exceed them in the hydro lakes.

- Water clarity meets bathing water standards (as set in the Environment Waikato Regional Plan) in the hydro lakes but not in the Waipa and lower Waikato. *E. coli* concentrations meet the contact recreation guidelines in the Waikato River and hydro lakes with minor exceedances in the lower Waipa. Consequently it is safe to swim everywhere in the main stem but not in many of the tributaries. 'Duck itch' may occur where aquatic weeds are abundant. Aquatic weeds are a problem in some places and require spraying or mechanical removal.

- In the degraded lowland lakes, there is a reduction in *E. coli* concentration as a result of excluding cattle but water and habitat quality remains largely unchanged from the present.

- Iinanga spawning is somewhat improved by fencing out cattle. Adult whitebait have more habitat as a result of voluntary actions to improve culverts and to fence and plant streambanks, but much potential habitat remains degraded or disconnected from the river. There may be some increase in whitebait abundance. Elvers continue to be transferred into the hydro dams but downstream migration of adult spawners is still impeded.

- Along the main stem of the Waikato and Waipa Rivers, pasture streambanks are being fenced and planted by community groups. Other streambanks on dairy farms have been fenced, and some may have been planted. Aquatic habitat in small streams shows some small improvements and *E. coli* concentrations have decreased as a result of cattle exclusion, but *E. coli* concentrations still exceed the contact recreation guidelines. There are localised improvements in habitat quality but ecological integrity and connectivity are still degraded.

6.5.2 Scenario 2:

For Scenario 2, the total net costs of restoration over the 30 year model duration are $1,660 million with a net present value of $900 million (Table 6.3). The scenario is expected to have a relatively neutral economic impact overall (Table 6.4). Value added increases by $1,260 million in the Waikato, and decreases by $1,009 million in the rest of New Zealand, producing a net increase for the country of (i.e., growth in the New Zealand economy will be stimulated by) $251 million (0.005 percent of GDP). Employment increases by 13,900 MEC job years in the Waikato region, but decreases by 15,850 MEC job years in the rest of New Zealand – a net loss of employment of 1,950 MEC job years (0.003 percent of national employment).

Table 6.3: Total direct costs and benefits for Scenario 2 ($\$_{2010}$ million)

	Total	*Present value*
CAPEX	630	520
OPEX	2,050	710
Total	**2,680**	**1,230**
Benefit	1,030	330
Net cost	**1,660**	**900**

Table 6.4: Cumulative and average net economic impacts for Scenario 2, 2011–2040

	Cumulative net economic impacts		*Average net economic impacts per year*	
	Value added $_{2007}$million[3]	*Jobs MEC*[1] *Years*	*Value added $_{2007}$million*[3]	*Jobs MEC*[1] *Years*
Waikato Region	1,260	13,900	42	460
New Zealand	-1,009	-15,850	-34	-530
Total	**251**	**-1,950**	**8**	**65**

Notes:

1 Modified Employment Count (MEC). This includes both employment counts and working proprietors.

2 Figures may not add due to rounding.

3 $_{2007}$million – The IO modelling is based on an IO table for the year ending March 2007 developed by Market Economics Limited. This is the latest year for which all economic data required to produce an updated IO table are available. A regional table was also produced from the 2006/2007 national table.

Scenario 2 is predicted to be cost neutral because expenditure on restoration stimulates the regional economy, and the economic benefits balance the costs of restoration for the national economy as a whole. There is some redistribution of capital and employment from the rest of New Zealand to the Waikato region, and between different sectors of the economy within the Waikato region, although the percentages involved are small. Specifically:

- There is increased capital expenditure, much of which is assumed (for the purposes of the economic modelling) to be funded by loans which require interest payments. However, the effects of loan payments on the regional economy are balanced by gains from capital purchases made within the region – industries responsible for capital purchases (e.g., the construction industry) are highly linked into the rest of the New Zealand economy.

- Second, it is assumed that some of the required expenditure will be funded by central government, but the goods and service will be provided by industries located within the Waikato. This will create positive benefits for the regional economy, but losses throughout the rest of the New Zealand economy.

- Third, expenditure is assumed to be partially funded by reductions in household consumption including commodities produced overseas[129]. The displacement of expenditure towards commodities produced in New Zealand acts as net gain to the local economy.

- Fourth, some changes in farming practice (e.g., improved nutrient management) improve farm profitability. However, for most farmers there is estimated to be some reduction in disposable income because of the need for capital investment in restoration (i.e., a net cost). For the regional economy this is balanced by increased expenditure by farmers which creates flow-on benefits through the entire economy.

Scenario 2 is estimated to deliver significant benefits for many of the aspirations, but still 'falls short' of meeting the vision expressed in Te Ture Whaimana for a healthy and well river (see Figure 6.2).

[129] Household consumption includes consumption of goods produced domestically and goods produced overseas. The assumption is that any reduction in expenditure would impact both on a pro-rata reduction basis.

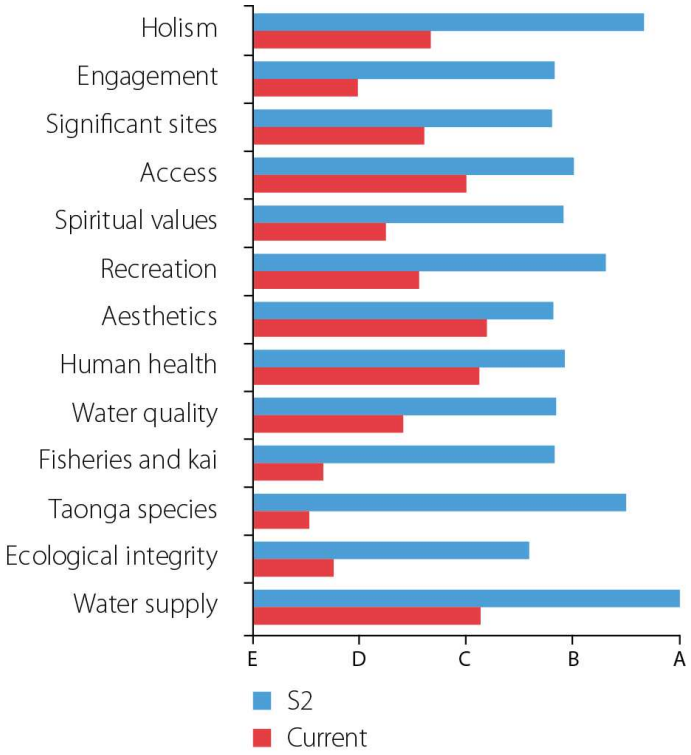


Figure 6.2: Progress towards meeting aspirations for the health and wellbeing of the Waikato River: comparison between Scenario 2 (blue) and the current situation (red). Benefits are relative to prescribed targets scaled from A to E. Note the economic aspirations (14 and 15) are not scored A to E, but presented in dollar and employment terms in Tables 6.3 and 6.4.

Full implementation of Scenario 2 would see the following outcomes:

- People have re-engaged with the river, its tributaries and major lakes. The community demonstrates an increasingly positive attitude about the health of the river and there is more collaboration between river iwi, community groups and industry in restoration activities. Cultural health monitoring tools are used by each river iwi to evaluate progress towards restoration targets based on maatauranga Maaori. This has increased the interaction of rangatahi, koroua and kuia with the river (including significant sites), reduced information deficiencies and provided more opportunities for river iwi to communicate with decision makers. Iwi have a greater voice in consent hearings.

- A consultative process has resulted in a strategic plan for footpaths, cycleways, boat ramps and reserves that meet community needs. All waahi tapu have been identified and strategic plans which prioritise sites for restoration are complete. Community understanding, knowledge and respect of waahi tapu and historical sites have been increased through publicity, signage and one visitor centre.

- Along the main stem of the Waikato River nutrient concentrations comply with guidelines, cyanobacteria numbers are unlikely to exceed the toxic warning guidelines and water clarity more than meets bathing water guidelines in the hydro lakes. Clarity in the Waipa and lower Waikato does not always meet bathing water guidelines partly because of fine sediment in run-off from pastoral farming on erodible hill country in the Waipa. *E. coli* concentrations are low in pasture streams and meet the Environment Waikato contact recreation standards in the Waikato River and hydro lakes with only minor exceedances in the lower Waipa. Consequently it is safe to swim everywhere in

the main stem, although 'duck itch' may still occur where aquatic weeds are abundant. Aquatic weeds remain a problem is some places and require spraying or mechanical removal.

- Sewage is no longer discharged directly to the river at Hamilton and several other small rural communities but where it is very costly or not technically feasible, discharge to water continues.

- Water quality in four previously degraded peat lakes, two dune lakes and two riverine lakes, is much improved. In those lakes, nutrient and sediment inputs have been reduced so that water clarity almost meets bathing water guidelines, and phosphorus concentrations almost meet mesotrophic status (moderate clarity, nutrients and algal productivity), but if cyanobacteria blooms occur they may still exceed guidelines. In the two large riverine lakes, Waahi and Whangapee, exotic weeds have been controlled, submerged and emergent native aquatic plants have been re-established, pest fish controlled and the quality of habitat suitable has been significantly improved to the point where it can support whitebait, tuna and taonga species. In Lake Ohakurii, a combination of weed control and nutrient input reduction has greatly improved ecological integrity and recreation potential.

- Restoration, protection and reconnection has significantly increased iinanga spawning and adult habitat in the lower Waikato River. Resource users and managers have collaborated to develop and implement a short-finned tuna and long-finned tuna management plan for the entire Waikato catchment. Tuna habitat has been increased and restored with the expectation that tuna abundance will increase significantly. Marae can provide whitebait and tuna caught in their rohe to guests on special occasions, and Ministry of Fisheries customary tuna catch limits are able to be harvested. Hapuu involve rangatahi in fishing and restoration, protection and conservation. The health risk of eating kai from the Waikato River and the risk posed by legacy arsenic and mercury in lake sediments have been assessed and guidelines published on safe consumption where appropriate.

- Riverbanks along major streams have been fenced and planted with appropriate natives, including taonga species, and invasive exotics have been removed in some places. Aquatic habitat in small streams has been restored and supports re-introduced iconic species and clean water communities. Actions addressing fisheries and riparian vegetation have greatly enhanced ecological integrity, connectivity and habitat for taonga species. Riparian areas now provide a rich source of plant materials for cultural practices.

6.5.3 Scenario 3:

For Scenario 3, the total net costs of restoration over the 30 year model duration are $4,020 million with a net present value of $3,180 million (see Table 6.5). Scenario 3 increases value added and employment in the region, but decreases it for New Zealand as a whole (Table 6.6). Unlike Scenario 2, however, the regional gains are significantly outweighed by the national losses (see Table 6.6).

For Scenario 3, value added increases by $600 million in the Waikato and decreases by $4,730 million in the rest of New Zealand, producing a net decrease for the country as a whole of $4,130 million (0.082 percent of GDP). Employment increases by 11,600 MEC job years in the

Waikato region, but decrease by 68,300 in the rest of New Zealand – a net loss of 56,700 MEC job years (0.085 percent of national employment).

Table 6.5: Total direct costs and benefits for Scenario 3 ($\$_{2010}$ million)

	Total	*Present value*
CAPEX	3,170	2,480
OPEX	6,420	1,980
Total	**9,590**	**4,460**
Benefit	5,570	1,280
Net Cost	**4,020**	**3,180**

Table 6.6: Cumulative and average net economic impacts for Scenario 3, 2011–2040

	Cumulative net economic impacts		*Average net economic impacts per year*	
	Value added $\$_{2007}$million[3]	*Jobs MEC*[1] *Years*	*Value added $\$_{2007}$million*[3]	*Jobs MEC*[1] *Years*
Waikato region	600	11,600	20	390
Rest of New Zealand	-4,730	-68,300	-158	-2,280
Total	**-4,130**	**-56,700**	**-138**	**-1,890**

Notes:

1 Modified Employment Count (MEC). This includes both employment counts and working proprietors.

2 Figures may not add due to rounding.

3 $\$_{2007}$million – The IO modelling is based on an IO table for the year ending March 2007 developed by Market Economics Limited. This is the latest year for which all economic data required to produce an updated IO table are available. A regional table was also produced from the 2006/2007 national table.

The economic outcomes for the country as a whole are more negative than in Scenario 2 largely because of land use change. In Scenario 3, 171,000 hectares of land is converted from sheep/beef farming to forestry (to reduce nutrient and sediment run-off from steep, erodible pasture). This reduces outputs from the meat processing and textile manufacturing industries. In theory these losses should be compensated by increased outputs from wood processing industries but many of these increases occur outside the 30 year time span of the economic analysis because of the sequential nature of restoration and the long delays between planting and harvesting forest. This skews the findings, underestimating benefits – this artefact of the 30 year timeframe for economic modelling is discussed further in Section 7 where we include this land use change in our list of recommended priority actions. There are also several very costly restoration projects in Scenario 3 (e.g., intake protection at the hydro dams and restoration of Lake Whangapee).

Scenario 3 is estimated to deliver significant benefits for 14 of the 15 aspirations, delivering much larger gains than Scenario 2 for taonga Species, spiritual values, fisheries and kai, engagement and ecological integrity (see Figure 6.3). It does not, however, meet Aspiration 15 since there is a significant effect on national economic prosperity.

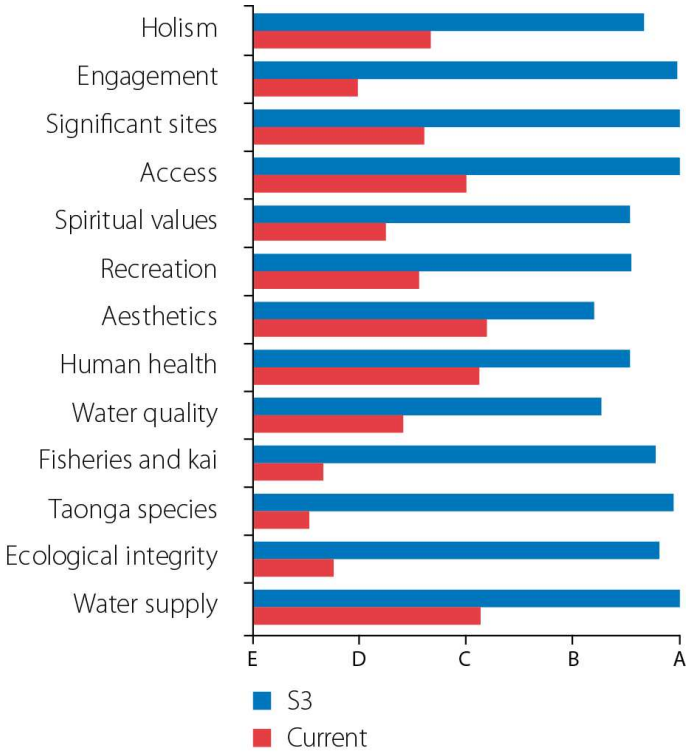


Figure 6.3: Progress towards meeting aspirations for health and wellbeing of the Waikato River: comparison costs between Scenario 3 (blue) and the current situation (red). Benefits are relative to prescribed targets scaled from A to E. Note the 'economic' aspirations (14 and 15) are not scored A to E, but presented in dollar and employment terms in Tables 6.5 and 6.6.

Full implementation of Scenario 3 would see the following outcomes:

- Community attitudes and behaviour have changed. All members of the community are increasingly re-engaged with the river, its tributaries and major lakes. The wider community understands and respects the spiritual relationship between the river iwi and the awa. Amongst iwi, there is resurgence in cultural practices centred on the river, and these traditions are being actively passed on to rangatahi. Iwi are directing and are key participants in the implementation of restoration actions in their rohe.

- Thanks to successful co-management, statutory planning takes a holistic approach and non-statutory agreements are in place between Waikato River Authority, Environment Waikato, local authorities and industry. Throughout the entire Waikato catchment, cultural health monitoring programmes (based on maatauranga Maaori) evaluate the reviving health and wellbeing of the river.

- The wider community demonstrates an increasingly positive attitude about the health of the river and there is a high level of local involvement – and pride – in restoration actions. Restoration enterprises have been established for iwi and the wider community.

- A consultative process has resulted in footpaths, cycleways, boat ramps and reserves that, together with riparian and water quality restoration, meet community needs. All waahi tapu have been protected, and priority significant sites have been restored. Community understanding, knowledge and respect of waahi tapu and historical sites has been increased through publicity, signage and five visitor centres.

- Along the main stem of the Waikato and the Waipa rivers, nutrient concentrations comply with guidelines and as a result cyanobacteria numbers are unlikely to exceed the toxic warning guidelines even if an algal bloom occurs. Water clarity more than meets bathing water guidelines in the hydro lakes. While greatly improved by reafforestation of erodible hill country pasture, water clarity still does not meet the bathing water guidelines in the Waipa and lower Waikato. Colour changes from blue in the upper Waikato to green-brown in the lower Waikato and Waipa. *E. coli* concentrations are much lower than at present in pasture tributaries because of fencing and run-off controls, and meet the Environment Waikato contact recreation standards in the main stem except for minor exceedances in the Waipa. Consequently it is safe to swim everywhere in the main stem, although 'duck itch' may still occur where aquatic weeds are abundant. These weeds remain a problem in some places and require spraying or mechanical removal.

- Sewage is no longer discharged directly to the river at Hamilton and several other small rural communities but where it is very costly or not technically feasible, discharge to water continues.

- In four previously degraded peat lakes, two dune lakes and two riverine lakes, nutrient and sediment inputs have been reduced so that water clarity meets bathing water guidelines, phosphorus concentrations meet mesotrophic status and cyanobacteria blooms rarely exceed health guidelines. In the two large riverine lakes, Waahi and Whangapee, exotic weeds have been eliminated, submerged and emergent native aquatic plants have been re-established, pest fish excluded and the lakes have been returned to high quality habitat suitable for supporting high stocks of whitebait, tuna and taonga species. In Lake Ohakurii, a combination of weed control and nutrient input reduction has minimised the risk of algal blooms, reduced the risk of 'duck itch' and greatly improved ecological integrity and recreation potential.

- Restoration, protection and reconnection has doubled iinanga spawning and adult habitat in the lower Waikato River. Tuna habitat has been increased and restored with the expectation that tuna abundance will double. Marae can provide whitebait and tuna caught in their rohe to guests on special occasions, including poukai, and Ministry of Fisheries customary tuna catch are able to be harvested. Hapuu involve rangatahi in fishing and restoration, protection and conservation. The health risk of eating kai from the Waikato River has been assessed and guidelines published on safe consumption where appropriate. The major non-natural sources of toxic geothermal chemicals have been controlled through reinjection and sediment capping.

- The majority of riverbanks have been fenced and planted with appropriate natives, including taonga species. Invasive exotics have been removed in many places. As a result, aquatic habitat in small streams has been restored and now supports re-introduced iconic species and clean water communities. Actions addressing fisheries and riparian vegetation have greatly enhanced ecological integrity, connectivity and habitat for taonga species.

6.5.4 Summary comparisons of costs and benefits of each scenario

As Figure 6.4 illustrates, it is possible to create bundles of actions which go a long way towards meeting iwi and community aspirations for a healthy and well Waikato River.

Scenario 1 assumes no additional expenditure over and above what would already be spent in future on current initiatives. It demonstrates that the aspirations would not be met solely by applying current practices to meet existing rules and industry codes of practice. Extra investment is clearly required.

Scenario 2 indicates that it is possible to do a great deal to improve the health and wellbeing of the river without damaging overall economic prosperity, since the overall economic impact is broadly neutral.

Scenario 3 shows that adding some extremely high cost actions to the bundle can alter the balance of economic impacts, so that the economic losses for New Zealand as a whole are much bigger than the economic gains for the region. Yet this Scenario does the most to restore the river.

Scenario 3 does not achieve the bathing water guideline for clarity of 1.6 metres in the lower Waipa and lower Waikato River. It is the Study team's view that the lower Waipa and lower Waikato River probably never achieved this clarity because of its geology and extensive peat swamps (as noted by von Hochstetter in 1867 *"the Waikato showed 68 Fahr. and its water light green and clear while that of the Waipa showed the dark brown colour of peat water and a temperature of 70 Fahr.")* Scenario 3 does, however, result in a significant improvement in baseflow water clarity – from 0.7 to 1.0 metres in the Waipa at Whatawhata and from 0.7 to 0.9 metres in the Waikato at Tuakau. Extrapolating from the available monitoring data for the Waipa, the Study team estimates that baseflow clarity in streams draining catchments that are 100 percent native forest average only about 1.9 metres (in a range of 1.3-3.2 metres), reflecting the naturally erodible geology through which these tributaries flow. It therefore only requires a small area of poorly fenced farmland to reduce water clarity (e.g., the Kaniwhaniwha catchment on the slopes of Mt Pirongia is only 38 percent pasture but baseflow clarity is 1.2 metres compared with 3.2 metres in the nearby and completely forested Mangauika Stream).

Under Scenario 3, converting low producing sheep-beef pasture in eroding hill country to forestry is expected to improve clarity to 1.9 metres in streams draining those catchments and to help improve clarity in the main stem of the Waipa from 0.7 to just above 1.0 metre. As discussed in Appendix 13: Water Quality, the Study team is not able, at this time, to quantify the effects of riparian fencing and planting on bank erosion (thought to be a major sediment source in the Waipa) and the likely benefits for water clarity although there is some evidence that replanting stream banks will result in significantly improved water clarity. Consequently the priority actions may achieve better baseflow water clarity than the 1.0 metre that is predicted but the extra benefit cannot currently be determined. Achieving water clarity of 1 metre in the Waipa is considered by the Study team to be a significant improvement that will make swimming safer and more attractive.

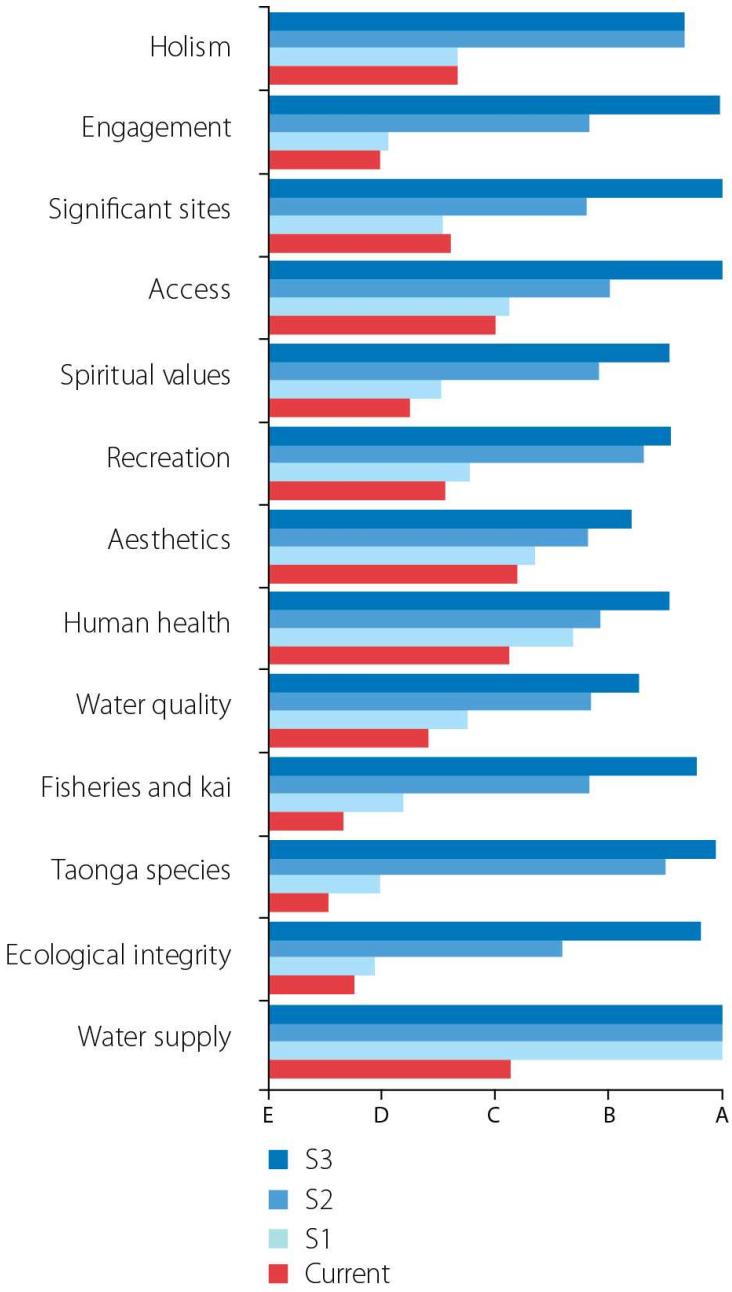


Figure 6.4: Comparison of all scenarios (in blue) and the current situation (in red), assessing how far they go towards meeting aspirations for a healthy and well Waikato River. Note the 'economic' aspirations (14 and 15) are not scored A to E, but presented in dollar and employment terms in Tables 6.7 and 6.8.

For ease of reference, Tables 6.7 and 6.8 below present the direct costs and benefits, and the economic impacts, of Scenario 2 and 3 again. Scenario 1 assumes no additional expenditure, so is not included in the tables.

Table 6.7: Total direct costs and benefits ($\$_{2010}$ million)

	Total	*Present value**
Scenario 2		
CAPEX	630	520
OPEX	2,050	710
Total	**2,680**	**1,230**
Benefit	1,030	330
Net cost	**1,660**	**900**
Scenario 3		
CAPEX	3,170	2,480
OPEX	6,420	1,980
Total	**9,590**	**4,460**
Benefit	5,570	1,280
Net cost	**4,020**	**3,180**

Notes:

1 *Discount rate eight percent.

2 Figures may not add due to rounding.

Table 6.8: Cumulative and average net economic impacts, 2011–2040

	Cumulative net economic impacts		*Average net economic impacts per year*	
	Value added $\$_{2007}$million[3]	*Jobs MEC1 Years*	*Value added $\$_{2007}$million*[3]	*Jobs MEC1 Years*
Scenario 2				
Waikato Region	1,260	13,900	42	460
Rest of New Zealand	-1,009 (0.005% GDP)	-15,850 (0.003% employment)	-34	-530
Total	**251**	**-1,950**	**8**	**-65**
Scenario 3				
Waikato Region	600	11,600	20	390
Rest of New Zealand	-4,730 (0.082% GDP)	-68,300 (0.085% employment)	-158	-2,280
Total	-4,130	-56,700	-138	-1,890

Notes:

1 Modified Employment Count (MEC). This includes both employment counts and working proprietors.

2 Figures may not add due to rounding.

3 $\$_{2007}$million – The IO modelling is based on an IO table for the year ending March 2007 developed by Market Economics Limited. This is the latest year for which all economic data required to produce an updated IO table are available. A regional table was also produced from the 2006/2007 national table.

In the following Section, the Study team outlines the recommended priority actions, and the rationale for the recommendations. The Study team believes it is possible to deliver more than Scenario 2 in terms of *"a healthy river which sustains abundant life"* whilst preserving the other component of the vision statement – *"prosperous communities"*. The recommended bundle is a composite of Scenario 2 and Scenario 3, which best bridges the gap between the current degraded state of the river and the aspirations of iwi and the wider community for a healthy and well Waikato River.

7 Recommended priority actions

7.1 Introduction

As part of the project brief, the Study team was asked to recommend a list of priority actions that, together, would lead to the restoration of a healthy and well Waikato River. This list of priority actions is intended to help guide the Waikato River Authority make decisions in its governance role, and in its role as trustee, for the Waikato River Clean-up Trust.

As a step towards arriving at the priority actions, in Section 6 the Study team conducted scenario modelling to predict the cumulative benefits of implementing three different 'bundles of actions' (called Scenarios 1, 2, and 3) and whether they achieve the full suite of aspirations held for a healthy and well river. This scenario modelling showed that:

- Scenario 1 delivered measurable benefits but fell well short of achieving the aspirations held for the river and therefore does not meet the objectives of Te Ture Whaimana.
- Scenario 2 delivered significant benefits that go a long way towards achieving the aspirations held for the river and, although still falling short, may be regarded as 'close' to meeting the objectives of Te Ture Whaimana.
- Scenario 3 delivered greater benefits than Scenario 2 on most aspirations, but was less attractive for those aspirations associated with maintaining prosperous communities. So, like Scenario 2 it may be regarded as 'close' to meeting the objectives of Te Ture Whaimana but for different reasons.

Given that Scenario 3 contains all the actions in Scenario 2 plus additional actions, it is likely that an optimal set of priority actions to meet Te Ture Whaimana represents some composite between these two scenarios. This Section develops the list of priority actions, provides cost estimates for their implementation and describes the expected benefits that would accrue should they be fully implemented.

7.2 Priority actions

The actions in Scenario 2 are suggested as priorities because they are cost effective and, in combination, result in significant progress towards fulfilling aspirations held for the river and thereby meeting Te Ture Whaimana. Additional actions from Scenario 3 were selected as priorities on the basis that they:

- Were technically feasible, based on available evidence from similar experiences in other restoration projects in New Zealand and overseas.
- Focused on addressing those aspirations that would remain unfulfilled by Scenario 2 alone.
- Did not hinder the achievement of other aspirations.

Actions in Scenario 3 that did not meet these three criteria were regarded as unnecessary and were therefore rejected. The set of recommended priority actions are presented in Table 7.1 and outlined in the following Sections. More details are also provided in the relevant appendices.

7.2.1 Farming systems

Diffuse pollution from farms is a key impediment to restoring the health and wellbeing of the Waikato River. For the purposes of this Scoping Study, it is assumed that pasture-based agriculture will continue to be a dominant feature of the Waikato. It would require a major change in national macro-economic settings for this premise to change. Section 5 described actions that mitigate the adverse effects of dairying and dry stock farming and in Section 6 bundles of these actions were predicted to have substantial benefits (including some cost-savings for individual farmers). The priority actions include several actions to provide information about the links between diffuse pollution and farming practices, and build on existing partnerships with the farming sector to help raise awareness of the problems and encourage farmer implementation of the solutions.

Dairy farms

Pollutant run-off from dairy farms is a major cause of the degraded state of the river and needs to be addressed if Te Ture Whaimana is to be met. Dairy farms are the cause of recent increases in nitrogen concentrations in the Waikato River system and are also a source of pathogens and phosphorus (see Section 3). Erosion is generally low on dairy farms which predominantly occupy flat to rolling topography. Nevertheless, access of cows to streams can cause bank erosion and direct input of pollutants.

High-cost but highly effective priority actions are the use of nitrification inhibitors ($138 million) to limit nitrogen transfer to waterways and the fencing and planting of five metre wide riparian buffers along all streams and drains on dairy land ($263 million) to prevent stock access. Well designed and managed riparian buffers will also intercept pollution in runoff (with benefits for water quality), supply leaf litter and stream wood and provide shade and overhang cover for fish (with benefits for ecological integrity and fish) and improve aesthetics.

Better nutrient management, achieved with the help of nutrient plans developed for all farms, is a priority action that has a cost ($10.5 million) that, upon implementation, would be recovered by savings on fertiliser. A low cost but effective action is to divert surface run-off from raceways and bare soils away from streams and into paddocks where the water and pollutants can be absorbed by the soil.

Dry stock farms

On dry stock farms, a priority action is to exclude stock, especially cattle, from streams because they increase sediment, phosphorus and pathogen inputs and damage stream ecology. Dry stock farming enterprises would have difficulty sustaining the costs of planted buffers on all streams in rolling country, and the more expensive fences to exclude sheep as well as cattle, bearing in mind that stream networks are more extensive in hill country than on flat land. Instead, the Study team recommends a lower cost option of excluding cattle (but not sheep) using single-wire electric fencing along all small hill country streams (first and second order) as well as providing off-stream drinking-water and planting poplars to provide shade and reduce erosion.

Scenario modelling in Section 6 demonstrated that further actions beyond the Scenario 2 suite would be required to achieve the aspirations held for the river (particularly in the Waipa River and lower Waikato) that are related to water clarity – particularly spiritual values, aesthetics and swimming. Three further priority actions are therefore recommended:

- Riparian fencing (for both cattle and sheep exclusion) and planting along third order streams and greater, to establish a 10 metre buffer ($66 million). This would strengthen the streambanks and reduce erosion along these larger streams. Co-benefits are run-off interception and stream habitat. Smaller streams are excluded because they have low stream power and are less susceptible to bank erosion than larger streams. Riparian fencing of these streams would also be very costly.

- Retire 68,000 hectares of marginal, erodible pasture in the hill country (mostly within the Waipa catchment) and replant (either for forestry or conservation) to reduce pollutant run-off. Co-benefits include improved stream habitat, reduced peak stream flows and, therefore, reduced erosive power. Over the 30 year period modelled this replanting for forestry has a net cost of $91 million. However, only a proportion of the first rotation of pine trees would be harvested in this time and at the end of the first complete rotation (36 years) there would be a net cash surplus of $937 million.

