Restoring the Rotorua Lakes

The ultimate endurance challenge

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Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata
PO Box 10-241, Wellington, Aotearoa New Zealand
www.pce.govt.nz

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Investigation team
Philippa Richardson and Kathryn Botherway

With assistance from
Helen Beaumont, Mike Moodie, and Iain McAuley

Internal reviewer
Nick Potter

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Editing
Write Group Limited, PO Box 9840, Wellington

Design and layout
Kathryn Botherway

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Preface

I begin by acknowledging the major efforts and considerable resources now being invested in protecting and hopefully restoring the Rotorua Lakes. It is superb.

However, it is clear the task is Herculean and that, globally and locally, there are some very tough realities associated with sustaining lake and river water quality as nutrient inputs increase.

In the recently released Millennium Ecosystem Assessment, a major United Nations initiative to assess the health of the world's natural capital, nutrient pollution of ecosystems was identified as a major new threat. The Assessement stated:

- *Human activities now produce more biologically usable nitrogen than is produced by all natural processes combined, and more than half of all the manufactured nitrogen fertiliser (first produced in 1913) ever used on the planet has been applied since 1985*
- *The flow of nitrogen to the oceans has doubled since 1860*
- *The use of phosphorus fertilisers and the rate of phosphorous accumulation in agricultural soils both increased nearly threefold between 1960 and 1990.*[1]

Nitrogen and phosphorus are rapidly building up in the world's soils. They then work their way through to surface and ground waters with all the attendant consequences.

Our Rotorua Lakes story is a microcosm of what is going on globally. We know that agricultural land use in the Lake Rotorua catchment accounts for 75 percent of the nitrogen, and 46 percent of the phosphorous entering the lake. The other important, and now well documented, part of the story is the length of time that nutrients take to get from the land to the lakes. One study cited in this report found eight out of 12 spring and groundwater well samples had a mean residence time of over 60 years. Therefore, the full effects of *recent* land use intensification are still many years away. Water quality will continue to get worse for some decades to come.

In light of this bleak scenario, the challenge is enormous – firstly, to halt current nutrient losses, secondly, to mitigate the effects of past losses as they impact on the lakes, and thirdly, to sustain and resource the long-term commitment. To turn back the nutrient tide we face some very tough land use decisions.

It is *not* mission impossible – but it is vital that the excellent focus and effort of today continue far into the future, and that the institutions and mechanisms in place are robust enough to carry that through.

My two recommendations to the Joint Strategy Committee – to strengthen the institutional framework by expanding its membership and to develop a long-term sustainability reporting system to measure progress – are essential to ensure that the commitment is maintained. This is at least a 50-year journey. The baton will have to be passed to many people over the decades. The biggest challenges are not the technical or even the financial ones, but the very human ones of keeping up the team spirit and effort over decades. It can be done but this long-term framework needs to be a substantive part of thinking, conversation and planning, now.

Dr J Morgan Williams
Parliamentary Commissioner for the Environment

Executive summary

This report sets out the findings and recommendations of a scoping investigation by the Parliamentary Commissioner for the Environment (PCE) into public authorities' environmental planning and management of the Rotorua Lakes.

In March 2003, members of the Rotorua community wrote to the Commissioner to express their concern at the declining state of the Rotorua Lakes. Since then, the PCE has been monitoring central and local government initiatives to improve the Lakes' water quality. The Commissioner agreed to examine the issues more thoroughly once resources became available, and this process began in early 2005. This report scopes the issues to determine whether a more detailed investigation would be helpful.

Under the umbrella of the Joint Strategy Committee and the Rotorua Lakes Protection and Restoration Programme, considerable resources are now being invested in protecting and restoring the Lakes (see Section 4.1). This positive programme is making excellent progress, and is undoubtedly a leading initiative in New Zealand. The Commissioner congratulates the agencies and the Rotorua community on their commitment and effort.

Using the findings from interviews and research, the investigation team identified six key issues for the Rotorua region and the country as a whole (see Section 6). These issues, which require further attention, are:

- long-term catchment management and redesign of land use
- national lake health and monitoring issues
- keeping up the momentum
- research funding
- short-term engineering works
- maintenance and protection of the healthier lakes.

Of these, the Commissioner feels that *keeping up the momentum* is the area where further work would be of most benefit. Maintaining and improving the health of the Rotorua Lakes will require ongoing commitment over decades rather than years. With an extensive range of projects started over the last 2–3 years, the challenge now is to keep the programme going.

The Commissioner recommends that, in order to build on the excellent progress made so far, the Joint Strategy Committee should:

1 Consider strengthening the institutional framework by expanding its membership to include representatives drawn from the wider community (see Section 7.1.1).

2 Develop a sustainability report card on progress with the Rotorua Lakes Protection and Restoration Programme, to help maintain community commitment over the long-term (see Section 7.1.2).

Further investigation by the Commissioner may focus on:

1. Research funding
2. Integrated catchment management
3. National lakes management.

The Commissioner will consider these projects alongside other proposals during the annual planning process.

1 Introduction

Nutrient enrichment of rivers and lakes in New Zealand is a growing concern. Nutrients from human activities (e.g. farming effluent and sewage) can end up in rivers and lakes and cause declining water quality, eutrophication, toxic algal blooms, aquatic ecosystem stress, and risks to human health.

Ten to 40 percent of New Zealand's more than 700 shallow lakes are eutrophic.[2] Most of these are in the North Island, in pasture-dominated catchments.[3] New Zealand's larger, deeper lakes, such as Lake Taupo and the Rotorua Lakes, are also at risk because of increased nutrient loads. Water quality in the Rotorua Lakes has been declining for 30 to 40 years, and toxic blue-green algal blooms have become a serious problem in some of the lakes.

1.1 Background

In March 2003, members of the Rotorua community wrote to the Commissioner to express their concern at the declining state of the Rotorua Lakes. Since 2003, the PCE has been monitoring initiatives taken by central and local government agencies to improve the Lakes' water quality. The Commissioner agreed to examine the issues more thoroughly once resources became available. PCE staff began this process in early 2005 by scoping the issues to determine whether a more detailed investigation would be helpful.

Section 16(1)(b) of the Environment Act 1986 enables the Commissioner to "investigate the effectiveness of environmental planning and management carried out by public authorities". This report is the outcome of the PCE's scoping exercise into the health of the Rotorua Lakes.

Issues that the Commissioner considered include:

- contributions to the deterioration in the Rotorua Lakes' water quality
- the current state of technical knowledge and scientific research
- the local economy and the relative value of the Rotorua Lakes in their various roles: for example, as amenity and recreational resources, and as receiving waters of urban, farming and forestry activities
- current and future land use in the major catchments
- governance and legislative arrangements and the regulatory environment
- the roles of the agencies involved
- the value placed on the Rotorua Lakes by tangata whenua and other stakeholders.

The PCE's 2004 report *Growing for good: Intensive farming, sustainability and New Zealand's environment* looks at how agricultural land use and nutrient management affects water quality. That investigation is relevant to the Rotorua Lakes issue.

1.2 Methodology

PCE staff gathered relevant research and information and interviewed key stakeholders. Most interviews were carried out in Rotorua from 14–18 March 2005. Others were carried out in Wellington. A list of the people interviewed is in Appendix A. A copy of the background document distributed to interviewees is in Appendix B.

The Commissioner distributed a draft report for comment on 13 September 2005. Feedback was received from:

- the Rotorua Lakes Joint Strategy Committee
- the LakesWater Quality Society
- Professor David Hamilton, EBOP Chair of Lakes Management and Restoration, Waikato University
- Environment Bay of Plenty
- Dr Dell Hood, Medical Officer of Health, Waikato District Health Board
- Ministry for the Environment
- Dr Stewart Ledgard, AgResearch
- Department of Conservation, Bay of Plenty Conservancy
- Brian Bell, Nimmo-Bell & Company Ltd
- Ross Price, Senior Health Protection Officer, Toi Te Ora Public Health, Rotorua
- John Quinn, NIWA.

1.3 Overview of this document

The report begins with an overview of the Rotorua District and its economy, and then examines water quality in the lakes and nutrient sources. It reviews action under way to improve the water quality and presents feedback from interviewees on perceived gaps and areas where the PCE could add value. Finally it outlines the key issues identified by the exercise and discusses a way forward.

2 The Rotorua District

Over 600 years ago, the Te Arawa people moved inland from the Bay of Plenty coast and settled in the Rotorua area. Today, the district has a multi-cultural population of 67,800 including rural and lakeside communities and the city of Rotorua.

Environment Bay of Plenty (EBOP) is the regional council responsible for the lakes of the Rotorua District, and the Rotorua District Council (RDC) the responsible territorial authority. EBOP's website contains considerable information about the Rotorua Lakes.[4] Figure 2.1 provides a useful summary of their history and status.

