

Title: LakesWater Quality Society and the Restoration of the Rotorua Lakes

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Key concepts

- Complacency: Water-quality in the 12 exciting Rotorua Lakes in NZ was degrading because of human activities in the catchments. Authorities and the community were complacent, believing that effective action was unnecessary or was impossible.
- Science and persuasion: A local voluntary community group - the LakesWater Quality Society - initiated action by first stimulating and then disseminating good science. Symposia to educate and inform, with world leaders as keynote speakers, proved an effective tool.
- Major works: Major expensive programmes were needed in the lake catchments to reduce nutrient outflows. These have greatly improved some lakes and are underway or planned with most others.
- Success: Lakes can be restored, and a few dedicated and effective people in the community can initiate the restoration.

Author summary

Although water quality in the Rotorua Lakes was degrading no action was being taken because leading scientists had false confidence and the authorities were complacent. A local environmental group was reinvigorated as the LakesWater Quality Society (LWQS) and initiated action. Good science describing what was happening in the lakes was the first need. LWQS ran 8 symposia over 12 years to stimulate and disseminate scientific knowledge and ideas. With hard work and focus LWQS persuaded government authorities to act, and to fund and execute remedial work. Major components were sewerage reticulation and treatment, some engineering works, better farm management in lake catchments, and some change in land use. To our surprise some lakes responded very quickly and in a few years water quality greatly improved. Work is underway or planned for most other lakes.

LakesWater Quality Society and the Restoration of the Rotorua Lakesⁱ

A community group, the (LWQS), successfully initiated action to restore water quality in a major group of lakes. This account is written from the perspective of the chair of the Society from 2000 to 2006. It deals with those years and briefly touches on the later implementation phase.

Situation

The twelve splendid Rotorua lakes are in the North Island of New Zealand.¹ All were formed by volcanic events, but vary in characteristics and water quality.

Volcanic domes and caldera dominate the landscape. Landforms are mantled by rhyolitic ash eruptions. Rainfall trickles through the soil into pumice aquifers, and some takes a century to reach a lake. Water from hydrothermal springs enters several lakes.

Before human settlement, the land was covered in temperate rain forest dominated by podocarps. Only limited changes were made in the vegetation by Maori,² who arrived about the fourteenth century.

Before 1880, when Rotorua town was formally established on the edge of Lake Rotorua, European settlement was slow.³ The city itself was largely a tourist town, and managed as a 'government town' for many years.⁴ As the town of Rotorua grew, nutrients from sewage were discharged into Lake Rotorua with little treatment,⁵ leading to deterioration in water quality.

Forest was felled for timber, and *Pinus radiata* plantations were developed in the twentieth century. Farming was slow to develop since sheep and cattle did not thrive. After a deficiency of cobalt was identified in 1935,⁶ livestock farming spread around some lakes, and eventually increased the flows of nitrogen compounds to these lakes. Government policies to stimulate farming encouraged livestock farming in the catchments.

In 1969 a visiting American compared Lake Rotorua to an "unflushed toilet" - to the horror of the Mayor.⁷ A few scientists warned of degradation of the lake water.⁸ Eventually public pressure led to a proposal to divert little-treated city effluent to the Kaituna River that flows out from through Lake Rotoiti (and hence drains Lake Rotorua as well). A local Maori leader objected and won a legal claim against the Government.^{ii,9}

ⁱ Helpful comments on the draft of this paper were provided by Elizabeth and Nick Miller, John and Ann Green and Professor David Hamilton. Their assistance is gratefully acknowledged. So too are the helpful suggestions by an anonymous peer reviewer and by Hannah Mueller.

ⁱⁱ Stan Newton.