- Engineering works to stabilise erosion ‘hot spots’ (e.g., earthflows and eroding river bends) ($15 million).

There are a small number of locations where earthflows (viz., deep-seated landslides) are contributing a large amount of sediment to the river – including several locations in the upper Waipa. There are also a small number of locations where serious bank erosion is occurring (e.g., at a river bend where the strong current is eroding a high bank or hillside) – again several in the upper Waipa. Engineering works would help stabilise these locations and thereby reduce sediment inputs and improve water clarity. For the purposes of costing the priority actions, the Study team has estimated the cost of these engineering works at $15 million. However, more detailed site-specific investigations would be needed to confirm these cost estimates. There is in sufficient information available to determine the impact of these erosion ‘hot spots’ on water clarity or to quantify the benefits of remediation. The Study team recommends that initially one or two of these ‘hot spots’ be remediated and the effectiveness carefully monitored in order to determine the cost-benefit of more widespread remediation

Two additional actions were considered but not recommended.

1 The Waikato River Clean-Up Trust purchasing farms and placing covenants on them to ensure they are farmed sustainably. This action has been taken by the Lake Taupoo Restoration Trust to help reduce nitrogen exports to the lake. It is unlikely that the Waikato River Authority would have sufficient capital to purchase enough farms to make a significant difference to the nutrient, sediment and pathogen inputs to the Waikato River. Instead, the

priority recommended actions include supporting 'model' farms and catchments that trial and demonstrate restoration actions, similar in concept to the current monitor farms run by such agencies as the Ministry of Agriculture and Forestry, DairyNZ, Meat New Zealand and others.

2 Herd shelters are not considered to be a priority action because of the high cost and lower benefit/cost ratio than other actions on dairy farms.

7.2.2 Hydro-power

Decommissioning and removing the hydro dams was an action suggested at several of the hui and community consultation meetings. The Study team considered the costs and benefits and concluded that this is not a priority action for two reasons.

1 The hydro-power system is a keystone asset in the regional and national economy, producing approximately 13 percent of New Zealand's total electricity. The dams and power stations will not need to be replaced for more than 30 years and no alternative power sources will be available in the short term.

2 Participants at hui and community meetings asked if removing the dams would restore the Waikato River to pre-1920 conditions immediately. It is clear from overseas studies, and from evidence presented at the consent hearings for the dams in 2000, that there are a number of legacy issues that would not make this possible. First, sediment that has accumulated in the lake beds behind the dams would erode and adversely affect colour and clarity for many years. Secondly, geothermal arsenic and mercury that has accumulated in lakebeds, notably at Lake Ohakurii, would be released, possibly leading to problems with toxicity. Thirdly, the dams would no longer provide flood storage and thus infrastructure in the lower Waikato would be threatened and necessitate the raising of stop banks. Fourthly, some sites of cultural significance which were flooded are likely to have been permanently damaged and it may not be possible to restore them. Finally, infrastructure assets and recreational amenities have developed around the presence of the hydro dams (e.g., the international rowing facility at Karaapiro) that are valued highly by the community.

The Study team does recommend, however, that in response to concerns raised, Mighty River Power and the Waikato River Authority consider ways to better advertise impending water level and flow changes below the hydro dams (e.g., using a cell phone system and/or electronic displays at key bathing sites) and continue to cooperate with groups running events on the river.

A second priority action is to monitor the impacts of the current operating regime to determine if it is having any adverse effects on bank erosion, ecology or safety. All three issues were raised in community meetings and hui during this Study. Each was the subject of investigation in the late 1990s and during the consent hearings for the hydro dams and, at that stage, evidence of adverse effects was not forthcoming.

7.2.3 Urban systems

Urban run-off flows into a small number of tributary streams. The recommended priority actions are to improve the aesthetics of urban streams by replanting and, where appropriate, improving access ($3 million), and re-introducing one or more taonga species (e.g., giant kookopu) ($0.2 million). The Study team does not recommend retrofitting storm water treatment systems because it would be costly and of limited benefit to achieving the

aspirations. Urban run-off from new urban developments in the Waikato River is managed through structure plans that aim to protect streams (e.g., requirements for swales, storm water detention ponds and rain gardens).

There is cause for concern about the potential cumulative impact of septic tanks, especially with the recent increase in rural-residential subdivisions. Contaminants from septic tanks enter the groundwater and it may take many years to detect any adverse effects. A priority action for the Waikato River Authority is to ensure that an assessment is made of the potential cumulative effects of septic tanks and that rules are in place to prevent adverse effects on groundwater and the river system (consistent with the precautionary approach outlined in Te Ture Whaimana). More regular cleaning of existing septic tanks ($18 million) is recommended.

7.2.4 Point source discharges

Major improvements in the treatment of point source waste discharges have occurred since the 1970s, although some point source waste discharges still cause concerns (see Section 3 and Appendix 13: Water Quality). In total, point source discharges of nutrients are small compared with non-point sources and generally have only a minor impact on the main stem of the Waikato River. There are two exceptions.

1 Where discharges are to small tributaries (e.g., Te Kuiti discharges to the Mangaokewa Stream) they can have a measurable impact. It was outside the scope of this Study to comprehensively review all consent conditions to ensure they are consistent with the aims and timetable of restoration, and to identify particular waste discharges that require upgrading, but the Study team does recommend such a review as a priority action.

2 Point source discharges near Hamilton significantly increase phosphorus concentrations in the lower Waikato where they exceed the guidelines for algal blooms. The two largest sources are: Hamilton City sewage and the AFFCO freezing works at Horotiu, with a smaller contribution from the Te Raapa dairy factory. A priority action is to investigate better wastewater nutrient treatment of these point sources to complement the benefit from actions that reduce nutrients in farm run-off. Hamilton City is moving towards chemical removal of phosphorus and this is accounted for in this Study's modelling. Any further reductions would require either very sophisticated treatment technology or land disposal.

Disposal of human sewage directly to water is offensive to Maaori, destroying spiritual values and the feeling of connection. Therefore, a recommended priority action is for land disposal of all municipal sewage wastewaters so that these aspirations can be met. This will require a high level of conventional treatment followed by discharge to wetlands, infiltration basins or irrigation to land. As well as meeting cultural health aspirations there are significant benefits for other aspirations (e.g., water quality, human health), particularly at the local-scale downstream of the discharge point. The cost will depend on agreement with iwi about disposal methods that meet their requirements together with an assessment of technical feasibility. For slow rate irrigation to land or infiltration basins at all sites, the total cost is estimated to be $1,080 million (see Option 2, Table 6 in Appendix 14: Wastewater Management). Sixty percent of this total is the cost for Hamilton City where a large area of very expensive farmland is required. For wetlands the total cost is estimated at $124 million. For the purposes of costing the priority actions, the Study team assumed that wetlands would be suitable at Hamilton, Te Kuiti and Te Kauwhata with land irrigation at all other sites – total cost $365 million. Note, however, that a more thorough analysis of the specific options at each location is required before a more definitive cost could be derived.

The Wairaakei Geothermal Power Station has been a major point source of arsenic, mercury and other contaminants (see Section 3). In recent years more stringent consent conditions have reduced, but not yet eliminated, these discharges. A priority action is to monitor compliance with current consent conditions and press for reinjection of geothermal wastewaters. There is also a legacy issue associated with natural and geothermal contaminants (notably arsenic and mercury) that have accumulated in the sediments of Lake Ohakurii. There is a risk that high nutrient inputs will change the lake, causing bottom-water deoxygenation, so that these contaminants escape from the sediments. The Study team recommends that the Waikato River Authority assess the risks of this happening, the threat this poses to the safety of drinking-water supplies and kai collected from the Waikato River and the effect on ecology. If the risks are determined to be high, then a priority action is to investigate the best way to 'cap' the lake sediments to prevent release. This would have the co-benefit of preventing nutrient release from the lakebed.

7.2.5 Public health

E. coli concentrations already comply with contact recreation guidelines in most places along the main stem of the Waikato and Waipa Rivers and are likely to fall further as a result of fencing cattle out of streams (see Section 7.2.1). The CLUES model was used to quantify the effect on *E. coli* concentrations of actions on farms (notably stock exclusion, riparian planting, effluent management, and raceway runoff diversion). The model did not consider land disposal because information was not available about the practicality and effectiveness of land disposal when the modelling was carried out. The model did not consider advanced sewage treatment (e.g., UV disinfection) because this was not identified as a priority action. Sewage inputs from Te Kuiti, Otorohanga and Te Awamutu sewage give high predicted *E. coli* concentrations in the Waipa River. Land disposal or wetland treatment of sewage at these three locations is expected to reduce *E. coli* concentrations in the Waipa below the guideline targets. Concentrations may not drop to the guidelines in all tributaries and shallow lakes because of local contamination from birds and sheep.

The restoration actions will reduce, but not eliminate, the risk from pathogens in river and lake water, and hence will not enable untreated water to be drunk safely. To provide safe drinking-water at marae, a priority action is to install drinking-water treatment facilities at all marae that require it ($23 million). This is important for community wellbeing.

7.2.6 Fisheries, kai, taonga species

The priority actions for whitebait are aimed at increasing their abundance through increases in habitat ($18 million), improvements in habitat quality ($44 million) and removing barriers to migration ($42 million) (see Table 7.3 and Section 5). It is also recommended that action be taken to bring the whitebait fishery under the control of a single agency to ensure holistic management and that traditional fishing spots are reserved for iwi.

The priority actions for tuna are also aimed at increasing abundance by creating at least 700 hectares of new habitat in wetlands and farm ponds ($177 million), continuing the transfer of elvers into the hydro lakes ($7 million) and improving the survival of these elvers by on-growing before release ($17 million). As part of the action to create new habitat, the Study team recommends investigating the re-flooding of areas of low-lying pasture in the Lower Waikato. Priority actions to increase the number of adult tuna returning to the sea to spawn include retrofitting 63 pumping stations with 'tuna friendly' pumps ($97 million), creating reserves in all headwater streams (first and second order) and in Lake Whangapee and its tributaries and

revising the fisheries regulations to increase the minimum size and impose a maximum size on tuna that can be taken ($4 million).

Two additional actions were considered but rejected.

1 Intake screens at the hydro-power stations might prevent adult downstream migrants being drawn into the turbines and killed. However, the benefits are unclear without a proven technology to capture and transfer migrants, meaning the adults cannot return to sea to spawn in any event. The costs are also extremely high and there are major technical difficulties. It would be more cost-effective to increase the number of adult migrations reaching the sea by actions taken below the hydro dams (e.g., reserves and reducing the maximum harvestable size).

2 Re-flooding prime whitebait spawning habitat at Aka Aka was considered but rejected because of the major disruption to existing infrastructure and extremely high cost compared with the benefit.

7.2.7 Lakes restoration

The Study team recommend the restoration (over the next 30 years) of two dune ($4 million) and four peat ($32 million) lakes in order to demonstrate what needs to be done and what can be achieved, in the expectation that this will complement existing local authority and community-driven restoration of other lakes.

The Study team also recommends the restoration of two larger riverine lakes – Waahi ($22 million) and Whangapee ($112 million) – and the Whirinaki Arm of Lake Ohakurii ($27 million). As Lake Waahi is the smaller, the least costly and most likely to recover more quickly, the Study team recommends it be restored first. Lake Whangapee is larger, costly and difficult to restore but the benefits of restoration are high and the Study team recommend it be restored second. This Study has determined that restoration is feasible and would have significant benefits, but more detailed engineering and ecological investigations are required before restoration commences.

Some actions to restore these lakes were considered and not recommended as priority actions. They were:

1 The construction of permanent concrete or earth wave barriers in Waahi and Whangapee was considered to be costly. Temporary barriers made from bundles of maanuka are preferable.

2 The option to drain and dredge Whangapee ensures that aquatic weeds and pest fish are eliminated but is technically challenging and costly. Crucially, the benefits would be negated by floods re-introducing aquatic weeds and pest fish from the main stem.

3 The restoration of Lake Waikare was considered but found to be much more challenging than the restoration of Waahi and Whangapee. This is because of its large size and because it is part of the Waikato River flood control scheme, which limits restoration options. Nevertheless, the Study team support the ongoing restoration work in the Mangaturu catchment, the main inflow and recommend that the Waikato River Authority consider further restoration in the future.

7.2.8 Engagement

Sustained progress towards the vision for the river will require a mix of actions to bring about behavioural change (e.g., farming practice) and actions to bring about physical change (e.g.,

riparian restoration). There is clear evidence that attitudinal and behavioural change requires education and support. For example, a recent Ministry of Agriculture and Forestry study has found good returns from farm advisory services (Dr Phil Journeaux, Ministry of Agriculture and Forestry, pers. comm.). An earlier study showed farmers were more likely to take environmental action (i.e., riparian management) in the presence of education and funding (Rhodes et al., 2002). Overseas research also indicates that engagement is essential to achieve adoption of restoration actions (Ison et al., 2007).

It is clear that farmer cooperation will be essential to restoring the health and wellbeing of the Waikato River. A priority action is, therefore, to improve engagement with farmers on restoration by building significantly on current efforts (e.g., through Dairy NZ, Environment Waikato, Federated Farmers, the Farm Environment Awards Trust and Landcare Trust). The Study team's analysis of actions in Section 5 (and associated Appendices) has shown that some restoration actions associated with better nutrient management will be win-win – i.e., both reduce pollutant run-off and increase farm profits – so would seem to have low barriers to widespread uptake, other than raising awareness. Other actions involve considerable change to current farm practice. Previous studies of waterway restoration in farming systems (e.g., Wilcock, et al., 2009; Quinn et al., 2010; Dodd et al., 2008) have shown that in-depth engagement with farmers is required to understand all the implementation issues from their perspective and to derive variants of the actions that work on a farm-by-farm basis. Monitoring and regular reporting on restoration progress has been shown to be integral to achieving engagement – farmers need to see the improvements that result from the actions they are taking and to receive acknowledgement for taking these actions.

Furthermore, hapuu and local community knowledge about how their restoration initiatives are progressing provides essential feedback for others to learn from and to guide the Waikato River Authority in its future decision making. Such adaptive management (sometimes called 'learning by doing') is well recognised as a key element in restoration. Without community engagement, the physical actions to restore the Waikato River are unlikely to be wholly implemented and, where implemented, not sustained in the long-term. Therefore, the list of recommended priority actions includes 17 items that address education, information and publicity.

The recommended priority actions focus on knowledge sharing and capacity building. To estimate costs, the Study team had to select specific actions to build up a package. The Waikato River Authority would want to develop a strategic engagement/public outreach plan which may differ in its emphasis amongst the individual actions. Essential features of such an engagement plan are that activities:

- Have a clearly defined purpose and audience, driven by the overall strategy.
- Are well coordinated.
- Enhance existing partnerships and activities which already have a proven track record.
- Include monitoring and evaluation to assess their success.

Key components are:

- Developing and maintaining wide and deep support for restoring the river.
- Reaching the next generation (and their whaanau) through schools.
- Building the restoration and co-management capacity of iwi.
- Improving the restoration capacity of the community.

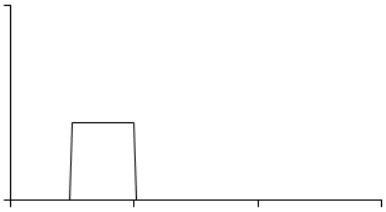
- Developing research capacity and addressing information gaps.
- Enhancing collaborations between industry, non-government organisations, statutory authorities and the wider community.

7.2.9 Summary of recommended priority actions

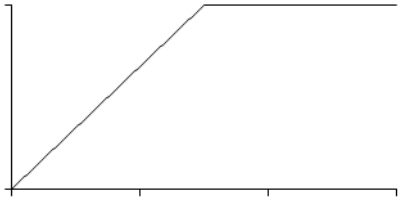
Table 7.1 summarises the recommended priority actions, costs and benefits.

It also includes 'schematics' to illustrate when results might be expected from a single action. Some actions have virtually immediate benefits – those are shown as a step change then maintained at the higher level. Actions in this category include fencing cattle out of streams which rapidly ensures fewer pathogens from effluent and less sediment from cattle trampling streambanks. Where actions are only required to be done once (such as the one-off investigation to determine whether to cap the sediment in Lake Ohakurii) these are shown as a 'top hat'. Some actions deliver gradual cumulative results – these are shown as an upward slope on a graph. For example, for big rivers, aesthetic improvements from riparian planting (especially with slow-growing natives) continue to accrue over several generations. By contrast, riparian planting of very small streams delivers benefits relatively quickly.

Top Hat



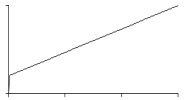
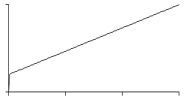
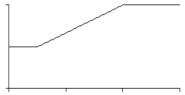
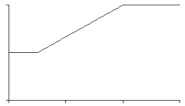
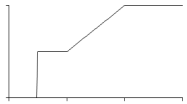
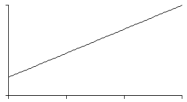
Gradual cumulative

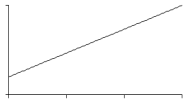
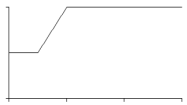
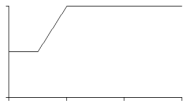
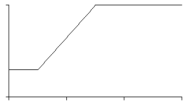
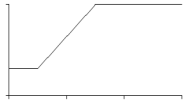
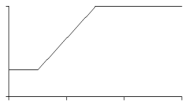


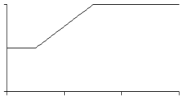
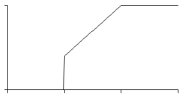
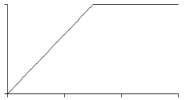
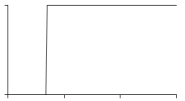
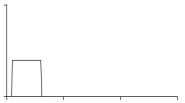
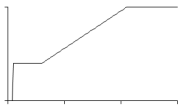
Where there is a logical reason for delay, for example because it is sensible to restore urban stream habitat before re-introducing taonga species, the schematic shows the line starting further to the right.

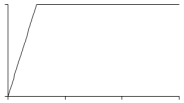
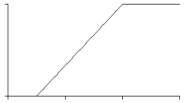
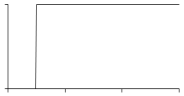
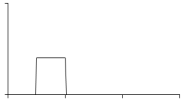
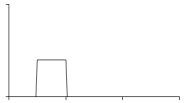
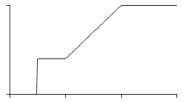
This is a Scoping Study and in some cases the Study team recommend more detailed investigation (e.g., on engineering aspects) before restoration action takes place. If the Waikato River Authority wishes to compile a different bundle of actions, this Study provides extensive material to assist in decision making, including the costs set out here and the scenario modelling framework described in Section 6.

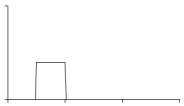
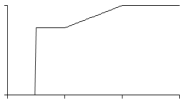
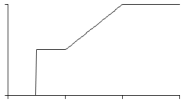
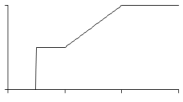
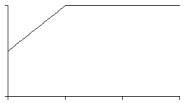
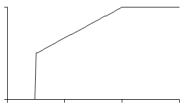
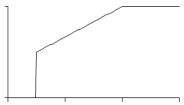
Table 7.1: Summary of recommended priority actions

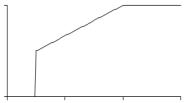
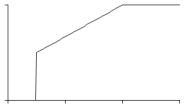
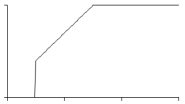
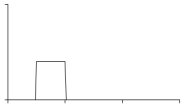
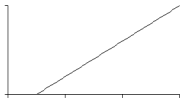
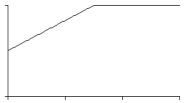
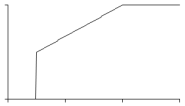
Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
					Dairy farms					
Nutrient management	Dairy farms	Nutrient export	Savings on fertiliser	10.5	3.3	EW Farmers, Fonterra, fertiliser industry	Information. Incentives for change.		Year 1-30	Include management plans (Farmers). Revise fertiliser Code of Practice (Fertiliser Industry). Auditing (Environment Waikato, Industry).
Effluent management	Dairy farms	Reduced run-off and leaching	Savings on fertiliser	36.1	27.7	Farmers, Fonterra, Fertiliser Industry, EW, MAF			Year 1-30	Continue to phase out two-pond systems that discharge to streams.
Divert runoff	Dairy farms	Reduced run-off		5.4	3.9	EW Farmers			Year 1-10	Low technology.
Wetlands	Dairy farms	Nutrient export	Tuna habitat GHG (disbenefit)	45	26.1	Farmers EW, F&GNZ	Incentive. Information: cost/benefit. Design and placement.		Demo Year 1-5 Policy Years 5-30	Demonstration wetlands. Publicise cost/benefit. Provide detailed design information. Develop industry accord and policy.
Planted riparian buffers	Dairy farms	Stock exclusion, reduced pollution	Stream habitat, aesthetics, taonga species	263.3	160.6	Farmers, Fonterra, WRA, Community Groups, DOC, EW	Incentive. Information: cost/benefit. Types of plant, width, maintenance. Availability of plants.		Demo Year 1-5 Policy Years 5-30	Needed: cost/benefit information, industry accord, plant nurseries, design guide, advice/support, lobby for carbon credits.
Nitrification inhibitors	Dairy farms	Nitrogen leaching	Pasture production GHG (benefit)	137.7	43.4	Farmers, Fertiliser Industry, EW	Cost. Incentives. Breaks down quickly here. Information: cost/benefit.		Year 1-30	ETS may improve economics.

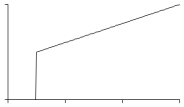
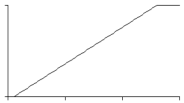
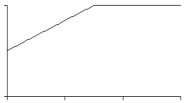
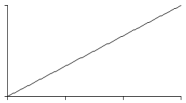
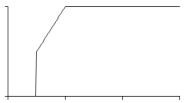
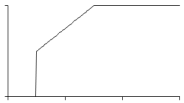
Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
Nutrient management	Cropping land	Nutrient export	Sediment export	-19.5	-6.1	Farmers, EW, Fertiliser Industry			Year 1-30	Immediate financial benefit (reduced fertiliser).
				478.5	**258.9**					
Dry stock farms										
Fence out cattle and plant poplars	1st and 2nd order streams	Reduced pollution and bank erosion	Stream shade	93	67.4	Farmers	Policy incentive. Lack of capital. High stream density.		Year 1-30	Needed: financial incentives.
Fence all stock and plant riparian buffers	3rd to 7th order streams	Reduced pollution and bank erosion	Stream and terrestrial habitat, biodiversity and aesthetics	66.3	36.3	Farmers, EW, DOC, Rivercare	Policy incentive. Lack of capital. High stream density.		Year 1-30	Needed: financial incentives, plant nurseries, design guide, advice/support, lobby for carbon credits.
Retire and afforest pasture	Steep, erodible pasture	Reduced erosion and sediment yield	Reduced flooding and nutrient. Stream and terrestrial habitat.	91 0	240	Farmers Foresters, EW	Capital to convert. Cashflow until harvest. Policy incentives.		Year 1-30 Cost = $937 NPV = $155	Publicise cost/benefits. ETS and incentive schemes would help cashflows. Water quality benefits not costed.
Erosion hotspots	River bends, major landslides	Reduced sediment yield	Improved water clarity	15	6	EW, Landowners, WRA	Engineering difficulties, Costs		Year 1-5: plan Year 5-30: works	Majority in Upper Waipa
Forest buffers	Forestry areas	Reduced erosion and sediment yield	Reduced water and pollutant yield	224.8	91.1	Foresters, MAF, MFE, EW			Underway	
				490.1	**440.8**					

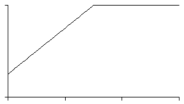
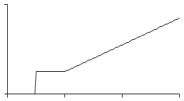
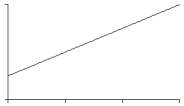
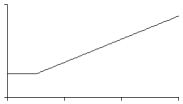
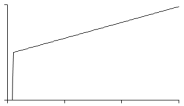
Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
					Urban streams					
Plant riparian buffers and enhance walkways	Towns	Aesthetics	Recreation and habitat	3	1.8	Local authorities Community groups			Underway	
Re-introduce taonga species	Urban and rural streams, shallow lakes	Wider distribution of taonga species	Biodiversity	3.5	1.6	Community groups, DoC	Rearing		Year 10-30	Restore stream habitat first.
				6.5	**3.4**					
					River aesthetics					
Native riparian buffers	3rd - 7th order streams	Aesthetics	Bank erosion, recreation, biodiversity	11.9	6.8	Farmers, LA, iwi, community group, EW, DOC	Additional to planting on farms.		Year 1-10	Ensure suitable native species used. Lobby for carbon credits.
Promote reinjection	Wairakei	Food safety	Water quality	Included in Review rules and consents	Included in Review rules and consents	WRA, EW	Existing consents. Industry collaboration. Information.		Year 5-10	
Investigate arsenic and mercury	Lake Ohakurii sediments	Determine actions	Nutrient reduction	0.7	0.7	WRA, consultants	Existing consents. Industry collaboration. Information.		Year 1-5	Only a problem if nutrient inflows continue to increase.
Assess and manage risk of arsenic and mercury in 'food basket'	Upper Waikato	Food safety	Hospitality	0.1	0.1	WRA, consultants	Existing consents. Industry collaboration. Information.		Year 1-5	
				12.7	**7.6**					

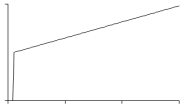
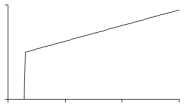
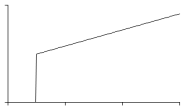
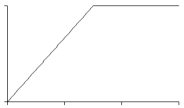
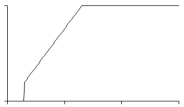
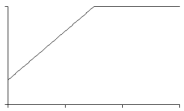
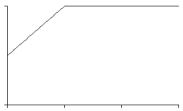
Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
					Human health					
Drinking-water treatment at marae	All 67 marae	Human health	Hospitality	23.1	15.6	Iwi, DOH	Cost		Implement: Year 5-10	Grants may be available from Department of Health.
Land/wetland disposal of sewage	Towns	Cultural health	Water quality	365	194	LA, EW	Small rating base for some LA. Feasibility and costs uncertain. Consenting takes time.		Consents: Year 1-5 Investigate: Year 1-10 Implement: Year 11-30	Re-examine iwi requirements, feasibility and costs at specific sites through JMAs.
More frequent septic tank cleaning	Rural	Reduced pollution		18.3	7	Landowners	Rule change.		Year 5-30	Requires rule change.
Assess cumulative effects of septic tanks	Rural residential sub-divisions	Reduced pollution		Included in Review plans		EW, WRA	Regional Plan rules.		Year 1-5	May require rule change.
				406.4	**216.6**					
					Access					
Strategic plan for cultural and historic sites	Whole river	Plan to guide actions	Manage access, privacy, place names, information	2.3	1.6	Iwi, community, LA, EW, HPT			Year 1-5	Linked in with CHI. Maaori-led.
Restoration of historic sites	Whole river	Plan to guide actions	Provide access or privacy, restoration, information	2	1.1	Iwi, community, LA, EW, DOC, HPT			Year 5-30	

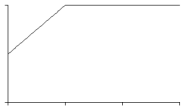
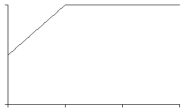
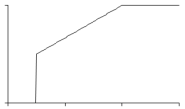
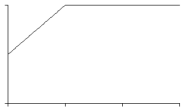
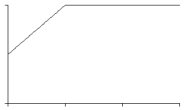
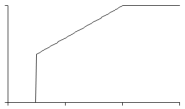
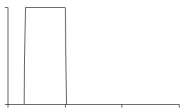
Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
Strategic access plan	Whole river	Plan to guide actions	Manage access, boating, recreation, hydro-peaking	1.5	1.4	EW, WRA, community groups, sports groups, LA, MRP, industry			Year 1-5	
Boat ramps	16 riverside marae	Cultural	Safety, engagement, recreation	7.4	7.4	Iwi, sports groups, community groups, LA			Year 5-10	Depending on Access Plan.
New public reserves	4 new reserves	Recreation	Engagement	13	5.7	LA, community groups, sports groups	Land ownership, Costs		Year 5-10	Depending on Access Plan.
Extend foot paths and cycle ways	Waikato and Waipa main stem	Recreation, tourism	Engagement	21.5	15.1	LA, community groups, landowners	Land ownership, Costs		Year 10-20	Depending on Access Plan.
Control physical hazards	40 key boating and swimming sites	Safety	Recreation, aesthetics	1.6	0.6	LA, EW			Year 1-30	Ongoing
				49.3	**32.9**					
						Whitebait				
Enhance spawning habitat	Lower river and tributaries	Increased spawning	Recruitment, abundance	5.9	4.9	Landowners, EW, DOC	Land ownership		Year 5-10	
Modify tide gates	23 tide/flood gates	Allows iinanga passage	Increased access to adult habitat	6.9	6.9	LA, EW, Drainage Boards	Consents. Costs.		Year 10-20	

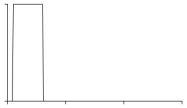
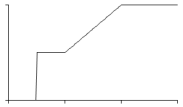
Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
Modify road culverts	100 road culverts	Allows iinanga passage	Increased access to adult habitat	4.6	2.8	NZTA, LA	Industry collaboration. Costs.		Year 5-10	
Modify farm culverts	1,600 farm culverts	Allows iinanga passage		30.3	21.9	Farmers, EW, Drainage Boards	Education. Costs.		Year 5-20	New culverts must comply. Retrofit over 20 years starting with high priority sites.
Manage aquatic weeds	900 km of drains and small streams	Improved habitat	Tuna habitat	44.3	29.9	Farmers, DOC, EW, LA, Drainage Boards	Mechanical control expensive		Year 5-30	Needs more detailed investigation to determine most cost-effective methods. Mechanical harvesting very expensive.
Single whitebait management agency		Holistic management		7.5	3	DoC, EW, WRA, MFish	Legislation			Flagged in the Deed of Settlement.
Replant adult banded kookopu habitat	Headwater streams near the coast	Increased abundance	Taonga species, biodiversity	9.9	6	Farmers, EW, DoC.	Costs		Year 5-30	
				109.4	**75.4**					
						Tuna				
Continue elver transfer program	Hydro lakes	Tuna fishery above Karaapiro	Taonga species, biodiversity	6.7	2.7	Quota holders, Iwi, MRP			Year 1-30	
On-grow elvers	Aquaculture ponds	Improved survival	Stock for ponds and wetlands	17.3	7.4	Quota holders, Iwi, MFish	Feasibility.		Year 5-30	New business model required.

Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
Modify pump stations	Lower Waikato	Adult spawner migration	Taonga species, biodiversity	96.5	70	EW, Drainage Boards	Cost. Consents.		Feasibility: Year 1-5 Priority sites: Year 5-10	Need to assess cost/benefit more carefully and identify priority sites.
Create 700 ha of new tuna habitat	Farm ponds and lowland wetlands	Increased abundance	Taonga species, biodiversity	177	90	Landowners, iwi, quota holders, EW	Cost. Feasibility. Consents.		Demo: Year 5-10 Implement: Year 10-30	Obtain stock from on-growing elvers. May need consents for ponds. Could use farm wetlands.
Tuna management plan and enforcement		Reserves, upper and lower limits, enforce	Taonga species, biodiversity	15.0	6.1	MFish, WRA, quota holders, iwi, MRP, DOC			Legislation: Year 5 Raahui: Year 1-10 Size limits: Year 5-30	Iwi could buy/retire quota and impose raahui to reduce fishing pressure. Reserves or raahui in lower Waikato may compensate for adults trapped in hydro lakes.
				312.5	**176.2**					
Water allocation										
Ensure RPV6 supports Te Ture Whaimana		Security of supply	Ecological flows	Included in review rules and consents		WRA			Year 1-30	
Shallow lakes										
Restore 2 dune lakes	Coastal	Water quality, biodiversity	Aesthetics	2.7	1.4	LA, landowners, Iwi, community groups, EW, F&GNZ, DOC	Land ownership. Consents. Cost. Feasibility.		Year 5-10	
Restore 4 peat lakes	2 Waipa, 2 Lower Waikato	Water quality, biodiversity	Recreation, aesthetics, fisheries, plant materials, cultural/ spiritual values.	32	16.3	LA, landowners, Iwi, community groups, EW, F&GNZ, DOC	Land ownership. Consents. Cost. Feasibility.		Year 5-10	Complement ongoing restoration by LA.

Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
Restore Waahi	Lower Waikato	Historic sites, water quality, kai, biodiversity	Recreation, aesthetics, fisheries, plant materials, cultural/ spiritual values.	22.4	13.6	LA, landowners, Iwi, community groups, EW, F&GNZ, DOC	Land ownership. Cost. Consents. Feasibility. Re-invasion by pests. Koiwi in lake bed.		Planning: Year 1-5 Restoration: Year 5-10 Monitoring: Year 5-30	Big challenge. Highly visible. Beyond the capacity of LA and community groups. Moderate size - test methods and apply to larger lakes (Whangapee, Waikare). Monitor and adapt methods.
Restore Whangapee	Lower Waikato	Historic sites, water quality, kai, biodiversity		112.3	65.1	LA, landowners, Iwi, community groups, EW, F&GNZ, DOC	Land ownership. Cost. Consents. Feasibility. Re-invasion by pests. Koiwi in lake bed.		Planning: Year 5-10 Restoration: Year 15-20	Actions on farms helping to reduce input – some for Waikare and other shallow lakes.
Restore Whirinaki Arm, Ohakurii	Upper Waikato	Recreation, water quality		26.7	13.1	LA, landowners, Iwi, community groups, EW, F&GNZ, DOC	Land ownership. Cost. Consents.			
				196.2	**109.5**					
						Engagement				
Educational material for schools	Including kura kaupapa	Increased engagement	Transfer of knowledge	7.0	3.2	WRA, DOE, RSNZ, EW, LA, DOC, F&GNZ			Year 1-30	
River Festival	Biannual	Increased engagement	Tourism, recreation	4.5	1.8	WRA, LA, iwi, community groups			Year 2, 4, 6…	

Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
Information and publicity about restoration		Increased engagement		11.1	4.5	WRA, LA, iwi, community groups, EW, DOC, NZLCT			Year 1-30	Important at start to inform and engage the community.
Training on restoration actions		Increased capacity	Links with industry and agencies	15	6.1	Iwi, Specialists, EW, DOC			Year 2, 4, 6…	
Marae-based enterprise training		Increased capacity	Links with industry and agencies	13.6	6.5	Iwi, community, LA			Year 1-30	Nurseries are needed immediately to supply native plants for planting buffers. Planting gangs will be needed.
Support research to fill information gaps	Including pest fish	Information to underpin adaptive management	Increased capacity, adaptive management	30	12.2	WRA, Waikato-Tainui Endowed College, Waikato University, CRIs, Community Groups, EW			Year 1-30	To coordinate filling information gaps on social science, economics and biophysical science.
Engagement continued										
Visitor centres	One in each iwi area	Improved knowledge and understanding	Tourism, engagement	15.5	6.4	Iwi, WRA, Community Groups	Cost. Consents.		Year 5-20	Consider a mobile facility.
Commissioner training		Enhanced iwi input to decision making	Builds iwi capacity	1.5	0.6	Iwi, WRA			Year 1, 3, 5….	Commissioners then run courses in the community.
Support community group coordinators		Co-ordinated action across catchment	Information sharing, networking, collaboration	5.0	2.0	WRA, LA, Iwi, Community groups, EW, DOC			Year 1-30	Support for existing coordinators.

Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
Promote industry and community collaboration		Information sharing, networking, collaboration	Conflict resolution	2.5	1.1	WRA			Year 1-5	Important at start to build industry accords.
Sponsor new restoration awards		Recognition, encouragement	Role models, innovation	4.0	1.6	WRA			Year 5-30	One way to acknowledge and publicise success.
Develop cultural health indicator		Maaori values respected	Better monitoring	13.1	5.7	WRA, iwi, specialists, MFE	Complexity - combines maatauranga and science		Year 1-10	Flagged in Te Ture Whaimana. Build on existing CHI but modify for Waikato River and lakes. Requires iwi input.
Monitoring Equipment		Information for adaptive management	Community engagement	1.0	0.8	WRA			Year 1-30	Important to gather baseline information before restoration gets underway.
Monitoring to complement existing monitoring		Information for adaptive management	Community engagement	46.3	18.4	WRA, EW, MAF, CRI, UOW, Industry			Year 1-30	Important to gather baseline information before restoration gets underway.
Centralised and managed database		Holistic management	Adaptive management	3.3	1.5	WRA, EW, LA			Planning: Year 1-2 Database: Year 3-30	Important to audit and collate monitoring data. Aids reporting on the progress of restoration. Consider a full-time coordinator.
Review rules and consents		Consistent with Vision and Strategy	Cumulative effects, pre-cautionary principle	4.0	2.4	WRA, EW, LA	Expiry dates vary		Initial review: Year 1-3 Audit: Year 5, 10, 15…	

Action	Location	Benefits	Co-benefits	Cost $2010 million	NPV $2010 million	Who	Impediments	Timing	Timing	Comment
Review plans		Consistent with Vision and Strategy	Cumulative effects, pre-cautionary principle	4.0	2.4	WRA, EW, LA	Expiry dates vary		Initial review: Year 1-3 Audit: Year 5, 10, 15…	
Co-management agreements		Maaori values protected	Consistency	2.0	1.2	WRA, LA, DOC, MFish, F&GNZ etc			Year 1-2	Important for WRA to establish good working relationships with LA, industry and stakeholders.
				183	**78.3**					
			Total	**2245**	**1399**					

Key

MRP = Mighty River Power
LA = Local Authorities
UOW = University of Waikato
F&GNZ = Fish & Game NZ
DOE = Department of Education
CRI = Crown Research Institutes
DOC = Department of Conservation
NZLCT = New Zealand Landcare Trust
EW = Environment Waikato
HPT = Historic Places Trust
MFE = Ministry for the Environment
WRA = Waikato River Authority
DOH = Department of Health
MAF = Ministry of Agriculture and Forestry
JMA = Joint Management Agreement

The recommended priority actions, outlined in Table 7.1, can be summarised into the following 'Ten Tonics':

1 Governance: Appropriate weight being given to Maaori aspirations for the protection and restoration of the Waikato River through the implementation of the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 by the Waikato River Authority and those with statutory obligations and responsibilities under the Act (local authorities and government departments). The relationship between the Waikato River Authority, Environment Waikato and other local authorities will be essential to the implementation of actions the Waikato River Authority chooses to fund.

2 Engagement: A strategic engagement/public outreach plan building on existing activities, including work with farmers, taangata whenua, schools and environmental groups.

3 Dairy farms: A suite of actions to reduce pollutant run-off, including improved nutrient and effluent management, preventing stock access to streams and use of nitrification inhibitors.

4 Dry stock farms: Measures to keep stock out of streams and afforestation of 68,000 hectares of marginal, erodible hill country pasture.

5 Point source discharges: Land disposal of all treated human sewage, a review of consent conditions for discharges and investigation of better treatment of some large point source discharges near Hamilton and of discharges to small streams.

6 Public health: Reductions in faecal contamination through actions on farms, the installation of safe drinking-water supplies on marae, and determining the safe limits for eating kai taken from geothermal areas (affected by toxic chemicals).

7 Access: More footpaths, cycleways, boat ramps and other measures to improve access to, and along, the Waikato River (where appropriate) for recreation and traditional uses.

8 Fisheries, kai, taonga species: Increasing the area and quality of habitat through riparian fencing and planting, creation of new wetland habitat and removing barriers to migration. Enhance tuna populations through elver capture, aquaculture and release.

9 Lakes restoration: A phased programme of restoration, focusing on two dune lakes, four peat lakes, and two larger riverine lakes (Waahi and Whangapee).

10 Protection: Application of a precautionary approach when revising policies and plans, and making decisions on resources so as to protect the Waikato River against adverse effects from continuing land use intensification and population growth.

7.3 Implementation issues

7.3.1 Decisions about timing of actions

The Waikato River Authority will need to consider the timing of actions after it has made final decisions on which suite of actions to implement. In order to restore the Waikato River quickly, restoration needs to start as soon as possible. However, there are a number of constraints.

First, international and local experience with restoration programmes (see Appendix 2: Restoration Case Studies) suggest that it is important to establish a sound community-based foundation before embarking on restoration initiatives. In particular, early attention should focus on:

- Setting clear restoration objectives agreed with co-management partners – through the Integrated Management Plan (as discussed in Section 3.2.3) and/or Waikato-Tainui Environmental Plan (see Waikato-Tainui Raupatu Claims Settlement Act 2010).
- Involving the community in establishing restoration objectives to get buy-in from the community.
- Managing expectations – the benefits of some restoration actions can take considerable time before they become apparent.
- Doing strategic planning carefully to avoid ad hoc decision making and to avoid costly delays through:
    - Co-management agreements with Environment Waikato and local authorities (see Waikato-Tainui Raupatu Claims Settlement Act 2010). These enable plans, policy statements and rules to be reviewed, and if necessary revised, to ensure they are consistent with the aims and objectives of restoration.
    - Partnerships (e.g., with iwi, farmer organisations, industry, local authorities) including industry accords (e.g., the Fonterra Clean Streams Accord) and industry codes of practice (e.g., those of the fertiliser and forestry industries). These will encourage and support stakeholders to change their behaviour without the need for statutory processes (e.g., rules and consents).
- Involving Environment Waikato, local authorities and the community in establishing a timetable for restoration, setting in place the management framework for restoration and coordinating restoration activities.

Development of an Integrated River Management Plan is a key activity arising from Section 35 of the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010. The purpose of this plan is primarily developing an integrated approach between the river iwi, Ministries of Conservation and Fisheries, Environment Waikato and the other agencies on management of aquatic life, habitats, and natural resources. However, the Waikato River Authority may wish to consider extending this Plan so that it becomes the key 'integration and coordination' document for implementation of the priority actions it decides to fund, setting out the frameworks, mechanisms and relationships that will be required if successful restoration of the Waikato River is to be achieved (see Appendix 28: Impediments).

The Study team also notes that while the preference is that restoration actions and behaviours occur voluntarily with community and stakeholder 'buy in' this will not always be the case and

the consequences of inaction need to be considered (e.g., the need for regulation, compliance measures and enforcement). Environment Waikato, local authorities and other agencies will play an essential role in developing and managing regulatory and planning frameworks and mechanisms that will support the implementation of the priority actions the Waikato River Authority chooses to fund and, in fact, may take lead roles in many of the priority actions.

Despite the need to establish a sound foundation, the Study team recommend that the Waikato River Authority look to get some early wins by implementing some of the priority actions which are highly visible, could deliver tangible results relatively quickly and have a positive effect on people's perception of the restoration project. These early actions could include:

- Extending walkways and cycleways featuring restored historic sites.
- Making water safe to drink at marae by installing water treatment systems.
- Setting up good monitoring programmes to complement existing monitoring (e.g., by Environment Waikato). This includes ensuring that baseline data is gathered now in order to judge progress (see Section 8).
- Assisting iwi to establish cultural health indicators and appropriate monitoring protocols.
- Establishing riparian buffers and suitable signage along high profile stretches of the river next to State Highway One.
- Establishing nurseries for native plants that will be required in large numbers for planted riparian buffers and lake restoration.
- Promotion of events that are centred on and around the river.
- Purchasing tuna quota from commercial fishers to immediately reduce fishing pressure and make it easier for iwi to collect tuna.

Secondly, there are some instances where there is good reason to delay the start of an action, including when:

- One action is effectively a pilot for another, e.g., the Study team recommends that the Waikato River Authority carefully monitor the restoration of Lake Waahi and use those results to adapt actions both at Lake Waahi and to inform the design of a restoration programme at Lake Whangapee. Work on Lake Whangapee is much more costly so should start after lessons have been learnt from Lake Waahi.
- Research should be conducted to refine or validate proposed actions, e.g., the Study team recommends thorough investigation of the need and technical requirements of sediment capping in Lake Ohakurii.
- Actions are constrained by capacity (e.g., planting gangs) or materials (e.g., eco-source plants).
- The phasing of expenditure can help build sustainable employment and opportunities for local business, e.g., a steady or gradually increasing demand may be better than a 'boom and bust' approach. This is especially true if afforestation of hill country pasture goes ahead. It may be sensible to spread out planting over 20-30 years to ensure there

is a steady supply of timber in subsequent rotations and also to provide steady employment.

- Actions need to be undertaken sequentially (e.g., reducing nutrient and sediment inputs (by wetlands and riparian fencing/planting) before restoring lakes (by replanting submerged vegetation)).

Once decisions have been made about what actions to fund then it will be possible to draw up a timetable for priority actions but a constraint will be when funds become available. The Waikato River Clean-up Trust must decide whether to fund restoration actions on a 'pay-as-you-go' basis or by raising loans. This will affect when 'one-off' high cost actions (e.g., restoring Lake Whangapee $112 million) can be undertaken but is less important for actions that can done progressively (e.g., farm ponds for tuna).

Figure 7.1 shows a possible timeline for expenditure on the priority actions. It uses the schematics in Table 7.1 showing how quickly benefits accrue from an action, together with the suggested timetable of expenditure, to estimate how benefits are likely to accumulate over 50 years. The first five years see rather few benefits because a lot of planning and preparation is required, although this will benefit engagement. Some actions (e.g., footpaths/cycleways, nutrient management, fencing cattle out of streams) produce benefits in years 10-20. Other actions (e.g., lake restoration, whitebait and tuna habitat restoration and afforestation) produce benefits in years 20-50 because they start later and because it takes several years to see the benefits (e.g., tuna grow slowly).

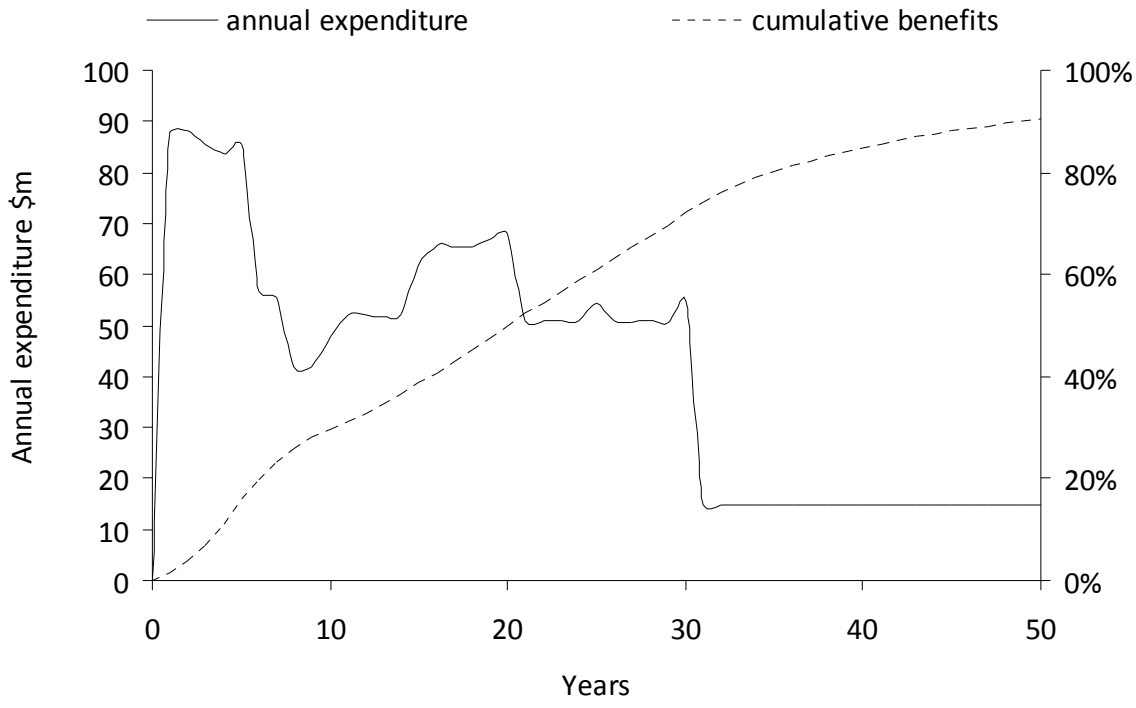


Figure 7.1: Possible timeline of expenditure and benefits for the priority actions summarised in Table 7.3. Benefits lag behind expenditure because of time delays and do not reach 100 percent within 50 years.

7.3.2 Decisions about where to implement actions

The Waikato River Authority will need to consider the appropriate locations for the suite of actions to implement. For some actions there is little or no flexibility. For example, iinanga spawning and adult habitat is confined to the lower Waikato and if the Waikato River Authority

(in its role as trustee for the Waikato River Clean-Up Trust) chooses to fund actions to help restore the whitebait fishery then that money can only be spent in the lower Waikato, the benefits will largely accrue to Waikato-Tainui, and other river iwi will derive little benefit from that action. Erosion occurs in many parts of the upper Waipa and causes degraded water clarity and sedimentation in the Waipa River and lower Waikato below the Waipa confluence at Ngaaruawaahia. Consequently, if the Waikato River Authority chooses to fund actions to improve water clarity in the Waipa and lower Waikato, then that money will need to be spent on controlling erosion in the upper Waipa, with benefits largely accruing to Maniapoto and Waikato-Tainui. Note, however, that the Waikato River Authority may also choose to fund erosion control in other parts of the catchment and thereby involve other river iwi. The Waikato River Authority will have a lot of flexibility about where it chooses to fund some actions. For example, tuna habitat can be created in many parts of the catchment – if natural recruitment is relied upon then habitat must be accessible by elvers but if stocked artificially this is not a requirement. Reserves, boat ramps, footpaths, and restoration of historic sites are other actions where the Waikato River Authority has flexibility over funding.

Once decisions have been made about the types of actions to fund, then the next phase of planning is decide where in the catchment the actions need to take place, and how much money will be required in each location. For some actions more detailed engineering investigations are required to decide what is feasible (e.g., land irrigation of treated sewage may or may not be feasible at towns like Te Kuiti and Otorohanga, a possible alternative being wetland treatment) and the results of these investigations will determine the costs. For some actions the precise locations of actions and/or the engineering required need to be refined (e.g., Environment Waikato has made preliminary estimates of the costs of soil conservation and river control works in the Upper Waipa to reduce erosion and thereby help improve water clarity (Bradly, 2010) and this further analysis will determine the final costs. It is beyond the scope of this study to undertake such analysis, but this will be a priority for the Trust in the immediate future.

7.3.3 Potential impediments to success

There are several impediments to successful implementation of these actions.

1. Uncontrolled development (e.g., dairy expansion) could negate the benefits of restoration. Given that one of the objectives of Te Ture Whaimana is that the river "*should not be required to absorb further degradation as a result of human activities*"[130], action must take place under all scenarios simply to address the effects of increased production and 'hold the line'. Farming is a permitted activity which does not require consents, except in Taupoo where it is a controlled activity which requires farming within a nitrogen export allowance (i.e., a nutrient cap). In order to require some of the priority actions on farms there may need to be rule changes through a review of the Regional Policy Statement and Regional Plan. A review of the Regional Policy Statement is currently underway and will likely set new objectives for the Waikato. However, judging by the time to implement Variation 5 at Taupoo, new rules may not be in place for five to 10 years. A priority action for the Waikato River Authority is to ensure that the Regional Policy Statement review delivers new objectives for the Waikato River that are consistent with Te Ture Whaimana.
2. Parts of the community could continue to ignore or mistreat the Waikato River even when it has been restored. In Taupoo, the community recognised the value of protecting the iconic lake. It is clear that many in the community are not so well informed about the needs and benefits of restoring the Waikato and Waipa Rivers. This will be an impediment to the

[130] See Appendix 3: Te Ture Whaimana – the Vision and Strategy for the Waikato River: Objective H.

community supporting and engaging in actions to restore the Waikato River and means that it is important to educate and inform the community.

3 Although direct monetary savings can be made from some actions that also benefit the Waikato River (e.g., optimal fertiliser use, enhanced pasture production from nitrification inhibitors and optimal stocking rates), these priority actions will involve the expenditure on farms of approximately net $600–700 million. Some dry stock enterprises may not have the capital to retire and replant erodible pasture and maintain cash flows from the balance of the farm, in which case financial incentives (e.g., carbon credits or grants) may be required.

7.4 Will implementing the priority actions meet Te Ture Whaimana?

For this priority actions scenario, economic modelling (see Section 6.5) predicts that total net costs of restoration over the 30 year model duration are $2,250 million with a net present value (NPV) of $1,400 million (see Table 7.2). The scenario is expected to have a slight economic impact overall (see Table 7.3) because it stimulates the local economy at the expense of a small contraction in the rest of the New Zealand economy – value added increases by $148 million in the Waikato, and decreases by $1,466 million in the rest of New Zealand, producing a net decrease for the country as a whole of $1,317 million (0.027 percent of GDP). Employment increases by 1,590 MEC job years in the Waikato region, but decreases by 21,160 MEC job years in the rest of New Zealand, producing a net loss of employment of 19,570 job years (0.029 percent of national employment). The Study team reiterates that this is a monetary market analysis and does not consider non-market values.

This priority action scenario is predicted to stimulate the regional economy. There is some redistribution of capital and employment between different sectors of the economy within the Waikato region. There is some redistribution of capital and employment from the rest of New Zealand to the Waikato region, although the percentages involved are small.

This monetary analysis does not factor in the Emissions Trading Scheme (ETS) because of uncertainties in the costs/benefits of carbon credits over the next 30 years (e.g., Pratt et al., 2010). Land use conversions from marginal pastoral farms to forestry assumed that these would be pine plantations on areas where it would be financially viable for timber harvesting and did not include planting native or exotic species at perpetual forests earning carbon credits through the ETS (i.e., carbon forests). As a result the actual economics of land use conversions to forestry (which are a major cost component) may be more favourable than presented here. The analysis is made assuming that the capital expenditure occurs during the first 10 years of the project because of the desire to achieve results quickly. This would require 'front loading' expenditure. If there is a need to fund actions on a 'pay-as-you-go' basis this may delay restoration and will alter the detail of the economics but not the major findings.

This analysis does not include benefits that cannot be ascribed a monetary value (e.g., recreation, cultural, spiritual, aesthetic, biodiversity, educational, some aspects of ecosystem services and existence values). Section 6 and Appendix 32 Non-Market Values discuss non-market values in more detail. Most people in the community consider these benefits to be critically important. Further work on non-market valuation (e.g., to quantify people's 'willingness to pay') would help to inform decision making about the investment in the river restoration actions. Nevertheless, the Waikato River Authority (acting in its role as trustee for the Waikato River Clean-Up Trust) will need to incorporate these important, but less tangible, benefits along with the hard economic information in its decision making.

Table 7.2: Total direct costs and benefits for the recommended priority actions ($2010 million)

	Total	PV
CAPEX	1,000	740
OPEX	3,830	1,230
Total	**4,830**	**1,970**
Benefit	2,590	570
Net cost	**2,240**	**1,400**

Table 7.3: Cumulative and average net economic impacts for the recommended priority actions, 2011–2040

	Cumulative net economic impacts		Average net economic impacts per year	
	Value added $\$_{2007}$million	Jobs MEC1 Years	Value added $\$_{2007}$million	Jobs MEC1 Years
Waikato Region	148	1,590	4.9	53
Rest of New Zealand	-1,466	-21,160	-48.9	-705
Total	**-1,317**	**-19,570**	**-43.9**	**-652**

Notes:

1 Modified Employment Count (MEC). This includes both employment counts and working proprietors.

2 Figures may not add due to rounding.

3 $\$_{2007}$million – The IO modelling is based on an IO table for the year ending March 2007 developed by Market Economics Limited. This is the latest year for which all economic data required to produce an updated IO table are available. A regional table was also produced from the 2006/2007 national table.

The benefits of implementing all the recommended priority actions were determined using the scenario modelling approach described in Section 6. This modelling predicted that implementing the priority actions will significantly improve the health and wellbeing of the Waikato River with all aspirations reaching a 'Good' (B) to 'Excellent' (A) ranking (see Figure 7.2). This compares to the current status of these aspirations which largely fall in the 'Poor' (D) to 'Very Poor' (E) ranking. When compared to the other scenarios (described in Section 6), the recommended priority actions provide the benefits required to meet the aspirations held but at the least cost (see Figure 7.3) – scenario 2 has a lower net cost but does not provide sufficient benefit to meet Te Ture Whaimana while scenario 3 has a much higher net cost with no significant extra benefit. The Study team therefore concludes that implementing the recommended priority actions is the best approach towards meeting the objectives of Te Ture Whaimana. The Study team acknowledge that there is considerable uncertainty in that prediction – this Scoping Study revealed information gaps that has led to that uncertainty and required the Study team to often take a 'weight of evidence' approach. Nevertheless, uncertainty is not uncommon in river restoration projects (Darby and Sear, 2008) and should not be used to delay action but rather as a signal to monitor the results of actions and modify appropriately (adaptive management).

Full implementation of the priority actions would see the following outcomes:

- Community attitudes and behaviour have changed. All members of the community are increasingly re-engaged with the river, its tributaries and major lakes. The wider community understand and respect the spiritual relationship between the river iwi and the awa. Amongst iwi, there is a resurgence in cultural practices centred on the river and these traditions are being actively passed on to rangatahi. Iwi are directing, and are

key participants in, the implementation of restoration actions in their rohe. Restoration activities have become 'part of the DNA' of the region, with many of the activities being initiated at the local level and being self-sustaining through the commitment of individuals.

- Marae are able to gather and provide kai awa at hui and poukai for which they were traditionally renowned. Compared with now, there will be many more whitebait, tuna and other species available for traditional harvest. Iwi will be able to exercise kaitiakitanga in relation to these resources, resulting in fisheries that are sustainable in the long-term. Hapuu involve rangatahi in fishing and restoration, protection and conservation.

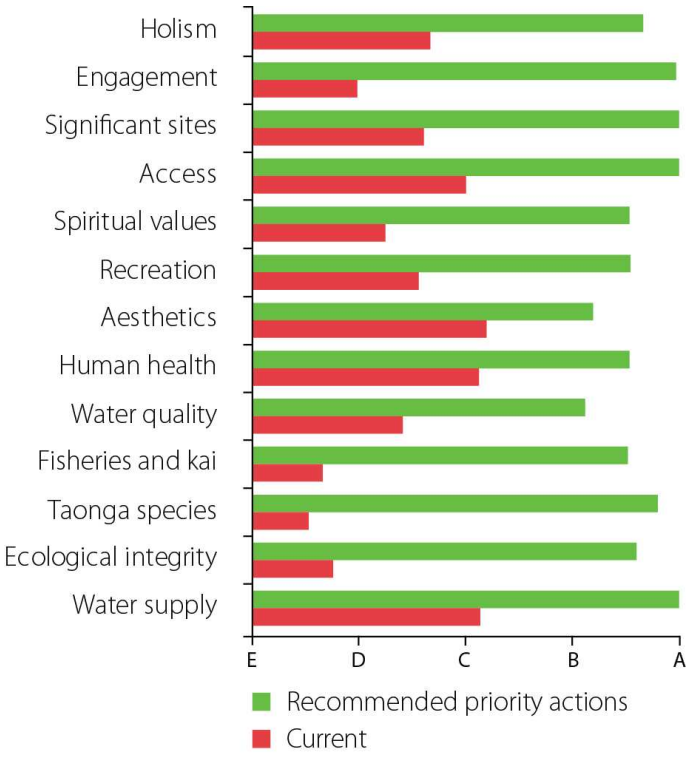


Figure 7.2: Predicted progress for each aspiration, compared with the current state assuming full implementation of the recommended priority actions. Green bars are scores for the recommended priority actions and red bars are scores for the current state.

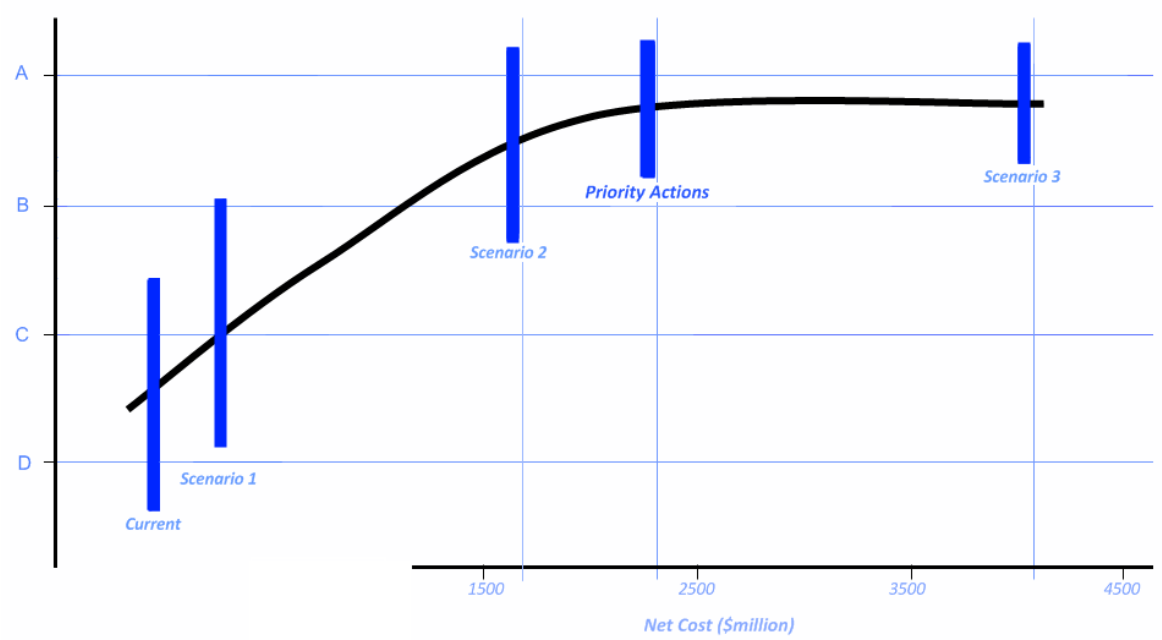


Figure 7.3: Summary of the improvement in health and wellbeing of the Waikato River with increasing net cost. Bars represent the range in aspiration scores for each scenario.

- Thanks to successful co-management, statutory planning takes a holistic approach and non-statutory agreements are in place between the Waikato River Authority, Environment Waikato, local authorities and industry. Activities that adversely affect the Waikato River are controlled through non-statutory agreements with landowners and industries, monitoring and auditing, and statutory policies and rules that operate when required.

- Throughout the entire Waikato catchment, cultural health monitoring programmes (based on maatauranga Maaori) evaluate the reviving health and wellbeing of the river. These sit alongside biophysical monitoring programmes and, together, provide a clear and unequivocal picture of improvement that is a source of pride to river iwi and the Waikato community generally.

- The wider community demonstrates an increasingly positive attitude about the health of the river and there is a high level of local involvement in restoration actions. Restoration enterprises have been established, and skills and knowledge about river restoration are high – the Waikato River restoration has become recognised internationally as a showpiece for best practice and local researchers and practitioners are asked to share their experiences worldwide.

- A consultative process has resulted in footpaths, cycleways, boat ramps and reserves that, together with riparian and water quality restoration, meet community needs. All waahi tapu have been protected and priority historic sites have been restored. Community understanding, knowledge and respect of waahi tapu and historical sites has been increased through publicity, signage and visitor centres.

- Along the main stem of the Waikato and the Waipa Rivers, water quality has been restored from its former degraded state (see Figure 7.4). Nutrient concentrations comply with guidelines and as a result phytoplankton concentrations are low and cyanobacterial dominated blooms numbers are unlikely to occur. Water clarity more

than meets the 1.6 metre bathing water guidelines in the hydro lakes. Water clarity is greatly improved by reafforestation of erodible hill-country pasture and meets a suggested guideline of 1.0 metre in the Waipa River and lower Waikato. The Waipa and lower Waikato will never become the clear blue of the upper Waikato, but they will no longer be murky. Over time, these river reaches will move from cloudy, muddy brown to clear but naturally coloured. Where feasible, sewage is irrigated to land or infiltration basins and elsewhere it is treated by wetlands. *E. coli* concentrations are much lower than at present in pasture tributaries because of fencing, run-off controls and land disposal of sewage and, therefore, meet the contact recreation guidelines in the main stems. Consequently it is safe to swim everywhere in the main stem.

- In four previously degraded peat lakes, two dune lakes and two riverine lakes, nutrient and sediment inputs have been reduced so that water clarity meets bathing water guidelines, phosphorus concentrations meet mesotrophic status and cyanobacteria blooms rarely exceed health guidelines. In the two large riverine lakes, Waahi and Whangapee, exotic weeds have been eliminated, submerged and emergent native aquatic plants have been re-established, pest fish controlled and the lakes have been returned to high quality habitat suitable for supporting high stocks of whitebait, tuna and taonga species. In Lake Ohakurii, a combination of weed control and nutrient input reduction has minimised the risk of algal blooms, reduced the risk of 'duck itch' and greatly improved ecological integrity and recreation potential. Traditional and recreational use of the restored lakes has increased significantly and has spurred community-led restoration initiatives in other lakes.

- The majority of riverbanks have been fenced and planted with appropriate natives, including taonga species which are harvested for traditional purposes by local iwi. Invasive exotics have been removed in many places. As a result, aquatic habitat in small streams has been restored and supports re-introduced iconic species and clean water biological communities. Actions addressing fisheries and riparian vegetation have greatly enhanced ecological integrity, connectivity and habitat for taonga species.