Rotorua District has an estimated economic output of two billion dollars per year, based on 2002 data.[5] The largest contributors are:

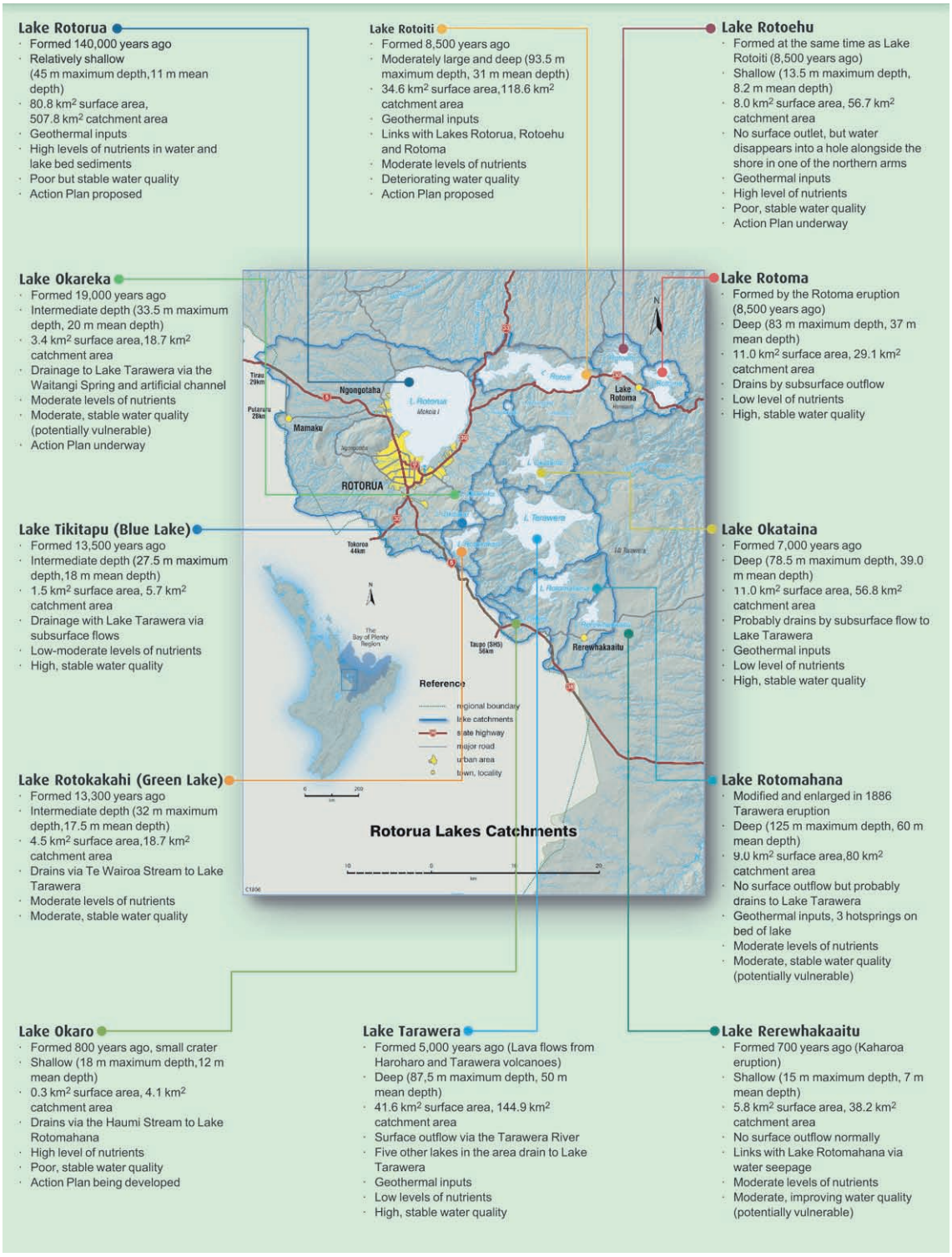
- tourism (around 11 percent)
- forestry (10.3 percent) and associated wood and paper processing (6 percent)
- agriculture (7.8 percent) and associated food processing (2 percent).[6]

Rotorua is one of New Zealand's main tourism centres, with many natural attractions including geothermal activity, forests, parks, and 14 freshwater lakes. Tourist activities include Maori cultural experiences, eco-tourism, trout fishing, and outdoor adventures.

Almost a third of all international visitors to New Zealand spend at least one night in Rotorua.[7] In 2003, Rotorua had 1.7 million day visitors and 1.5 million overnight visitors (totalling 4 million visitor nights).[8] Tourists spent $567 million in the district.

Nearly a quarter of the Rotorua District is in plantation forestry and around 45 percent is in pasture. The main agricultural activities in the district are dairy, beef, sheep and deer farming. Dairying accounts for almost three quarters of Rotorua's agricultural economic output.[9]

Figure 2.1 Lakes of the Rotorua District



Source: EBOP, 2004b.

3 Water quality in the Rotorua Lakes

Water quality in the Rotorua Lakes has been declining for at least 30 to 40 years due to increasing nutrient loads (particularly nitrogen and phosphorus). The resulting eutrophication and the increasing occurrence of toxic blue-green algal blooms in some lakes are of particular concern.

Eutrophication is the natural, very slow process of water body ageing. As nutrient levels increase, organic material accumulates, and the water body[10] gradually fills in.

Unfortunately, some human activities increase the rate of nutrient input into waterways and eutrophication happens much more quickly. Nutrient inputs from human activities include agricultural fertilisers, discharge from septic tank soak fields, and urban runoff.

Elevated nutrient levels over-stimulate algal growth, reducing water clarity and oxygen in the water. These conditions affect the health and diversity of fish, plant, and animal populations, limit recreational water use, and can have implications for public health.

High nutrient loads in some Rotorua Lakes have led to cyanobacterial blooms. Cyanobacteria (commonly known as blue-green algae) are photosynthetic, and need nitrogen and sunlight to grow and reproduce. Cyanobacteria occur as single cells or as colonies of cells. Unlike algae, some cyanobacteria can capture (or fix) atmospheric nitrogen (N_2) if there is not enough in the water. Given the right conditions, cyanobacteria can grow into colonies large enough to see – blooms – that are often visible in some of the Rotorua Lakes as a pea-green soupiness.[11] Some strains of cyanobacteria can poison humans and animals that drink or come in contact with affected water. Cyanobacterial toxins can attack various parts of the body, such as the liver or nervous system.

3.1 Nutrient sources

Nitrogen and phosphorus enter the Rotorua Lakes from a diverse range of sources including:

- farming (animal waste, fertiliser)
- erosion (both natural and accelerated by land disturbance)
- septic tank effluent
- stormwater
- community sewerage schemes
- rainfall

- springs
- geothermal sources
- internal loads from lakebed sediment.[12]

Table 3.1 presents annual nitrogen and phosphorus inputs for Lake Rotorua. Agricultural land use accounts for three quarters of the nitrogen and 46 percent of the phosphorus entering Lake Rotorua. Note that the Ohau Channel runs from Lake Rotorua into Lake Rotoiti, delivering 60 percent of Lake Rotoiti's nitrogen input and 51 percent of its phosphorus input.

Table 3.1 Annual nitrogen and phosphorus inputs for Lake Rotorua (October, 2004)

Nutrient source	Catchment area (hectares)	% cover	Nitrogen load (tonnes/ year)	%	Phosphorus load (tonnes/ year)	%
From land						
Native forest and scrub	10,588	23.9	42	5.5	1.3	3.3
Exotic forest	9,463	21.4	28	3.7	1.0	2.4
Cropping and horticulture	282	0.6	17	2.2	0.6	1.4
Pasture	20,112	45.4	573	75	18.1	45.7
Lifestyle blocks	556	1.3	11	1.5	0.5	1.3
Urban	3,267	7.4	50	6.6	3.8	9.6
Springs	-	-	-	-	13.0	32.8
Geothermal	-	-	42	5.5	1.4	3.5
Total	**44,268**	**100**	**763**	**100**	**39.7**	**100**
From sources other than land						
Rain	-		32		1.2	
Internal load	-		308		24.0	
Lake	8,079					
Total	**52,347**		**1,103**		**64.9**	
Wildfowl (recycling)			1.43		1.37	

Note: The phosphorus in springs is derived from the underlying geology and is not accounted for as a land use factor, whereas the nitrogen component is included as a land use output and appears in the other parts of the nutrient budget. Source: EBOP, 2004d.

As the table shows, nutrients enter Lake Rotorua from a number of sources. An increase in nutrient inputs from sewage contributed to a decline in Lake Rotorua's water quality in the 1980s. The lake's water quality improved after the diversion of sewage in the early 1990s, but has declined again since then as nitrate levels into the lake have increased.[13]

Much of the increase in nitrate load in recent years comes from streams that drain agricultural land.[14] From dairy farms, for example, cow urine and other waste that contains nutrients (particularly nitrogen) leach down through the soil into the groundwater. The groundwater eventually carries the nutrients into a stream, spring or lake. It can take years for such pollution to reach the waterways because the district's volcanic aquifers have a large groundwater storage capacity, and so groundwater can spend a long time in the aquifers.[15]

3.2 The lag time issue

The Institute of Geological and Nuclear Sciences (IGNS) recently assessed the time taken, or lag time, for nutrient enriched groundwater to move from pastoral land to springs, streams, and lakes in the Rotorua District.[16] Water from five springs and seven groundwater wells in the western Rotorua and northern Okareka lake catchments were age-dated. Eight of the 12 samples were considered to be relatively old, with mean residence times of over 60 years.[17]

The effect of *recent* land use intensification is not yet evident in these older samples, but is evident in the younger groundwater samples.[18] It is estimated that 94 percent of the nitrate in the young groundwater originates from land use in the catchment.[19] IGNS states that "dramatic increases in nutrient load are expected in the future for the large old water fractions" and that "the nitrogen concentration in [Lake Rotorua] is therefore expected to increase significantly".

The movement of nutrients into groundwater, streams and lakes is occurring at the catchment level, so it makes sense to tackle the issue at the catchment level, over the long-term (given the time scales discussed above). Rule 11 in EBOP's *Proposed Regional Water and Land Plan* takes a catchment approach around the issue of land use activities and related nutrient loss. (See Section 4.2 for further discussion of Rule 11.)

4 Action under way to improve water quality

Sections 4 and 5 of this report cover information obtained through interviews and discussions with stakeholders, and further research into relevant reports and scientific papers. The scoping process focused on three key questions:

1. What action is currently under way?
2. Are there any gaps not addressed by this action?
3. Where could the PCE add value and contribute to the environmental sustainability of the Rotorua Lakes?

The present section covers the first question – action currently under way. Section 5 covers the second and third questions, summarising the opinions of the stakeholders interviewed.

Much of the current activity aimed at improving the Rotorua Lakes' water quality has been extensively documented in reports by EBOP and others.[20] The key actions most directly affecting or likely to affect the Lakes are outlined in this section.

