

TE WAIHORA/LAKE ELLESMERE

State of the Lake and Future Management

Edited by KENNETH F.D. HUGHEY and KENNETH J.W. TAYLOR

CHAPTER EXCERPT



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Edited by **KENNETH F.D. HUGHEY** and **KENNETH J.W. TAYLOR**
Lincoln University Environment Canterbury

CHAPTER EXCERPT



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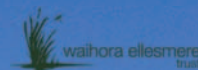
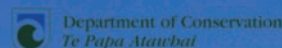
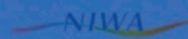
SHELLEY McMURTRIE

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SHUTTERSTOCK

KENNETH F.D. HUGHEY Lincoln University KENNETH J.W. TAYLOR Environment Canterbury

Te Waihora/Lake Ellesmere¹ is a large coastal lake, intermittently open to the sea. It is highly regarded for its conservation and related values, some of which are of international significance. Its function as a sink for nutrients from its large predominantly agriculturally based catchment, currently undergoing accelerated intensification, is also recognised, at least implicitly. It is the resulting conflict from these value sets which is mainly responsible for the ongoing debate about the future of the lake, a debate long fuelled by rhetoric and informed by a body of science which highlights the lake's complexity as a biophysical system, but has many gaps. It is a debate that now has substantial statutory implications, arising from factors which include:

- the requirements of conservation, and indigenous needs and entitlements which are growing in prominence and statutory (including property rights based) legitimacy;
- public interest in legal processes associated with further major intensification of agriculture planned for the catchment;
- a recent Environment Court decision in which serious questions about the overall biological health of the lake were raised; and
- the consequences arising from the need for Environment Canterbury to obtain resource consents for the lake operating regime.

In addition, in recent times the Waihora Ellesmere Trust (WET), a community based group advocating for improved management of the lake, has been established. It is within these diverse contexts that this State of Te Waihora/Lake Ellesmere report has been prepared—it results from the 2007 Waihora/Ellesmere Living Lake Symposium, held from 31 October-3 November 2007 at Lincoln University, Canterbury. The symposium was initiated and organised by the WET (see www.wet.org.nz).

The Living Lake Symposium had several key objectives:

- To determine the overall state of the lake, by first defining the key value sets, and indicators that could be reported against;
- To suggest future management actions that would address key issues affecting the defined values;
- To provide a forum within which lay individuals, scientists and managers could openly debate issues; and
- To provide a launching pad for integrated and focused future management of the lake and its environs.

The programme incorporated three keynote speakers: Dr Larry Hildebrand from Environment Canada, Dr Hamish Rennie from Lincoln University, and Dr Bryan Jenkins from Environment Canterbury—their addresses made a major contribution to the symposium although none are included in this report, because it is focused primarily on the science and the management options associated with the lake.

The format of this report is designed to be readily updateable. Ten of the principal presentations in the main sessions of day two of the symposium are included in this report—two Power Point presentations (both regarding water quantity and related issues) are provided as appendices to improve completeness. Over time, however, topic areas not available as full papers for this report, e.g., surface water quantity, will be written up and included in detail. Similarly, the papers herein will themselves be updated as new and significant data become available. Each subject area will be reconsidered within the same structure and context as has been provided here. One paper, 'Te Waihora/Lake Ellesmere: An integrated view of the current state and possible futures', was presented on the final formal day of the symposium and it is included as the concluding chapter of this report.

Finally, the Waihora Ellesmere Trust and many of the others attending the symposium saw merit in reconvening the event

around two years after the initial symposium, to report on progress with management, indicator monitoring, scientific understanding and other matters. We support that suggestion.

In terms of report format it is important that readers note the following:

- All authors were provided with 'briefs of work' and were requested to contextualise their work with that contained within the Taylor (1996) report on the lake—this was more easily achievable for some than others. Given some lack of consistency between symposium presentations and final papers it is our intention that a revised set of agreed indicators will be considered and included in any follow-up symposium and associated reports—some considerable work will be required in some areas to achieve this objective;
- Only the wildlife and integration papers included in this report have been formally peer reviewed; and
- All other papers have been standardised and style edited—some changes have been suggested by the report editors and made by the paper authors.