- In their own diverse ways, people will start to express the same sentiment as Kiingi Taawhiao:

"Tooku awa koiora me oona pikonga he kura tangihia o te maataamuri.

The river of life, each curve more beautiful than the last."

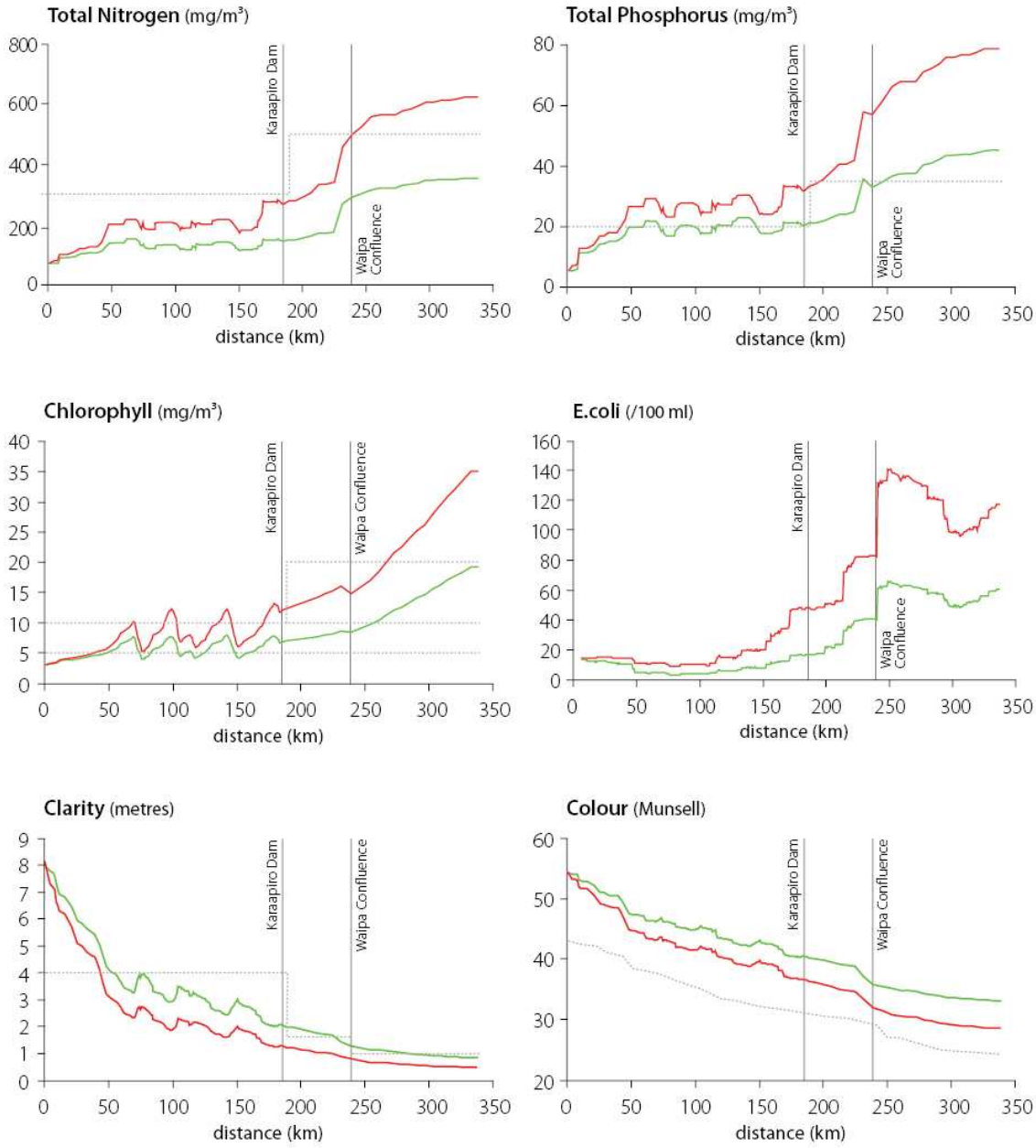


Figure 7.4: Current (red line) and predicted (green line) variation with distance downstream of phosphorus, nitrogen, chlorophyll, *E. coli*, water clarity and colour at base flow in the Waikato River. The dotted grey lines are targets. Note that for colour, the current state is already better than the target values. Predictions made using the Waikato Catchment Model, except for *E. coli* where CLUES was used.

7.5 Conclusions

This Section identifies a list of priority actions intended to help the Waikato River Authority make decisions in its governance role and in its role as trustee for the Waikato River Clean-up Trust. The main findings are:

- It is estimated that the bundle of priority actions will restore the Waikato River to the point where it meets the objectives of Te Ture Whaimana. This assessment is supported by the international case studies reviewed and experiences of the Study team members in restoration projects elsewhere in New Zealand.

- The estimated net expenditure required is $2,240 million (PV $1,400 million) which includes cost savings to farmers and income from forestry. This expenditure is estimated to stimulate the local economy, redistribute capital and employment between different sectors of the economy within the Waikato region and to redistribute capital and employment from the rest of New Zealand to the Waikato region, although the percentages involved are small.

- There are benefits that cannot be ascribed a monetary value (e.g., recreation, wellbeing). Preliminary estimates suggest these non-market values are comparable with the costs of restoration but further work (e.g., on willingness to pay) is required.

- There are information gaps on aspects of restoration that need to be addressed. These include research on fish, engineering design, identifying suitable sites and making 'how to' guides available to stakeholders.

- This project is unique in using a combination of maatauranga Maaori, social and biophysical science, and economics to identify the actions required to meet the aspirations of Maaori and the wider community for improving the health and wellbeing of the Waikato River.

- A key to the success of restoration will be to change people's attitudes and behaviour. This requires a significant effort to engage with the community, industry and local government but if people understand and support the objectives of restoration then it is more likely to be successful.

8 Monitoring and evaluation

8.1 Introduction

8.1.1 The need for monitoring

This Section provides observations and guidance on developing a monitoring and evaluation programme to support the restoration of the health and wellbeing of the Waikato River. The programme proposed includes cultural, social, environmental and economic aspects all of which are an important part of a holistic approach to restoration (see Section 5).

Reasons for monitoring include:

- Measuring success: Assessing and reporting progress towards the implementation of restorative actions and achieving a healthy and well Waikato River.
- Supporting adaptive management: Ongoing reviews of progress that allow strategies to be adapted to meet targets if the expected progress does not occur.
- Providing accountability: The Waikato River Authority will need to provide transparency and accountability for actions it chooses to fund (in its role as trustee for the Waikato River Clean-up Trust).
- Engaging communities: Community-based environmental monitoring programmes assist individuals, community groups and organisations to actively participate in caring for their surrounding environmental resources and assets.

8.1.2 The importance of engagement in monitoring and restoration

The United Nations Environment Programme stresses public participation as an essential component of sustainability (Au et al., 2000). Community-based environmental monitoring programmes assist individuals, community groups and organisations to actively participate in caring for their surrounding environmental resources and assets (e.g., in India[131] and Canada[132]).

[131] http://www.sipcotcuddalore.com/

Such initiatives provide the coordination, networks, collective learning, training and support required by communities to monitor, track and respond to issues of common concern (Conrad and Daoust, 2008; McKenzie et al., 2000; Whitelaw et al., 2003).

Community involvement in choosing relevant indicators of success and monitoring progress towards restoration goals is increasingly recognised as an important component of sustainable and effective management (Fraser et al., 2006; Jollands and Harmsworth, 2006; Leach et al., 1999; Owens, 2000; Reed et al., 2008; Whitelaw et al., 2003). A shift towards participatory 'bottom-up' (community driven) approaches combined with conventional 'top-down' (agency driven) systems is evident internationally, largely due to the failure of 'top-down' systems to either achieve the restoration goals and/or to sustain them in the long-term (Fraser et al., 2006; Sharpe and Conrad, 2006). Changing behaviour and practices in order to restore systems to a desired state requires engagement, knowledge sharing (including maatauranga Maaori, social, economic, biophysical sciences and practical experience) and monitoring to allow for adaptive management as well as providing evidence of the improvements that are being made to ensure that participants continue to be motivated (e.g., Burgess et al., 1998; Dodd et al., 2008; Wilcock et al., 2009; Fenemor et al., 2008; Quinn et al., 2010; Ison and Watson, 2007).

International reviews show that monitoring is often neglected in restoration projects. This results in poor accountability and an inability to implement adaptive management practices or 'learning by doing'. For example, only 14 percent of 2,247 restoration projects in Victoria, Australia, have any form of post-implementation monitoring (Brooks and Lake, 2007), resulting in little information to demonstrate that construction works remained intact or riparian planting survived. Similarly, 43 percent of restoration projects in a North West Pacific survey had no success criteria or were unaware of any criteria for measuring success (Rumps et al., 2007). Practitioners were frustrated by the lack of emphasis on monitoring, and funding provided for it, which meant that expenditure and progress was not tracked, that success was not confirmed, documented and publicised and that scientists, engineers, managers and the wider community could not learn from the restoration projects (see Appendix 2: Restoration Case Studies). Restoration ecology is a rapidly developing, but relatively new, science (Ormerod, 2004; Lake et al., 2007) and monitoring and adaptive management can allow actions that appear to be failing to be made more successful by applying knowledge gained in other studies (Palmer et al., 1997).

8.2 *Indicators of restoration*

The success of restoration actions is typically monitored using indicators that measure changes in the current state towards the restoration targets or aspirations for health and wellbeing. Indicators may be direct measures of aspirations (e.g., water clarity, suitability for swimming). More often indicators are simplified ways of measuring complex environmental responses (e.g., *E. coli* as an indicator of microbial disease risk), actions (e.g., the change in length of streams fenced and planted in a random sample of pasture streams (see the Storey (2010) data in Appendix 11: Riparian Aesthetics), knowledge or changes in people's attitudes (e.g., Blackett, 2009). The Study team contend that social indicators (e.g., attitude, knowledge and action) should be included along with more traditional environmental response indicators of restoration success because:

[132] http://www.envnetwork.smu.ca/

- Changes in attitude and knowledge have a strong influence on current and future behaviour and it is important to monitor whether engagement strategies are producing desired changes (see Section 5).

- Many environmental responses involve time lags (e.g., due to 'old' leached nitrate stored in groundwater and time for planted trees to grow large enough to stabilise streambanks, improve aesthetics and increase shading). These lags mean that it may be decades before some responses are fully realised and it is important to have indicators measuring whether restoration is on the right track during lag phases.

- Information on whether commitments to restoration actions are being carried out and maintained is vital not only for auditing but also for interpreting environmental responses and adapting restoration methods.

8.2.1 State indicators

Traditionally, indicators used in restoration measure state. Examples of indicators for state of health currently employed in the Waikato River include water clarity, *E. coli*, and nutrient levels. Examples of indicators of the state of wellbeing are community perception of water quality and iwi satisfaction with swimming safety and aesthetics.

Indicators can be derived from, and assessed, using maatauranga Maaori or science methods. For example, when assessing actions to restore the abundance of kooura, an appropriate indicator would be kooura numbers and biomass. These could be measured using tau kooura by catching kooura in bracken fern bundles (whareweku) deployed on a lakebed or riverbed following traditional fishing methods (Kusabs and Quinn, 2009) or by scuba divers counting kooura along transect lines (Kusabs et al., 2005).

8.2.2 Action indicators

The Study team also recommend the use of a variety of action indicators in monitoring restoration progress. For example, the decrease in the number of culverts that act as barriers to iinanga is proposed as an indicator of progress towards restoring the whitebait fishery. Action indicators have a clear target (i.e., the total number of culverts which need restoration) and so the 'success' of the action can be easily assessed against this clear target.

As well as their auditing function, action indicators can act as surrogates for environmental state indicators that may be very difficult and expensive to measure. For example, an obvious state indicator of the health of whitebait fishery is whitebait catch numbers (or better yet, catch numbers per unit effort), but past attempts to measure the whitebait catch have proved to be very time-consuming and the uncertainty in estimated numbers has been high. This is because fishers are not currently required to record or report their catch, and there is no centralised processing industry where catch data could be easily collected. There are a large number of part-time fishers and monitoring catch numbers accurately requires a major effort to interview fishers and record catches and their time spent fishing.

A more subtle problem is that the preferred state indicator may be affected by several processes besides the restoration action that it is intended to measure. For example, the whitebait catch is affected by recruitment from the ocean, which varies from year to year because of changes in ocean currents, sea temperature and nutrient supply. Consequently, even if reliable estimates of whitebait catch can be made, natural variability will mean that many years of data will need to be collected before it will be possible to detect any increasing

trend. This will be exacerbated by time lags between restoration of habitat and the build-up of whitebait abundance.

For these reasons, the Study team recommend the use of action indicators to complement and, in some cases, to act as surrogates for state indicators where the latter are subject to high natural variability, time lags and/or are very expensive to measure. For whitebait, for instance, the recommended 'surrogate' indicators measure the restoration of whitebait habitat. They would include the:

1 Length of spawning habitat restored and protected.

2 Area of adult habitat restored and protected.

3 Reduction of barriers to migration remaining between the sea and adult habitat.

There are additional reasons for monitoring and reporting action indicators. As mentioned above, some of the time lags between actions and improvements in state can be very long. Parkyn et al. (in press) provides time scales for the change in many common biophysical indicators after restoration. This is typically many years and can be even as long as about 100 years (e.g., for canopy closure of riparian vegetation on large streams). Therefore, action indicators play an important role in providing early feedback to managers and the community about changes brought about by restoration and prevent the risk that slow changes in some state indicators may lead to disenchantment with progress (Burgess et al., 1998). This feedback will also help to engage the community and bring about changes in people's behaviour because they can see and experience the type of practices that bring about restoration. This will be further reinforced by any positive results from monitoring state indicators.

8.2.3 Proposed indicators

The Study team proposes that four categories of indicators are used to monitor progress towards achieving the aspirations for restoring the health and wellbeing of the river (see Table 8.1).

Table 8.1: Types of indicators proposed for monitoring the health and wellbeing of the Waikato River

	Health of the river (usually a biophysical aspect)	*Wellbeing of the river (could be social, cultural, spiritual or economic in nature)*
State indicators	e.g., Water clarity, phosphorus, algal biomass (*Chlorophyll a*), kooura catch using tau kooura.	e.g., Employment in the region, satisfaction surveys, ability to serve locally caught kai at marae.
Action indicators	e.g., Length of spawning habitat for iinanga, number of iinanga migration barriers, tuna transferred over hydro dams.	e.g., Number/attendance at training workshops, numbers involved in environmental care groups, number of students obtaining curricula credits on the Waikato River.

Some key indicators were selected by the Study team based on maatauranga Maaori, community consultation, biophysical science, social science and economics. The proposed indicators are listed in Appendix 30: Report Cards (also see Appendix 29: Monitoring and Evaluation). Some indicators, especially those for cultural and spiritual values, will need to be developed by the five river iwi based on their own maatauranga for their own purposes. A Cultural Health Index is proposed to formally include these indicators (see Section 8.3). To ensure maximum success in restoration, the Study team also recommend engaging the wider Waikato community when choosing indicators for each of the aspirations (see Section 8.1).

The selection of state indicators should be as robust as possible because there are definite advantages in maintaining a consistent set of indicators to enable trend analysis, as has been demonstrated by New Zealand's National River Water Quality Network (Ballantine and Davies-Colley, 2009; Davies-Colley et al., submitted). Nevertheless, new indicators may need to be added as new information and knowledge comes to hand, as is part of the process in developing a monitoring programme (e.g., this occurred in the South-East Queensland Healthy Waterways project (Bunn et al., 2010)). Indicators that are not delivering useful information may need to be revised or replaced. If the initial indicator selection process is well considered and widely consulted, then these changes are expected to be minor.

8.3 Cultural Health Indices

The Cultural Health Index (CHI) articulates cultural values, assesses the state of the environment from a cultural perspective and assists with incorporating maatauranga Maaori into environmental monitoring (for more information see Appendix 29: Monitoring and Evaluation). Tipa and Teirney (2006a and b) provide guidelines for iwi that outline how to identify areas to be evaluated, set up a CHI programme and collect and analyse data so that sites requiring restoration can be identified, and changes monitored with indicators that are relevant to Maaori aspirations. It is important to note that, thus far, the CHI has only been utilised in streams (Tipa and Teirney, 2003; Tipa and Teirney 2006a and b) and further research will be required to extend it to other river and lake types in the Waikato.

It is for river iwi to identify the range of cultural indices that they want to see developed to meet their values and aspirations. It is unrealistic to expect one CHI (in effect 'a one size fits all' approach) to be developed that is applicable in its entirety to all five iwi. However, it is essential that cultural indices are integrated and reported alongside scientific and economic data to achieve holistic assessments of the health and wellbeing of the Waikato River. Therefore, it is recommended that a subset of cultural indicators (e.g., presented in Appendix 29: Monitoring and Evaluation) be assessed by all river iwi. For example, iwi could use their list of potential indicators (see Appendix 29: Monitoring and Evaluation) and Tipa and Teirney's (2006a and b) CHI framework to develop a Cultural Recreational Index to monitor the progress of the restoration actions in realising Aspiration 6: Swimming and boating, which relates to improving the use of the Waikato River for recreational purposes (see Table 8.2). The Study team would expect that a wide range of indicators would feed into an overall CHI (see Figure 8.1).

Table 8.2: Indicators that could be monitored by river iwi to derive a Cultural Recreation Index (as a component of their overarching Cultural Health Index) and incorporated in their aspirational 'Swimming and boating' Report Card

Cultural Recreation Index	
Indicators	***Indicator description***
Boat ramps	Iwi satisfaction regarding access to boat ramps, their location and condition.
Access	Number of negotiated access agreements over private land.
Swimming sites	Number of safe swimming sites.
Waka ama/waka taua	Satisfaction of iwi users in relation to waka ama/waka taua with (a) flow and water levels, (b) ability to enter and exit water safely, (c) amount of weed and algae present, (d) water quality.
Pest species	Satisfaction of iwi users with swimming and boating experiences given presence of invasive species.
Significant sites	Satisfaction of whaanau and hapuu with protection of key sites/river reaches.
Traditional practices	Satisfaction of iwi with their ability to use preferred skills, practices and methods when interacting with the river.

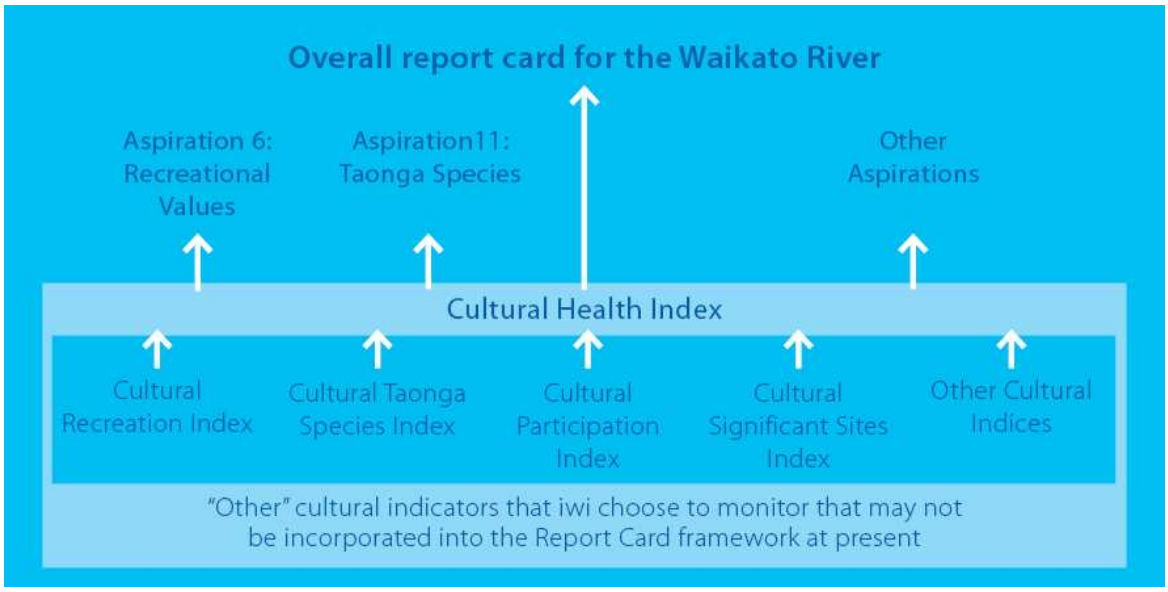


Figure 8.1: The relationship between cultural indices, overall Cultural Health Index, aspirational Report Cards and an overall Report Card for the Waikato River as a whole.

8.4 Report Cards

Summarising and communicating large amounts of complex monitoring information is challenging but is an essential part of restoration. Typically this involves producing Report Cards on a group of indicators that describe the state of the environment (e.g., nutrient concentrations) and assign it a 'grading', sometimes simply A, B, C, D and E much like an old-fashioned school report card. These condense monitoring information on indicators into an easily understood table or diagram. Figures 6.1–6.3 (the 'ladder' diagrams) are examples of Report Cards on the predicted ability of scenarios to reach targets. Report Cards can be constructed for any part of the river and for sets of indicators for any aspiration, or groups of aspirations.

It is important that the system for building Report Cards is robust and defensible. This requires it to be transparent so that the process can be clearly understood and audited and that the assumptions used are clear. This process must also be efficient, flexible, consistent and

repeatable. This is best achieved by creating an automated process to generate the Report Cards from input data.

To ensure transparency and accountability throughout the entire restoration framework the Study team recommend two 'levels' of assessment, aggregation and reporting. They are:

1 Report Cards for each of the identified aspirations for the health and wellbeing of the river (e.g., engagement, holism, water quality, fisheries and kai – see Section 4) incorporating an appropriate mixture of action and state indicators.

2 Overall Report Cards for the health and wellbeing of the Waikato River.

3 In each Report Card, the complex data on cultural, social, environmental and economic aspects is summarised by scoring (i.e., A to E) each indicator, thus turning both qualitative and quantitative data into a common format. These grades are then aggregated and presented in the Report Cards. Monitoring data will be used to score the indicators in the following way:

4 Measure the indicator (e.g., water clarity is currently 0.9 metres on average).

5 Compare the indicator to the target (e.g., the target for water clarity is 1.6 metres on average) and the minimum value (e.g., minimum water clarity of 0 metres).

6 Develop a formula that translates indicator measurements and targets into scores (e.g., an average clarity of 0.9 metres equates to a score of C+, for a target of 1.6 metres and a minimum of 0 metres, assuming a straight-line formula).

7 Report the scores for the indicators that are then used in the Report Cards.

The Study team has used the following scoring system in Table 8.3 to develop the Report Cards provided in this Report.

Table 8.3: The scoring system used by the Study team for Report Cards

Score	*Description*	*Ranking*
A	Always meets or exceeds the target	Excellent
B	Is consistently close to meeting the target	Good
C	Is consistently below the target	Fair
D	Is consistently well below the target	Poor
E	Is unacceptably low compared to the target (i.e., indicator is at or below the minimum)	Very poor

8.4.1 Kaupapa for Report Cards

As noted in Section 8.2.1, many of the indicators of health and wellbeing of the river have been derived from maatauranga Maaori. The Study team has opted not to separate these out or to identify them differently from science or social science indicators in the Report Cards. In a truly integrated approach, the origin of the indicators does not matter. In this Study, the kaupapa (philosophy) for selecting indicators and communicating them using Report Cards is an underpinning framework of principles and values. These were drawn from maatauranga Maaori, hui and community meetings held during the Study, and the Study team's review of the long-term council community plans (LTCCPs), and were accepted by the Guardians Establishment Committee (see Figure 8.2).

Figure 8.2: Underpinning framework for Report Cards

These principles and values dictate what information is fundamental for reporting purposes, but, given the high level nature of principles and values, there is not a one-to-one correlation between them and the indicators. The same principles and values are expressed through the aspirations for the health and wellbeing of the river, and all link to Te Ture Whaimana.

8.4.2 Example Report Cards

Proposed Report Cards on the restoration of aesthetics and the whitebait fishery are shown as examples in Tables 8.4 and 8.5 respectively. The aesthetics Report Card includes three indicators that require development and/or data to be collected in order for a useful score to be given. Provision has been made for indicator development in the proposed actions outlined (see Section 5). However, the available data indicates an overall aesthetics score of C for the middle Waikato.

Table 8.4: Report Card for aesthetics showing current scores for the middle Waikato (specifically Horotiu for colour and clarity)

	Aesthetics Report Card			Score	
	Indicator	*Target*	*Current*	*Current*	*Finish*
1	Proportion of pastoral stream length with RMC score ≥ 4 weighted for stream size (%)	85	32	D	A-
2	Colour of water (change in Munsell colour units)	<10	16.3	C-	B-
3	Clarity of water (black disc visibility, m)	1.6	1.28	B	A
4	Sediment composition	TBD[a]	TBD	TBD	TBD
5	Community/iwi satisfaction with the appearance of the river	TBD	TBD	TBD	TBD
6	Rubbish	TBD[b]	TBD	TBD	TBD

TBD = to be developed.

a A current Envirolink Project is producing protocols for assessing riverbed sedimentation that will likely inform this development.

b The rubbish indicator is constrained by the absence of data but Parkyn et al. (in press) will inform this indicator.

Unlike the aesthetics Report Card (which only includes state indicators), the whitebait Report Card includes a mixture of action and state indicators (see Table 8.5). For action indicators, the current score is given but note that all actions will score A when completed successfully. Many of the state indicators cannot be scored at this time (i.e., there is no monitoring data or the indicator needs development). To predict the current and future state of the whitebait fishery (as in Figure 6.1 to 6.3) action indicators were used as surrogates for state indicators. In the future, state indicators would mainly be used to assess the health and wellbeing of the fishery, but action indicators would still be monitored and reported as long as it is sensible to do so. For biophysical actions this may be when the action is complete (e.g., for restoring culverts), although monitoring needs to ensure that the situation does not deteriorate again (e.g., new culverts creating barriers). Note that the whitebait catch has been included as a proposed indicator despite the challenges in developing this indicator described in Section 8.2.2, because over a long time period (when restoration actions are taking effect and year-to-year variability is better understood) it will probably become a very valuable indicator and management tool. The whitebait Report Card indicators for which data are available indicate an overall current score of D.

Table 8.5: Waikato River whitebait Report Card (which is part of the 'Fisheries and kai' aspiration Report Card)

	Action Indicators			
	Measure or indicator	*Target*	*Current*	*Score*
1	Stream length of prime adult iinanga habitat (km).	800	350	C-
2	Stream length of prime iinanga spawning habitat (km).	20	10.5	C
3	Weeds managed appropriately in lowland drains to enhance adult iinanga habitat (km).	3,460	1,800	C
4	Number of impassable tide gates made fish-friendly in prime potential habitat area at Aka Aka (number).	23a	0	E
5	Number of road culverts passable to migrant iinanga.	180	70	D
6	Number of farm culverts passable to migrant iinanga.	5,000	2,000	D
7	Total stream length of potentially prime habitat for banded kookopu with restored riparian vegetation (km).	310	250	B
8	Number of farm culverts passable to migrant banded kookopu (number).	4,000	2,560	C
9	Restore shallow lake habitat (see Ecological Integrity – Lakes Report Card in Appendix 30: Report Cards).	2 large riverine lakes	Very poor habitat	E
10	Whitebait habitat score (weighted summary of above).	See above	See above	D-
11	The impact of pest fish on juvenile whitebait is reduced.	Research completed	Research underway	D
12	All aspects of the whitebait fishery come under the control of a single regulatory agency.	Legislation enacted	Several agencies	E

State indicators		*Current*		*Future*	
13	For individual fishers, average catch per unit effort.	20g/hr[b]	2g/hr[b]	D	B
14	Total catch.	TBD	TBD	TBD	TBD
15	Water clarity (measured by Ariari board, m).	1	0.6[c]	C	A
16	Abundance restored to allow marae to provide locally caught whitebait (number of events).	20[d,e]	0[d]	E[d]	B[d]
17	Access to traditional fishing sites.	TBD[f]	D[e]	D[e]	B[e]
18	A measure of activities associated with knowledge transfer.	TBD[f]	TBD[f]	TBD[f]	TBD[f]

Grey text indicates the Study team's best professional judgement.
TBD = to be developed.

a Total number – some may already be partially passable.
b Based on expert opinion and surveys of Bay of Plenty fishers (Saxton et al., 1987).
c Measured at Tuakau.
d Based on 8–10 marae in lower Waikato for own poukai and supply to Koroneihana.
e Strictly speaking these can only be scored by iwi but tentative scores were given by the Study team based on feedback from the consultation hui.
f These indicators can only be scored by iwi. Actions recommended for engagement (see Section 5) include that every year, two workshops be run for each iwi on restoration methods including traditional fisheries.

8.4.3 Constructing Report Cards

Constructing Report Cards is a relatively simple stepwise process. Six steps are outlined below:

Step 1: Select the aspiration that will be reported in the Report Card (e.g., see aesthetics in Table 8.4 or whitebait fishery in Table 8.5).

Step 2: Select the location. Report Cards can be developed for any location, as long as there is sufficient monitoring information available. Report Cards could be for the whole Waikato River catchment, one of Environment Waikato's four economic zones within the catchment (e.g., upper Waikato, middle Waikato, lower Waikato and Waipa) or other regional subdivisions could be used (e.g., iwi boundaries, individual water bodies (e.g., a particular lake such as Lake Whangapee) or groups of lakes (e.g., Waipa District Council peat lakes)).

Step 3: Select the appropriate action or state indicators to monitor. Proposed indicators for actions and aspirations are listed in Appendix 30: Report Cards.

Step 4: Select the appropriate target, minimum value and formula for each indicator

Step 5: Using monitoring data, score these indicators using a quantitative system.

An example is provided in Table 8.6 for two of the indicators in Table 8.5 (i.e., adult iinanga habitat and whitebait spawning habitat).

Table 8.6: An example showing how biophysical action indicators might be scored, from A to E (Appendix 30: Report Cards provides guidance for scoring other indicators)

Indicator	*Scoring Method*
Adult iinanga habitat (km)	This indicator reflects the amount of potential high quality iinanga habitat in rivers and streams. Unknown pre-European amount of habitat, present habitat also unknown but can be estimated from Fish Occurrence Models (Leathwick et al., 2009) for the Waikato. These suggest 800 km of potential high quality iinanga habitat, with 450 km in low gradient 1st to 3rd order streams targeted for restoration by riparian fencing and planting with shrubs. Scores: A = >800 km; B = 800–600 km; C = 600–400 km; D = 400–200 km; E = <200 km (25 percent of the potential total).
Iinanga spawning habitat (km)	Length of intact bank habitat within which spawning could have occurred. Historical length unknown, but if all banks in the river with appropriate tidal range and salinity had been utilised, spawning could have occurred within 30 km of the coast, but it is likely that only about 20 km was used at any one time. Present day potential habitat = 17 km in main stem and tributaries, of which about 10 km is reasonably intact. Additional spawning areas (up to 4 km) could be created by constructing spawning embayments at tributary/main stem confluences. Scores: A = >20 km; B = 20 – 15 km; C = 15 – 10 km; D = 10 – 5 km; E = < 5 km (about 20 percent of original habitat).

Step 6: Combine the scores for each indicator to give an overall score for the Report Card. Step six considers all the indicators that affect a particular aspiration. For example, the aspiration 'Fisheries and kai' is affected by all of the indicators that score the:

- Abundance of whitebait and tuna.
- Customary catch available to iwi that enables them to supply guests with the specialty foods for which they are renowned.
- Cultural connection between hapuu and the Waikato River through actions to manage, conserve and gather kai.

The Report Card process requires a summary score to be estimated by:

1 Identifying which indicators best reflect progress towards the aspiration.

2 Assigning weightings to these indicators which account for some indicators being more important than others.

3 Combining the weighted scores into a single score for each aspiration.

The key question in selecting indicators (Step 3) is its overall contribution to describing the health and wellbeing of the Waikato River. If some indicators are more important than others, then they should receive a higher weighting or a weighted average should be used. Indicators that are not particularly important, or that measure the same thing as another indicator, should not be selected for the Report Card (e.g., there is no need to include the length of fencing if the area of fenced habitat conveys the same information).

Care needs to be taken when averaging scores, especially if there are interactions between indicators. For example, no benefit would be derived from restoring adult iinanga habitat if migration barriers (e.g., perched culverts or tide gates) prevented iinanga from getting to that habitat. In this case the score for the physically restored, but inaccessible habitat, needs to be weighted lower until the barriers are removed.

The suggested basic Report Card format is shown in Tables 8.4 and 8.5. Example Report Cards for all aspirations identified in this Study have been prepared (see Appendix 30: Report Cards). Over time Report Cards could be developed to incorporate graphic presentations of the data if required. The Study team recommend that they be kept relatively simple and on as few pages as possible (preferably one), because their primary function is as a visual representation of progress towards targets that can be rapidly and easily understood by a wide range of audiences.