Rotorua city had a population of over 50,000¹⁰ in 1991 and by then was building a modern sewage treatment plant to remove most nutrients.⁴

Local government and the community relaxed: it appeared that Lake Rotorua was saved.¹¹ Little concern was shown about the other apparently less threatened lakes.ⁱⁱⁱ In 1999 the Regional Council (BoPRC, or EBOP) estimated a cost of only \$3.84m to “Protect the twelve lakes ... for ecological, recreational and cultural importance...”¹²

In 2000 EBOP proposed the Regional Water and Land Plan (RWLP) which became effective in due course. This included *Rule 11* which prohibited any further intensification of land use that could increase nutrient discharge to Lake Rotorua or four other lakes.

The RWLP included individual targets for water quality for the Rotorua Lakes. The realistic objective was water quality for each lake as it was in 1960, rather than pristine purity. The indicator of quality was the Trophic Level Index (TLI).^{iv,13}

We lakeside dwellers became concerned in the late 1990s. Cyanobacterial blooms occurred annually in a few lakes and other algae came and went: waternet, and foam-producing algae. Slowly, almost imperceptibly the water in the linked lakes Rotoiti and Rotorua became murkier. Leading scientists were unconcerned. EBOP no longer monitored water quality annually in all lakes.

LWQS mobilises

A local community group called the “Lakeweed Control Society” was struggling to survive. Founded 40 years earlier by an eminent lawyer^v the Society had initiated government action to control the oxygen weed *Lagarosiphon* by spraying with Diquat. By 1999 the control programme was well established, and the Society had achieved its original purpose.

I became chair of the committee of the Society in 1999. The Society changed its name and tackled water quality issues. The first problem we faced was limited knowledge as to what was happening in the lakes.

ⁱⁱⁱ A monitoring programme had been set up by the Regional Council but was scaled back in the late 1990s.

^{iv} This index aggregated measurements of water clarity and chlorophyll, and phosphorus and nitrogen levels in the water. TLIs were accepted as a target by the Plan even though not many people in the community had a good understanding of the concept. Although the subject of some criticism, the TLI has been used as an indicator and target for the lakes programs throughout.

^v Leonard Leary QC.

We informally approached the National Institute of Water and Atmospheric Research (NIWA) seeking research on water quality in the Lakes. We were rebuffed. A very senior executive told us that enough was already known about the Lakes^{vi}.

The LWQS committee reacted strongly. One urged action,^{vii} and another^{viii} advocated a scientific seminar to determine research requirements. So the first transforming symposium was initiated.^{ix}

The first symposium was held in March 2001 in Rotorua. Its theme was 'Research Needs in the Rotorua Lakes'. Over 100 people attended, including scientists, local government leaders and managers, local people and executives from lakes-related industries.

The infectious enthusiasm of keynote speaker Professor Willie Ripl of Berlin University enlivened the Symposium. He pointed us beyond the lakes to complete catchment systems.

That symposium had unexpected but far-reaching outcomes. The chair of EBOP,^x asked me if I would write a letter to his council asking them to endow a chair in lake science at the University of Waikato. With alacrity I agreed, EBOP endowed the chair and a brilliant choice was made of Dr David Hamilton as inaugural professor.

A second outcome of the Symposium was the message that a farmer^{xi} took home to his colleagues around Lake Rerewhakaaitu: "The water quality in Lake Rerewhakaaitu is deteriorating. It is our lake. We as farmers are causing the problem. It is up to us to fix it."

Since then seven symposia have been held, each dealing with the current issues facing restoration of the lakes^{xii,14} and with up to 250 people attending.

^{vi} In the restructuring of government research in the early 1990s, NIWA had incorporated the former Taupo Research Laboratory of the Department of Scientific and Industrial Research (DSIR). Its focus changed over time to estuarine and coastal waters, and research on inland waters languished.

^{vii} Lindsay Brighouse.

^{viii} Nick Miller.

^{ix} Others involved were Elizabeth Miller, Warren Webber and Brentleigh Bond.

^x John Keaney.

^{xi} Chris Sutton.