4.1 The Rotorua Lakes Protection and Restoration Programme

The 2000 report *Strategy for the lakes of the Rotorua district – Te kaupapa mo Nga Taonga o Rotorua: Protecting the jewels in the crown of the lakes of the Rotorua district*[21] sets out the overall management strategy for the Rotorua Lakes and their catchments. The vision, goals and tasks set out in the non-statutory strategy are summarised in Appendix C.

The strategy was adopted in 2002. A Joint Strategy Committee[22] made up of representatives from Te Arawa Maori Trust Board, EBOP and RDC was established to monitor implementation. The strategy and committee structure coordinates the efforts of these three agencies, and appears to be an effective cross-authority vehicle to progress action on the Lakes. A project coordinator has been appointed to manage implementation.

The 2004 report *The Rotorua Lakes Protection and Restoration Programme*[23] developed plans to deal with the Lakes' water quality problems. The cornerstone of implementation is the development of action plans for the various lakes. An action plan is activated when the trophic level index (TLI)[24] of a lake exceeds the target TLI by 0.2 for two years in a row, as set out in EBOP's *Proposed Regional Water and Land Plan*.

The Protection and Restoration Programme is set out in some detail in Appendix D, and Appendix E shows the timetable for management of the Lakes' water quality. Much of the activity is focused on managing nutrient input. Two technical advisory groups (TAGs) assist with evaluating and coordinating research. One TAG focuses on lake dynamics and the hydrological/water quality interface, the other on best land management practices and land use change options.

Progress with the action plans is as follows:[25]

- Lake Okareka:
  - action plan adopted 2004
  - first of three annual applications of Phoslock[26] applied on 15 August 2005
  - design and evaluation of an integrated sewage reticulation system for Lakes Okareka and Tikitapu almost complete and will be available to the community shortly
  - negotiations with landowners to assess land use change options to reduce nutrient inputs are ongoing.[27]
- Lake Okaro:
  - action plan operative in early 2006[28]
  - 2.3 hectare wetland opened February 2006
  - negotiations with landowners on riparian management and other initiatives are ongoing.[29]
- Lake Rotoehu:
  - action plan under development[30]
  - various treatment technologies are being trialled within the catchment including treatment boxes to decrease nitrogen loads
  - a detailed evaluation of a constructed wetland is under way.[31]
- Lakes Rotorua and Rotoiti:
  - action plan under development.

Urgent actions for Lakes Rotorua and Rotoiti include:

- the Ohau channel diversion (resource consents granted in November 2005, subject to conditions)
- reviewing stormwater management and the implementation of best management practices to reduce nutrient loads to the lakes
- upgrading Rotorua City's central sewage treatment plant to reduce nitrogen loading before it enters the forest irrigation system
- completing sewage reticulation of various communities around the lakes (Mourea and Okawa Bay are almost completed).[32]

4.2 RMA statutory plans

The *Proposed Regional Water and Land Plan* (notified October 2002) sets water quality goals (TLIs) for each lake. Rule 11[33] addresses the loss of nitrogen and phosphorus from land use activities in the catchments of Lakes Rotorua, Rotoiti, Rotoehu, Okaro and Okareka.[34] The rule includes a cap on increased nutrient loss from land use change/intensification. Nutrient leaching model NPLAS[35] will set a benchmark for each farm. The benchmark will be based on information relating to the three years from 1 July 2001 to 30 June 2004. Agricultural production could be increased if the environmental effects are avoided, remedied or mitigated.

The *Operative On-site Effluent Treatment Regional Plan* (1 December 1996), under review from January 2003, was notified in June 2004. The plan's goal is to reduce the impact of contaminants from on-site effluent treatment systems on the environment, including groundwater and the water margins of lakes, estuaries and shorelines within the region.

EBOP's draft Annual Plan for 2005/06[36] proposed allocating $3.2 million for technical investigation and coordination of Lakes work. It also budgeted $5.7 million to assist with capital work – specifically the diversion of the Ohau Channel.

Priorities for action in 2005/2006 include:

- overviewing and coordinating implementation of the Lakes Strategy and the Lakes Protection and Restoration Programme
- continuing to implement the Lake Okareka action plan
- completing the development of the Okaro and Rotoehu Lakes action plans
- continuing to develop the joint Rotorua/Rotoiti Lakes action plan
- implementing further short-term engineering options for the remediation of Lakes Rotorua and Rotoiti

- continuing to monitor the water quality and water levels of the Rotorua Lakes
- commencing the assessment of water quality status for the higher quality lakes
- considering financial assistance to district councils for the cost of small-scale sewage reticulation schemes that meet the evaluation criteria.[37]

However, as a result of the submission process, it now appears that EBOP has cut its overall proposed rate take for the next financial year by $1.2 million, mostly through deciding to borrow $1 million to put towards Rotorua Lakes restoration work rather than funding it from the general rates.[38] In its 2004–2014 long-term council community plan (LTCCP), EBOP budgeted $15 million over three years. However, in its new draft LTCCP it is reviewing the Lakes programme and considering the inclusion of $40 million above operational expenditure.[39]

Over the next 10 years RDC proposes to spend $98 million on new community sewerage schemes as well as a range of other initiatives that will benefit the Lakes. These initiatives include water conservation strategies and engineering expertise. A separate Lakes Enhancement Rate of $14.63 per annum will fund the public benefit component of lakeshore sewerage schemes.[40]

In January 1998, the Environment Court directed RDC to undertake a Variation to the Proposed Rotorua District Plan to take better account of the landscapes and natural features of the Rotorua Lakes environment. This resulted in Variation 12 covering Part 20 of the Proposed District Plan – the Lakes Zone A, which became operative on 9 December 2005.[41]

4.3 Ministry for the Environment

In 2003, the Ministry for the Environment (MfE) commissioned Australian consultant Dr Bruce Hamilton to provide advice on managing algal blooms and other symptoms of poor water quality in Lakes Rotoiti and Rotorua.[42]

In June 2004 the Government approved funding of $7.2 million to improve Lake Rotoiti's water quality. Of that, up to $4 million will contribute to urgent remedial engineering works, and $3.2 million will (subject to resource consent) address sewage disposal issues through the Ministry of Health's Sanitary Works Subsidy Scheme.[43]

MfE's Statement of Intent for 2005–2008[44] includes the outcome "Improve the quality and allocation of freshwater in New Zealand". The statement identifies water quality in Lakes Rotorua, Rotoiti and Taupo as a key focus for remedial work.[45]

4.4 Treaty settlement

In December 2004, Te Arawa and the Crown signed a Treaty settlement relating to the Rotorua Lakes. The Te Arawa Lakes Deed of Settlement is the final settlement of all Te Arawa's historical claims relating to 14 lakes, resulting from acts or omissions by the Crown before 21 September 1992, and any remaining annuity issues from after that date.

The settlement includes:

- an agreed historical account and Crown acknowledgements, which form the basis for a Crown apology to Te Arawa
- cultural redress, including the transfer of 13 lakebeds with public access protected
- financial and annuity redress.

No private land is involved in the redress, only Crown assets. Existing rights of public access remain. The benefits of the settlement will be available to all members of Te Arawa, wherever they live.[46]

In recognition of Te Arawa's traditional, historical, cultural, and spiritual association with the lakes covered by the settlement, title to 13 lakebeds will be returned to Te Arawa. The title includes the ownership of the lakebeds (including plants attached to the lakebeds) and subsoil (referred to as the Te Arawa stratum). However, the title specifically excludes the water column (the space occupied by the water) and airspace (referred to as the Crown stratum), which remain in Crown ownership.[47]

The Deed also provides for the settlement legislation to deem the Rotorua Lakes Strategy Group, currently known as the Rotorua Lakes Strategy Joint Committee, to be a joint committee under the Local Government Act 2002. The settlement legislation will provide for the Group's permanence, Te Arawa's membership as of right, and the Group's purpose, which is:

> *…to contribute to promoting the sustainable management of the Rotorua Lakes and their catchments for the use and enjoyment of present and future generations, while recognising and providing for the traditional relationship of Te Arawa with their ancestral lakes.*

4.5 Community initiatives

A key organisation in the community effort to protect and enhance the Rotorua Lakes is the LakesWater Quality Society (LWQS).

This group has been particularly influential through a series of symposia on:

- the research needs of the Rotorua Lakes (2001), which led to an increase in research on the Lakes and the endowment by Environment Bay of Plenty of a Chair in Lakes Management and Restoration at Waikato University
- lakeside communities and sewerage (2002), which brought together the work of RDC and EBOP on Lake Okareka and led to the start of an action plan for that lake
- practical management for good lake water quality (2003), which raised awareness of the need for integrated catchment management
- restoring lake health – nutrient targets and cyanobacteria (2004), which led to increased attention to the need to reduce phosphorus levels in the Lakes, with field scale trials now under way.

A further symposium was held in March 2006. The themes included economic issues related to the value of the Lakes, and methods for achieving fair sharing of funding.

LWQS makes special presentations to RDC and EBOP as well as submitting on annual plans and other processes. A major public awareness effort brought more pressure from the community on to the authorities. LWQS participates in the Action Plan committees and continues to encourage authorities to take speedy and effective action.[48]

The Rotorua Lakes and Land Trust[49] obtained funding from the Sustainable Management Fund (SMF) in 2004 for a community-led project to address the Rotorua Lakes' water quality. The goal of the Trust is "Better lake water quality and at the same time the best use of the land around the lakes". The project focuses on the Rotorua Lakes' catchments and seeks the cooperation of local authorities to integrate the best methods for sustainable land use and land management. Another facet of the project is understanding land users' capacity to change, while simultaneously restoring the health of the Rotorua Lakes. The project will work with local and regional authorities, research providers, non-government agencies, schools, iwi, and land incorporations. An independent facilitator will facilitate the short and long-term outcomes of the project.[50]

In 2004, Ngati Whakaue Tribal Lands Incorporated, supported by Te Arawa Federation of Maori Authorities, Rotorua-Taupo Federated Farmers and LWQS, obtained funding from the Sustainable Farming Fund for a project called *Practical mitigation options to reduce P and N loss from farms into Rotorua Lakes*. This project aims to define and field-test new management practices for sheep, beef, deer, and dairy farms in the Rotorua catchments that will reduce phosphorus and nitrogen loss while allowing increased profitability. Two case study farms will be measured to define spatial variability and develop risk maps for nutrient loss. Meetings with farmers to evaluate potential management practices will also be held.[51]

Vision Rotorua[52] is an independent 'think tank' initiated by the Rotorua Chamber of Commerce. It comprises a cross-section of interests including forestry, tourism, agriculture, retail, manufacturing, construction, education, health, Maori business, and professional services. The group can see many opportunities for the District and is concerned about a lack of progress in key areas. Vision Rotorua aims to identify issues and solutions to address them.