Step 7 (optional): Constructing overall or regional Report Cards. Overall Report Cards are constructed by combining all the scores from aspiration Report Cards together (see Figure 8.1). It is suggested that further community input be undertaken to determine appropriate weightings between aspirations that contribute to health and wellbeing before producing an average overall score. Note that while combining grades simplifies things by giving one metric for a number of indices, information is lost in the process and grades tend to converge on 'middle' values.

Similarly, Report Cards can be created for a particular region or combination of aspiration and region. For example, in the whitebait example used, scores calculated for specific waterways (see Figure 8.3) could be combined to give a regional score.

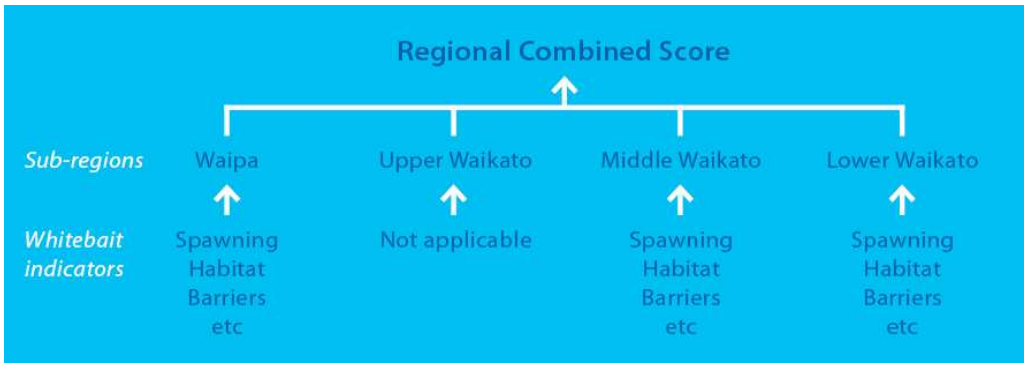


Figure 8.3: A flow chart illustrating how scores for indicators for a Report Card (in this case whitebait) are combined to give an overall score for a zone, which can in turn, be combined to give an overall score for the whole region.

8.4.4 Automating the Report Card generation process

The Study team recommend that the process for generating Report Cards be automated. This would involve:

1. Creating a central database into which monitoring data is entered.
2. Designing an auditing and checking system for monitoring data.
3. Agreeing upon targets for each indicator and the formula used to convert measurements and targets into scores.
4. Developing computer code that takes the measurements and targets, calculates the scores and generates Report Cards.

The Study team developed a prototype system (as an Excel spreadsheet model) for generating Report Card scores that was used to score the current state and scenarios in Figures 6.1 to 6.3. This prototype Report Card Modelling Framework is available to the Guardians Establishment Committee Waikato River Authority on request.

The Report Card Modelling Framework will need to be flexible. It will need to allow other types of Report Cards to be developed as and when required. In order to generate another type of Report Card, all that is required is to choose the aspirations, actions, indicators and locations the Report Card is reporting on. Computer code can be written which selects monitoring data from the database, converts them to scores and averages the scores.

A pre-requisite for an automated system for producing Report Cards is a reliable, audited database for monitoring results. Development of such a database is a priority action recommended in Section 7.

8.5 Conclusion

As this Section notes, successful restoration and protection of the Waikato River will be dependent on a sound monitoring and evalaution programme that allows the the Waikato River Authority to apply adaptive management to the restoration actions they choose to fund (in their role as trustee for the Waikato River Clean-Up Trust). Monitoring helps to measure the success of actions chosen, supports adaptive management, provides accountability for the actions funded and helps to engage communities to actively participate in the restoration activities.

The success of restoration actions is typically monitored using indicators that measure changes in current state but the Study team also recommends using a variety of action indicators for the

Waikato River restoration programme to complement and, in some cases, act as surrogates for state indicators where state indicators are subject to high natural variability, time lags and/or are very expensive to measure. The Study team also recommends using both state and action indicators to measure both the health and wellbeing of the Waikato River.

The Study team believes that the two monitoring tools outlined in this Section will provide the Waikato River Authority with a comprehensive monitoring and evaluation process that they can use to robustly assess and measure the success of the funded actions as they move towards full restoration and protection of the Waikato River and achieving the vision and strategy set out in Te Ture Whaimana. In doing so, the monitoring tools will also provide accountability to interested parties on how the the Waikato River Clean-Up Trust funds are being allocated. Those two tools are:

1. Cultural Health Indices, which will help assess the state of the environment from a cultural perspective and assist in incorporating maatuaranga Maaori into the environmental monitoring. It will be the role of each individual iwi to identify the range of cultural indices appropriate to their own values and aspirations.
2. Report Cards, which summarise and communicate large amounts of complex monitoring information in a robust, defensible, transparent, clear and user friendly way. (A full set of sample Report Cards for the aspirations outlined in Section 4 is provided to the Waikato River Authority in Appendix 30: Report Cards.)

9 Towards restoration

9.1 The Waikato River Independent Scoping Study

The Waikato River Independent Scoping Study is of national and international importance. It is nationally significant because it will guide the most comprehensive co-management agreement established in New Zealand history between the Crown and iwi to restore and protect the health and wellbeing of one of our national assets, the Waikato River, which is a taonga to all New Zealand people. It is internationally significant because it provides other countries with a unique example of integrating the values of an indigenous people with Western science and culture.

The Study team has successfully grappled with the complexities of integrating these two knowledge sets – maatauranga Maaori and science. Around the world there are many studies relating to river restoration[133]. Some are at a catchment-wide scale, some use social science and some incorporate traditional or indigenous knowledge. This Study is unusual in that it has all those features. Moreover, its findings will be used by a decision-making body (the Waikato River Authority) on which indigenous and non-indigenous people have an equal say in a new era of co-management. Globally, that is rare indeed.

The unique features of the Waikato River Independent Scoping Study have presented the Study team with many challenges, which sometimes required unique solutions and other times have required a reliance on weight of evidence and expert judgement.

Robust biophysical information, for example, already exists for some aspects of the river – most of it quantitative, much of it statistically significant, some direct measurements and some in the form of predictive model output. In fact, the Waikato River is probably the best studied river system in New Zealand. Yet, despite this, the Study team found themselves often having to fall back on 'weight of evidence', expert opinion and local knowledge because robust causal relationships have not yet been proven. The Study team observes that this uncertainty is a common experience to other river restoration initiatives worldwide.

[133] See Appendix 2: Restoration Case Studies.

On the social science side, information is sparser and the Study team had to rely more heavily on qualitative approaches. On key questions (e.g., people's willingness to pay for restoration actions), large-scale quantitative surveys of the Waikato population were beyond what a scoping study of this nature can deliver.

Maatauranga Maaori was the focus of much of the primary data gathering for this Study because the amount of written record on maatauranga Maaori *specifically related to the Waikato River and its catchment* was not sufficient to adequately address the project's purpose given the overall co-management objectives underpinning this Study. Nevertheless, the Study team used as many possible sources of maatauranga Maaori available to guide development of the priority actions outlined in Section 7. As Section 2 notes, maatauranga Maaori and science are complementary but not directly comparable. Some intangibles in maatauranga Maaori (e.g., spiritual aspects) are difficult to analyse and quantify. Integrating quantitative scientific approaches and value-based knowledge systems requires care and sensitivity, but it is a challenge which must be met if the aspirations for the restoration of the Waikato River are to be realised.

The Study team believes that the processes, methodologies and recommended priority actions outlined in this Report will provide valuable information to other restoration projects, in New Zealand and around the world, to help grapple with similar challenges in the future.

The Study does not purport to provide an instant remedy to restore and protect the Waikato River but it outlines bold and innovative steps the Waikato River Authority can take towards restoration. As the Study team has noted throughout this Report, full restoration and protection of the Waikato River will take time, money, resources, cooperation, determination, engagement, adaptive management and, often, persuasive argument. But, like the Guardians Establishment Committee, the Study team believe that "*to do nothing until you know everything*" is not an option.

The Study itself does not make final decisions about what actions the Waikato River Authority will fund in its role as trustee of the Waikato River Clean-Up Trust. Nor is it the job of this Scoping Study to do so. Deciding which specific actions should be chosen for rehabilitating the Waikato River is solely the responsibility of the Authority. But the Study team is certain that it has provided the Crown and the five river iwi with a sound and objective basis on which to finalise the amount, scope and key components of the Crown contribution to a clean-up fund (administered by the Waikato River Authority in its role as trustee for the Waikato River Clean-Up Trust) to restore and protect the health and wellbeing of the Waikato River for future generations. It identifies restoration priorities in relation to the river, its lakes, wetlands and tributaries and the likely cost of the priority actions. And it provides useful information to the establishment and operation of the Waikato River Clean-Up Trust.

9.2 Critical success factors for restoration

The Study team acknowledges the difficult decisions ahead that the Waikato River Authority (in its role as trustee for the Waikato River Clean-Up Trust) will have to make in order to meet the vision for the Waikato River set out in Te Ture Whaimana:

"….where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come."

But the new era of co-management provides a strong foundation on which those decisions can be made. Over the past 30 years, there has also been a substantial increase in river restoration efforts worldwide (see Appendix 33: Restoration Case Studies). Restoration efforts can provide guidance to the Waikato River Authority on critical factors for successful restoration (see highlighted box).

1. Restoration requires investment – restoration projects on a catchment-scale can typically require budgets of many millions of dollars.
2. Restoration is long-term – it may be several decades before significant restoration is achieved.
3. Collaboration is needed – Restoration often requires participation, cooperation and collaboration from many parties including state and local government agencies, industry, universities, and representatives of indigenous groups, environmental care groups, recreational sports groups and the wider community.
4. Build on existing initiatives – attempts should be made to build on existing restoration activities, environmental management and monitoring activities.
5. Define the desired outcome– the overall outcome that is desired from restoration needs to be well defined. Te Ture Whaimana provides that in this case.
6. Set agreed objectives – it is important to have clearly defined and agreed restoration objectives that will meet the desired outcome, and all partners need to be committed to achieving these.
7. Use traditional knowledge and science – successful restoration relies on incorporating traditional knowledge (in this case, maatauranga Maaori) and science. Also, scientific input must incorporate multi- and interdisciplinary approaches (e.g., drawing on physical, chemical, geomorphological and ecological expertise).
8. Use science – use the extensive and growing body of restoration science to inform actions, monitoring and analysis.
9. Track expenditure and progress – records of expenditure and completion of specific restoration activities need to be recorded and audited.
10. Monitor – progress towards completing restoration activities, achievement of objectives and progress towards the overall outcome need to be monitored and the results publicised.
11. Learn from monitoring – monitoring results need to be analysed to determine the effectiveness of the actions undertaken.
12. Use adaptive management – because the outcome of specific restoration actions will not be reliably predictable there needs to be ongoing review of progress and if necessary modification and re-setting of objectives and actions.
13. Outreach – there needs to be easy access to project information, objectives, planned actions, resources and monitoring results for all stakeholders and the community.
14. Plan for the future – restoration projects are typically of a long duration and this needs to be considered when setting up administrative and management systems. Staff turnover and operational restructuring need to be allowed for with robust systems able to survive in the long-term. Planning has to include information security and backup and archiving. Standardised data systems and mandatory reporting are needed and changes in computing systems need to be considered so that information is not lost.

9.3 A new journey towards restoration

More than 20 years ago, Sir Robert Mahuta began a journey to remedy the wrongs done to his iwi and his awa tupuna through the Crown's raupatu which denied Waikato-Tainui their rights and interests in the Waikato River. It was a search for redress and justice that spanned more than 120 years, beginning in 1884 when Kiingi Taawhiao led a delegation to England to seek an audience with Queen Victoria. Historical records note that Kiingi Taawhiao felt a physical and emotional "*intense yearning*" for the Waikato River when his people were displaced from the area (Kirkwood, 2000). The depth of his longing and love is expressed in his maimai aroha or lament that has been included in Te Ture Whaimana to reinforce the vision, and inspire the actions, that will be necessary to restore the health and wellbeing of the Waikato River.

"Tooku awa koiora me oona pikonga he kura tangihia o te maataamuri.

The river of life, each curve more beautiful than the last."

In an alternative translation of Kiingi Taawhiao's lament the word beautiful is instead translated as "*precious*" – and to the river iwi, and many members of the wider Waikato community, that is just what the Waikato River is – a taonga and a precious source of sustenance, recreation, spirituality, resources and healing (Roa, 2003).

Now the journey that Sir Robert Mahuta began more than two decades ago takes a new direction, from redress and justice, towards full restoration and protection of the awa tupuna – te Awa o te Waikato. It is a journey that all five river iwi will take together, woven through whakapapa in a spiritual korowai (cloak). But without a sound community-based foundation, any efforts to restore and protect the health and wellbeing of the Waikato River will undoubtedly fail. The input and engagement of the whole Waikato community and all stakeholders, alongside the river iwi, will be critical to achieving the objectives of Te Ture Whaimana. That is the true spirit of the co-management arrangements set out in the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 and co-management deeds signed with Raukawa, Te Arawa River Iwi and Tuwharetoa[134].

This Study provides the information the Study team believes the Waikato River Authority will need to meet the aspirations that the five river iwi and the wider community have for a healthy and well Waikato River and the vision and strategy outlined in Te Ture Whaimana. Only when Te Ture Whaimana has been met will Mana o te Awa and Mana Whakahaere be restored to the river iwi. And only then will the Waikato River – the heart and the veins of its people – be restored as a taonga for future generations.

"Ngaa awa itiiti e paa ana ki te wai o Waikato, ko ngaa uaua o too taatou awa. Too taatou awa he manawa. All the little streams and rain that flow into the Waikato River are like the veins of the body. The River is our heart." Sir Robert Te Kotahi Mahuta

Heoi anoo raa e ngaa uru kahika, ngaa whakamireirei o teenaa iwi, o teeraa iwi e noho nei i ngaa tahataha o te awa tupuna o Waikato me Waipa hoki, raatou te hunga kua whetuurangitia, kaare e aarikarika ngaa mihi ki a koutou katoa e tauwhanga ana moo teenei puurongo, teenei

[134] The Office of Treaty Settlements is continuing to negotiate a co-management deed with Maniapoto.

rautaki hei whakaoranga anoo i te mana, i te tapu, i te ihi, i te wehi, i te wana otiraa i te mauri o te awa moo Ngaai Taatou. Noo reira teenaa raa koutou katoa.

Glossary

Glossary of Maaori terms		
Te Reo Maaori term	**English terminology**	**Scientific term**
A		
Ariari	Board used during whitebaiting	
Aroha	Show sincerity and mutual respect	
Atua	Ancestor with continuing influence, god, supernatural being, deity	
Aua	Yellow eyed mullet	*Aldrichetta forsteri*
Awa	River, stream, creek	
H		
Hani-a-te-waewae-i-kimi-atu	The male element	
Hapuu	Sub-tribe	
Harakeke	Flax	*Phormium tenax*
Hui	Assemble, assembly, meeting, gathering	
I		
Iinanga	Common galaxias, juveniles are a component of the whitebait catch	*Galaxias maculatus*
Iwi	Tribe, nation, people, society	
K		
Kaaeo	Freshwater mussel	*Hyridella menziesi*
Kaainga	Home, abode, dwelling	
Kaakahi	Freshwater mussel	*Hyridella menziesi*
Kahikatea	White pine	*Dacrycarpus dacrydioides*
Kai	Eat, food, dine	
Kai awa	Food from the river	
Kaihoe	Paddler, rower	
Kaitiaki	Guardian, caretaker, manager, trustee	
Kaitiakitanga	Guardianship	
Kanohi kitea	The `seen face'	
Karakia	Incantation, prayer, chant	
Kaumaatua	Elders, not gender specific	
Kaupapa	Strategy, theme, philosophy	
Kawa	Ceremonial rituals, protocol, principles of protocol and ritual	
Kiingitanga	The King Movement - a movement which developed in the 1850s, established to stop the loss of land and promote Maaori authority, to maintain law and order, and to promote traditional values and culture	
Koikoi	Species of fern	*Blechnum minus*
Kooaro	Climbing galaxias, juveniles are a	*Galaxias brevipinnis*

Glossary of Maaori terms		
Te Reo Maaori term	*English terminology*	*Scientific term*
	component of the whitebait catch	
Koohanga	Nest, nursery	
Kookopu	Galaxiids (including banded, giant, and short jaw kookopu), juveniles are a component of the whitebait catch	
Koorero	Speech, narrative, story, news, account, discussion, conversation, discourse	
Kooura	Freshwater crayfish	*Paranephrops spp.*
Koowhai	Trees in the genus *Sophora* native to New Zealand	*Sophora spp.*
Korimako	Bellbird	*Anthornis melanura*
Koroneihana	Coronation - the year's biggest gathering of followers of the Kiingitanga, celebrating the anniversary of the anointing of the King (or Queen)	
Koroua	Male elder	
Korowai	Cloak	
Kuia	Female elder	
Kura	School, education, learning, gathering. (Kura kaupapa are schools which operate under Maaori custom, using Maaori as the medium of instruction)	
Kuta	Great spike rush, bamboo spike-sedge	*Eleocharis sphacelata*
M		
Maahaki	Exercise humility	
Maanuka	Tea tree	*Leptospermum scoparium*
Maaori	Indigenous person of *Aotearoa*/ New Zealand	
Maatauranga Maaori	Maaori knowledge - the body of knowledge originating from Maaori ancestors, including the Maaori world view and perspectives, Maaori creativity and cultural practices. As an organic and living knowledge base, maatauranga Maaori is ever growing and expanding and includes contemporary Maaori knowledge and knowledge bases	
Mahinga kai	Food gathering areas	
Maimai aroha	Lament, mourn /expression of affection shown to the person who has passed away	
Mana	Prestige, authority, control, power, influence, status, spiritual power, charisma - mana is a supernatural	

Glossary of Maaori terms		
Te Reo Maaori term	*English terminology*	*Scientific term*
	force in a person, place or object	
Mana o Te Awa	Seeks respect for: • He tupuna awa (ancestral river) • Whakapapa and unity of the River tribes • The unique relationship of the people with the River • Responsibilities of Waikato-Tainui and other river iwi to protect the mana of the River	
Mana Whakahaere	Refers to the authority that Waikato-Tainui and other river iwi have established in respect of the River, over many generations	
Manaaki tangata	Practise reciprocity and generosity	
Manaakitanga	Hospitality (ability of hosts to care for their visitors), kindness, blessing	
Manuhiri	Visitor, guest	
Marae	Sacred meeting place, courtyard in front of the wharenui (meeting house)	
Mate Maaori	Spiritual sickness (from a Maaori worldview)	
Mauri	Life principal/force, entity	
Mokopuna	Grandchild, descendant	
N		
Ngaa Aitanga a Tiki	Descendents of Tiki, human beings	
Ngaawhaa	Geothermal hot pools, boiling spring, volcanic activity, boiling mud pool, fumarole, sulphur water, geyser	
P		
Paa	Traditional settlement	
Paa tuna	Eel weirs	
Paanui	Announcement, advertise	
Paatiki	Flounder	*Rhombosolea plebeia*
Piiharau	Lamprey	*Geotria australis*
Poorohe	Common smelt	*Retropinna retropinna*
Poukai	Annual visitation to marae aligned to the Kiingitanga – to contribute and discuss important tribal affairs, to feed the widowed, bereaved and the destitute	
Puhi	Variety of tuna, Waikato-Tainui term	
R		
Raahui	To put in place a temporary ritual prohibition, closed season, ban, reserve - traditionally a raahui was placed on an area, resource or	

Glossary of Maaori terms		
Te Reo Maaori term	*English terminology*	*Scientific term*
	stretch of water as a conservation measure or as a means of social and political control for a variety of reasons which can be grouped into three main categories: pollution by tapu, conservation and politics	
Raaranga	Weaving arts	
Rama kooura	Spotlighting - to catch kooura by torchlight	
Rangatahi	Youth, younger generation	
Rangatira	Chief (male or female), leader, proprietor - qualities of a leader is a concern for the integrity and prosperity of the people, the land, the language and other cultural treasures and an assertive and sustained response to outside forces that may threaten these	
Rangatiratanga	Sovereignty, chieftainship, leadership, right to exercise authority, chiefly autonomy, self-determination, self-management, ability to lead, ownership	
Raupatu	Crown invasion and war by land and by the Waikato River, and subsequent Crown confiscation of Waikato lands	
Raupoo	Bullrush, cat's-tail	*Typha orientalis*
Riiringi	To pour, sprinkle (water)	
Rohe	Tribal boundary, district, region, territory, area, border	
Rongoaa	Remedy, medicine, drug, cure, medication, treatment, solution (to a problem), tonic	
Ruru	Morepork	*Ninox novaeseelandiae*
T		
Tamariki	Children	
Taangata whenua	People of the land, locals, host, resident, people born of the whenua, i.e. of the placenta and of the land where the people's ancestors have lived and where their placenta are buried	
Tangi	Mourn, funeral	
Tangihanga	Weeping, crying, funeral, rites for the dead	
Taniwha	Metaphor for a chief, a being or deity good and bad that can reside in water, taniwha take many forms from logs to reptiles and whales and often live in lakes, rivers or the sea. They are often regarded as	

Glossary of Maaori terms		
Te Reo Maaori term	*English terminology*	*Scientific term*
	guardians by the people who live in their territory. Also can be an area to be aware of danger/kia tuupato – see tapu	
Taonga	Goods, possessions, effects, treasure, gifts, something prized	
Taonga tuku iho	Treasure handed down, similar to inheritance	
Tapu	Restriction - a supernatural condition. A person, place or thing is dedicated to an atua and is thus removed from the sphere of the profane and put into the sphere of the sacred. It is untouchable, no longer to be put to common use. Tapu was used as a way to control how people behaved towards each other and the environment, placing restrictions upon society to ensure that society flourished	
Tau kooura	Te Arawa method of catching kooura	
Te Ira Atua	God essence	
Te Reo Maaori	Maaori language	
Te Ture Whaimana	The Vision and Strategy for the Waikato River	
Teina (singular), teeina (plural)	Younger brother(s) (of a male), younger sister(s) (of a female), junior relative(s)	
Tikanga	Correct procedure, custom, habit, lore, method, manner, rule, way, code, meaning, plan, practice, convention	
Toetoe	Species of tall grasses native to New Zealand	*Cortaderia spp.*
Tohu	Sign, identify, mark, symbol, indicate	
Tootara	Species of podocarp tree endemic to New Zealand	*Podacarpus totara*
Tuakana (singular), Tuaakana (plural)	Elder brother (of a male), elder sister (of a female), senior relative	
Tuna	Freshwater eel	*Anguilla dieffenbachii (longfin); Anguilla australis (shortfin)*
Tupuna (singular), tuupuna (plural)	Ancestor(s)	
Awa tupuna	Ancestral river	
Tuuii	Parson bird	*Prosthemadera novaeseelandiae*
Tuurangawaewae	A place to stand, home ground, place where one has rights of	

Glossary of Maaori terms		
Te Reo Maaori term	*English terminology*	*Scientific term*
	residence and belonging through kinship and whakapapa	
Tuupatotanga	Demonstrate caution	
U		
Urupaa	Cemetery, burial place, graveyard	
W		
Waahi tapu	Shrine, sanctuary, sacred area/place	
Waananga	Place of learning	
Wai	Water	
Wairua	Spirit, soul	
Waka	Canoe	
Waka ama	Outrigger canoe	
Waka taua	War canoe	
Waka tiiwai	Dugout canoe with attached sides	
Whaanau	Extended family, family group, to be born	
Whakairo	Carving	
Whakamaa	Be ashamed, shy, bashful, embarrassed	
Whakapapa	Genealogy, genealogical table, lineage, descent, ancestry	
Whakawhanaungatanga	Honour relationships	
Whanaungatanga	Relationship, kinship, sense of family connection - a relationship through shared experiences and working together which provides people with a sense of belonging. It develops as a result of kinship rights and obligations, which also serve to strengthen each member of the whaanau. It also extends to others to whom one develops a close familial, friendship or reciprocal relationship	
Whareweku	Bracken fern bundles, component of the tau kooura	
Whenua	Land, country, earth, placenta, afterbirth	

References

Executive Summary

There are no references in this section.

Section 1: Introduction

There are no references in this section.

Section 2: Study methods

ANZECC (2000). Australian and New Zealand guidelines for fresh and marine water quality. Canberra, Australia*. National Water Quality Management Strategy Paper No. 4*. Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand.

Bewsell, D.; Kaine, G.; Higson, M. (2005). Adoption of environmental best practice in the dairy industry. *Client Report of FRST Enhancing surface water quality in managed landscapes CIOX0320*. 34 p.

Bewsell, D.; Monaghan, R.M.; Kaine, G. (2007). Adoption of stream fencing among dairy farmers in four New Zealand catchments. *Environmental Management 40*: 201–209.

Blackett, P. (2004). Biophysical; institutional challenges to management of dairy shed effluent; stream management practises on New Zealand dairy farms. *Thesis,* Auckland. 271 p.

Burns, N.; Bryers, G.; Bowman, E. (2000). Protocols for monitoring trophic levels in New Zealand lakes and reservoirs. Ministry for the Environment, Wellington. 122 p.

Burns, N.M.; Rutherford, J.C.; Clayton, J.C. (1999). A monitoring and classification system for New Zealand lakes and reservoirs. *Journal of Lakes Research and Management 15(4)*: 255–271.

Costanza, R. et al., (2004). Estimates of the Genuine Progress Indicator (GPI) for Vermont, Chittenden County and Burlington, from 1950 to 2000. *Ecological Economics* 139–155.

Darby, S.; Sear, D. (eds). (2008). River restoration: Managing the uncertainty in restoring physical habitat. Wiley.

Dodd, M.B.; Quinn, J.M.; Thorrold, B.S.; Parminter, T.G.; Wedderburn, M.E. (2008). Improving the economic and environmental performance of a New Zealand hill country farm catchment: 3. Short term outcomes of land use change. *New Zealand Journal of Agricultural Research 53*: 155–169.

Hamilton, D.P.; Vant, W.N.; Nielsen, K.A. (2010). Lowland Lakes. *In*: Collier, K.; Hamilton, D.P.; Vant, W.N.; Howard-Williams, C. (eds). Waters of the Waikato. Environment Waikato and University of Waikato, Hamilton, pp. 245–264.

Marsh, D.; Davies, A.; Petch, A. (2009). Willingness to pay for water quality in the Karaapiro catchment – a case study of residents. Report to the Environment Committee, Environment Waikato, 31 July 2009. 10 p.

Ministry for Environment (1994). Water quality guidelines No. 2: Guidelines for the management of water colour and clarity. Ministry for the Environment, Wellington. 77 p.

Ministry for Environment; Ministry of Health. (2003). Microbial water quality guidelines for marine and freshwater recreation areas. Ministry of Environment and Ministry of Health, Wellington. 159 p.

Miller, R.E.; Blair, P.D. (2009). Input-Output Analysis: Foundations and Extensions (2nd ed.) New York: Cambridge University Press.

Patterson, M.; Cole, A. (1999). Assessing the value of New Zealand's biodiversity. *Occasional Paper Number 1*, School of Resource and Environmental Planning, Massey University, February 1999.

Quinn, J.M.; Dodd, M.B.; Thorrold, B.S. (2007). Whatawhata catchment management project: the story so far. *Proceedings of the New Zealand Grassland Association 69*, pp. 229–233.

Rutherford, J.C. (2003). Lake Rotorua nutrient load targets. *NIWA Client Report HAM2003-155*, October 2003.

Rutherford, J.C.; Williamson, R.B.; Davies-Colley, R.J.; Shankar, U. (2001). Waikato Catchment Water Quality Model. *NIWA Client Report ELE90229/3* prepared for Mighty River Power Ltd. August 2001.

Williams, J. (2009). "O ye of little faith" traditional knowledge and Western science. *Journal of the Royal Society of New Zealand 39(4)*: 167–169.

Section 3: Current state of the Waikato River

Abad, F.; Xavier, A.F.; Pintó, R.M.; Gajardo, R.G.; Bosch, A. (1997). Viruses in mussels: Public health implications and depuration *Journal of Food Protection 60(6):* 677–681.

Aggett, J.; Kriegman, M.R. (1988). The extent of formation of arsenic (III) in sediment interstitial waters and its release to hypolimnetic waters in Lake Ohakuri. *Water Research 22*: 407–411.

Andersen, J.C. (1942). Maori place names – also personal names and names of colours, weapons and natural objects. Polynesian Society, Wellington.

ANZECC (2000). Australian and New Zealand guidelines for fresh and marine water quality. Canberra, Australia. *National Water Quality Management Strategy Paper No. 4.* Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand.

Baird, C.M. (2010). Wetlands and lowland floodplains. *In:* Collier, K.J.; Hamilton, D.; Vant, W.N.; Howard-Williams, C. (eds). Waters of the Waikato, Environment Waikato and the University of Waikato, Hamilton, pp. 265–280.

Baker, C.; James, M. (2010). Effects of Huntly Power Station on Waikato River Biota – Literature Review February 2001. *NIWA Client Report HAM2009-173*.

Beentjes, M.P.; Chisnall, B.L.; Boubée, J.A.; Jellyman, D.J. (1997). Enhancement of the New Zealand eel fisheries by elver transfer. *New Zealand Fisheries Technical Report No. 45*.

Brown, E., Haigh, A. (2004). Future Water Demand from Pasture Irrigation in the Waikato Region. *Environment Waikato Technical Report 2005/01.*

Brown, E. (2010). Flow regime and water use. *In:* Collier, K.J.; Hamilton, D.; Vant, W.N.; Howard-Williams, C. (eds). Waters of the Waikato, Environment Waikato and University of Waikato, Hamilton, pp. 29–45.

Burlakova, L.E.; Karatayev, A.Y. (2007). The effect of invasive macrophytes and water level fluctuations on unionids in Texas impoundments. *Hydrobiologia 586:* 291–302.

Champion, P.D.; Clayton, J.S. (2010). Native macrophytes and aquatic weeds. *In:* Collier, K.J.; Hamilton, D.; Vant, W.N.; Howard-Williams, C. (eds). Waters of the Waikato, Environment Waikato and the University of Waikato, Hamilton, pp. 153–171.

Chapman, MA., (1996). Human impacts on the Waikato River system, New Zealand. *GeoJournal 40.1-2*: 85–99.

Clarkson, B.D.; McQueen, J.C. (2004). Ecological restoration in Hamilton City, North Island, New Zealand. Presented at the 16th International Conference, Society for Ecological Restoration, August 24–26, 2004, Victoria, Canada.

Clarkson, B.D.; Wehi, P.M.; Brabyn, L.K. (2007). A spatial analysis of indigenous cover patterns and implications for ecological restoration in urban centres, New Zealand. *Urban Ecosystems 10*: 441–457.

Collier, K.J.; Hamilton, D.; Vant, W.N.; Howard-Williams, C. (eds). (2010). Waters of the Waikato. Environment Waikato and the University of Waikato, Hamilton.

Depree, C.; Franklin, P.; Hickey, C.; Hudson, N.; Martin, M.; van Houte-Howes, K.; Wells, R. (2008). Monitoring of lakes Maraetai and Waipapa in compliance with Environment Waikato Resource Consent 961348. *Client Report HAM2008–206.* Project Number CHH8201.

Donnison, A.M.; Ross, C.M. (1999). Animal and human faecal pollution in New Zealand rivers. *New Zealand Journal of Marine and Freshwater Research 33(1)*: 119–128.

Donnison, A.; Ross, C.; Dixon, L. (2009). Faecal contamination of watercress *(Nasturtium officinale)* gathered by Maori protocol in New Zealand streams. *New Zealand Journal of Marine and Freshwater Research 43*: 901–910.

Donnison, A.; Dixon, L.; Ross, C. (2010). Pastoral agriculture, water quality and microbially safe Maori food. *In:* Currie, L.D.; Christensen, C.L (eds). Farming's future: Minimising footprints and maximising margins, Fertilizer and Lime Research Centre, Massey University, Palmerston North, *Occasional Report 23*:152-160.

Eberhart-Phillips, J.; Walker, N.; Garrett, N.; Bell, D.; Sinclair, D.; Rainger, W.; Bates, M. (1997). Campylobacteriosis in New Zealand: results of a case-control study. *J. Epidemiol. Community Health 51*: 686–691.

Edwards, T.; Clayton, J.S.; de Winton, M. (2009). Assessment of the ecological condition of lakes in the Waikato Region using LakeSPI – 2009. *NIWA Client Report 2009/64.*

Environment Waikato (1998). *Waikato State of the Environment Report*, 244 p.

Environment Waikato (2006). Waikato region economy-environment futures report, a report prepared by Market Economics Ltd for Environment Waikato, *Environment Waikato Technical Report 2006/51*.