Finally, an attempt has been made to present the papers in a logical sequence of 11 chapters: chapter 1 sets the scene; chapters 2-7 cover the biophysical science dimensions (groundwater, water quality, native vegetation, native fisheries, trout, wildlife); chapters 8-10 deal with the human dimensions (Ngāi Tahu, recreation, economics); and chapter 11 deals with integration of the findings from the previous chapters and setting the scene for future management.

¹ Note that the Geographic Place Names Board has defined the name as Lake Ellesmere (Te Waihora). It is not our intention to debate the nomenclature, but rather to put the focus where we consider it should lie, within the lake's initial historical and cultural context for indigenous Maori.



COLIN HILL

CULTURAL HEALTH of the lake

CRAIG PAULING Te Rūnanga o Ngāi Tahu JASON ARNOLD Te Rūnanga o Ngāi Tahu

KO NGĀ HAU KI ĒTAHI WĀHI, KO NGĀ KAI KI ORARIKI

No matter which way the wind blows, there is always food at Orariki.

This whakatuaki refers to the year round abundance of food that was available at Orariki, the pā of Te Ruahikihiki, near Taumutu.

There was mahinga kai in all seasons, in all weather.

The State of the Takiwā tool developed by Te Rūnanga o Ngāi Tahu was used to assess the cultural health of Te Waihora in April 2007. Its development arose as the result of an agreement by Environment Canterbury to undertake a range of research programmes, including a Cultural Health Assessment, as a condition of the consent to open the lake. In parallel a Te Waihora specific cultural health tool is being developed through a joint Ngāi Tahu-NIWA-Health Research Council funded project that will provide a more comprehensive tool and provide a more complete cultural health assessment which the Takiwā tool cannot currently provide for this environment. The preliminary findings from the Takiwā based assessments, showed that the lake, and in particular the lake edge, still holds significant mahinga kai values, despite obvious water quality, modification, pressure and native vegetation issues. It also showed that although the lake edge received a moderate assessment, water and native fish values were not able to be directly assessed due to a limitation with the Takiwā method. Therefore, the development of a specific lake cultural health tool by Ngāi Tahu and NIWA will be important to gain a more accurate picture of the cultural health of the lake and the lake edge into the future.

8.1 Te Kōrero Whakataki Introduction

While there is much ‘western’ science based research and monitoring reported for Te Waihora there is little of what can be described as reflecting a cultural health assessment. Cultural health information for Te Waihora is important considering the significance of the lake to Ngāi Tahu history, identity and ongoing wellbeing, and in particular due to the return of the lake-bed to Ngāi Tahu as part of the Ngāi Tahu Claims Settlement Act 1998, as well as the joint management of the lake bed and surrounding conservation lands under the Te Waihora Joint Management Plan.

This chapter outlines the development of a cultural health monitoring tool for Te Waihora, and the results of a preliminary study using the Takiwā tool to monitor its core methods, some results from application to the lake, and related conclusions and recommendations. This chapter is based on two projects. The first involves the development of the Takiwā tool by Te Rūnanga o Ngāi Tahu, supported by the Ministry for the Environment, and its use to monitor the impacts of the lake opening consent held by Environment Canterbury, who also contributed to the development of the tool. The second project is the joint Ngāi Tahu/NIWA project to develop a specific cultural health tool for Te Waihora supported by the Te Waihora Management Board and funded by the Health Research Council.

8.2 Tāhuhu Kōrero Background

State of the Takiwā is an environmental monitoring approach developed by Te Rūnanga o Ngāi Tahu as part of their Ki Uta Ki Tai—Mountains to the Sea Natural Resource Management framework (Pauling 2003) and outlined in the tribal vision, Ngāi Tahu 2025 (Te Rūnanga o Ngāi Tahu 2001). Its development has been partly funded by the Ministry for the Environment (MfE) and supported by Environmental Science and Research, Manaaki Whenua Landcare

Research, NIWA, Envirolink Southern Community Laboratories, Environment Southland and Environment Canterbury.

The major objective behind State of the Takiwā is to ensure that tāngata whenua can build robust and defensible information on the health of the environment. This information can in turn be used to assess the effectiveness of both internal policy and practices as well as those of external agencies, including local councils which have statutory responsibilities to undertake monitoring and report on the state of the environment (Pauling 2004).