4.6 Research

Water quality in Lake Rotoiti has been the subject of research since 1955.[53] Scientific evidence of the gradual degradation of the lake's water quality has been available for more than 20 years.[54] More recently, the Rotorua Lakes Protection and Restoration Action Programme has set up or completed a range of research on the Rotorua Lakes and catchments. Most of this research is funded by EBOP, and links to several technical reports are available on their website.[55] EBOP's 2004 report *The Rotorua Lakes protection and restoration programme* provides an overview of Rotorua Lakes research and monitoring.[56]

EBOP's environmental scientists monitor lake water quality and calculate the Lakes' trophic level index (TLI) as part of its state of environment monitoring and its assessment of the Lakes' TLI targets.

In 2002, EBOP established a Chair in Lakes Management and Restoration at Waikato University. The chair is currently held by Professor David Hamilton, whose main research involves in-lake ecological (water quality) modelling of Lakes Rotoiti and Rotorua. EBOP also supports a number of students at Waikato University working on lakes research projects. In June 2005, the Foundation for Research Science and Technology (FRST) granted $10 million to Waikato University for research on lakes restoration over 10 years, focusing on the Rotorua Lakes.

EBOP has also contracted relevant research out to a number of agencies. For example:

- the National Institute of Water and Atmospheric Research Limited (NIWA) has been undertaking hydraulic modelling, complementing Professor Hamilton's work (particularly in relation to EBOP's planned Ohau Channel diversion wall)
- the Institute of Geological and Nuclear Sciences Limited (IGNS) has looked into groundwater age, time trends in water chemistry, and future nutrient load in Lakes Rotorua and Okareka (discussed in Section 3.2)
- Nimmo-Bell has been commissioned by EBOP to undertake a number of economic studies. An economic evaluation of the implications for land owners in the Lake Rotorua and Rotoiti catchments of various nitrogen output reduction scenarios found potential for "a considerable [financial] loss to land owners… associated with the various scenarios examined".[57] Another Nimmo-Bell study investigated the willingness of residents to pay for improved water quality.[58] Rotorua residents were more willing to pay than residents of the wider region, whilst Auckland anglers demonstrated the highest willingness to pay.[59]

In addition to this and other research, AgResearch is researching nitrogen and phosphorus loss from farms as part of a Sustainable Farming Fund project (discussed in Section 4.5). It has completed a report for EBOP titled *Land use impacts of nitrogen and phosphorus loss and management options for intervention.*

Te Arawa and NIWA are undertaking research in the Rotorua Lakes on the use of a traditional fishing method to monitor koura (freshwater crayfish) populations. The Te Arawa/Ngati Tuwharetoa tau koura method involves placing bundles of bracken fern on the lakebed to provide a refuge for koura, then retrieving the bundles. Monitoring trends in koura abundance can assist in resource management decisions such as determining sustainable harvesting levels.

The Rotorua Lakes and Land Trust has contracted the NZ Landcare Trust to develop a research action plan for the Rotorua Lakes' catchments. The research action plan will aim to support the uptake of research outputs/outcomes. It will focus on research into land use practices and strategies for minimising the effects of land use intensification on lake water quality.

Other research has focused on diverting spring flows, wetland construction, and alum dosing to precipitate phosphorus. For the last four years, the LakesWater Quality Society has held an annual symposium for scientists working on lakes research relevant to Rotorua (see Section 4.5).

5 Stakeholder feedback

This section summarises the information and opinions collected from stakeholder interviews. It does *not* represent the PCE's perspective, which may be different. The Commissioner thanks all the people interviewed for giving up their time and making such a valuable contribution to this scoping exercise.

5.1 Gaps identified by stakeholders

Stakeholder concerns were loosely grouped around six issues: resources and funding; central government; local government; research; the healthier lakes; and leadership. The main comments are summarised below.

5.1.1 Resources and funding

Stakeholders were concerned about resources and funding. Some felt that:

- more funding from central government is needed, including funding for resource consent applications
- there is an absence of a funding framework for work over the next few years (apart from sewerage work)
- EBOP may not be putting sufficient resources into, and priority on, project management
- more effort could go into harnessing volunteer energy more successfully.

5.1.2 Central government

There were requests for central government to contribute more funding and other resources. Some commented that:

- MfE is under-resourced in the lakes area
- ministerial call-in for quick decision-making is needed
- central government should provide more support, but is hard to engage with
- there is an apparent lack of interest from government.

5.1.3 Local government

On the issue of local government organisation, integration and management, some commented that:

- there is a lack of Mayor/Council CEO presence in Wellington to present the Rotorua Lakes' case to central government
- delay is creeping into EBOP's projects
- EBOP's economic analysis was inadequate
- RDC is slow to integrate its planning provisions with the Lakes Strategy and EBOP activity
- the important thing is *land use management*, and the split in responsibility for land management (RDC) and water management (EBOP) is seen as a fundamental problem.

5.1.4 Research

Concerns were raised about lakes research. Some felt that:

- a more strategic overview of FRST (Foundation for Research Science and Technology) funding investment decisions should be made
- the cut of $70m in FRST funding for farming-related research needed addressing
- there is a gap in ongoing funding for integrated catchment management (ICM) projects
- not enough funding for basic lakes research is available, and more research could be done on some of the other lakes
- the current funding system for research is flawed, and that:
  - since the loss of the Water Quality Centre in Taupo in 1992 there has been a major reduction in science capacity and serious funding issues, thus basic science is not being done and lakes research has been run down
  - scientists are required to spend too much time writing research proposals
  - there is little room for collaboration between scientists e.g. between the University of Waikato and NIWA

- the current state of lake health monitoring in New Zealand is inadequate, providing little or no capacity to examine ecological change or identify trends, and that regional councils need to undertake regular, monthly sampling, measuring the same parameters
- the content of research needed challenging – there are gaps and assumptions
- the Lakes Strategy relies too much on water quality outcomes – native species and ecosystems issues are overlooked
- phosphorus loss is an issue in Rotorua – knowledge of phosphorus loss from pumice soils is lacking
- more research on mitigation options is needed, e.g. the use of bark to pick up nutrients
- discussion is needed about what level of nitrogen is acceptable (that is, catchment specific nutrient standards).

5.1.5 The healthier lakes

There were some concerns expressed about the healthier lakes. Some felt that:

- preventive action for the healthier lakes is required, before they degrade
- it is not acceptable to let some of the lakes go (e.g. Lake Rotoehu) and focus on those in better health (e.g. Lake Tarawera)
- action plans should be under way for the healthier lakes.

5.1.6 Leadership

Around the issue of leadership, some felt that:

- more urgent action on the Lakes is needed
- there needs to be more discussion around leadership
- there is not enough local ownership of the issues
- think tanks are needed to work at the higher strategic level.

5.1.7 Other comments

- Because farming is an easily identifiable problem, farmers are an easy target in the search for solutions and the first to be blamed. There are other problems too, such as trout in the lake, and phosphorus from natural sources.
- There is a lack of discussion about taking the trout out of one of the lakes to improve the ecology, or removing the trout hatchery from the catchment.

- Consultation and liaison with iwi/hapu groups has been poor.
- Drinking water can be affected by cyanobacterial toxin, which cannot be removed using conventional particulate filtration. In fact the filtration process can rupture cyanobacteria cells and release any toxins that may be present. Unfortunately, testing for cyanobacterial toxin is slow, expensive, not widely available, and of little help in assessing risk unless measured regularly. Total cyanobacteria cell counts and species identification are used as a proxy measure of health risk while cell counts remain below a conservative minimum (rather than measuring cyanobacterial toxin present in the water). This is an imperfect measure of drinking water safety.
- The Nimmo-Bell work is valuable in *broad* terms, that is, looking at the relative differences of the costs of mitigation processes, rather than quoting exact figures. It may be of use to policy makers.
- It takes time for farmers to accept the impacts of farming and take action. The SMF-funded Lakes and Land Trust is useful for keeping up the momentum. It may be useful to research this process. The Taupo example of getting farmers on board should be regarded as good practice.

5.2 Adding value

Stakeholder ideas on where the PCE could add value were mainly in relation to the gaps identified above.

In relation to *resources and funding*, some felt the PCE could:

- assist in resolving funding issues e.g. central/regional government splits, funding for basic research on the in-lake issues.

In relation to *central government*, some commented that the PCE could:

- encourage central government to be more involved
- define the national interest in the Rotorua Lakes more clearly.

In relation to *local government*, some commented that the PCE could:

- encourage EBOP and RDC to work together more closely
- meet more regularly with the strategy committee
- review the EBOP strategy and priorities for action from a long-term perspective
- set up an independent framework for monitoring progress on implementation
- facilitate relationships between local and central government.

In relation to *research*, some felt that the PCE could:

- advocate for funding for long-term lakes science and monitoring
- investigate the wider issue of lakes management in New Zealand
- highlight the need for research on the impacts of forestry, urban and peri-urban land use on lakes water quality
- investigate practical redesign at the catchment level, linked with the 'redesign' promoted in *Growing for good* – what does it mean?
- back Ngati Whakaue in requiring discipline/value for money/outcomes from the Sustainable Farming Fund research
- clarify who the true beneficiaries of Lakes improvements are, who is responsible, who should pay, who is gaining from using the Lakes negatively and positively; and develop a methodology for cost/benefit analysis.