^{xii} The titles of the symposia were:

2001 - 'A symposium on Research Needs in the Rotorua Lakes'
2002 - 'A workshop on Lakeside Communities and Sewerage'
2003 - 'Practical Management for Good Lake Water Quality'
2004 - 'Restoring Lake Health – Nutrient Targets and Cyanobacteria'
2006 - 'Wonderful Lakes - What Value? - Who Pays?'
2008 - 'Nutrient Sensitive Zones - Nitrogen and Phosphorus, Lakes and Waterways'
2011 - 'Fix a Lake and Grow a City' - A Case Study of Rotorua
2013 - 'Transferable Development Rights'

Steps to a solution

By 2000, only a few scientists maintained an interest in the Rotorua Lakes. The consensus was that their problems had been fixed by treatment of urban sewage and by soil conservation measures, and that the Lakes were recovering.^{15,10,xiii}

Professor David Hamilton was the key to re-evaluating the science. His measurements described what was happening in the lakes, and his models enabled remedies to be tested. His students and the body of expertise created at the University of the Waikato rejuvenated lake science in New Zealand.^{xiv}

NIWA contributed with science related to the catchments, and with Geological and Nuclear Sciences (GNS), discovered the long lag-times between nutrients entering the soil and reaching the lakes.¹⁶ This explained why water quality in Lake Rotorua was again deteriorating after improving when nutrient inflows from sewage were reduced. N inflows from the increase in farming were delayed in reaching the lake.

A Technical Advisory Group (TAG) provided valuable external scientific advice to the lakes programme.

Our symposia reported and publicised scientific developments, and we also provided support for post-graduate students.

Three levels of government share the responsibility for the lakes: central government, the Regional Council and the Rotorua District Council (RDC).^{xv} Each needed to be convinced that action was necessary.

LWQS used many channels to persuade. We lobbied local councillors and made presentations to their meetings. We were received courteously and often invited to join in a nice lunch. Some managers patronised us offensively. We made submissions to Annual Plans and Long Term Plans.^{xvi}

Initially these submissions had no effect. We were told either that the lakes were satisfactory; or if they weren't, that eutrophication was irreversible; or that action already

^{xiii} Also, after bitter scientific argument, the accepted view was that growth of algae in the Rotorua lakes was nitrogen limited. See White, E. Lake eutrophication in New Zealand—a comparison with other countries of the organization for economic co-operation and development. *New Zealand Journal of Marine and Freshwater Research* 17, 437-444 (1983), doi: 10.1061/(ASCE)0733-9496(1989)115:4(431). Also see and Williamson, R, Smith, C, and Cooper, A. Watershed Riparian Management and Its Benefits to a Eutrophic Lake. *Journal of Water Resources Planning and Management* 122(1), 24–32 (1996)

^{xiv} Google scholar discovers 125 papers which he has authored or co-authored since his presentation *An Historical and Contemporary Review of Water Quality in the Rotorua Lakes*. [online] LWQS 2003 symposia http://www.lakeswaterquality.co.nz/index.php?option=com_content&view=article&id=79&Itemid=81

^{xv} District councils have a role similar to city councils and counties in other countries.

^{xvi} These plans are required by law and determine the pattern of activities, spending and funding for local authorities.

taken would eventually lead to better water quality. In any case, nothing could, should or would be done. Despite the lack of response, LWQS presented the case without rancour.^{xvii}

RDC was in denial as to the need for further sewerage reticulation. The Mayor said the lakes would take 200 years to fix and hence there was no urgency. His complacency was disturbed when, on arriving late at a public meeting on lake water quality degradation, he found the room so crowded that the local Member of Parliament was sitting on the floor and he himself could not get a seat.

The media, especially the NZ Herald and TV, were helpful, especially after widespread algal blooms in 2002.

LWQS engaged with central government through the local Member of Parliament and through the Ministry for the Environment (MfE) of which the chief executive Dr Barry Carbon was serendipitously well qualified in environmental water sciences. He came to look for himself. He spent most of a week investigating, meeting managers and technical staff from both councils, inspecting the lakes and catchments, and listening to LWQS and other community groups. Finally he met managers from both councils. He told them that they had a major problem, that they needed to deal with it, and that he would provide help. That moment was a turning point in the history of the Rotorua Lakes.