Currently, the State of the Takiwā approach incorporates a specially designed Access database and associated monitoring forms, developed to allow tangata whenua to capture, store, analyse and report their impressions of site quality gathered in a systematic manner over time. Overall the approach provides for recognition and incorporation of Māori values in relation to environmental management. It also links with the MfE Environmental Performance Indicator (EPI) programme, and with the Cultural Health Index (CHI) for rivers and streams (developed by Gail Tipa and Laurel Tierney). The Takiwā tool therefore provides a diagnostic tool for identifying issues (and sites) of concern to iwi and allows for remedial action to be prioritised, implemented and monitored for performance over time.

While it is being used as a ‘one stop monitoring shop’ by the iwi, it has been driven by concerns around water quality, and has been focused around assessing the health of rivers and streams. It is therefore limited in its application for monitoring species health and in assessing the health of other ecosystems including lakes, and requires further development of specific tools that can be added to the overall system. The joint Ngāi Tahu/NIWA project funded by the Health Research Council offers an opportunity to develop such a tool. The Te Waihora Cultural Health Study being undertaken within this project is therefore attempting to develop a tool that will provide for a more comprehensive assessment of Te Waihora. Unique themes and indicators developed through the Te Waihora Cultural Health

Study will be incorporated into the State of The Takiwā database system enabling easy access and reporting.

8.3 Ngā Kauneke Methods

Takiwā Site Assessments

State of the Takiwā data are captured and inputted from monitoring forms completed in the field for particular sites and visits. The system also allows for the collection and storage of historical information as well as photos, pictures or graphs about a site. Recent developments allow for data to be inputted onsite using electronic forms on a Panasonic Toughbook PC that eliminates ‘double handling’ of data.

Index/scoring calculations are included to grade and compare sites including the general Takiwā site health assessment, native species abundance, as well as the Cultural Health Index for Rivers and Streams, and the Stream Health Monitoring and Assessment Kit (SHMAK) for stream health at a site. An integrated reporting function allows users to print a range of reports on the data collected. It is envisioned that the upcoming Te Waihora tool will be simply incorporated into the electronic Takiwā database as a separate tab, in the same way as the CHI and SHMAK are currently.

Takiwā Monitoring Forms

These are aimed at recording observations and assessments by tangata whenua for a particular site using three main forms:

Site Definition

- Names, Site location, legal protection, special features, heritage/site significance, traditional species, etc.

Visit Details

- Date, time, weather conditions as well as prompts to ensure photographic references are taken

Assessment Questionnaire

- Overall health/state of a site
- Levels of modification/change at a site
- Suitability of the site for harvesting mahinga kai

- Access issues in relation to the site
- Amount of pressure from external factors
- Presence, abundance and diversity counts for taonga (valued) bird, plant and fish species, and other culturally significant resources as well as pest and weed species
- Willingness to return to the site for harvesting mahinga kai.

Te Waihora Cultural Health Assessment

The cultural health assessment undertaken in this study was done as a condition of the Te Waihora/Lake Ellesmere Lake Opening Consent obtained by Environment Canterbury. David O'Connell and Craig Pauling developed the initial brief and selected sites in liaison with David Aires (Environment Canterbury). Jason Arnold and Craig Pauling then developed a work plan and submitted it to Environment Canterbury for review.

The work plan outlined the following types of assessment:

- Takiwā
- CHI
- SHMAK
- *E. coli* assessments
- Electric fishing where appropriate.

Fourteen sites around the edge of lake were chosen, including seven associated with lake tributaries. A data collection hikoi occurred over 11–12 April 2007; a report on the findings was submitted to Environmental Canterbury and presented at the 2007 Living Lake Symposium. Ultimately all this effort is assisting in development of a Cultural Health Tool for Te Waihora which will be the final tool of choice as it provides a fuller assessment of the cultural health of Te Waihora.

Ngā Kaimahi me ngā Kaiawhina People involved

Those involved were:

Fieldwork: Lisa Smith (Ngāi Te Ruahikihiki), David O'Connell (Ngāi Te Ruahikihiki), Craig Pauling (Ngāi Te Ruahikihiki), Jason Arnold (WaihoraCoordinator),

Dave Aires (ECan), Leigh Skerten (ECan)

Lab Work/*E. coli*:

John Aitken (Envirolink Labs) processed the *E. coli* samples.