Other areas where stakeholders thought the PCE could add value included:

- exploring how landowners could connect with sustainable land management practices and incorporate them into their business; noting that home-grown efforts are very important in making these connections
- encouraging action plans for the healthier lakes (e.g. Lake Tarawera)
- validating the Lakes Strategy, to encourage the community to have more confidence in it.

A comment was also made that work on the Lakes Strategy needs to keep going and that a PCE investigation could hinder progress.

6 Key issues

The Joint Strategy Committee and the Rotorua Lakes Protection and Restoration Programme (see Section 4.1), are now investing considerable resources in protecting and restoring the Lakes. This positive implementation programme is undoubtedly a leading initiative in New Zealand. However, in synthesising the material from interviews and research, the investigation team identified a number of issues for the Rotorua region and the nation as a whole which require further attention:

- long-term catchment management and redesign of land use practices
- national lake health and monitoring issues
- keeping up the momentum
- research funding
- short-term engineering works
- the maintenance and protection of the healthier lakes.

6.1 Long-term catchment management

Rotorua District's economy and people are inextricably linked to its natural resource base. Farming and forestry need suitable soils and climate; tourism relies on clean lakes; and the local people want their waterways unpolluted. Unfortunately, nutrient input from land use activities, such as farming and urban and settlement living, contribute to the declining water quality in some of the district's lakes. Add all this up, and the picture is very complicated and large-scale (that is, catchment scale). The potential benefits of promoting integrated and sustainable management at the catchment level include healthier waterways and soils, improved biodiversity, and a greater resilience to the effects of climate change. Financial costs also need to be assessed and accounted for as part of the process.

Long-term land use change and redesign at the catchment level is required to address the sources of water quality problems in the Rotorua Lakes. The lake action plans will be influential in this regard. Most of the plans, with the exception of Lakes Okareka[60] and Okaro, are still under development (see Appendix F for more information about the Lake Okareka action plan). Rule 11 will also generate change as it is implemented (see Section 4.2 for explanation). Integrated catchment management (ICM) needs to encompass social, economic, cultural and environmental sustainability. The development of long-term council community plans (LTCCPs) by EBOP and RDC, as required under the Local Government Act 2002, may offer opportunity for the community to consider the ICM approach in this regard.

6.2 National lake health and monitoring issues

Some stakeholders expressed concern about the declining state of other lakes in New Zealand and the lack of monitoring and research to determine such trends. The Commissioner acknowledges that state of environment monitoring is generally weak around New Zealand.[61]

However, a newly established Reporting and Review work group has been set up within MfE to inform "the government and the national/international community of the progress being made towards an environment that New Zealanders expect and deserve and environmental data which should be taken into account in decision making".[62] The Commissioner would expect this group to address the issue.

6.3 Keeping up the momentum

The overall Lakes strategy is complex, interconnected, multi-layered and long-term, requiring integration between:

- statutory and non-statutory plans
- different agencies, e.g. EBOP, RDC and MfE
- different legislation, e.g. RMA and LGA
- iwi, community groups and NGOs.[63]

Some stakeholders are concerned about on-going delays with specific projects and whether sufficient resources are available to keep it all going over the long-term. The number of projects being driven by organisations other than the councils makes the picture even more complex.

Coordinating both local and national[64] initiatives will be challenging, especially as no single institution is responsible for ensuring the maximum benefits are achieved. There are elements of that coordination in the Joint Strategy Committee (see Section 4.1). However, the links between the formal institutional framework and community groups could be stronger. Funding is dependent on the ongoing commitment of councils, which may change over time. It is unclear whether the current institutional framework will be able to maintain the long view over several decades.

The current momentum needs to keep up until there are tangible improvements in the state of the environment, particularly water quality. This could take several decades.

At present, responsibility for monitoring implementation of the Rotorua Lakes Protection and Restoration Programme lies with the Joint Strategy Committee. The Lakes project coordinator reports regularly to the committee. Additionally, working parties set up to develop action plans for individual lakes continue to oversee implementation of those action plans. EBOP also reports annually on the water quality of the Rotorua Lakes.

Drawing on other initiatives that engage more formally with a wider group,[65] there is room for extending this monitoring framework. Keeping the Rotorua and Bay of Plenty communities engaged into the future will be important for keeping up the momentum. Communicating action and progress to the wider national community is also important to demonstrate and promote good practice.

6.4 Research funding

Several concerns were raised in some of the Rotorua interviews about the current research funding system, including:

- a decline in lakes research in New Zealand since the closure of the Water Quality Centre in Taupo in 1992
- the excessive time it takes to prepare research funding proposals
- the lack of room for collaboration, e.g. between the University of Waikato and NIWA, due to the fully contestable nature of New Zealand's public good science funding system.

Similar concerns about the fully contestable nature of New Zealand's public good science funding system were identified in the PCE report *Missing links: Connecting science with environmental policy* (2004). Concerns included:

- the potential loss of cooperation between researchers forced to compete for funds
- uncertainty among scientists and researchers about longer-term employment prospects if their bid fails.[66]

In September 2003 a group of scientists wrote an open letter to the Minister of Research, Science and Technology expressing concern about changes to the structure and role of research institutes and the nature of funding since the 1992 science reforms. They felt that these fundamental changes were jeopardising New Zealand's long-term core research capability. More than 700 respondents signed this letter, and 271 provided further comment. These comments were summarised and presented to the Minister in October 2004.[67]

In 2005, the Minister outlined his view of the future for New Zealand science and technology. This vision included:

- devolving an increased portion of public good science funding to research organisations, thus placing greater trust in them to make decisions on the research undertaken
- providing enhanced opportunities for collaboration.[68]

6.5 Short-term engineering works

Some of the projects currently under way can be described as short-term engineering works aimed at reducing the flow of nitrogen and phosphorus into various lakes. The most significant is diverting water from the Ohau Channel away from Lake Rotoiti and into the Kaituna River.[69] Detailed modelling indicates that over 70 percent of Lake Rotoiti's nutrients come through the Ohau Channel from Lake Rotorua, and it is hoped that the diversion will have an immediate positive effect.

Such major engineering interventions in ecosystems can have unexpected environmental outcomes. Their implementation requires careful planning, management and monitoring. Both the short-term and long-term effects of the Ohau Channel diversion on Lake Rotoiti and the Kaituna River are uncertain. EBOP and RDC granted resource consents to EBOP (Operations Group)[70] in October 2005, subject to a suite of conditions.[71] The project is part of a short-term intervention phase (1–3 years), which will be followed by long-term catchment management measures (3+ years).

6.6 The healthier lakes

Lakes Rotorua, Rotoiti, Okareka, Okaro, and Rotoehu all have trophic level index values worse than the targets set out in the Proposed Regional Water and Land Plan. These lakes are subject to the development of action plans, from which further activity follows (see Table 6.1).

With the exception of Lakes Tikitapu and Okataina, monitoring indicates no change in water quality in the other lakes (Table 6.1). However, in December 2005 EBOP announced that it would bring five more lakes under the Rotorua Lakes Protection and Restoration Programme from 2006.[72] These lakes are Tarawera, Rotoma, Tikitapu, Okataina and Rotokakahi.

Some stakeholders believe that action should be taken now to ensure that the healthier lakes are protected from the conditions that cause water degradation. Other stakeholders argue that the work now under way on the degraded lakes will provide lessons and knowledge that can readily be transferred if necessary.

Table 6.1 Long-term trends and three-yearly average trophic level index (TLI) values for the Rotorua Lakes in comparison to the TLI values set in the Regional Water and Land Plan

Lake	3-yearly average TLI to 2002 (TLI units)	3-yearly average TLI to 2003 (TLI units)	3-yearly average TLI to 2004 (TLI units)	***Regional Water & Land Plan (TLI units)***	Long-term trend (In terms of TLI units over analysis period)	Lake type based on trophic level[73]
Okaro	-	5.5*	5.5*	***5.0***	Degraded but definite improvement	Supertrophic
Rotorua	4.8	4.9	4.9	***4.2˜***	Degraded No change	Eutrophic
Rotoehu	4.7	4.7	4.6	***3.9´***	Degraded No change	Eutrophic
Rotoiti	4.0*	4.3*	4.3	***3.5˜***	Definite degradation	Eutrophic
Okareka	3.2	3.2	3.3	***3.0ˆ***	No change	Mesotrophic
Tikitapu	3.0*	3.1*	3.2	***2.7ˆ***	Probable degradation	Oligotrophic
Okataina	2.8*	3.0*	3.0	***2.6ˆ***	Possible degradation	Oligotrophic
Tarawera	2.8*	2.9*	2.9	***2.6ˆ***	No change	Oligotrophic
Rotoma	-	2.5*	2.6	***2.3ˆ***	No change	Oligotrophic
Rerewhakaaitu	3.4*	3.4	3.4	***3.6ˆ***	No change	Mesotrophic
Rotomahana	-	3.6*	3.7	***3.9ˆ***	Possible improvement	Mesotrophic
Rotokakahi	-	-	-	***3.1***	-	Mesotrophic

* 2-year average (Rotokakahi has not been monitored in the last 3 years)

ˆ Based on 1994 data

´ Based on 1993 data

˜ Based on 1960 data

Source: EBOP, 2004c.

7 Moving forward

7.1 Keeping up the momentum

Of the six key issues identified in the previous section, the Commissioner feels that *keeping up the momentum* is the issue where further work would be of most benefit to the Rotorua Lakes. Maintaining and improving the health of the Rotorua Lakes is a goal that will require ongoing commitment over decades rather than years. With an extensive range of projects started over the last 2–3 years, the key challenge now is to keep the programme going.

7.1.1 Strengthening the institutional framework

As noted in Section 6.3, an important aspect of keeping up the momentum is an institutional framework able to maintain the long view over several decades. Elements of the framework are in place through the Joint Strategy Committee. However, the links between the formal institutional framework and community groups could be stronger.