Environment Waikato (2007). Clean Streams Project survey of farmers June 2007. *Environment Waikato Technical Report 2008/08*. 37 p.

Environment Waikato (2008). The health of the Waikato River and catchment. Information for the Guardians Establishment Committee, 62 p.

Environment Waikato (2008a). The condition of rural water and soil in the Waikato region. Hamilton, Environment Waikato, 55 p.

Environment Waikato (2008b). Proposed Waikato Regional Plan Proposed Variation No.6 – Water Allocation. *Environment Waikato Policy Series 2008/14*.

Fish and Game NZ (2008). Eastern Whangamarino Restoration Project. Hamilton. 26 p.

Fletcher, P.; Galvin, W.T. (2002). Ngati Tahu-Ngati Whaoa Social and Cultural Report on Te Awa o Waikato. *Unpublished report for Mighty River Power.* 158 p.

Frost, E.T. (1947). By Maori trail and Pakeha Road: Tales of bush and river.

FSANZ. Guidelines for microbial examination of ready-to-eat foods. Food Standards Australia New Zealand, 2001. from http://www.foodstandards.gov.au/scienceandeducation/publications/guidelinesformicrobi1306.cfm

Gibbons, P.J. (1977). Astride the river: A history of Hamilton. Whitcoulls for Hamilton City Council, Christchurch. 381 p.

Grant, S.; Littler, C.; Hill, R. (2010). Catchment environmental monitoring report: 2008/09. *Environment Waikato Technical Report No. 2010/5*, 32 p.

Hamilton, D.P.; Vant, W.N.; Neilson, K.A. (2010). Lowland lakes. *In:* Collier, K.J.; Hamilton, D.P.; Howard-Williams, C.W. Waters of the Waikato. Environment Waikato and the University of Waikato, pp. 245–264.

Hewitt, J.; Greening, G.E. (2004). Survival and Persistence of Norovirus, Hepatitis A Virus, and Feline Calicivirus in Marinated Mussels. *Journal of Food Protection 67(8)*: 1743–1750.

Hewitt, J.; Greening, G.E. (2006). Effect of heat treatment on Hepatitis A virus and norovirus in New Zealand greenshell mussels (*Perna canaliculus*) by quantitative real-time reverse transcription PCR and cell culture. *Journal of Food Protection 69(9)*: 2217–2223.

Hickey, C.W.; Roper, D.S.; Buckland, S.J. (1995). Metal concentrations of resident and transplanted freshwater mussels *Hyridella menziesi* (Unionacea: Hyriidae) and sediments in the Waikato river, New Zealand. *The Science of the Total Environment 175*: 163–177.

Hicks, D.M.; Webby, M.G.; Duncan, M.J.; Harding, S. (2001). Waikato River sediment budget and processes. *NIWA Client Report: CHC01/24*. Project No: MRP00506. June 2001.

Hicks, D.M.; Hill, R.B. (2010). Sediment regime: sources, transport and changes in the riverbed. *In:* Collier, K.J.; Hamilton, D.P.; Howard-Williams, C.W. Waters of the Waikato. Environment Waikato and the University of Waikato, pp. 71–86.

Hitchmough, R.; Bull, L.; Cromarty, P. (2005). New Zealand Threat Classification lists. Science & Technical Publishing, Department of Conservation, Wellington.

Hochstetter, F. von (1867). New Zealand: its physical geography, geology and natural history with special reference to the results of government expeditions in the provinces of Auckland and Nelson. J.G. Cotta.

Holland, P.T.; Rahman, A. (1999). Review of trends iin agricultural pesticide use in New Zealand. *MAF Policy Technical Paper 99/11.*

Huakina Development Trust (2007). Waikato Iwi Management Plan: Manuka. Prepared by the Huakina Development Trust on behalf of Te Puaha Ki Manuka O Waikato. 170 p.

Hughes, H.R. (1981). New Zealand conservation strategy – executive summary. *In:* Integrating conservation and development: A proposal for a New Zealand conservation strategy. Nature Conservation Council, Wellington.

James, M.R.; Ogilvie, S.C.; Henderson, R. (1998). Ecology and potential use in biomanipulation of the freshwater mussel *Hydridella mensiesi* (Gray) in Lake Rotorua. *NIWA Client Report HCC90201/1.*

Jellyman, D.J.; Booker, D.J.; Watene, E. (2009). Recruitment of glass eels (*Anguilla* spp.) in the Waikato River, New Zealand. Evidence of declining migrations? *Journal of Fish Biology 74:* 2014–2033.

Kahotea, D.T. (1990). Waahi Tapu. Report for the Hamilton City Council Planning and Development Group. June 1990. 40 p.

King, D.N.T.; Goff, J.; Skipper, A. (2007). Māori environmental knowledge and natural hazards in Aotearoa–New Zealand. *Journal of the Royal Society of New Zealand 37(2):* 59–73.

King, D.N.T.; Skipper, A.; Tawhai, W.B. (2008). Māori environmental knowledge of weather and climate change in Aotearoa – New Zealand. *Climatic Change 90(4):* 385–409.

Kirk, T. (1871). Notes on the botany of certain places in the Waikato District. *Transcripts of the New Zealand Institute 3*: 142–147.

Law, G. (2002). Archaeology of the Bay of Plenty. *Science 7 Technical Publishing*, Department of Conservation. June 2008. 149 p.

McCan, D. (2001). Whatiwhatihoe. The Waikato Raupatu Claim. Huia Publishers, Wellington. 388 p.

McConchie, J.A. (2001). Waikato River geomorphic processes. *Report prepared for Mighty River Power Ltd*, School of Earth Sciences, Victoria University, Wellington.

Ministry for Environment (2009). New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters: Interim Guidelines. Ministry for the Environment, Wellington. 82 p.

Mills, G.N. (1995). Mercury and arsenic in Waikato River fish. *No. SCJ129/06*. Environment Waikato, Hamilton. 47 p.

Ministry for the Environment/Ministry of Health. (2003). Microbial water quality guidelines for marine and freshwater recreation areas. Ministry of Environment and Ministry of Health, Wellington. 159 p.

Ministry of Health (2001). A Report on the Chemical Quality of New Zealand Community Drinking Water Supplies. *No. FW01200.* Institute of Environmental Science and Research report by H. Davies, C. Nokes and J. Ritchie for the Ministry of Health, Wellington. 312 p.

Ministry of Health (2010). Annual Review of Drinking-Water Quality in New Zealand 2008/9. Institute of Environmental Science and Research report by A. Ball, J. Ritchie, A. Ferguson and C. Nokes for the Ministry of Health, Wellington. 208 p.

More, D. (1977). Between the river and the hills: Waikato County 1876–1976. Wilson and Horton, Auckland. 383 p.

Mosley, M.P. (2004). Rivers and the riverscape. *In*: Harding, J.S.; Mosley, M.P.; Pearson, C.P.; Sorrell, B.K. (eds). Freshwaters of New Zealand, pp. 8:10–8:18. New Zealand Hydrological Society and New Zealand Limnological Society, Christchurch.

NZFSA (2005). Review of Non-Commercial Wild Food in New Zealand. *NZFSA Draft Position Paper (No: 01/05).* New Zealand Food Safety Authority, Wellington. 28 p.

Orbell, M. (1985). The natural world of the Maori. Auckland, New Zealand, William Collins Publishers. 230 p.

O'Sullivan, S.J.; Te Hiko, N.H. (2010). Raukawa and the river. *In*: Collier, K.J.; Hamilton, D.; Vant, W.N.; Howard-Williams, C. (eds). Waters of the Waikato, Environment Waikato and the University of Waikato, Hamilton, p. 9.

Neems, J. (2010). Leaving behind a lake legacy. Waikato Times 3 July 2010.

Parkyn, S.M.; Collier, K.J. (2004). Interaction of press and pulse disturbance on crayfish populations: food impacts in pasture and forest streams. *Hydrobiologia 527(1)*: 113–124.

Parkyn, S. M.; Wright-Stow, A.; Quinn, J.M. (2003). Photo survey: do people like riparian management on farm streams? *Water and Atmosphere 11(4)*: 20–21.

Parkyn, S.; Quinn, J. (2006). Urban streamscapes: what people want to see in their neighbourhood. *Water and Atmosphere 14 (1):* 14–15.

Parkyn, S.M.; Kusabs, I. (2007). Taonga and mahinga kai species in the Te Arawa lakes: a review of current knowledge – Koura. *NIWA Client Report HAM2007-022.* NIWA, Hamilton.

Paul, D. (1996). The Māori cookbook. Harper Collins, Auckland, New Zealand.

Phillips, N.; Parkyn, S.; Kusabs, I.; Roper, D. (2007). Taonga and mahinga kai species of the Te Arawa Lakes: a review of current knowledge - Kakahi. *Client Report HAM2007–022.* 15 p.

Phillips, W.J. (1947). The Rua Hoata shelter, Waikato River. *Journal of the Polynesian Society 56*: 336–339.

Prickett, N.; McGovern-Wilson, R. (eds). (2009). Occasional Publications in Archaeology No. 1. Planning a Future for New Zealand War Sites and Landscapes. New Zealand Historic Places Trust. 6 July 2009, 93 p.

Quinn, J.M. (2009). Riparian Management Classification reference manual. *NIWA Client Report: HAM2009-072.* Hamilton. 60 p.

Reed, A.W. (2002). The Reed dictionary of New Zealand placenames. Auckland, New Zealand. Reed Publishing.

Reeves, P.; Craggs, R.; Stephens, S.; de Winton, M.; Davies-Colley, R. (2002). Environmental changes at Lake Waikare, North Waikato. Wave climate, water quality and 'biology'. *NIWA Client Report: EVW002235*. 69 p.

Robinson, B.; Kim, N.; Marchetti, M.; Moni, C.; Schroeter, L.; van den Dijssel, C.; Milne, G.; Clothier, B. (2006). Arsenic hyperaccumulation by aquatic macrophytes in the Taupo Volcanic Zone, New Zealand. *Environmental and Experimental Botany 58:* 206–215.

Russell, D.; Parnell, W.; Wilson, N. (1999). NZ Food: NZ People Key results of the 1997 National Nutrition Survey. Ministry of Health, Wellington. pp. 280.

Sagar, P.M. (2010). Bird-life. *In*: Collier, K.J.; Hamilton, D.; Vant, W.N.; Howard-Williams, C. (eds). Waters of the Waikato, Environment Waikato and the University of Waikato, Hamilton, pp. 220–240.

Sinclair Knight Merz (2010). Regional Council Practice for Setting and Meeting RMA-Based Limits for Freshwater flows and Quality. Ministry for the Environment. *National Summary Report.*

Sinton, L. (2001). Microbial contamination of New Zealand's aquifers. *In:* Rosen, M.R.; White, P.A. (eds). Groundwaters of New Zealand, Caxton Press/New Zealand Hydrological Society, Christchurch, pp. 221–251.

Storey, R. (2010). Riparian characteristics of pastoral streams in the Waikato region, 2002 and 2007. *Environment Waikato Technical Report 2010-07*. 57 p.

Te Pumautanga o Te Arawa Trust and the Raukawa Trust Board and the Sovereign (2008). Agreement in relation to a Co-Management Framework for the Waikato River. 4 September 2008. 56 p.

Te Purongo Maniapoto (2002). Te Purongo Maniapoto State of the Environment Report – A Tribal Perspective. 34 p.

The New Zealand Railways Magazine (1929). Volume 4, Issue 5 (September 1, 1929).

Till, D.G.; McBride, G.B. (2004). Potential public health risk of *Campylobacter* and other zoonotic waterborne infections in New Zealand. *In:* Cotruvo, J.A.; Dufour, A.; Rees, G.; Bartram, J.; Carr, R.; Cliver, D.O.; Craun, G.F.; Fayer, R.; Gannon, V.P.J. Waterborne Zoonoses: Identification, Causes and Control, IWA publishing, London, for the World Health Organization, Chapter 12.

Turner, N.; Cressey, P.; Lake, R.; Whyte, R. (2005). Review of Non-Commercial Wild Food in New Zealand. *Institute of Environmental Science & Research Ltd Report to New Zealand Food Safety Authorit*y. 180 p. http://www.nzfsa.govt.nz/consumers/wild-foods-review/esr-report-in-full.pdf.

Waitangi Tribunal (1985). Report to the Waitangi Tribunal on the Manukau Claim. Brooker & Friend, Wellington.

Waitangi Tribunal (1993). The Pouakani Report. Brooker & Friend, Wellington.

Vant, W.N.B. (2010). Water quality. *In:* Collier, K.J.; Hamilton, D.; Vant, W.N.; Howard-Williams, C. (eds). Waters of the Waikato, Environment Waikato and University of Waikato, Hamilton, pp. 93–114.

Wall, K.; Clarkson, B. (2001). Gully restoration guide: A guide to assist in the ecological restoration of Hamilton's Gully systems. Hamilton City Council, Hamilton. 52 p.

Williamson, W.M.; Ball, A.; Wolf, S.; Hewitt, J.; Lin, S.; Scholes, P.; Ambrose, V.; Robson, B.; Greening, G.E. (2010 in press). Enteric viruses in New Zealand drinking-water sources. *Water Science and Technology*.

Wood, S.A.; Briggs, L.R.; Sprosen, J.; Ruck, J.G.; Wear, R.G.; Holland, P.T.; Bloxham, M. (2006). Changes in concentrations of microcystins in rainbow trout, freshwater mussels, and cyanobacteria in Lakes Rotoiti and Rotoehu. *Environmental Toxicology 21:* 205–222.

Section 4: The desired state of the Waikato River

ANZECC (2000). Australian and New Zealand guidelines for fresh and marine water quality. Canberra, Australia. *National Water Quality Management Strategy Paper No. 4*. Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand.

Burns, N.; Bryers, G.; Bowman, E. (2000). Protocols for monitoring trophic levels in New Zealand lakes and reservoirs. Ministry for the Environment, Wellington. 122 p.

Environment Waikato (2008) http://www.ew.govt.nz/policy-and-plans/Water-allocation-variation/ Accessed 10 June 2010.

Downing, J.A.; Watson, S.B.; McCauley, E. (2001). Predicting cyanobacteria dominance in lakes. *Canadian Journal of Fisheries and Aquatic Sciences 58*: 1905-1908.

Gravitas Research and Strategy Ltd (2006). Environmental Awareness, Attitudes and Actions 2006. A Survey of residents of the Waikato Region. *Environment Waikato Technical Report 2006/07*.

Hegarty, S.; Thomas, A.; Phillips, F.; (2001). Future Water Allocation Issues. Ministry of Agriculture and Forestry, Wellington. 78 p.

Huakina Development Trust (2007). Waikato Iwi Management Plan: Manuka. Prepared by the Huakina Development Trust on behalf of Te Puaha Ki Manuka O Waikato. 170 p.

Landman, M.J.; van den Heuval, M.R.; Ling, N. (2005). Relative sensitivities of selected freshwater fishes and invertebrates to acute hypoxia. *New Zealand Journal of Marine and Freshwater Research 39:* 1061–1067.

Ministry for the Environment (1992). Water quality guidelines No. 1: Guidelines for the control of undesirable biological growths in water. Ministry for the Environment, Wellington. 57 p.

Ministry for the Environment (2009). New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters: Interim Guidelines. Ministry for the Environment, Wellington. 82 p.

Mosley, M.P. (2004). Rivers and the riverscape. *In*: Harding, J.S.; Mosley, M.P.; Pearson, C.P.; Sorrell, B.K. (eds). Freshwaters of New Zealand, New Zealand Hydrological Society and New Zealand Limnological Society, Christchurch, pp. 8:10–8:18.

Pridmore, R.D.; McBride, G.B. (1983). Prediction of chlorophyll a concentration in impoundments with short hydraulic retention time. *Journal of environmental management 19:* 343–350.

Rutherford, J.C.; Williamson, R.B.; Davies-Colley, R.J.; Shankar, U. (2001). Waikato Catchment Water Quality Model. *NIWA Client Report ELE90229/3*, prepared for Mighty River Power Ltd. August 2001.

Smith, D.G.; Maasdam, R. (1994). New Zealand's National River Water Quality Network 1. Design and physico-chemical characterisation. *New Zealand Journal of Marine and Freshwater Research 28*: 19–25.

Statistics New Zealand and Ministry for Culture and Heritage (2003). A measure of culture: Cultural experiences and cultural spending in New Zealand. June 2003. 165 p.

Wilcock, R.J.; Nagels, J.W.; McBride, G.B.; Collier, K.J.; Wilson, B.T.; Huser, B.A. (1998). Characterisation of lowland streams using single-station diurnal curve analysis model with continuous monitoring data for dissolved oxygen and temperature. *New Zealand Journal of Marine & Freshwater Research 32*: 67–69.

Winitana, C. (2005). Central North Island Inquiry. WAI 1200, WAI 575, WAI 61, 178, 226,269 & 490. *The Ngati Tuwharetoa Comprehensive Claim: a claim filed by the ariki Tumu Te Heuheu on behalf of Nga Hapu o Tuwharetoa*: Evidence of Chris Winitana. Auckland, Tamatekapua Law.

Section 5: Potential actions to restore the Waikato River's health and wellbeing.

Berry, N.; Dresser, M. (2010). Keeping our water clean. *Fact sheet – June 2010*. Community sustainable land management for Waikato lakes catchments. 2 p. http://www.landcare.org.nz/user-content/2300-silt-trap-fact-sheet.pdf

Boon, P.J. (1998). River restoration in five dimensions *Aquatic Conservation: Marine and Freshwater Ecosystems 8*: 257–264.

Collins, R.; McLeod, M.; Hedley, M.; Donnison, A.; Close, M.; Horne, D.; Rioss, C.; Davies-Colley, R.; Bagshaw, C.; Matthews, L. (2007). Best management practices to mitigate faecal contamination by livestock in New Zealand waters. *New Zealand Journal of Agricultural Research 50*: 267–278.

Connor, J.; Hay, M.; Coleman, G. (2006). Extension through education programs with kids - who are we educating? Presented at the Practice change for sustainable communities: Exploring footprints, pathways and possibilities. Proceedings of APEN International Conference, 6–8 March 2006. ISBN 1 920842 31 4, Beechworth, Victoria, Australia.

De Vos, R.; Headley, T. (2006). Pōhatuiri Marae Development – Phase I investigation of Pōhatuiri Marae electricity, water and sewage treatment options. *NIWA Client Report AKL2006-032*, prepared for Pōhatuiri Marae Trust, April 2006.

Di, H.J.; Cameron, K.C. (2004). Treating grazed pasture with a nitrification inhibitor, eco-nTM, to decrease nitrate leaching in a deep sandy soil under spray irrigation - a lysimeter study. *New Zealand Journal of Agricultural Research 47*: 351–361

Dodd, M.B.; Thorrold, B.S.; Quinn, J.M.; Parminter, T.G.; Wedderburn, M.E. (2008). Improving the economic and environmental performance of a New Zealand hill country farm catchment: 1. Goal development and assessment of current performance. *New Zealand Journal of Agricultural Research 51(1)*: 127–141.

Dodd, M.B.; Thorrold, B.S.; Quinn, J.M.; Parminter, T.G.; Wedderburn, M.E. (2008). Improving the economic and environmental performance of a New Zealand hill country farm catchment: 2. Forecasting and planning land use change. *New Zealand Journal of Agricultural Research 53(1)*: 143–153.

Dodd, M.B.; Quinn, J.M.; Thorrold, B.S.; Parminter, T.G.; Wedderburn, M.E. (2008). Improving the economic and environmental performance of a New Zealand hill country farm catchment: 3. Short term outcomes of land use change. *New Zealand Journal of Agricultural Research 53*: 155–169.

Dodd, M.B.; Wedderburn, M.E.; Parminter, T.G.; Thorrold, B.S.; Quinn, J.M. (2008). Transformations towards agricultural sustainability in New Zealand hill country pastoral landscapes. *Agricultural Systems 98*: 95–107.

Donnison, A.; Ross, C. (2004). Land use effects on the faecal microbial quality of hill-country streams. *New Zealand Journal of Marine and Freshwater Research 38*: 845–855.

Fenemor, A.; Deans, N.; Davie, T.; Allen, W.; Dymond, J.; Kilvington, M.; Phillips, C.; Basher, L.; Gillespie, P.; Young, R.; Sinner, J.; Harmsworth, G.; Atkinson, M.; Smith, R. (2008). Collaboration and modelling – Tools for integration in the Motueka catchment, New Zealand. *Water SA (Special HELP edition) 34(4):* 448–455.

Fraser, E.D.G.; Dougill, A.J.; Mabee, W.E.; Reed, M.; McAlpine, P. (2006). Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management 78:* 114–127.

Gibbons, P.J. (1977). Astride the river: A history of Hamilton. Whitcoulls for Hamilton City Council, Christchurch. 381 p.

Gravitas Research and Strategy Ltd (2006). Environmental Awareness, Attitudes and Actions 2006. A Survey of residents of the Waikato Region. *Environment Waikato Technical Report 2006/07*.

Harrison, C.M.; Burgess, J.; Filius, P. (1996). Rationalizing environmental responsibilities - a comparison of lay publics in the UK and the Netherlands. *Global Environmental Change - Human and Policy Dimensions 6*: 215–234.

Hicks, D.M.; Hill, R.B. (2010). Sediment regime: sources, transport and changes in the riverbed. *In:* Collier, K.J.; Hamilton, D.; Vant, W.N.; Howard-Williams, C. (eds). Waters of the Waikato, Environment Waikato and the University of Waikato, Hamilton, pp. 71–86.

Ison, R.; Watson, D. (2007). Illuminating the possibilities for social learning in the management of Scotland's water. *Ecology and Society 12(1)*: 21 online URL: http://www.ecologyandsociety.org/vol12/iss21/art21/

Jollands, N.; Harmsworth, G. (2006). Participation of indigenous groups in sustainable development and monitoring: rationale and examples from New Zealand. *Ecological Economics 62:* 716–726.

Knowles, L. (1991). An evaluation of agroforestry on a Bay of Plenty hill country farm. Proceedings of the New Zealand Grasslands Association 53: 161–168.

Lynn, I.H.; Manderson, A.K.; Page, M.J.; Harmsworth, G.R.; Eyles, G.O.; Douglas, G.B.; Mackay, A.D.; Newsome, P.J.F. (2009). Land use capability survey handbook - a New Zealand handbook for classification of land. 3rd edition. AgResearch, Landcare Research, GNS Science, Hamilton. 163 p.

McKenzie-Mohr, D. (2000). Promoting sustainable behaviour: An introduction to community-based social marketing. *Journal of Social Issues 56*: 543–554.

Monaghan, R.; Wilcock, B.; Smith, C.; Houlbrooke, D.; McGowan, A.; Quinn, J.; Bramley, M.; Rutherford, C.; Cotton, S. (2009). Best Practice Dairy Catchments Study: Summary Report to SFF. June 2009. 17 p. http://www.maf.govt.nz/sff/about-projects/search/06-029/best-practice-dairy-catchment-study.pdf (accessed 21 October 2009).

Mosley, M.P. (2004). Rivers and the riverscape. *In*: Harding, J.S.; Mosley, M.P.; Pearson, C.P.; Sorrell, B.K. (eds). Freshwaters of New Zealand, New Zealand Hydrological Society and New Zealand Limnological Society, Christchurch, pp. 8:10–8:18.

Neilson, K. (2008). The state of the shallow Waikato lakes. Presented to "Waikato Shallow lakes restoration workshop" University of Waikato, 1 December 2008. http://www.niwa.co.nz/__data/assets/pdf_file/0003/80742/3._The_state_of_Waikato_shallow_lakes_Neilson.pdf

Parkyn, S.M.; Shaw, W.; Eades, P. (2000). Review of information on riparian buffer widths necessary to support sustainable vegetation and meet aquatic functions. *NIWA Client Report ARC00262*. 32 p.

Parminter, T.; Waters, C.; Mortimer, C. (2006). Examples of extension and policy strategies developed using theories of human behaviour and social marketing. Presented at the Practice

change for sustainable communities: Exploring footprints, pathways and possibilities. Proceedings of APEN International Conference, 6-8 March 2006, Beechworth, Victoria, Australia.

Piper, J. (2005). Water resources of the Reparoa Basin. *Environment Waikato Technical Report 2005/57,* Hamilton, 55 p. http://www.ew.govt.nz/PageFiles/4961/TR05-57.pdf

Pratt, J.P.; Handford, P.; Wallwork, C. (eds). (2010). To tree or not to tree - projected farm business analysis. In: Currie, L.D. and Christensen, C.L. (eds.), *Farming's future: Minimising footprints and maximising margins*. Fertilizer and Lime Research Centre Occasional Report No. 23, Massey University, Palmerston North. pp. 338-343.

Quinn, J.M.; Dodd, M.B.; Thorrold, B.S. (2007). Whatawhata catchment management project: the story so far. Proceedings of the New Zealand Grassland Association 69: 229–233.

Quinn, J.M.; Croker, G.F.; Smith, B.J.; Bellingham, M.A. (2009). Integrated catchment management effects on runoff, habitat, instream vegetation and macroinvertebrates in Waikato, New Zealand, hill-country streams. *New Zealand Journal of Marine and Freshwater Research 43(3)*: 775–802.

Quinn, J.M.; Monaghan, R.M.; Wilcock, R.J. (2010). Linking farm and waterway values - the Bog Burn catchment. *In:* Currie, L.D. and Christensen, C.L. (eds). Farming's future: Minimising footprints and maximising margins. *Fertilizer and Lime Research Centre Occasional Report No. 23*. Massey University, Palmerston North, pp. 63–77.

Reeves, P.; Craggs, R.; Stephens, S.; de Winton, M.; Davies-Colley, R. (2002). Environmental changes at Lake Waikare, North Waikato. Wave climate, water quality and 'biology'. *NIWA Client Report: EVW02235*. 69 p.

Reeves, P.; Meleason, M.; Matheson, F. (2006). Sustainable riparian plantings in urban and rural landscapes. *Water & Atmosphere 14(1)*: 16–17.

Rhodes, H.M.; Leland, L.S.; Niven, B.E. (2002). Farmers, streams, information, and money: Does informing farmers about riparian management have any effect? *Environmental Management 30(5):* 665–677.

Rogers, E.M. (1983). Diffusion of innovations. 3rd edition. The Free Press, New York.

Smith, C.M. (1989). Riparian pasture retirement effects on sediment, phosphorus, and nitrogen in channelised surface run-off from pastures. *New Zealand Journal of Marine and Freshwater Research 23*: 139–146.

Stenger, R.; Bidwell, V.; Wall, A.; Clague, J.; Moorhead, B. (2009). Nitrogen concentration in groundwaters: What are the important flowpaths in the Toenepi dairying catchment? *Lincoln Ventures Progress Report No. 3653/3*. 55 p.

Stewart, M.K.; Mehlhorn, J.; Elliott, S. (2007). Hydrometric and natural tracer (oxygen-18, silica, tritium and sulphur hexafluoride) evidence for a dominant groundwater contribution to Pukemanga Stream, New Zealand. *Hydrological Processes 21*: 3340-3356. http://dx.doi.org/10.1002/hyp.6557

Tanner, C.C.; Sukias, J.P.S.; Yates, C.R. (2010). New Zealand guidelines: Constructed wetland treatment of tile drainage. *NIWA Information Series No. 75*. 48 p.

Till, D.G.; McBride, G.B. (2004). Potential public health risk of *Campylobacter* and other zoonotic waterborne infections in New Zealand. *In*: Cotruvo, J.A.; Dufour, A.; Rees, G.; Bartram, J.; Carr, R.; Cliver, D.O.; Craun, G.F.; Fayer, R.; Gannon, V.P.J. Waterborne Zoonoses: Identification, Causes and Control. IWA publishing, London, for the World Health Organization, Chapter 12.

Tipa, G.; Tierney, L. (2003). A Cultural Health Index for Streams and Waterways: Indicators for recognising and expressing Māori values. ME475, June 2003. Ministry for the Environment, Wellington.

Tipa, G.; Tierney, L. (2006a). Using the Cultural Health Index: How to assess the health of streams and waterways. *ME711,* February 2006. Ministry for the Environment, Wellington.

Tipa, G.; Tierney, L. (2006b). A Cultural Health Index for Streams and Waterways: A tool for nationwide use. *ME710*, April 2006. Ministry for the Environment, Wellington.

Wall, K.; Clarkson, B. (2001). Gully restoration guide: A guide to assist in the ecological restoration of Hamilton's Gully systems. Hamilton City Council, Hamilton. 52 p. http://www.gullyguide.co.nz/files/Gully%20Book%20Mar%2007.pdf.

West, G.; Poole, B.; Molony, K. (2009). Impacts of carbon trading on the economics and environmental benefits of tree planting options: Envirolink study on the McRae Trust Land, Wairoa Hawkes Bay *No. Envirolink Report*. 23 p.

Wilcock, R.J.; Monaghan, R.M.; Thorrold, B.S.; Meredith, A.S.; Betteridge, K.; Duncan, M.J. (2007). Land-water interactions in five contrasting dairy catchments: issues and solutions. *Land Use and Water Resources Research 7:* 2.1–2.10.

Wilcock, R.J.; Betteridge, K.; Shearman, D.; Fowles, C.; Scarsbrook, M.R.; Thorrold, B.S.; Costall, D. (2009). Riparian protection and farm best management practices for restoration of a lowland stream in an intensive dairy farming catchment: a case study. *New Zealand Journal of Marine and Freshwater Research 34(3)*: 803–818.

Section 6: Scenario modelling

There are no references in this section.

Section 7: Recommended priority actions

Bradly, N. (2010). Review of Waikato River Scoping Study on behalf of Maniapoto Maaori Trust Board, August 2010.

Darby, S.; Sear, D. (eds). (2008). River restoration: Managing the uncertainty in restoring physical habitat. Wiley.

Dodd, M.B.; Wedderburn, M.E.; Parminter, T.G.; Thorrold, B.S.; Quinn, J.M. (2008). Transformations towards agricultural sustainability in New Zealand hill country pastoral landscapes. *Agricultural Systems 98*: 95–107.

Ison, R.; Watson, D. (2007). Illuminating the possibilities for social learning in the management of Scotland's water. *Ecology and Society 12(1)*: 21 online URL: http://www.ecologyandsociety.org/vol12/iss21/art21/.

Pratt, J.P.; Handford, P.; Wallwork, C. (eds). (2010). To tree or not to tree - projected farm business analysis. In: Currie, L.D. and Christensen, C.L. (eds.), *Farming's future: Minimising footprints and maximising margins*. Fertilizer and Lime Research Centre Occasional Report No. 23, Massey University, Palmerston North. pp. 338-343.

Quinn, J.M.; Monaghan, R.M.; Wilcock, R.J. (2010). Linking farm and waterway values - the Bog Burn catchment. *In:* Currie, L.D. and Christensen, C.L. (eds). Farming's future: Minimising footprints and maximising margins. *Fertilizer and Lime Research Centre Occasional Report No. 23*. Massey University, Palmerston North, pp. 63–77.

Rhodes, H.M.; Leland, L.S.; Niven, B.E. (2002). Farmers, streams, information, and money: Does informing farmers about riparian management have any effect? *Environmental Management 30(5)*: 665–677.

Wilcock, R.J.; Betteridge, K.; Shearman, D.; Fowles, C.; Scarsbrook, M.R.; Thorrold, B.S.; Costall, D. (2009). Riparian protection and farm best management practices for restoration of a lowland stream in an intensive dairy farming catchment: a case study. *New Zealand Journal of Marine and Freshwater Research 34(3)*: 803–818.

Section 8: Monitoring and evaluation

Au, J.; Bagchi, P.; Chen, B.; Martinez, R.; Dudley, S.A.; Sorger, G.J. (2000). Methodology for public monitoring of total coliforms, *Escherichia coli*, and toxicity in waterways by Canadian high school students. *Journal of Environmental Management 58*: 213–230.

Ballantine, D.J.; Davies-Colley, R.J. (2009). Water quality trends at National River Water Quality Network sites for 1989–2007. Ministry for the Environment, Wellington. 43 p. http://www.mfe.govt.nz/publications/water/water-quality-trends-1989-2007/index.html

Blackett, P.; Walcroft, J.; Bewsell, D.; Payne, T.; Brown, M. (2009). Preliminary report on social and industry networks which support on-farm innovation. *A report prepared for the Foundation for Research, Science and Technology.*

Brooks, S.S.; Lake, P.S. (2007). River restoration in Victoria, Australia: Change is in the wind, and none too soon. *Restoration Ecology 15(3)*: 584–591.

Bunn, S.; Abal, E.; Smith, M.; Choy, S.; Fellows, C.S.; Harch, B.D.; Kennard, M.J.; Sheldon, F. (2010). Integration of science and monitoring of river ecosystem health to guide investments in catchment protection and rehabilitation. *Freshwater Biology 55*: 223–240.