Wāhi Whakamātau Monitoring Sites (see Figure 1):

1. Irwell River mouth, Irwell
2. Boggy Creek mouth, Irwell
3. Harts Creek mouth, Lakeside
4. Pakoau, Johnsons Road, Lakeside
5. Water Tower, Taumutu Commonage, Taumutu
6. Fishermans Point (overlooking Te Koru and Lake Opening), Taumutu
7. West end of Te Koru, Taumutu
8. Lower Selwyn Huts
9. North Greenpark Sands, off Wolfes Road
10. Mid Greenpark Sands, off Clarkes Road
11. Mouth Halswell River, Greenpark
12. Kaituna
13. Te Waiomakua Mahinga Kai Site, Kaitorete Spit
14. Harakeke (Flax) Swamp, Lower Kaitorete Spit



FIGURE 1. Location of the State of the Takiwā monitoring sites. Base Map sourced from ECan.

8.4 Te Waihora Cultural Health Study Ngāi Tahu NIWA Process

The first part of the process concerned tool development and trialling. Specifically it involved the following steps:

- Key participants identified and interviewed
- Analyse interviews and draft report

- Identify indicator themes, sites and mahinga kai to be measured
- Hui to develop draft tool
- Test the draft tool at 3–4 sample sites;
- Currently development is at this stage of the process
- Work with local tangata whenua to develop further indicators and assessment methods for monitoring individual mahinga kai species, including Tuna,

Pātiki, Harakeke and Kakī Anau (see Appendix A)

- Statistically correlate assessments to refine key indicators
- Finalise tool
- Assess remaining sites using final tool.

8.5 Ngā Hua Results

Takiwā Cultural Health Assessment

Based on the baseline data collected using the Takiwā tool the Te Waihora/Lake Ellesmere lake edge was found to be in a state of moderate cultural health (Table 1 summarises the data collected for the best and worst sites):

- 72% of sites were found to be of moderate health
- 21% rated as good
- 7% being rated as poor.

Overall, the sites scored well on willingness to harvest mahinga kai and access indicators but poorly on pressure, modification, and native species abundance indicators, particularly in relation to native vegetation dominance. Kaitorete Spit sites (Te Waiomakua and Harakeke Wetland) were the highest ranking sites (Figure 2), while Pakoau followed by the Kaituna River Mouth Site were the lowest scoring. Because the method was not specifically designed for



Photo Kaitorete Spit sites 13 - Te Waiomakua mahinga kai site and 14 - Harakeke (Flax) Swamp, ranked the highest in terms of their cultural health representing two of the most 'intact' sites around Te Waihora. Photography David Aires.

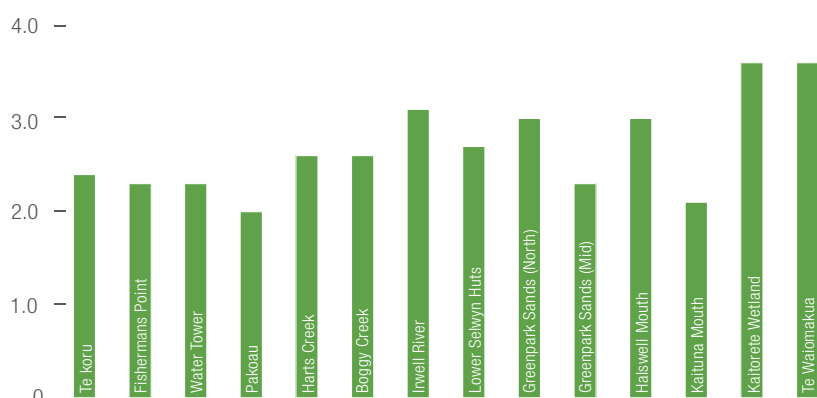


FIGURE 2. Takiwā Cultural Health Scores for 14 sites at Te Waihora/Lake Ellesmere–2007.