The Joint Strategy Committee could consider formally including representatives from independent community groups (subject to clarification from Te Arawa that inclusion does not cut across the provisions of the Te Arawa Lakes Treaty Settlement).

The Fraser Basin Council in Canada is an example of a strengthened institutional framework.[74] This council brings together the various levels of Canadian Government, the private sector, and the community, to create an "organisation that is focused on advancing sustainability throughout the entire Fraser River Basin".[75] It has played a key leadership role in helping to resolve conflicts, educate the public about sustainability, and advance sustainability throughout the Fraser River Basin.

These ideas are part of a developing approach to government that is "both bottom-up, reflecting the issues that matter to the community, and top-down, demonstrating the willingness of the government to lead on difficult community issues".[76]

7.1.2 Developing a report card

Another aspect of keeping up momentum is getting and holding community commitment. Broadening the existing monitoring and reporting framework to communicate information about progress more effectively should help this process.

EBOP produces a water quality monitoring report, but this reflects only a part of the activity going on. Producing a regular publication to present the big picture for the local, regional and national community would be useful. The Commissioner calls this a 'report card'.

The basic elements of a report card could include:

- a set of sustainability indicators covering fresh water quality,[77] the land/water interface, and economic, social and cultural factors
- institutional action to support and fund the Rotorua Lakes Protection and Restoration Programme
- progress on implementation of the Rotorua Lakes Protection and Restoration Programme[78]
- progress on action plans for the various lakes
- progress with the Te Arawa Lakes Settlement and the involvement of Te Arawa in ongoing activity
- progress on and outcomes from projects carried out by other agencies and groups
- integration of community actions with the overall programme
- community satisfaction with the programme and its involvement.

7.2 Other key issues

The remaining key issues are:

- *Research funding*: Scientists are concerned that fundamental changes to the structure and role of research institutes and the nature of funding since the science reforms of the early 1990s are jeopardising New Zealand's long-term core research capability. There may be future opportunity for the PCE to investigate research funding issues.
- *National lake health and monitoring issues*: The issue of monitoring the state of New Zealand's environment is pertinent, amid concerns of declining water quality in lakes across the country. As mentioned in Section 6.2, the newly established MfE Reporting and Review work group is expected to address the national issues related to monitoring lake health.
- It may also be appropriate in the future for the PCE to explore what integrated catchment management, redesign for farming or other alternative approaches might encompass in the context of a 'real' situation, drawing on the PCE's 2004 report *Growing for good*.

7.3 Where to from here?

In order to build on the excellent progress made so far, the Commissioner recommends to the Joint Strategy Committee that it:

1. Consider expanding its membership to include representatives drawn from the wider community
2. Develop a sustainability report card on progress with the Rotorua Lakes Protection and Restoration Programme

The Commissioner will consider undertaking investigations into:

1. Research funding issues
2. Integrated catchment management
3. National issues associated with lake management

The Commissioner will consider these projects alongside other proposals during the annual planning process, when it is decided which investigations will go ahead.

Glossary

Eutrophic	Eutrophic lakes have a high concentration of nutrients. This results in high algal biomass that gives poor water clarity.[79]
Mesotrophic	The water quality of mesotrophic lakes is intermediate between oligotrophic and eutrophic lakes.[80]
Oligotrophic	Oligotrophic lakes have a low concentration of nutrients. This results in low algal biomass and high water clarity.[81]
Secchi disc	A device for measuring visual clarity.
Supertrophic	Supertrophic lakes are fertile and saturated in phosphorus and nitrogen, often associated with poor water clarity.[82]
Trophic level index (TLI)	An indicator of the environmental quality of a lake. It is comprised of four variables – total P, total N, chlorophyll *a*, and secchi disc depth.

Acronyms

EBOP	Environment Bay of Plenty
FRST	Foundation for Research Science and Technology
ICM	Integrated catchment management
IGNS	Institute of Geological and Nuclear Sciences Limited
LGA	Local Government Act 2004
LTCCP	Long Term Council Community Plan
LWQS	LakesWater Quality Society
MfE	Ministry for the Environment
NGO	Non-governmental organisation
NIWA	National Institute of Water and Atmospheric Research Limited
PCE	Parliamentary Commissioner for the Environment
RDC	Rotorua District Council
RMA	Resource Management Act 1991
SMF	Sustainable Management Fund
TAG	Technical advisory group
TLI	Trophic Level Index

Endnotes

1 Millennium Ecosystem Assessment, 2005.

2 MAF, 1993.

3 *ibid*. A catchment is a natural drainage area bounded by natural features such as hills, in which water flows to the lowest point.

4 See EBOP's website for further information: http://www.ebop.govt.nz/Water/Lakes/Lakes.asp [Accessed 17 May 2005].

5 APR Consultants, 2005.

6 *ibid*.

7 APR Consultants, 2005.

8 Which equates to an average length of stay of 2.67 nights.

9 *ibid*.

10 Such as lake, slow moving stream, or estuary.

11 Cyanobacteria visibility depends on the strain – the dominant cyanobacterial species in Lake Rotoiti over the 2004/05 summer, *Aphanocapsula holsatica*, caused less water discolouration than cyanobacterial species present in other years.

12 The following excerpt explains about internal nutrient loads (EBOP, 2004b: 16): *…when the water is well oxygenated there is a net loss of nutrients to the [lakebed] sediment. When lakes stratify, dead algal cells and other organic material falling into the bottom waters depletes the oxygen due to the decomposition process. No replenishment of oxygen is possible from the atmosphere. As the bottom waters run out of oxygen the chemistry of the sediment surface is changed and nitrogen and phosphorus are released from the sediment into the water. The nutrients are trapped in the bottom water until the lake mixes vertically. With a flush of nutrients algal production is enhanced if other environmental or climatic factors favour this after mixing.*

13 Note that a direct relationship between the diversion of sewage from Lake Rotorua and an improvement in water quality is difficult to discern, and is thus not necessarily the causal factor. It is likely that the changes in water quality after the sewage diversion were part of a natural cycle in phytoplankton biomass, the causes of which have still to be fully clarified (Professor David Hamilton, feedback received 17 October 2005).

14 *ibid*.

15 IGNS, 2004.

16 *ibid*.

17 It is important to note that it is a *mean* residence time. For example in a sample with a mean residence time of 73 years, 30 percent of that sample contained water that was less than 40 years old (which is considered to be relatively young). Similarly, a proportion of the water in the sample is older than 73 years.

18 Increases in nitrate, potassium and sulphate in groundwater were all considered to be indicators of land use intensification.

19 "The natural background level of nitrate (before land use intensification) is assessed to be 0.15 mg/L, and the current recharge level to be 2.7 mg/L." (IGNS, 2004)

20 See, for example, http://www.ebop.govt.nz/Water/Lakes/Lakes.asp [Accessed 11 May 2005].

21 Te Arawa Maori Trust Board, EBOP & RDC, 2000.

22 To be replaced by a new strategy group when the Te Arawa Lakes Settlement comes into effect – see Section 4.4.

23 EBOP, 2004b.

24 Trophic level index (TLI) is an indicator of the environmental quality of a lake. It is comprised of four variables – total P, total N, chlorophyll *a*, and secchi disc.

25 http://www.ebop.govt.nz/Water/Lakes/Lake-Action.asp

26 Phoslock is a modified clay that irreversibly absorbs phosphorus in almost all natural situations. It was developed by the Western Australian Department of the Environment and CSIRO (Hamilton, 2003).

27 Joint Strategy Committee feedback, 17 October 2005.

28 EBOP, 2003b.

29 Joint Strategy Committee feedback, 17 October 2005.

30 EBOP, 2003a.

31 Joint Strategy Committee feedback, 17 October 2005.

32 Joint Strategy Committee feedback, 17 October 2005.

33 Rule 11 is comprised of Rules 11A, 11B, 11C, 11D and 11E. It is now operative with all appeals settled.

34 http://www.ebop.govt.nz/water/media/pdf/Lakes_Rule_11_v2.pdf [Accessed 23 May 2005].

35 Nitrogen, Phosphorus Load Assessment System – developed by NIWA.

36 EBOP, 2005a.

37 EBOP, 2005a: 53.

38 http://www.ebop.govt.nz/publications/media/050617-rate-ac.doc [Accessed 14 July 2005].

39 Joint Strategy Committee feedback, 17 October 2005.

40 RDC, 2005.

41 RDC press release 14 November 2005.

42 Hamilton, 2003.

43 http://www.mfe.govt.nz/issues/water/rotorua-lakes/index.html [Accessed 10 May 2005].

44 http://www.mfe.govt.nz/publications/about/soi/2005/html/index.html [Accessed 27 May 2005].

45 http://www.mfe.govt.nz/publications/about/soi/2005/html/part1/4ministry-outcomes.html [Accessed 27 May 2005].

46 Office of Treaty Settlements, 2004.

47 *ibid*.

48 LakesWater Quality Society feedback, October 2005.

49 The trust is made up of Te Arawa Federation of Maori Authorities, Rotorua-Taupo Federated Farmers and the LakesWater Quality Society.

50 SMF project 3060 http://www.smf.govt.nz/projects/summary.php?series=3000 [Accessed 9 May 2005].

51 Sustainable Farming Fund Project 04/091 http://www.maf.govt.nz/sff/about-projects/successful-projects-2004-over-10k.htm [Accessed 9 May 2005].

52 http://www.visionrotorua.co.nz/ [Accessed 10 May 2005].

53 For a bibliography of Rotorua Lakes water quality research undertaken see: http://www.ebop.govt.nz/media/doc/rotorua_lakes_water_quality_research_bibliography.doc

54 See, for example, Vincent *et al*., 1984.

55 http://www.ebop.govt.nz/Water/Lakes/Technical-Reports.asp [Accessed 13 May 2005] and http://www.ebop.govt.nz/Water/Lakes/Lakes.asp [Accessed 13 May 2005].