Burgess, J.; Harrison, C.M.; Filius, P. (1998). Environmental communication and the cultural politics of environmental citizenship. *Environment and Planning A 30*: 1445–1460.

Conrad, C.T.; Daoust, T. (2008). Community-based monitoring frameworks: Increasing the effectiveness of environmental stewardship. *Environmental Management 41:* 358–366.

Davies-Colley, R.J.; Smith, D.G.; Ward, R.; Bryers, G.G.; McBride, G.B.; Quinn, J.M.; Scarsbrook, M.J. (submitted June 2010). Twenty Years of New Zealand's National Rivers Water Quality Monitoring Network: A Review. *Journal of the American Water Resources Association*.

Dodd, M.B.; Quinn, J.M.; Thorrold, B.S.; Parminter, T.G.; Wedderburn, M.E. (2008). Improving the economic and environmental performance of a New Zealand hill country farm catchment: 3. Short term outcomes of land use change. *New Zealand Journal of Agricultural Research 53*: 155–169.

Fenemor, A.; Deans, N.; Davie, T.; Allen, W.; Dymond, J.; Kilvington, M.; Phillips, C.; Basher, L.; Gillespie, P.; Young, R.; Sinner, J.; Harmsworth, G.; Atkinson, M.; Smith, R. (2008). Collaboration and modelling – Tools for integration in the Motueka catchment, New Zealand. *Water SA (Special HELP edition) 34(4):* 448–455.

Fraser, E.D.G.; Dougill, A.J.; Mabee, W.E.; Reed, M.; McAlpine, P. (2006). Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management 78*: 114–127.

Ison, R.; Watson, D. (2007). Illuminating the possibilities for social learning in the management of Scotland's water. *Ecology and Society 12(1)*: 21 online URL: http://www.ecologyandsociety.org/vol12/iss21/art21/.

Jollands, N.; Harmsworth, G. (2006). Participation of indigenous groups in sustainable development and monitoring: rationale and examples from New Zealand. *Ecological Economics 62*: 716–726.

Kusabs, I.; Emery, W.; Parkyn, S.; Hickey, C.; Quinn, J. (2005). Monitoring koura. http://www.niwa.co.nz/our-science/freshwater/research-projects/all/restoration-of-aquatic-ecosystems/monitoring_koura.

Kusabs, I.; Quinn, J.M. (2009). The use of a traditional Māori harvesting method, the tau kōura, for monitoring kōura (freshwater crayfish, *Paranephrops planifrons*) in Lake Rotoiti, North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 43(3)*: 713–722.

Lake, P.S.; Bond, N.; Reich, P. (2007). Linking ecological theory with stream restoration. *Freshwater Biology 52*: 597–615.

Leach, M.; Mearns, R.; Scoones, I. (1999). Environmental entitlements: Dynamics and institutions in community-based natural resource management. *World Development 27(2)*: 225–247.

Leathwick, J.R.; Elith, J.; Rowe, D.; Julian, K. (2009). Robust planning for restoring diadromous fish species in New Zealand's lowland rivers and streams. *New Zealand Journal of Marine and Freshwater Research 43*: 659–671.

McKenzie, L.J.; Lee Long, W.J.; Coles, R.G.; Roder, C.A. (2000). Seagrass-watch: Community based monitoring of seagrass resources. *Biol. Mar. Medit. 7(2)*: 393–396.

Ormerod, S.J. (2004). A golden age of river restoration science? *Aquatic Conservation-Marine and Freshwater Ecosystems 14(6)*: 543–549.

Owens, S. (2000). 'Engaging the public': information and deliberation in environmental policy. *Environment and Planning A 32*: 1141–1148

Palmer, M.A.; Ambrose, R.F.; Poff, N.L. (1997). Ecological theory and community restoration ecology. *Restoration Ecology 5*: 291–300.

Parkyn, S.; Clapcott, J.; Collier, K.; David, B.; Davies-Colley, R.; Matheson, F.; Quinn, J.; Shaw, W.; Storey, R. (in press). The restoration indicator toolkit: Indicators for monitoring the ecological success of stream restoration. *NIWA Envirolink Report* (in press).

Quinn, J.M.; Monaghan, R.M.; Wilcock, R.J. (2010). Linking farm and waterway values - the Bog Burn catchment. *In:* Currie, L.D. and Christensen, C.L. (eds). Farming's future: Minimising footprints and maximising margins. *Fertilizer and Lime Research Centre Occasional Report No. 23*. Massey University, Palmerston North, pp. 63–77.

Reed, M.S.; Dougill, A.J.; Baker, T.R. (2008). Participatory indicator development: what can ecologists and local communities learn from each other. *Ecological Applications 18*: 1253–1269.

Rumps, J.M.; Katz, S.L.; Barnas, K.; Morehead, M.D.; Jenkinson, R.; Clayton, S.R.; Goodwin, P. (2007). Stream restoration in the Pacific Northwest: Analysis of interviews with project managers. *Restoration Ecology 15(3)*: 506–515.

Saxton, B.A.; Rowe, D.K.; Stancliff, A.G. (1987). Species composition and relative importance of whitebait fisheries in 13 Bay of Plenty rivers. New Zealand Ministry of Agriculture and Fisheries. *Fisheries Environmental Report No. 79*. 63 p.

Sharpe, A.; Conrad, C. (2006). Community based ecological monitoring in Nova Scotia: Challenges and opportunities. *Environmental Monitoring and Assessment 113*: 395–409.

Storey, R. (2010). Riparian characteristics of pastoral streams in the Waikato region, 2002 and 2007. *Environment Waikato Technical Report 2010-07*. 57 p.

Tipa, G.; Tierney, L. (2003). A Cultural Health Index for Streams and Waterways: Indicators for recognising and expressing Māori values. ME475, June 2003. Ministry for the Environment, Wellington.

Tipa, G.; Tierney, L. (2006a). Using the Cultural Health Index: How to assess the health of streams and waterways. *ME711*, February 2006. Ministry for the Environment, Wellington.

Tipa, G.; Tierney, L. (2006b). A Cultural Health Index for Streams and Waterways: A tool for nationwide use. *ME710*, April 2006. Ministry for the Environment, Wellington.

Whitelaw, G.S.; Vaughan, H.; Craig, B.; Atkinson, D. (2003). Establishing the Canadian Community Monitoring Network. *Environmental Monitoring and Assessment 88:* 409–418.

Wilcock, R.J.; Betteridge, K.; Shearman, D.; Fowles, C.; Scarsbrook, M.R.; Thorrold, B.S.; Costall, D. (2009). Riparian protection and farm best management practices for restoration of a lowland stream in an intensive dairy farming catchment: a case study. *New Zealand Journal of Marine and Freshwater Research 34(3)*: 803–818.

Section 9: Conclusions

Kirkwood, C. (2000). Tawhiao - King or Prophet. MAI Systems Ltd, Huntly. 244 p.

Roa, T. (2003). He Maimai Aroha Mō Waikato Nā Tawhiao. 1 p.

Maatauranga Maaori Bibliography

This bibliography lists documents consulted by the Study team relating to maatauranga Maaori and an indigenous approach to health and wellbeing.

Agrawal, A. (2009). Why “indigenous” knowledge. *Journal of the Royal Society of New Zealand 39(4):* 157–158.

Airey, L. (2003). Nae as nice a scheme as it used to be: lay accounts of neighbourhood incivilities and well-being. *Health and Place 9:* 129–137.

Allen, W.; Ataria, J.M.; Apgar, J.M.; Harmsworth, G.; Trembley, L.A. (2009). Kia pono te mahi putaiao – doing science in the right spirit. *Journal of the Royal Society of New Zealand 39(4)*: 239–242.

Altman, J. (2004). Indigenous interests and water property rights. *Dialogue 23*: 29–43.

Anderson, J.C. (1942). Maori place names – also personal names and names of colours, weapons and natural objects. Polynesian Society, Wellington.

Anderson, K.; Gale, F. (1992). Inventing Places: Studies in Cultural Geography. New York, Longman Cheshire.

Annabell, R. (1963). Pioneers of the pumice. *Te Ao Hou 42*: 44–47.

Anon (1952). Maori small farming to be assisted. *Te Ao Hou 1*: 40–41.

Anon (1955). Pioneers on pumice lands. *Te Ao Hou 12*: 50–51.

Anon (2006). A cultural evaluation of the land for upon which Hamilton Airport stands. Appendix 11. Signed for on behalf of Nga Iwi Toopu O Waipa me Nga Mana Toopu O Kirikiriroa. 14 p.

Anon (2009). Ngati Tahu-Ngati Whaoa Matauranga. *Unpublished report*. 8 August 2009. 10 p.

Au, J.; Bagchi, P.; Chen, B.; Martinez, R.; Dudley, S.A.; Sorger, G.J. (2000). Methodology for public monitoring of total coliforms, *Escherichia coli*, and toxicity in waterways by Canadian high school students. *Journal of Environmental Management 58*: 213–230.

Awatere, S. (2005). The influence of cultural identity on willingness to pay values in contingent valuation surveys. A contributed paper to the 2005 New Zealand Agricultural & Resource Economists Society conference.

Axelrod, R. (1976). Structure of Decision. The Cognitive Maps of Political Elites. Princeton University Press, Princeton, New Jersey.

Barber, K.; Rumley, H. (2003). A Study and Report Prepared for the Water and Rivers Commission. http://portal.water.wa.gov.au/portal/page/portal/WaterManagement/Groundwater/Ord/Content/ABORIGINAL_VALUES.pdf

Barlow, C. (1991). Tikanga whakaaro: Key concepts in Maori culture. Oxford University Press, United Kingdom. 187 p.

Barnhart, R.; Harrison, B. (1993). Developing tribal education strategies in indigenous communities. *The Australian Journal of Educational Studies*: October 1993.

Baskett, J. (2000). The four cornerstones of well-being in a multicultural society. *Age & Ageing 29*: 465–466.

Beentjes, M.P.; Boubée, J.; Jellyman, D.; Graynoth, E. (2005). Non-fishing mortality of freshwater eels (Anguilla spp.) *New Zealand Fisheries Assessment Report 2005/34*.

BECA (2000). Te Raranga a Mahi: Developing Environmental Management Plans for Whānau, Hapū and Iwi. Ministry for Environment, *Ref. ME619*.

Behrendt, J.; Thompson, P. (2004). The recognition and protection of Aboriginal interests in NSW rivers. *Journal of Indigenous Policy 3*: 37–140.

Berkes, F. (1991). Co-management: the evolution of the theory; practice of joint administration of living resource. Paper presented at the Second Annual Meeting of IASCP, Winnipeg, Canada.

Berkes, F. (1994). Comanaging: Bridging the two solitudes. *Northern Perspectives 22(2-3)*: Summer/Fall.

Berkes, F. (1999). Sacred Ecology: Traditional Ecological Knowledge and Resource Management. Philadelphia and London, Taylor & Francis.

Berkes, F. (2010). Indigenous ways of knowing and the study of environmental change. *Journal of the Royal Society of New Zealand 39(4)*: 151–156.

Berkes, F.; Folke, C. (1998). Linking Social and Ecological Systems. Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press, Cambridge.

Buchan, D. (2007). Not Just Trees in the Ground: The Social and Economic Benefits of Community-led Conservation Projects. 45 p.

Buck, P.H. (1921). Maori food supplies of Lake Rotorua, with methods of obtaining them, and usages and customs appertaining thereto. *Transactions of the Royal Society of New Zealand 52*: 433–451.

Buck, P.H. (1950). The coming of the Maori. Second edition. Whitcombe & Tombs, Wellington.

Burgess, J.; Harrison, C.M.; Filius, P. (1998). Environmental communication and the cultural politics of environmental citizenship. *Environment and Planning A 30*: 1445–1460.

Cajete, G. (2000). Native science: Natural laws of interdependence. Santa Fe, New Mexico: Clearlight Publishers.

Cairns, D. (1941). Life history of the two species of New Zealand freshwater eel. Part I. Taxonomy, age and growth, migration and distribution. *New Zealand Journal of Science and Technology 23(1)*: 53–72.

Campbell, G. (2009). Gordon Campbell on the challenges that the RMA changes pose for the Maori Party. 4th February 2009. http://gordoncampbell.scoop.co.nz/gordon-campbell-on-the-challenges-that-the-rma-changes-pose-for-the-maori-party/

Centre for Maaori Studies and Research (1999). The Waikato River Report. *Volume 2: Environmental Report.* Confidential working document. University of Waikato. 253 p.

Chambers, C. (2009). Mixing methodologies: the politics of research techniques. *Journal of the Royal Society of New Zealand 39(4)*: 197–199.

Clayton, J.; Severne, C. (2005). Review of diquat reports of relevance to iwi values in Lake Karapiro. *Environment Waikato Technical Report 2006/03*. December 2005. 15 p.

Collier, K.J.; Hamilton, D.; Vant, W.N., Howard-Williams, C. (eds). (2010). Waters of the Waikato. Environment Waikato and the University of Waikato, Hamilton.

Conrad, C.T.; Daoust, T. (2008). Community-based monitoring frameworks: Increasing the effectiveness of environmental stewardship*. Environmental Management 41*: 358–366.

Coombes, B. (2000). Ecological impacts and planning history. An environmental history of the Turanganui-a- Kiwa casebook area. Report prepared for Crown Forestry Rental Trust. Auckland Uniservices Ltd, Auckland.

Cowan, J. (1929). Orakei-Korako: Scenes and Stories in a Waikato Wonder Valley. *The New Zealand Railways Magazine 4(5)*: 1 September 1929. New Zealand Government Railways Department.

Cox, M.E.; Johnstone, R.J.; Robinson, J. (2003). A conceptual model of impacts of environmental change on human well-being. *In:* Albrecht, G. (ed.) Proceedings of the Airs Waters Places Transdisciplinary Conference on Ecosystems in Australia: the University of Newcastle, April 14-15-16, 2003. 278 p.

Craig, D. (2005). Indigenous Property Rights to Water: Environmental Flows, Cultural Values and Tradeable Property Rights. Accessed from www.law.mq.edu.au/MUCEL/craig/

Craig, D. (2006). Indigenous property rights to water: environmental flows, cultural values and tradeable property rights. *In:* Smajgl, A. and Larson, S. (eds). Adapting rules for sustainable resource use. *CSIRO Sustainable Ecosystems, Townsville*: 153–172.

Cram, F. (2002). Maaori and Science – three case studies. 87 p.

Crawford, S. (2010). Matauranga Maori and western science: The importance of hypotheses, predictions and protocols. *Journal of the Royal Society of New Zealand 39(4)*: 163–166.

Crengle, H. (2002). The Legal Basis for a Consideration of Cultural Values of Kai Tahu. *In:* Tipa, G.; Crengle, H.; Davis, K.; Allingham, B.; Symon, A. Cultural Impact Assessment – Project Aqua. Meridian Energy Ltd, New Zealand.

Crighton, E.J.; Elliott S.J.; van der Meer, J.; Small, I.; Upshur, R. (2003). Impacts of an environmental disaster on psychosocial health and well-being in Karakalpaksta. *Social Science & Medicine 56*: 551-567.

Curtis, S. (2004). Health and Inequality, Geographical Perspectives. Sage Publications. London, United Kingdom. 299 p.

Daaleman, T.P.; Kuckelman Cobb, A.; Frey, B.B. (2001). Spirituality and well-being: an exploratory study of the patient perspective*. Social Science & Medicine 53(11)*: 1503–1511.

David, H. (undated). Nga Ingoa Tawhito O Waitomo e Mau Tonu. Me Timate Nga Tohu o Waitomo (landmarks). Unpublished material. 8 p.

Davis, M.D.; Threlfall, J. (2006). Integrated water resource management in New Zealand: Legislative framework and implementation. *Journal of Contemporary Water Research and Education 135*: 86–99.

de Oca Munguía, O.M.; Harmsworth, G. (2008). Representing Cultural Values in IDEAS. *Motueka Integrated Catchment Management (Motueka ICM) Programme Report.* May 2008. 17 p.

Dickison, M. (2009). The asymmetry between science and traditional knowledge. *Journal of the Royal Society of New Zealand 39(4)*: 171–172.

Dieffenbach, E. (1843). Travels in New Zealand: with contributions to the geography, geology, botany and natural history of that country. Vol I and Vol II. Reprint, Caper Press, Christchurch. 431 p.

Dodds, A.; Hostetler, S.; Jacobson, G. (2001). Community water supplies in the Anungu Pitjantjatjara Lands, South Australia: sustainability of groundwater resources. Bureau of Rural Sciences, Canberra.

Donnison, A.; Ross, C.; Dixon, L. (2009). Faecal microbial contamination of watercress (*Nasturtium officinale*) gathered by a Māori protocol in New Zealand streams. *New Zealand Journal of Marine & Freshwater Research 43*: 901–910.

Douglas, E.T.K. (1991). Waiora: a water typology. Terra Nova: the resource management magazine of New Zealand, August.

Downes, T.W. (1917). Notes on eels and eel-weirs (tuna and pa-tuna). Transactions and proceedings of the Royal Society of New Zealand 50: 296–316.

Driscoll, S. (2003). Camas-bulb Restoration Honors Tribal Traditions. Horizon Magazine November: 37–49.

Durie, M. (1994). Whaiora: Maori Health Development. Oxford University Press. Auckland, New Zealand.

Durie, M. (2004). Te Pae Mahutonga, Maori Health Models. http://www. maorihealth.govt.nz/moh.nsf/pagesma/196 (accessed 16 March 2007).

Eden, C. (1989). Using cognitive mapping for Strategic Options Development and Analysis – SODA. *In:* Rosenhea, J. (ed). Rational Analysis in a Problematic World. Wiley, London.

Environment Waikato (2010). Our economy. http://www.ew.govt.nz/environmental-information/About-the-Waikato-region/Our _economy/#Heading2.

Environment Waikato (2009). Waikato Tainui River Settlement – Significant Cultural Sites. *GIS Request No: 18105*. 3 June 2009.

Environment Waikato (1998). Waikato State of the Environment Report. 244 p.

Environment Waikato (1996). Learning to Care for Our Environment: A Preliminary Implementation Strategy for Environmental Education. Environment Waikato Regional Council, Hamilton.

Fenemor, A.; Deans, N.; Davie, T.; Allen, W.; Dymond, J.; Kilvington, M.; Phillips, C.; Basher, L.; Gillespie, P.; Young, R.; Sinner, J.; Harmsworth, G.; Atkinson, M.; Smith, R. (2008). Collaboration and modelling – Tools for integration in the Motueka catchment, *New Zealand. Water SA (Special HELP edition) 34(4)*: 448–455.

Fenge, T. (1996). Towards Sustainable Development in the Circumpolar North. *In*: Report of the Second Conference of Parliamentarians of the Arctic Region, Minister of Public Works and Government Services, Ottawa, pp 21–41.

Fenton, H.H. (1850). A letter written by Harold Hyde Fenton to his mother Mrs Fenton. Written 14th November 1850, and received in Derby on 30th April 1851.

Fletcher, P.; Galvin, W.T. (2002). Ngati Tahu-Ngati Whaoa Social and Cultural Report on Te Awa o Waikato. Unpublished report for Mighty River Power. 158 p.

Forester, J. (1989). Planning in the Face of Power. University of California press, Berkeley.

Forester, J. (1999). The Deliberative Practitioner: Encouraging Participatory Planning Processes. The MIT Press, Cambridge.

Fowler, P.J. (1987). The contemporary past. *In*: Wagstaff, J.M. (ed). Landscape and Culture: Geographical and Archaeological Perspectives, Oxford, Blackwell, pp 173–191.

Fraser, E.D.G.; Dougill, A.J.; Mabee, W.E.; Reed, M.; McAlpine, P. (2006). Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management 78*: 114–127.

Freeman, A.M.I. (2003). The measurement of environmental and resource values: theory and methods, Resources for the Future. Washington DC.

Frost, E.T. (1947). By Maori trail and Pakeha Road: Tales of bush and river. Reed Publishing, Wellington. 90 p.

Garibaldi, A.; Turner; N. (2004). Cultural keystone species: implications for ecological conservation and restoration. *Ecology & Society 9(3)*: 1.

Gaze, P.; Smith, R. (2009). A harvesting waananga on Titi Island: maintaining connections by rekindling a wildlife harvest. *Journal of the Royal Society of New Zealand 39(4)*: 193–196.

Gesler, W.M. (1992). Therapeutic landscapes: medical geographic research in light of the new cultural geography. *Social Science & Medicine 34(7)*: 735–746.

Gesler, W.M.; Kearns, R.A. (2002). Culture/Place/Health. Routledge. London, United Kingdom. 161 p.

Gibbons, P.J. (1977). Astride the river: A history of Hamilton. Whitcoulls for Hamilton City Council, Christchurch. 381 p.

Gisborne, W. (1847). Journal of a trip by Messrs Petre and Gisborne from Auckland to the hot springs at lakes Rotorua and Rotomahana in May and June 1847.

Grace, J.T.H. (1959). Tuwharetoa. The history of the Maori people of the Taupo district. Auckland, Reed Publishing. 567 p.

Grace, M. (2010). Māori Values and Regional Resource Management. Report prepared for the Te Upoko Taiao - Natural Resource Plan Committee, Greater Wellington Regional Council. 21 April 2010. 7 p.

Greenwood, J. (1864). Journey from Taupo to Auckland, Brigade-Major Greenwood, 31st regiment, 1864.

Guardians Establishment Committee (2008). Restoring and protecting the health and wellbeing of the Waikato River. Vision and Strategy for the Waikato River. 14 p. http://www.river.org.nz

Haigh, T.; Matsuyama, A. (2003). Water resources of Wadeye (Port Keats) and Nauyiu (Daly River) Region. NT Department of Infrastructure Planning and Environment.

Hamilton, A. (1908). Fishing and sea-foods of the ancient Maori. Bulletin No 2 Dominion Museum, Wellington.

Hammond, A.; Adriaanse, A.; Rodenburg, E.; Bryant, D.; Woodward, R. (1995). Environmental indicators: a systematic approach to measuring and reporting on environmental policy performance in the context of sustainable development. World Resources Institute, Washington DC. 4 p.

Harmsworth, G.R. (2002). Indigenous concepts, values and knowledge for sustainable development: New Zealand case studies.
http://www.landcareresearch.co.nz/research/sustainablesoc/social/indigenous_index.asp

Harmsworth, G. (2002). Coordinated Monitoring of New Zealand Wetlands, Phase Two, Goal 2: Maori environmental performance indicators for wetland condition and trend. Report prepared for Lincoln University. Landcare Research, Palmerston North. 66 p.

Harmsworth, G.R.; Tipa, G. (2006). Māori environmental monitoring in New Zealand: progress, concepts and future direction. http://icm.landcareresearch.co.nz/knowledgebase/publications/public/2006_Māorienvmonitoring_harmsworth_tipa.pdf

Hayes, L. (1931). Report on whitebait investigations on Waikato River – February 25th to March 11th. Unpublished New Zealand Marine Department Report, Ministry of Agriculture and Fisheries Archives, Wellington. 8 p.

Heckler, S. (2009). Landscape, process and power. Re-evaluating Traditional Ecological Knowledge. Volume 10: Studies in Environmental Anthropology and Ethnobiology. Berghahn Books, New York. 289 p.

Her Majesty the Queen in the right of New Zealand and Waikato-Tainui (1995). Deed of Settlement. 22 May 1995. 46 p.

Her Majesty the Queen in the right of New Zealand and Waikato-Tainui (2008). Deed of Settlement in relation to the Waikato River. 22 August 2008. 115 p.

Huakina Development Trust (1994). Waikato Iwi Cultural Management Plan. Report prepared for Watercare Services Limited. 8 August 1994. 94 p.

Huakina Development Trust (2007). Waikato Iwi Management Plan: Manuka. Prepared by the Huakina Development Trust on behalf of Te Puaha Ki Manuka O Waikato. 170 p.

Hurst, M.R. (1992). First pictorial records of Waipa – J J Merrett. *In*: Te Awamutu Historical Society.; Otorohanga Historical Society.; Te Kuiti Historical Society.; Waitomo Caves Museum Society. Footprints of history. Pp 193–198.

Hutton, J. (2009). Raukawa. Traditional history summary report. Pre-publication draft for limited circulation. *Report commissioned by the Crown Forestry Rental Trust*, Wellington. 328 p.

Ihaka, M.; Awatere, S.; Harrison, D. (2000). Tangata whenua perspectives of wastewater. A report prepared for the Gisborne District Council. Gisborne District Council, Gisborne.

Indigenous People's Restoration Network (IPRN). (2005). IPNR Home Page. Accessed November 10, 2005. http://www.ser.org/iprn/default.asp

Ingersoll-Dayton, B.; Saengtienchai, C.; Kespichayawattana, J.; Aungsuroch, Y.; (2004). Measuring Psychological Well-Being: Insights From Thai Elders. *Gerontologist 44*: 596–604.

Ison, R.; Watson, D. (2007). Illuminating the possibilities for social learning in the management of Scotland's water. *Ecology and Society 12(1):* 21 online URL: http://www.ecologyandsociety.org/vol12/iss21/art21/

Izquierdo, C. (2005). When 'health' is not enough: societal, in and biomedical assessments of well-being among the Matsigenka of the Peruvian Amazon. *Social Science & Medicine 61*: 767–783.

Jackson, S. (2005). Indigenous values and water resource management: a case study from the Northern Territory. *Australasian Journal of Environmental Management 12*: 136–46.

Jackson, S. (2006). Compartmentalising culture: the articulation and consideration of Indigenous values in water resource management. *Australian Geographer 37*: 19–31.

Jackson, S. (2007). Indigenous Interests and the National Water Initiative – water management, reform and implementation. Background Paper and Literature Review, North Australian Indigenous Land and Sea Management. Accessed from

http://www.nailsma.org.au/nailsma/projects/downloads/NAILSMA_NWI_Review_UPDATEDec07.pdf

Jackson, S.; Langton, M. (2006). Indigenous cultural values and water resource management: workshop overview and introduction. *In*: Jackson, S. (ed). Recognising and protecting Indigenous values in water resource management: a report from a workshop held in Darwin, 5–6 April 2006. Darwin, CSIRO.

Johnson-Laird, P.N. (2000). The current state of the mental model theory. *In*: García-Madruga, J.; Carriedo, M.; Gonsález-Labra, M.J. (ed). Mental models in reasoning. Pp 17–40. Madrid, UNED.

Jollands, N.; Harmsworth, G. (2006). Participation of indigenous groups in sustainable development and monitoring: rationale and examples from New Zealand. *Ecological Economics 62*: 716–726.

Jacobson, C.; Stephens, A. (2010). Cross-cultural approaches to environmental research and management: A response to the dualisms inherent in Western science? *Journal of the Royal Society of New Zealand 39(4)*: 159–162.

Jones, P.T.H.; Biggs, B. (1995). Nga Iwi O Tainui. The traditional history of the Tainui people. Nga korero tuku iho o nga tuupuna. Auckland University Press, Auckland. 402 p.

Kaminstein, D.S. (1996). Persuasion in a toxic community: Rhetorical aspects of public meetings. *Human Organization 55(4)*: 458–464.

Kauwhata, N. (1966). He Maemae Mo Wahine-iti. Te Ao Hou 55: 19–21. June 1966. (Translation and footnotes by Pei Te Hurinui).

Kahotea, D.T. (1990). Waahi Tapu. Report for the Hamilton City Council Planning and Development Group. June 1990. 40 p.

Kaplan, R.; Kaplan, S. (1989). The Experience of Nature: A Psychological Perspective. Cambridge University Press. New York, United States of America.

Kelly, L.G. (1949). Tainui: a story of Hoturoa and his descendants. Polynesian Society memoir 25, Wellington. 484 p.

Kesley, J. (1999). Reclaiming the future. New Zealand and the global economy. Bridget Williams Books, Wellington. 434 p.

Kimmerer, R. (2000). Native Knowledge and Native Ecosystems. *Journal of Forestry 98(8)*: 4–9.

King, D.N.T.; Goff, J.; Skipper, A. (2007). Māori environmental knowledge and natural hazards in Aotearoa–New Zealand. *Journal of the Royal Society of New Zealand 37(2)*: 59–73.

King, D.N.T.; Skipper, A.; Tawhai, W.B. (2008). Māori environmental knowledge of weather and climate change in Aotearoa – New Zealand. *Climatic Change 90(4)*: 385–409.

Kirk, T. (1871). Notes on the botany of certain places in the Waikato District. *Transcripts of the New Zealand Institute 3*: 142–147.

Kirkwood, C. (2000). Tawhiao - King or Prophet. Huntly, N.Z., MAI Systems Ltd. 244 p.

Kōwhai Consulting Ltd (2007). He Mahere Taiao. The Maniapoto Iwi Environmental Management Plan 2007. Prepared by Koowhai Consulting Ltd for the Maniapoto Māori Trust Board. 66 p.

Kōwhai Consulting Ltd and the Ministry for the Environment (2002). Te Purongo, Maniapoto State of the Environment Report. A Tribal Perspective. 34 p.

Kimmerer, R. (2000). Native Knowledge and Native Ecosystems. *Journal of Forestry 98(8)*: 4–9.

King, M. (ed). (1992). Te Ao Hurihuri: Aspects of Maoritanga. 1st edition. Reed Publishing Group Ltd, Auckland, NZ.

King, M. (1983). Maori. A photographic and social history. Revised edition. Reed Publishing (NZ) Ltd, Auckland. 289 p.

King, M. (1977). Te Puea: A Life. Fourth edition, reprinted 2006. Reed Publishing (NZ) Ltd, Auckland. 372 p.

Korpela, K.M.; Ylén, M. (2007). Perceived health is associated with visiting natural favourite places in the vicinity. *Health & Place 13*: 138–151.

Kusabs, I.; Quinn, J.M. (2009). The use of a traditional Māori harvesting method, the tau kōura, for monitoring kōura (freshwater crayfish, *Paranephrops planifrons*) in Lake Rotoiti, North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 43(3)*: 713–722.

Kusabs, I.; Emery, W.; Parkyn, S.; Hickey, C.; Quinn, J. (2005). Monitoring koura. http://www.niwa.co.nz/our-science/freshwater/research-projects/all/restoration-of-aquatic-ecosystems/monitoring_koura.

Langton, M. (2002). Freshwater. *In:* Lingiari Foundation (ed). Background briefing papers: Indigenous rights to waters. Lingiari Foundation, Broome, pp. 43–64.

Langton, M. (2006). Earth, wind, fire and water: the social and spiritual construction of water in Aboriginal societies. *In*: Bowmen, D.; Barker, B.; McNiven, I. (eds). The Social Archaeology of Australian Indigenous Landscapes. Aboriginal Studies Press, Canberra, pp. 139–160.

Law, G. (2002). Archaeology of the Bay of Plenty. Technical Publishing, Department of Conservation. June 2008. 149 p.

Leach, M.; Mearns, R.; Scoones, I. (1999). Environmental entitlements: Dynamics and institutions in community-based natural resource management. *World Development 27(2)*: 225–247.

Ligar, C.W. (1846). Diary November 22 1845 - November 19 1846 NZMS 240, Auckland Public Library.

Lincoln, Y.S.; Guba, E.G. (1985). Designing a naturalistic inquiry. *In:* Lincoln, Y.S.; Guba, E.G. (eds). Naturalistic Inquiry. Sage Publications. Newbury Park, California, United States of America, pp 221–249.

Locke, S. (1882). Historical traditions of Taupo and East Coast tribes, in historical traditions of the Taupo and East Coast tribes. *Transactions and Proceedings of the Royal Society of New Zealand 15*: 433–459.

Lowe, B.J.; Carr, D.J.; McCallum, R.E.; Myers, T.; Gorham, A.; Holmes, H.; Holtham, C.; Matenga, L.; Miller, L.; Ngarimu-Cameron, R.; Raumati, W.; Te Kanawa, K. (2009). Consultation, collaboration and dissemination. *Journal of the Royal Society of New Zealand 39(4)*: 225–228.

Lyver, P.; Jones, C.; Moller, H. (2009). Looking past the wallpaper: considerate evaluation of traditional environmental knowledge by science. *Journal of the Royal Society of New Zealand 39(4)*: 219–223.

MacLean, D. (1845). Extracts from a journal kept during a visit to tribes in the interior of the Northern Island of New Zealand 1845 by Donald MacLean.

MacLean, K.; Cullen, L. (2009). Research methodologies for the co-production of knowledge for environmental management in Australia. *Journal of the Royal Society of New Zealand 39(4)*: 205–208.

Mahuta, D.P.S. (2005). Ko taku rau kotahi. Thesis submitted for the degree of Master of Arts, University of Otago, Dunedin. 138 p.

Mahuta, D.P.S. (2008). Raupatu: A Waikato perspective. *Te Kaharoa 1*: 174–182.

Mahuta, R.T.K. (1988). Keynote address to the Ecopolitics III Conference. Hamilton, N.Z., Environmental Studies Unit, University of Waikato. 9 p.