TABLE 1. Comparison of the best and worst cultural health monitoring sites at Te Waihora.

| Criteria | Specific criteria | Te Waiomākua | Pākoau |
|-----------------------------|------------------------|---|---|
| Takiwā Assessment | Pressure | 4 | 2 |
| | Degree of modification | 3 | 2 |
| | Access for harvesting | 5 | 2 |
| | Willingness to harvest | 5 | 3 |
| | Would you return? | Yes | Yes |
| Overall health | | 4 | 1 |
| Birds | | Kāhu > | Karoro > Matuku > Papango |
| Plants | | Reeds > > Ribbonwood Saltmarsh Ribbonwood >>> Rushes > > | Clubrush > > Kiokio >> Threesquare >>> Orchids |
| Fish | | Not assessed | Not assessed |
| Pests | | Exotic Grasses/Weeds > > | Exotics: Exotic Grasses/Weeds > > Tall Fescue >>> Willow >>> Gorse>>> Finch> Swallow> |
| Native Vegetation Dominance | | 50% | 15% |
| Valued Species | | 39 Traditional vs Current 5 | 39 Traditional vs Current 7 |
| Takiwā score: | | 3.6/5.0 | 2.0/5.0 |
| Abundance score: | | 8.0 | 2.0 |

lakes, water and native fish values were not directly assessed. With the new tool being developed fish species and mahinga kai health will be able to be assessed as well.

Native Species Abundance and Vegetation Dominance

Saltmarsh Ribbonwood was the most prevalent native plant, being found at eight of the 14 sites. Kākī Anau (black swans) were the most commonly encountered taonga bird species, being found at nine sites. Native freshwater fish were not assessed at lake edge sites. Shortfin tuna (eels) were however encountered at a number of river mouth sites.

The most common exotic plants encountered during the fieldwork were exotic pasture grasses and weeds, including Tall Fescue and thistle (12 sites). Willow and gorse

were also common (seven sites).

Overall, native species abundance and in particular native vegetation dominance around the lake edge was poor. Seventy percent of sites had less than 15% dominance in native vegetation. Seventeen percent had moderate native vegetation dominance (between 35–65% dominant), but there were no sites with greater than 50% of native vegetation dominance (Figure 3).

E. coli results

E. coli results were poor (Figure 4). Forty two percent of the 12 sites tested failed the national recreational guideline for water quality and no sites achieved the shellfish/food gathering standard or were fit for drinking (Ministry of Health 2000; Ministry for the Environment, 2003—see Appendix A). Alarmingly, *E. coli* at 83% of sites

sampled showed resistance to antibiotics, with Ampicillin (a human antibiotic) being the most common (Aitken 2007). The worst record was Greenpark Sands, and the best was Pākoau. More testing, over a greater time frame and using more samples, as well as testing any impacts this *E. coli* may have on fish health would be important to understanding the extent of any serious health or environmental problems.

Te Waihora Cultural Health Tool

As a result of the Ngāi Tahu/NIWA Te Waihora Cultural Health Tool study and in particular the interviews with tangata whenua, a number of unique themes and health indicators for Te Waihora (as well as known generic ones) have emerged, including:

Drivers of Change:

- Catchment land use modification and intensification
- Drainage, management and reclamation of wetlands
- Decline in quantity, quality and access to mahinga kai
- Decline in inflow and lake water quality and quantity

Change over time:

- Loss of mahinga kai habitat
- Loss of matauranga Ngāi Tahu
- Domination of fishery by commercial operators
- Declining access and use of the lake and mahinga kai
- Degradation of mauri of the lake and mana

Desired outcomes:

- Regenerating, restoring native habitat
- Higher and fluctuating lake
- Native birds
- Reduced sediment and erosion
- Integrated management action (re-sourcing)
- More Ngāi Tahu and community use
- Mahinga kai activity rejuvenated
- Te Kete Ika o Rākaihautū/The Fish Basket of Rākaihautū restored