56 EBOP, 2004b: pp14-22.

57 Nimmo-Bell, 2004a:3.

58 Nimmo-Bell, 2004b.

59 *ibid*.

60 See the completed action plan for Lake Okareka: http://www.ebop.govt.nz/media/pdf/locmap-final_1.pdf [Accessed 30 May 2005].

61 PCE, 2004a; PCE, 2004b.

62 http://www.mfe.govt.nz/about/workgroups.html [Accessed 6 May 2005].

63 See Appendices 1 and 2 for more information.

64 The Water Programme of Action led by MfE.

65 For example, the Fraser Basin Council, Canada, http://www.fraserbasin.bc.ca/index.html

66 PCE, 2004b.

67 *Open letter to the Minister of Research, Science and Technology, October 24 2004*. http://www.psa.org.nz/library/psa/general/open_letter_submission.pdf [Accessed 14 July 2005].

68 http://www.rsnz.org/news/policy/papers/maharey.php [Accessed 16 August 2005].

69 http://www.ebop.govt.nz/Water/Lakes/Ohau-Channel-Diversion.asp [Accessed 16 May 2005] and EBOP, 2005b.

70 Resource consent applications have been prepared and lodged (4 July 2005) with both the Rotorua District Council and Environment Bay of Plenty. The proposed structure requires five resource consents: two from the district council and three from the regional council. Decisions granting the consents were released in November 2005.

71 Joint Hearings Committee report on the Ohau Channel Flow Diversion Structure 31 October 2005.

72 *More lakes to go under protection programme* [EBOP press release dated 5 December 2005].

73 See Glossary for definitions.

74 http://www.fraserbasin.bc.ca/index.html [Accessed 17 November 2005].

75 http://www.fraserbasin.bc.ca/index.html [Accessed 17 November 2005].

76 Moran, 2005:11.

77 EBOP, 2004c.

78 EBOP, 2004b.

79 LakesWater Quality Society Inc. 2004. *Rotorua Lakes 2004: Restoring lake health – Nutrient targets and cyanobacteria*. 16-17 September 2004. Park Heritage Hotel, Rotorua.

80 *ibid*.

81 *ibid*.

82 *ibid*.

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Appendix A: People interviewed for this report

Dr Stewart Ledgard	AgResearch Ruakura
Simon Smale David Marshall Kim Young	Department of Conservation
Paul Dell John MacIntosh	Environment Bay of Plenty
Dr David Hamilton	Environment Bay of Plenty Chair, Lakes Management and Restoration, University of Waikato
Jamie Paterson and others	Federated Farmers of New Zealand Inc
Steve Smith Rob Pitkethley	Fish & Game New Zealand
Kevin Winters, Mayor, Rotorua District Council Peter Guerin, CEO, Rotorua District Council John Cronin, Chairman, EBOP Paul Dell, Group Manager Regulation & Resource Management, EBOP Anaru Rangiheuea, Chairman, Te Arawa Maori Trust Board Roku Mihinui, GM, Te Arawa Maori Trust Board	Joint Strategy Committee, Rotorua Lakes Protection and Restoration Programme
Ian Maclean and others	LakesWater Quality Society
Dr Dell Hood Dr Phil Shoemack Ross Price	Medical Officer of Health, Waikato Medical Officer of Health, BOP Toi Te Ora Public Health
Sue Powell Tim Bennetts	Ministry for the Environment
Rick Vallance	Ngati Whakaue Tribal Lands Inc
Brian Bell Michael Yap	Nimmo-Bell & Company Limited
David Roper Kit Rutherford John Quinn	NIWA Hamilton
Don Morrison Dr Nick Edgar	NZ Landcare Trust
Greg Manzano	Rotorua District Council
Melanie Schauer	Rotorua Lakes Project Manager
Councillor Mike McVicker Councillor Cliff Lee	Rotorua Lakes Protection Society

Appendix B: Project information

Possible PCE investigation into the environmental sustainability of the Rotorua Lakes

February 2005

Introduction

Since 2003 the PCE has been monitoring the initiatives of central and local government agencies with respect to the Rotorua Lakes' water quality. Algal blooms in Okawa Bay, Lake Rotoiti and the requests of people in the Rotorua community prompted this focus. A commitment was made to investigate more thoroughly when resources became available.

Scope

At this stage, *only* scoping is being carried out. The intention is to gather sufficient information about the issues to determine the need for and focus of any further investigation. Should the need be established, terms of reference and a detailed project plan will be prepared.

Scoping will be carried out pursuant to section 16(1)(b) of the Environment Act 1986. The purpose is to assess the effectiveness of environmental planning and management carried out in relation to the environmental sustainability of the Rotorua Lakes.

We will consider the contributions to deterioration in water quality in the Rotorua Lakes and how the issues are being addressed. The investigation will cover, amongst other things:

- the current state of technical knowledge and scientific research
- the local economy and the relative value of the Lakes in their various roles, for example, as amenity and recreational resources, and as sewage and farm effluent receiving waters
- current and future land use in the major catchments
- governance and legislative arrangements and the regulatory environment
- the roles of the agencies involved
- the values placed on the Lakes by tangata whenua and stakeholders.

Project information can be found on the PCE website, http://www.pce.govt.nz/citizens/pce_citizens_new.shtml.

Timing

This scoping work is programmed to run to the end of June 2005. Broad stages include:

Interviews, site visits, and consultation	March
Research and identify investigation options	April/May
Decision on need for investigation	June

For further information contact the project team:

Philippa Richardson (project leader) Ph 495-8352, Philippa@pce.govt.nz

Kathryn Botherway

Iain McAuley

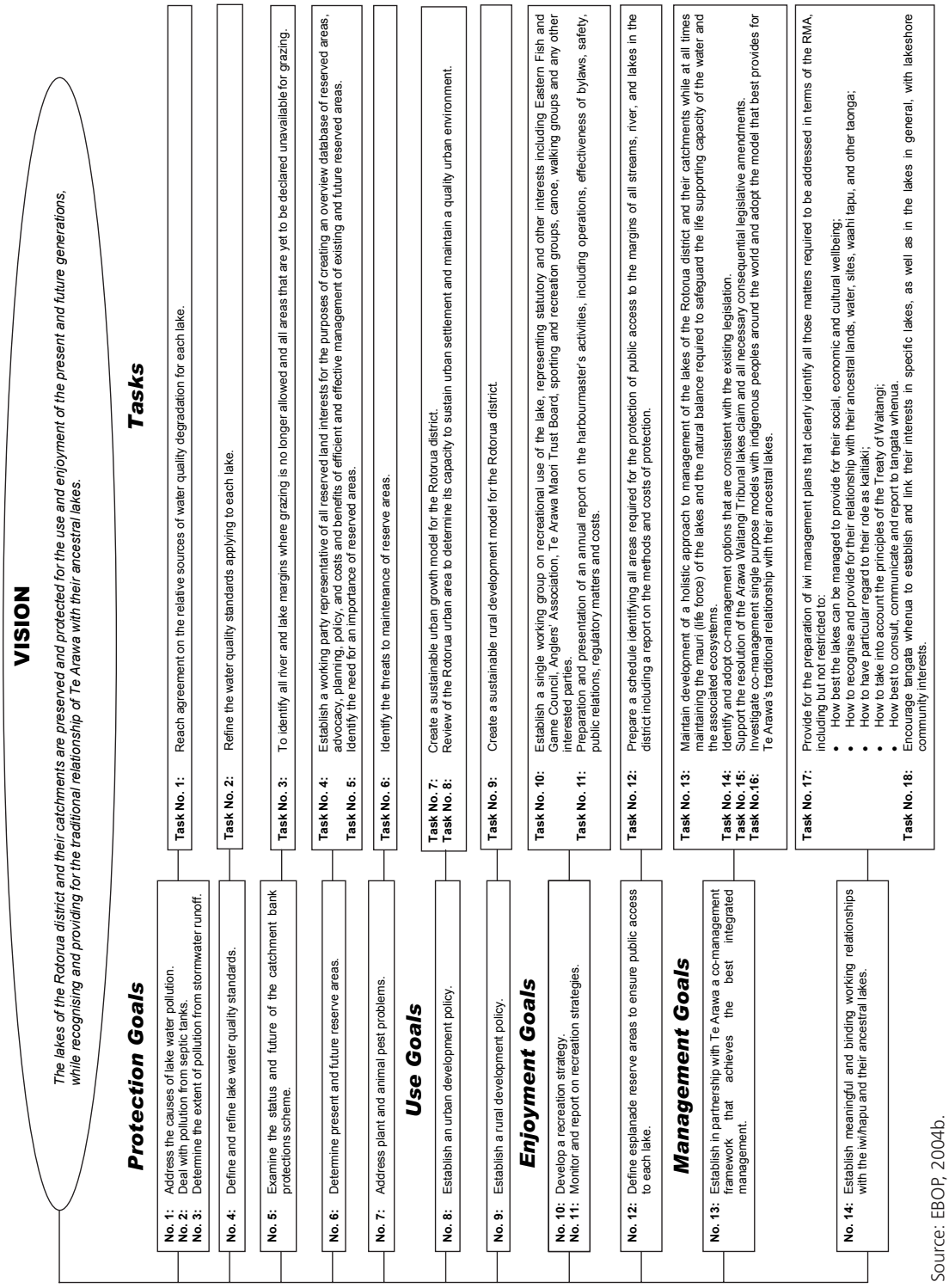
Theresa Cooper

Key issues and questions

The key issues and questions that scoping will explore include:

- What action is currently under way?
- Are there any gaps not addressed by current activity?
- Where could the PCE add value and contribute to the environmental sustainability of the Rotorua Lakes?