Mahuta, R.T.K.; Nottingham, I. (1989). Towards sustainable development: A Maaori perspective. Hamilton, N.Z., Centre for Maaori Studies and Research, University of Waikato. 12 p.

Mahuta, R.T.K. (1989). Commemorative Symposium on Race Relations in New Zealand: 150 years after the Treaty of Waitangi. Hamilton, N.Z., Centre for Maaori Studies and Research. 30 p.

Mahuta, R.T. (1990). Taawhiao's Dream. 1990 McMillan Brown Lecture, University of Waikato. 21 March 1990. 25 p.

Mahuta, R.T. (1993). Raupatu. 1993 Surveyor's Conference NZ Institute of Surveyors "River, Land and People". University of Waikato. 18 October 1993. 17 p.

Mahuta, R.T.K. (1998). Mahuta and ors vs Waikato District Council and Anchor Products Ltd. Hearing before the Environment Court, Auckland. Decision No. A91/98.

Mandeno, J.F. (1992). Early settlers of the West Coast, Waikato and Waipa. *In*: Te Awamutu Historical Society.; Otorohanga Historical Society.; Te Kuiti Historical Society.; Waitomo Caves Museum Society (authors). Footprints of history. Pp 199–202.

Mandeno, J.F. (1993). Early settlers of the West Coast, Waikato and Waipa. *In*: Te Awamutu Historical Society.; Otorohanga Historical Society.; Te Kuiti Historical Society.; Waitomo Caves Museum Society (authors). Footprints of history. Pp 219–222.

Maniapoto, H. (1998). Nature and extent of the Maori customary access and use of Tuna (Anguilla species) in the Ngati Maniapoto region (King Country). Prepared on behalf of the Maniapoto Maori Trust Board. A Ministry of Fisheries Research Project. October 1998. 54 p.

Maniapoto Māori Trust Board (2009). *Annual Report 2009*. 66 p.

Maniapoto Māori Trust Board and the Sovereign in right of New Zealand (2008). Agreement in principle between Maniapoto and the Crown in respect of a co-management settlement for the Waipa River. September 2008. 19 p.

Manukau, T.T. (2006). Statement of Evidence of Timothy Tuihu Manukau - In the Matter of the RMA 1991 and the application by Wairakei Pastoral Ltd with regard to its application for Resource Consents to abstract water from the Waikato River.

Māori Affairs Select Committee (2008). Affiliate Te Arawa Iwi and Hapu Claims Settlement Bill. 223–1. *Report of the Māori Affairs Select Committee*. 28 August 2008. 12 p.

Māori Affairs Select Committee (2010). Bill Digest No. 1763. Waikato-Tainui Raupatu Claims (Waikato River Settlement Bill 2008 (2010 No 302-2). 24 March 2010. 5 p.

Martinez, D. (1995). Karuk tribal module of main stem salmon watershed analysis: Karuk ancestral lands and people as reference ecosystem for eco-cultural restoration in collaborative ecosystem management. Unpublished report. On file with: U.S. Department of Agriculture, Forest Service, Klamath National Forest, 1312 Fairlane Road, Yreka, CA 96097. Contract #43-91W8-5-7017.

Matunga, H. (1992). Benefits for Both Parties. Planning Quarterly, December 1992.

McCan, D. (2001). Whatiwhatihoe. The Waikato Raupatu Claim. Huia Publishers, Wellington. 388 p.

McDowell, R.M. (in press). Ikawai: Māori Freshwater Fisheries.

McDowall, R.M. (1984). The New Zealand Whitebait Book. A.H. & A.W. Reed Ltd, Wellington.

McDowall, R.M. (1990). New Zealand Freshwater Fisheries - A Natural History and Guide. Heinemann Reed, Auckland.

McDowall, R.M.; Eldon, G.A. (1980). The ecology of whitebait migrations (Galaxiidae: Galaxias spp.) fisheries. *Research Bulletin No. 20*. New Zealand Ministry of Agriculture and Fisheries, Wellington, New Zealand.

McGregor, D.P.; Morelli, T.P.; Matuoka, J.K.; Minerbi, L. (2003). An ecological model of wellbeing. *In*: Becker, H.A.; Vanclay, F. (eds). The International Handbook of Social Impact Assessment: Conceptual and Methodological Advances. Edward Elgar: Cheltenham.

McKenzie, L.J.; Lee Long, W.J.; Coles, R.G.; Roder, C.A. (2000). Seagrass-watch: Community based monitoring of seagrass resources. *Biol. Mar. Medit. 7(2):* 393–396.

Mead, H.M. (2003). Tikanga Māori. Living by Māori values. Huia Publishers, Wellington. 398 p.

Memmott, P.; Long, S. (1998). The significance of Indigenous place knowledge to Australian cultural heritage. *In*: Indigenous Law Bulletin. Sydney, Law Bulletin, Indigenous Law Centre, Faculty of Law, UNSW, pp 9–13.

Menzies, C. (2006). Local knowledge and contemporary resource management: historicizing indigenous knowledge. *In*: Menzies, C. Traditional Ecological Knowledge and Natural Resource Management. Board of Regents of the University of Nebraska.

Mikaere, B. (2000). Designing our future – a new whakaaro. A Maori perspective on water. This material is copyright in anticipation of its future publication in a book on a Maori perspective on water management. 12 p.

Minhinnick, R. (2003). Water and Maori People. Proceedings of the theme Water and Cultural Diversity. Third World Water Forum, 16–23 March 2003, Tokyo, pp 19–23.

Ministry for Culture and Heritage (2009). Cultural indicators for New Zealand. Tohu Ahurea mō Aotearoa. June 2009. Ministry for Culture and Heritage, Wellington, 93 p.

Ministry for Culture and Heritage (2006). Māori Peoples of New Zealand: Ngā iwi o Aotearoa. Auckland, N.Z., David Bateman Ltd, 294 p.

Ministry for the Environment (2007). Environment New Zealand. Ministry for the Environment, Wellington.

Ministry for the Environment (2005). Wai Ora: Report of the Sustainable Water Programme of Action Consultation Hui. Ministry for the Environment, Wellington, 236 p.

Ministry for the Environment (MfE) (1999). Environmental Education: A Guide for Programme Providers – How to Develop, Implement and Evaluate Strategies and Programmes. Ministry for the Environment, Wellington.

Ministry for the Environment (MfE) (1998). Learning to Care for Our Environment: Me Ako ki te Tiaki Taiao – A National Strategy for Environmental Education. Ministry for the Environment, Wellington.

Ministry for the Environment (1997). Environmental Performance Indicators: Proposals for Air, Freshwater and Land. Ministry for the Environment, Wellington.

Ministry for the Environment (MfE) (1995). Environment 2010 Strategy: A Statement of the Government's Strategy on the Environment. Ministry for the Environment, Wellington.

Ministry of Fisheries (2009). New Zealand eel (tuna) fishery. *Information brief 2009*. Ministry of Fisheries.

Ministry of Health (2002). He Korowai Oranga – Māori Health Strategy. Wellington: Ministry of Health.

Mills, L.S.; Soule, M.E.; Doak, D.F. (1993). The keystone-species concept in ecology and conservation. *Bioscience 43(4)*: 219–224.

Mitchell, C.P. (1990). Whitebait spawning grounds on the Lower Waikato River. *New Zealand Freshwater Fisheries Miscellaneous Report No. 42.*

Moller, H. (2010). Science and maatauranga Maaori: do they mix? Engagement with Iwi, Maatauranga Maaori and Science, 21 April 2010.

Moller, H. (2009). Maatauranga Maaori, science and seabirds in New Zealand. *New Zealand Journal of Zoology 36*: 203–210.

Moller, H.; Lyver, P.; Bragg, C.; Newman, J.; Clucas, R.; Fletcher, D.; Kitson, J.; McKechnie, S.; Scott, D.; Rakiura Titi Islands Administering Body (2009). Guidelines for cross-cultural Participatory Action Research partnerships: a case study of a customary seabird harvest in New Zealand. *New Zealand Journal of Zoology 36*: 211–241.

Moller, H.; Charleton, K.; Knight, B.; Lyver, P. (2009). Traditional Ecological Knowledge and scientific inference of prey availability: harvests of sooty shearwater (Puffinus griseus) chicks by Rakiura Maaori. *New Zealand Journal of Zoology 36*: 259–274.

More, D. (1977). Between the river and the hills: Waikato County 1876–1976. Wilson and Horton, Auckland, 383 p.

Morgan, M.; Strelein, L.; Weir, J. (2004). Indigenous water rights within the Murray Darling Basin. *Indigenous Law Bulletin 5*: 17–20.

Morgan, M.; Strelein, L.; Weir, J. (2007). Authority, knowledge and values: Indigenous nations engagement in the management of natural resources in the Murray–Darling Basin. *In*: Langton, M.; Mazel, O.; Palmer, L.; Shain, K.; Tehan, M. (eds.). Settling with Indigenous peoples. Federation Press, Annandale.

Morgan, T.K.K.B. (2006). An indigenous perspective on water recycling. *Desalination 187(1-3)*: 127–136.

Muru-Lanning, M. (2007). Tupuna Awa and Sustainable Resource Knowledge Systems of the Waikato River. *Mai Review 1(6)*: 1–6.

Naveh, Z. (1998). Ecological and cultural landscape restoration and the cultural evolution towards a post-industrial symbiosis between human society and nature. *Restoration Ecology 6(2)*: 135–143.

Nevins, H.M.; Adams, J.; Moller, H.; Newman, J.; Hester, M.; Hyrenbach, D.D. (2009). International and cross-cultural management in conservation of migratory species. *Journal of the Royal Society of New Zealand 39(4)*: 183–185.

New Zealand Government (1995). Whitebait Fishing Regulations 1994. Reprint 15 August 1995. Wellington, New Zealand. 12 p.

New Zealand Government (2008). Waikato Tainui Raupatu Claims (Waikato River) Settlement Bill. Wellington, New Zealand. 65 p.

New Zealand Government (2008). Affiliate Te Arawa Iwi and Hapu Claims Settlement Act 2008. Wellington, New Zealand. 110 p.

New Zealand Government (2010). Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010. Wellington, New Zealand. 122 p.

Nga Kaihautu o Te Arawa Executive Council and her Majesty the Queen in the right of New Zealand. Agreement in Principle for the Settlement of the Historical Claims of the Affiliate Te Arawa Iwi/Hapu. 5 September 2005. 49 p.

Ngata, A. (1956). Waikato of a hundred taniwhas. *Te Ao Hou 17*: 15.

Ngata, A. (1957). Waikato Taniwharau. *Te Ao Hou 18*: 19–21.

Ngāti Tūwharetoa Māori Trust Board (2002). Ngāti Tūwharetoa Environmental Iwi Management Plan 2003. 64 p.

Notzke, C. (1994). Aboriginal Peoples and Natural resources in Canada. Captus University Publications: Canada.

Novak, J.D. (1991). Clarify with concept maps: A tool for students and teachers alike. *The Science Teacher 58*: 45–49.

Orbell, M. (1985). The natural world of the Maori. Auckland, New Zealand, William Collins Publishers. 230 p.

O'Sullivan, S. (2009). Presentation by Raukawa Trust Board to the Board of Inquiry regarding the proposed National Policy Statement on Freshwater Policy. Presentation to Ministry for the Environment Proposed National Policy Statement for Freshwater Management Board of Inquiry, Hamilton. August 2009.

O'Sullivan, S.J.; Te Hiko, N.H. (2010). Raukawa and the river. *In*: Collier, K.J.; Hamilton, D.; Vant, W.N.; Howard-Williams, C. (eds). Waters of the Waikato, p. 9. Hamilton.

Panelli, R.; Tipa, G. (2007). Placing well-being: recognizing culture-environment specificity. *Ecohealth 4(4)*: 445–460.

Parkyn, S.M.; Kusabs, I. (2007). Taonga and mahinga kai species in the Te Arawa lakes: a review of current knowledge – Koura. *NIWA Client Report HAM2007-022*. NIWA, Hamilton.

Parminter, T.; Waters, C.; Mortimer, C. (2006). Examples of extension and policy strategies developed using theories of human behaviour and social marketing. Presented at the Practice change for sustainable communities: Exploring footprints, pathways and possibilities. Proceedings of APEN International Conference, 6-8 March 2006, Beechworth, Victoria, Australia.

Pauling, C.; Lenihan, T.M.; Rupene, M.; Tirikane-Nash, N.; Couch, R. (2007). State of the Takiwā: Te Ahuatanga o Te Ihutai: Cultural Health Assessment of the Avon-Heathcote Estuary and its Catchment.

Pauling, C. (2008). Ngā Wai Pounamu: Cultural Health Assessment of South Island Waterways. Paper presented at the Environmental Defence Society Conference: Conflict in Paradise: the Transformation of Rural New Zealand. June 2008. 15 p.

Pauling, C.; Arnold, J. (2009). Cultural Health of the Lake. *In*: Te Waihora/Lake Ellesmere: State of the Lake and Future Management. Hughey, K.F.D.; Taylor, K.J.W. (eds). EOS Ecology, Christchurch, pp. 77–84.

Pere, R. (1997). Te Wheke: A Celebration of Infinite Wisdom, 2nd ed. Ao Ako Global Learning New Zealand. Gisborne, New Zealand.

Phillips, F.L. (1995). Landmarks of Tainui - Nga Tohu a Tainui: Historical Places of the Tainui People. Volume One. Otorohanga, N.Z., Tohu Publishers. 301 p.

Phillips, F.L. (1989). Landmarks of Tainui - Nga Tohu a Tainui: Historical Places of the Tainui People. Volume Two. Otorohanga, N.Z., Tohu Publishers. 214 p.

Phillips, W.J. (1947). The Rua Hoata shelter, Waikato River. *Journal of the Polynesian Society 56*: 336–339.

Pimbert, M.; Pretty, J. (1997). Diversity and sustainability in community based conservation. Paper presented at the UNESCO-IIPA regional workshop on community based conservation, India.

Pinkerton, E.W. (1989). Cooperative Management of Local Fisheries: New Directions for improved management and Community Development. Vancouver: University of British Columbia Press.

Pinkerton, E.W. (1992). Translating legal rights into management practice: overcoming barriers to the exercise of co-management. *Human Organization 52(4)*: Winter.

Pond, W. (1997). The Land with All Woods and Waters. Rangahaua Whanui National Theme U. Unpublished draft. May 1997. Waitangi Tribunal Rangahaua Whanui Series. (http://www.waitangi-tribunal.govt.nz)

Prickett, N., McGovern-Wilson, R. (eds). (2009). Occasional Publications in Archaeology No. 1. Planning a Future for New Zealand War Sites and Landscapes. New Zealand Historic Places Trust. 6 July 2009, 93 p.

Puginier, O. (1999). Can participatory land use planning at community level in the highlands of northern Thailand use Geographic Information Systems (GIS) as a communication tool? (https://www.uni-ohenheim.de/atsaf/download/iaks/puginier_part+gis.pdf)

Ramstad, K.M.; Paine, G.; Dunning, D.L.; Geary, A.F.; Keall, S.N.; Nelson, N.J. (2009). Effective partnerships between universities and indigenous communities: a case study in tuatara conservation in Aotearoa. *Journal of the Royal Society of New Zealand 39(4)*: 229–231.

Rapport, D.; Gaudet, C.; Karr, J.; Baron, J.; Bohlen, C.; Jackon, W.; Jones, B.; Naiman, R.; Norton, B.; Pollock, M. (1998). Evaluating Landscape Health: Integrating Societal Goals and Biophysical Processes. *Journal of Environmental Management 53*:1–15.

Raukawa and the Raukawa Settlement Trust and the Sovereign in the right of New Zealand. Deed in relation to a Co-management Framework for the Waikato River. 17 December 2009. 118 p.

Raukawa Trust Board (undated). Raukawa River AIP Workshops. Presentation.

Raukawa Trust Board (2006). Whakareia Te Kakara o Te Hinu Raukawa. Te Rautaki Reo A Raukawa. The Raukawa Reo Strategy. 34 p.

Raukura Consultants (1993). Kaupapa Maori and the National Institute of Water and Atmospheric Research. July 1993. 34 p.

Reed, A.W. (2002). The Reed dictionary of New Zealand placenames. Auckland, New Zealand. Reed Publishing.

Reed, M.S.; Dougill, A.J.; Baker, T.R. (2008). Participatory indicator development: what can ecologists and local communities learn from each other. *Ecological Applications 18*: 1253–1269.

Reid, W.V., et al. (eds). (2006). Bridging Scales and Knowledge Systems: concepts and applications in ecosystem assessment. A contribution to the Millennium Ecosystem Assessment. Washington, D.C., Island Press.

Richmond, C.; Elliott, S.J.; Matthews, R.; Elliott, B. (2005). The political ecology of health: perceptions of environment, economy, health and well-being among 'Namgis First Nation. *Health and Place 11*: 349–365.

Ritchie, J.E. (1992). He kaupapa a rohe mo ngaa iwi Maaori o Waipa : a report to the Waipa District Council. Hamilton, N.Z., Centre for Maaori Studies and Research, University of Waikato.

Ritchie, J. (2003). The applications of qualitative methods to social research. *In*: Ritchie, J.; Lewis, J. (eds). Qualitative research practice: A guide for social science students and researchers. Sage Publications. London, United Kingdom, pp. 24–46.

Roa, T.; Beggs, J.R.; Williams, J.; Moller, H. (2009). New Zealand's Performance Based Research Funding (PBRF) model undermines Maori research. *Journal of the Royal Society of New Zealand 39(4)*: 233–238.

Roa, T. (2003). He Maimai Aroha Mō Waikato Nā Tawhiao. 1 p.

Roa, T.; Tuaupiki, J.T. (undated). Tikanga Tainui; Tikanga Whare Wānanga. Te Pua Wānanga ki te Ao, University of Waikato. 6 p.

Roberts, N. (2002). Planning and Tangata Whenua Issues: A Proactive Approach. *In:* Kawharu, M. Whenua: managing our resources. Reed Publishing.

Robinson, S.T. (2005). Tohunga the revival ancient knowledge for the modern era. Reed Publishing (NZ) Ltd, Auckland. 320 p.

Robson, J.P.; Miller, A.M.; Idrobo, C.J.; Burlando, C.; Deutsch, N.; Kocho–Schellenberg, J.E.; Pengelly, R.D.; Turner, K.L. (2009). Building communities of learning: indigenous ways of knowing in contemporary natural resources and environmental management. *Journal of the Royal Society of New Zealand 39(4)*: 173–177.

Rose, D. (2004). Fresh Water Rights and Biophilia: *Indigenous Australian Perspectives. Dialogue 23(3)*: 35–43.

Rotarangi, S.; Russell, S. (2009). Social-ecological resilience thinking: can indigenous culture guide environmental management? *Journal of the Royal Society of New Zealand 39(4)*: 209–213.

Royal, C.T. (1998). Te Whare Tapere: Towards a New Model for Performing Arts. Unpublished doctorate dissertation, Victoria University of Wellington, NZ.

Royal, T.A.C. (2003). The woven universe: selected writings of Rev. Māori Marsden. Estate of Rev. Maori Marsden. 187 p.

Royal, C. (2004). Mātauranga Māori and Museum Practice: A discussion. Prepared for Te Papa National Service – Te Paerangi. October 2004. 76 p.

Ruru, J. (2009). The legal voice of Māori in freshwater governance. A literature review. *Report prepared for Landcare Research NZ.* October 2009. 105 p.

Rutherford, K. (2009). Waikato River Independent Scoping Study – Baseline report – Framework for restoration based on Maatauranga Maaori. *NIWA Client Report HAM2009–117*.

Sauer, C. (1925). The morphology of landscape. *In:* Leighly, J. (ed). Land and Life: A Selection from the Writings of Carl Ortwin Sauer. University of California Press. Berkley, United States of America.

Sharp, B.; Kerr, G. (2005). Option and existence values for the Waitaki catchment. A report commissioned by MfE for the Waitaki Catchment Water Allocation Board (ISBN: 0-478-18991-5).

Sharpe, A.; Conrad, C. (2006). Community based ecological monitoring in Nova Scotia: Challenges and opportunities. *Environmental Monitoring and Assessment 113*: 395–409.

Skipper, A. (2009). Ko ngā Pūrākau me ngā Whakapapa mō Ngāti Raukawa, Ngāti Tūwharetoa, Ngāti Whaita me Ngāti Wairangi ko Te Hiko te kai kōrero. Unpublished report. 25 p.

Skolimowski, H. (1981). Eco-philosophy: Designing new tactics for living. Boston, Marion Boyars. 119 p.

Sole, T.; Woods, K. (1996). Protection of indigenous sacred sites: The New Zealand experience. Ministry of Maori Affairs, New Zealand. 13 p.

Speirs, D.A.; Allen, D.G.; Kelleher, R.M.; Lake, M.D.; Marchant, A.N.; Mayes, K.A.; Watene-Rawiri, E.M.; Wilson, B.J. (2010). River management. *In:* Collier, K.; Hamilton, D.; Vant, W.N; Howard-Williams, C. (eds). Waters of the Waikato: Ecology of New Zealand's Longest River. Waikato University's Centre for Biodiversity and Ecology Research and Environment Waikato, pp. 13–25.

Stack, E.R.J. (1858). Jottings from my New Zealand Journey 1858.

Stancliff, A.G.; Boubée, J.A.T.; Mitchell, C.P. (1988). The whitebait fishery of the Waikato River. New Zealand Freshwater Fisheries Report No 95. New Zealand Ministry of Agriculture and Fisheries.

Steenstra, A. (2009). Accommodating indigenous cultural values in water resource management: The Waikato River, New Zealand; the Murray-Darling Basin, Australia; and the Colorado River, USA. Paper to the 53rd annual Australian Agricultural & Resource Economics Society conference, Cairns, Queensland, 10–13 February 2009.

Steenstra, A. (2008). The Waikato River settlement and natural resource management in New Zealand. New Zealand Agricultural and Resource Economics Society (Inc.) Conference 2008, "Economic instruments – an idea whose time has come". 28–29 August 2008, Nelson. 12 p.

Stephenson, J.; Moller, H. (2009). Cross–cultural environmental research and management: challenges and progress. *Journal of the Royal Society of New Zealand 39(4)*: 139–149.

Stevens, S. (1998). Conservation through Cultural Survival. Island Press. Covelo California, United States of America.

Strang, V. (2001a). Evaluating Water; Cultural Beliefs and Values about Water Quality, Use and Conservation. Water UK, Ipswich.

Strang, V. (2001b). Negotiating the river: cultural tributaries in far north Queensland. *In*: Bender, B.; Winer, M. (eds). Contested landscapes: movement, exile and place. Oxford berg, pp. 69–86.

Tainui Tuna Working Group (2001). Tainui region tuna management plan (final draft). March 2001. 32 p.

Tan, P-L. (1997). Commercial Implications of Native Title. *In*: Horrigan, B.; Young, S. (eds). The Federation Press, Sydney, pp. 157–199.

Tanner, C.C.; Skipper, A.; Tiakiwai, S. (2005). Finding common ground: dialogue between iwi and scientists to find improved wastewater management systems that address Maori cultural and spiritual values. Presented at the Engaging with the Community on Science Issues Seminar, Auckland, February 2005.

Taonui, R. (2009). Ngā waewae tapu. Māori exploration. Tainui and the Waikato. Te Ara, the Encyclopaedia of New Zealand. http://www.teara.govt.nz/en/nga-waewae-tapu-maori-exploration/4/2

Taranaki District Council (TDC). (2007). A cultural health index for Reservoir Creek. Indicators for recognising and expressing Tangata Whenua ki Whakatu values. June 2007. 35 p.

Te Aho, L. (2009). Negotiating co-management of the Waikato River. Indigenous peoples' legal water forum, "Exploring indigenous peoples' legal rights to govern, own and manage freshwater". 27 July 2009, Wellington. 7 p.

Te Aho, L. (2009). Enhancing governance of freshwater: A co-management solution for the Waikato River. Manu-Ao series, Massey University. November 2009.

Te Arataura (2007). Whakatupuranga Waikato-Tainui 2050. 8 p. (can be downloaded from www.tainui.co.nz/docs/WhakatupurangaWT2050.pdf)

Te Arawa Maori Trust (undated). Iwi Resource Management Strategy Plan.

Te Pumautanga o Te Arawa Trust and the Raukawa Trust Board and the Sovereign (2008). Agreement in relation to a Co-Management Framework for the Waikato River. 4 September 2008. 56 p.

Te Purongo Maniapoto (2002). Te Purongo Maniapoto State of the Environment Report – A Tribal Perspective. 34 p.

Te Wai Māori (2007). Fact Sheet 1 – Fishing for Tuna. 2 p.

Te Wai Māori (2007). A guide to the preparation of Freshwater Iwi Management Plans http://waimaori.maori.nz/publications/Iwi%20Management%20Plan%20final%20April%202007.pdf

The Affiliate Te Arawa Iwi/Hapu and the Trustees of the Te Pumautanga o Te Arawa Trust and the Sovereign in right of New Zealand (2008). Deed of Settlement of the Historical Claims of the Affiliate Te Arawa Iwi/Hapu. 11 June 2008. 151 p.

Thomas, W.H. (2009). The Forest Stewards Initiative: a new institution for safeguarding traditional ecological knowledge in Papua New Guineas. *Journal of the Royal Society of New Zealand 39(4)*: 187–191.

Tiakiwai, S.J.; Tanner, C.C.; Skipper, A.; Philip-Barbara, G.; Greensill, A. (2004). Finding common ground– dialogue on wastewater management to address Māori cultural and spiritual values. *NIWA Client Report HAM2004-139* for the Ministry of Science, Research and Technology.

Tipa, G. (1999). Taieri River Case Study. *Technical Paper No. 58*. Ministry for the Environment, Wellington.

Tipa, G.; Tierney, L. (2002). Mauri and mahinga kai indicators project: developing a Cultural Health Index. Unpublished report. Tipa and Associates, Dunedin.

Tipa, G.; Tierney, L. (2003). A Cultural Health Index for Streams and Waterways: Indicators for recognising and expressing Māori values. *ME475*, June 2003. Ministry for the Environment, Wellington.

Tipa, G.; Tierney, L. (2006). Using the Cultural Health Index: How to assess the health of streams and waterways. *ME711,* February 2006. Ministry for the Environment, Wellington.

Tipa, G.; Tierney, L. (2006). A Cultural Health Index for Streams and Waterways: A tool for nationwide use. *ME710*, April 2006. Ministry for the Environment, Wellington.

Toussaint, S.; Sullivan, P.; Yu, S. (2005). Water ways in Aboriginal Australia: an interconnected analysis. *Anthropological Forum 15*: 61–74.

Townsend, C.R.; Tipa, G.; Teirney, L.D.; Niyogi, D.K. (2004). Development of a tool to facilitate participation of Maori in the management of stream and river health. *EcoHealth 1*: 184–195.

Treasury (2008). Deed of Settlement between Waikato-Tainui and the Crown in relation to the Waikato River: Summary. 22 August 2008. 8 p.

Trigger, D. (1985). The social meaning of water for Aboriginal people in Australia's Gulf country. Paper delivered at School of Environmental Studies. Griffith University.

Uhlmann, S.S.; Almstadt, B.S. (2009). Beyond the great divide: do cross-cultural partnerships require spiritual scientists? *Journal of the Royal Society of New Zealand 39(4)*: 215–217.

Underwood, S.; Arguello, L.; Siefkin, S. (2003) Restoring ethnographic landscapes and natural elements in Redwood National Park. *Ecological Restoration 21(4)*: 278–283.

Waikato Raupatu Lands Trust (undated). Whakatupuranga Waikato Tainui 2050. Rautaki 2012. He Ahunga Whakamua. *Tribal Development Plan 2008–2012*.

Waikato Raupatu Lands Trust and Ministry of Fisheries (2009). Implementation strategy. Agreements and mechanisms outlined in the Waikato-Tainui Waikato River Fisheries Accord. May 2009. 31 p.

Waikato Raupatu Lands Trust and Waikato Raupatu River Trust (2009). *Annual Report 2009*. 86 p.

Waikato Raupatu Trustee Company Ltd (2009). Submission on proposed National Policy Statement for Freshwater Management. 23 January 2009. 7 p.

Waikato Tainui and Her Majesty the Queen in the right of New Zealand (2007). Agreement in Principle for the Settlement of the Historical Claims of Waikato-Tainui in relation to the Waikato River. 16 December 2007. 32 p.

Waikato Tainui (2007). About the river claim – key facts and industry users. www.tainui.co.nz/riverclaim/keyfacts.htm (accessed 22.07.09)

Waikato-Tainui and her Majesty the Queen in right of New Zealand (2007). Agreement in Principle for the Settlement of the Historical Claims of Waikato-Tainui in relation to the Waikato River. 16 December 2007. 33 p.

Waitangi Tribunal (1985). Report to the Waitangi Tribunal on the Manukau Claim (WAI-8). Brooker & Friend Wellington.

Waitangi Tribunal (1993). The Pouakani Report (WAI-33). Brooker & Friend, Wellington.

Waitangi Tribunal (2008). He Maunga Rongo: The Report on the Central North Island Claims, Stage 1 (WAI-1200). Brooker & Friend, Wellington.

Wehi, P.M.; Whaanga, H.; Roa, T. (2010). Missing in translation: Maori language and oral tradition in scientific analyses of traditional ecological knowledge (TEK). *Journal of the Royal Society of New Zealand 39(4)*: 201–204.

Weir, J. (2009). Murray River Country: An ecological dialogue with traditional owners. Aboriginal Studies Press.

Welch, F.R.G.S. (1909). The waterloo of the Waikato, fought in 1830, and its effects on the after-enacted land laws of that part of the North Island. Transactions and Proceedings of the Royal Society of New Zealand 42: 114–118.

Whangapirita, L.; Awatere, S.; Nikora, L. (2003). Maori perspectives of the environment. A review of Environment Waikato Iwi Environmental Management Plans. *Technical Report No. 2, Environment Waikato Internal Series 2004/01*. September 2003. 15 p.

Whitelaw, G.S.; Vaughan, H.; Craig, B.; Atkinson, D. (2003). Establishing the Canadian Community Monitoring Network. *Environmental Monitoring and Assessment 88:* 409–418.

Williams, A. (1999). Therapeutic Landscapes: the Dynamic between Place & Wellness. University Press of America. Lanham MD, United States of America.

Williams, J. (2009). "O ye of little faith" traditional knowledge and Western science. *Journal of the Royal Society of New Zealand 39(4)*: 167–169.

Willis, E.; Pearce, M.; Jenkin, T.; Wurst, S.; Mccarthy, C. (2004). Water Supply and use. In: Aboriginal communities in South Australia: Report to South Australian Department of Aboriginal Affairs and Reconciliation. Adelaide, Flinders University.

Wilson, K. (2003). Therapeutic landscapes and First Nations peoples: an exploration of culture, health and place. *Health & Place 9*: 83–93.

Winitana, C. (2005). Central North Island Inquiry. WAI 1200, WAI 575, WAI 61, 178, 226,269 & 490. The Ngati Tuwharetoa Comprehensive Claim: a claim filed by the ariki Tumu Te Heuheu on behalf of Nga Hapu o Tuwharetoa: Evidence of Chris Winitana. Auckland, Tamatekapua Law.

Wood, V.; Brooking, T.; Perry, P. (2008). Pastoralism and politics: reinterpreting contests for territory in Auckland Province, New Zealand, 1853–1864. *Journal of Historical Geography 34*: 220–241.

Woodley, E.; Crowley, E.; Dookie, E.; Carm, A. (2006). Cultural indicators of Indigenous Peoples' food and agro-ecological systems. Draft summary 1 for discussion. Prepared for the Second Global Consultation on the Right to Food and Food Sovereignty for Indigenous Peoples organised by the International Indian Treaty Council (IITC) in its role as Indigenous Peoples' Focal Point for

Sustainable Agriculture and Rural Development (SARD) Puerto Cabezas, Nicaragua, 7–9 September 2006.

World Commission of Environment and Development (1987). Report on World Commission of Environment and Development.

Young, R.; Harmsworth, G.; Walker, D.; James, T. (2008). Linkages between cultural and scientific indicators of river and stream health. *Motueka Integrated Catchment Management (Motueka ICM) Programme Report*. November 2008. 39 p.

Yuen, E.; Anda, M.; Mathew, K.; Ho, G. (2001). Water harvesting techniques for small communities in arid areas. *Water Science and Technology 44*: 189–194.

Zinsli, C. (2002). Consultation with Maori. *In:* Kawharu, M. Whenua: managing our resources. Reed Publishing.

Zurba, M. (2009). Bringing local synthesis into governance and management systems: the Girringun TUMRA case in Northern Queensland, Australia. *Journal of the Royal Society of New Zealand 39(4)*: 179–182.

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