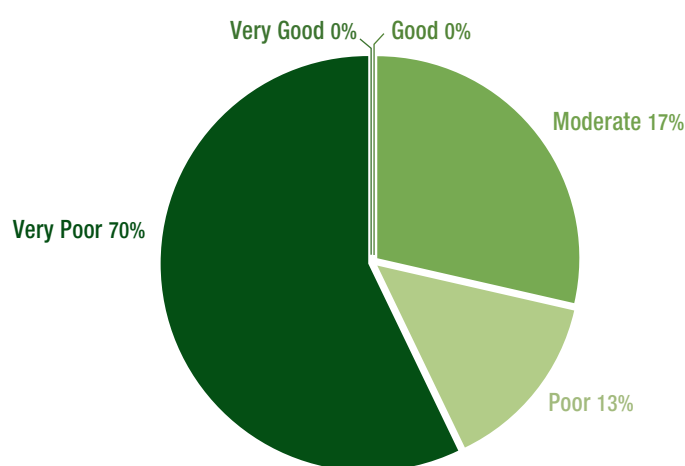


FIGURE 3. Native vegetation results for Te Waihora/Lake Ellesmere monitoring sites.

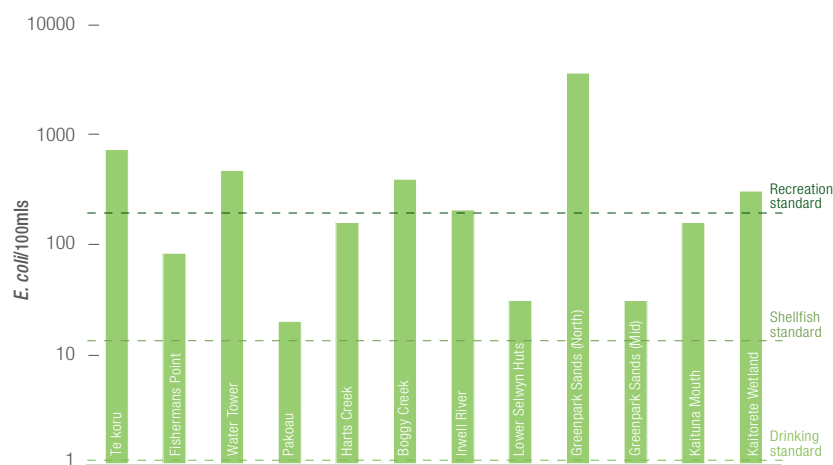


FIGURE 4. *E. coli* results for Te Waihora/Lake Ellesmere monitoring sites.

Management Requirements:

- Protection and enhancement of margins and tributaries
- Implement non-commercial areas
- Lake openings for mahinga kai/ecological values
- Re-establishing aquatic weed beds
- Sustainable waterway management
- Commercial activities managed
- Monitoring of cultural health, including the assessment of individual mahinga kai species such as Tuna, Pātiki, Harakeke and Kākī Anau (see Appendix B).

8.6 Te Whakamutunga Conclusions and Recommendations

Some preliminary conclusions can be drawn. The lake, and in particular the lake edge, still holds significant mahinga kai values, despite obvious water quality, modification, pressure and native vegetation issues.

Although the lake edge received a moderate assessment, water and native fish values were not able to be directly assessed due to a limitation with the Takiwā method.

E. coli results indicate that water quality and quantity are degraded and warrant further more specific investigation to understand overall health.

The development of a specific lake cultural health tool (Jason Arnold/NIWA) will be important to gain a more accurate picture of the cultural health of the lake and the lake edge.

Recommendations from the above are:

- Development and use of a lake cultural health tool and the closer investigation of water quality and quantity and native fish issues for future assessments.
- Inclusion of indicators for water quality, quantity/lake-level, lakebed, native fish and customary food gathering effort and quality within the lake cultural health tool.
- Protection & enhancement of native lake edge vegetation to provide greater habitat for taonga bird and fish species

as well as providing a buffer from land use and lake level changes.

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8.8 Appendices

Appendix A Water Quality Standards

Microbiological Water Quality Guidelines for Marine & Freshwater Recreational Areas (Ministry for the Environment 2003)

Freshwater Contact Recreation:

No single sample greater than 260 *E. coli* / 100 mL.

Marine Water Contact Recreation:

No single sample greater than 140 enterococci / 100 mL.

Shellfish Gathering:

The median faecal coliform content of samples taken over a shellfish-gathering season shall not exceed a Most Probable Number (MPN) of 14 / 100 mL, and not more than 10% of samples should exceed an MPN of 43 / 100 mL (using a five-tube decimal dilution test).