Appendix C: The visions, goals and tasks of the Strategy for the Lakes of the Rotorua District



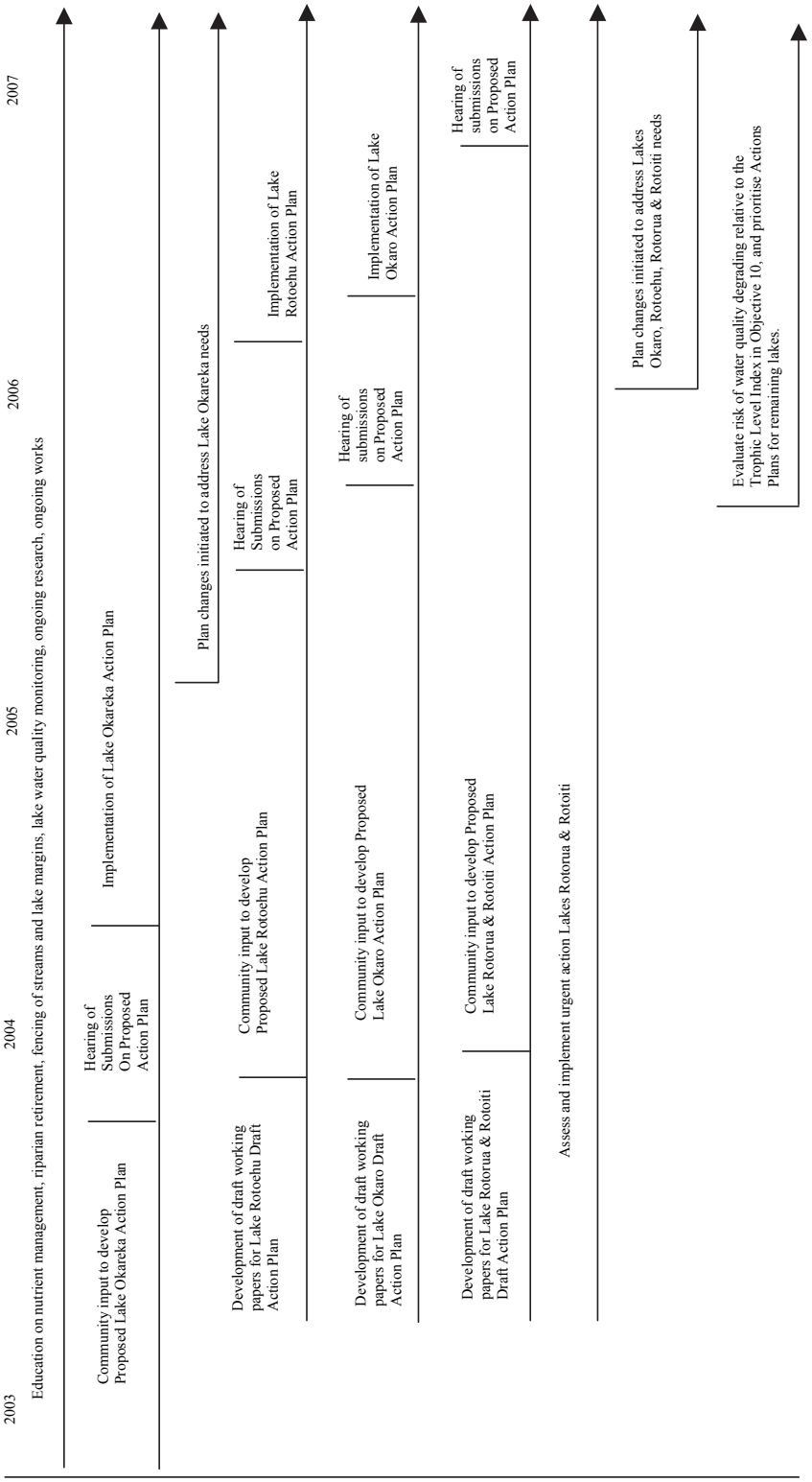
Source: EBOP, 2004b.

Appendix D: Rotorua Lakes Protection and Restoration Action Programme

Completed research and monitoring	Ongoing research and monitoring	Action plans	Funding	Works	Best management practices	Education and communication	Regulations
See Chapter 3 in EBOP, 2004b	• Chair in Lakes Management & Restoration - In lake modelling - Student research • Contract research - NPLAS - Nutrient assessments - Nutrient reduction targets - Treatment wall trial - Wetland design & trial - Groundwater flow and age assessment - Flocullation trials • Water quality monitoring • Algal monitoring • Pollen assessment • Lake level impacts	• Statutory - Okareka - Rotoehu - Okaro - Rotorua/Rotoiti • Future - Rerewhakaaitu - Tarawera - Rotoma - Okataina - Tikitapu - Rotokakahi - Rotomahana	• Policy review - EBOP policy - RDC policy • Economic assessment - Financial incentives - Land purchase - Entitlement • Funding sources - Goverment - Regional - District - Landowners	• Sewage treatment • Riparian management/ fencing • Treatment walls • Wetlands treatment • Flocculation • Change in land-use • Engineering options - Aeration/ oxygenation - Diversion - Stormwater design - Dredging - Syphon (hypolimnetic discharge)	• On site effluent treatment systems • Pasture nutrient management - Animals - Fertiliser - Effluent - Nitrogen inhibitors • Urban stormwater maintenance • Domestic nutrient management • Wildlife management	• Communication strategy • Fact sheets - Lake quality - Land processes - Lake algae - Wetlands - Monitoring/TLI - Farm nutrient assessment - Effluent management • Lakes education resource kit • Booklet *Living near lakes*	• Regional Water & Land Plan & changes - TLI - Stock in waterways - Nutrient rules - Action plans • District Plan & changes • On site effluent treatment plan review • Consents • Consent compliance

Source: EBOP, 2004b.

Appendix E: Lake water quality management timetable (indicative only)



Source: EBOP, 2004b.

Appendix F: Identified actions in Lake Okareka Catchment Management Action Plan

Identified action	Agency	Section reference
Proceed with urgency with a fully reticulated sewage scheme within the Lake Okareka catchment that makes provision for limited additional dwellings within the catchment and amenities at Lake Tikitapu.	RDC	1
Proceed to establish wetlands, pending the outcome of consultation, investigations and the granting of any resource consents required.	EBOP	1
Discuss with individual rural landowners best practice options for land use management to control and reduce the nutrient load to the lake.	EBOP & RDC	1
Make provision for land use changes in the Lake Okareka catchment, including: regional and district plan changes; consultation and negotiation with landowners on an individual or collective basis; investigation of a regional park concept.	EBOP & RDC	1
Continue to evaluate engineering and treatment options, including but not limited to, the hypolimnetic discharge.	EBOP	1
Implement a monitoring programme to assess the ongoing nutrient load status within the catchment and the effectiveness of individual actions, and report the results back to the LOCMAP working party and the community.	EBOP	1
LOCMAP to assist in lobbying local Ministers of Parliament, the Minister for the Environment and central government for assistance to ensure that the recommendations contained in the action plan are actioned as soon as possible.	RLJSC	2.5.7
LOCMAP to be included as part of briefing papers to Cabinet.	RLJSC	2.5.7
Integrate LOCMAP provisions into Long Term Council Community Plans.	RDC & EBOP	2.5.7
Evaluate the addition of sewered facilities at popular walkways, reserves and boat ramps in the Lake Okareka catchment.	RDC & EBOP	3.3.1
A 50% subsidy for the scheme to be sought from the Ministry of Health for the Okareka sewerage scheme	RDC	3.9
Public education is to play an important role in the establishment of wetlands around Lake Okareka.	EBOP	4.1.4
Identify further sites for potential wetlands in the Lake Okareka catchment.	EBOP	4.3.1
Investigate the enhancement of lake-edge reed and wetland areas around Okareka.	EBOP	4.3.2
Give attention to using wetland areas to help treat stormwater flows from the Okareka settlement.	EBOP & RDC	4.3.2
Negotiate fencing and revegetation of the Lake Okareka outlet channel and nearby lake margins with landowner.	EBOP	4.3.3
Consult with landowners, wider community, and relevant organisations about wetland sites, designs and maintenance.	EBOP	4.5
Discuss options to avoid, remedy or mitigate the adverse effects of private jetty access to the lake through lake edge reed beds and wetlands.	EBOP, RDC & OKR	4.7.4

Identified action	Agency	Section reference
Inform landowners in the Lake Okareka catchment about new farming practices and products that improve lake water quality as they become available.	EBOP	5.1.3
Discuss the relevance and effectiveness of section 9.4 of the Regional Water and Land Plan and possible changes with the LOCMAP working party, landowners and the wider community.	EBOP	5.4.2
Update and distribute the *Living near Lakes* booklet.	LWQS & EBOP	5.6.2
Review provisions in the Regional Air Plan to address the effects of aerial topdressing of fertiliser within the Rotorua Lakes catchments, especially near the lakes themselves.	EBOP	5.7.2
Consider facilitation of an Okareka large landowner group to collectively discuss land use changes that are reasonable to all parties.	EBOP & RDC	6.2.2
Trial a treatment wall beside Lake Rerewhakaaitu, and consider its applicability to improve the water quality of Lake Okareka.	EBOP	7.1.2
Assess the hypolimnetic discharge and decide whether or not to proceed with the proposal.	EBOP	7.2.3
Evaluate the use of biomanipulation as a tool to improve the water quality of Lake Okareka.	EBOP	8.1.5
A long-term strategy for lake weed and pest fish management is to be presented to the RLJSC for integration into overall lake management.	EBOP	8.2.1
Undertake surveillance and destruction of koi carp or catfish if they are found in Lake Okareka.	EBOP & DOC	8.2.1
Review Okareka's stormwater infrastructure to identify areas where swales, grass strips, wetlands or other filtering systems could be put in place to reduce nutrients and improve the quality of stormwater entering Lake Okareka.	RDC	8.3.2

Key

LOCMAP	Lake Okareka Catchment Management Action Plan
EBOP	Environment Bay of Plenty
RDC	Rotorua District Council
TAMTB	Te Arawa Maori Trust Board
RLJSC	Rotorua Lakes Joint Strategy Committee
DOC	Department of Conservation
LWQS	LakesWater Quality Society
OKR	Okareka residents

Source: EBOP, 2004a: 51.