New Zealand Drinking Water Standards Ministry of Health 2000

E. coli

The indicator organism chosen to indicate possible faecal contamination of drinking-water is *E. coli*. Thermotolerant coliforms (faecal coliforms) and total coliforms (which include both faecal and environmental coliform bacteria) may also be used to monitor water quality, but the results are harder to interpret than those from *E. coli*. If total coliforms or faecal coliforms are used for drinking-water monitoring to demonstrate

compliance with the Standards instead of *E. coli*, a positive result shall be treated as though it were an *E. coli* result.

E. coli should not be present in drinking-water in the distribution zones. However, unlike the drinking-water leaving the treatment plant, whose microbiological quality is under the control of the treatment plant management, the quality of drinking-water in the distribution zones may be subjected to contamination from a variety of influences.

Some of these may arise from poor management practices, such as faulty reservoir construction and maintenance, or poor sanitary practices by water supply workers.

Other contamination sources arise from the water users themselves, such as poor sanitation while making connections to the service or inadequate backflow prevention. *E. coli* may, therefore, occasionally be found in the reticulation. The presence of *E. coli* must always be followed up. If more than 0.2 mg / L free available chlorine (FAC) is maintained in the drinking-water supply reticulation, coliform bacteria and *E. coli* are rarely, if ever, found. For this reason it is permissible to substitute monitoring of FAC for some (but not all) of the *E. coli* monitoring.

Appendix B Assessing the Cultural Health of Hua Kaki Anau-black swan eggs

Hua Kaki Anau or black swan eggs were identified through initial interviews as one of the key mahinga kai species that should be subject to specific assessment as part of the wider Te Waihora Cultural Health Tool. Swan eggs were a very important seasonal mahinga kai at Te Waihora and Ngāi Tahu have a long association with the collection of bird eggs generally. Therefore an informal assessment of swan egg health was carried out in conjunction with the 2007 seasonal customary harvest.

Under the authority of the Acclimatisation Society earlier last century swan egg collection became an illegal activity. Rangers were employed to camp up towers overlooking the swan breeding areas to deter would be egg gatherers. In the 1960s there were over 80,000 birds, but the population crashed after the Wahine storm in 1968 with a recovered population of between 4–10,000 currently.

A permit to gather eggs was recently granted to Ngāi Tahu by the North Canterbury Fish and Game Council. Notwithstanding the Council process there are still a number of barriers to returning to this

cultural practice. The swans nest largely on private land and access is limited by 4wd vehicle or boat depending on landowner consent. The site is also severely degraded in terms of the indigenous vegetation and erosion is rapidly destroying the main nesting area. Further research and understanding is needed to ensure this is a sustainable practice into the future. Using the Cultural Health Assessment forms specifically for swan eggging it is hoped that a valuable dataset can be obtained to support a sustainable mahinga kai practice.

As part of the swan egg harvest, a thorough nest and egg count was carried out in conjunction with Fish and Game North Canterbury. A total of 368 nests were found with 1,537 eggs recorded at an average of 4.17 eggs per nest. Following the first legal swan eggging in what is thought to be over a century, there were many positive reports of sponges, birthday cakes, omelettes and scrambled eggs. Mātauranga (knowledge) was also shared by kaumātua with rangatahi ensuring this practice is continued.



Photo The protection and enhancement of lake edge vegetation provides greater habitat for bird and fish species as well as providing a buffer from land use and fluctuating lake levels. Photography Colin Hill.

CHAPTER EXCERPT

The Waihora/Lake Ellesmere is a large coastal lake, intermittently open to the sea. It is highly regarded for its conservation and related values, some of which are of international significance. Its function as a sink for nutrients from its large predominantly agriculturally based catchment, currently undergoing accelerated intensification, is also recognised, at least implicitly. It is the resulting conflict from these value sets which is mainly responsible for the ongoing debate about the future of the lake.

This book serves to quantify the nature of this debate by documenting changes to lake values, both over time and spatially. It provides a standardised approach to reporting these changes, set against indicators that are value-specific. Ultimately, it provides a template for thinking about future management scenarios for the lake and its environs. Given this approach the book ultimately serves as a resource for helping understand the ever-changing and current and possible future states of the lake, under a variety of management requirements and implications.