Dr Carbon commissioned an Australian scientist^{xviii} to review short-term management options for Lakes Rotorua and Rotoiti. Several major recommendations in that review¹⁷ were implemented, leading to great improvement in Lake Rotoiti and improvement in Lake Rotorua.

Once persuaded of the need for action, EBOP moved vigorously.¹⁸ Paul Dell as a Group General Manager attacked the lakes' problems with vigour and was supported by the Chair. RDC responded with a sewerage extension programme.^{xix}

EBOP, RDC and Te Arawa (see below) had worked together to produce a high-sounding but ineffective 'Lakes Strategy Plan'.¹⁹ The coordinating body (the Rotorua Te Arawa Lakes Strategy Group) was given formal status in 2006 in legislation that transferred ownership of lakebeds back to Te Arawa,²⁰ and has over time become effective.²¹

LWQS had considerable support from the public and from other community groups including the Mourea Okawa Bay Action Committee (the MOB),^{xx} the Lake Rotoiti Ratepayers and Residents Association,^{xxi} and residents' groups at other lakes. Owners of holiday homes around the lakes, particularly from Auckland, provided funds and support.

^{xvii} In part this was because such attacks could be counter-productive, and in part it was because we recognised that the problem was poor scientific advice.

^{xviii} Dr Bruce Hamilton.

^{xix} Designed and built by engineer Greg Manzano and under the leadership of Mayor Kevin Winters.

^{xx} Led by Don Atkinson.

^{xxi} Now the Lake Rotoiti Community Association

Many local people supported our work. We found little interest amongst tourist operators or their organisations, despite their commercial interest in making lakes more attractive. Few businesses in Rotorua city provided support.^{xxii} The city had turned its back on the lake. Te Arawa is the Maori iwi (tribe) whose territory covers the Rotorua district. Te Arawa owns most lake beds,^{xxiii} and Maori trusts are major land-owners. The status of Te Arawa as *tangata whenua* (people of the land) is recognised in law. Te Arawa have had involvement with lakes programmes since 1998.²²

LWQS has benefited from Maori representation on its committee and Rangatira (chiefs)^{xxiv} have given strong support.

Barry Carbon proposed collaboration between LWQS and farmers to deal with lake problems. He offered government funding to set up a body: the Lakes and Land Trust. Partners were LWQS, local Federated Farmers, and Ngati Whakaue Tribal Lands Ltd.^{xxv} Management services were provided by NZ Landcare Trust, an environmental NGO that worked extensively with MfE.

Despite goodwill the Trust never fulfilled its purpose. Not all farming leaders recognised a need to reduce nutrient flows into Lake Rotorua. Also:

- Landcare Trust sought to copy the *Taieri Model* (their work in the Taieri river catchment in the South Island). The model did not transplant because of different institutional relationships in Rotorua.
- MfE grants required tangible outputs to trigger payment of funds, but much of the work of the Trust was not quantifiable. Artificial milestones (e.g. drafting a science strategy) were created to release funding. These diverted work away from effective activities.^{xxvi}
- No mediator was involved, nor was there funding to encourage farmers to reduce nutrient outflows.

The Trust remains in existence as a collective of landowners.

Central government funding was needed to assist lake restoration, but was hard to obtain despite a benign fiscal climate. A turning point was a visit by the Prime Minister.^{xxvii} She was brought by local officials to Lake Rotoiti and stood on the shore. A woman member of the

^{xxii} A notable exception was Greg Brown who gave strong support.

^{xxiii} Apart from that of Lake Okaro. Lake Rotokakahi is also different in that the lake itself is privately owned by the local Tuhourangi sub-tribe.

^{xxiv} Including Anaru Rangihueua, Tai Eru, Sir Toby Curtis and Roku Mihinui.

^{xxv} A trust belonging to a sub-tribe of Te Arawa.

^{xxvi} I personally saw this distortion as ironic, since in a former role as Chair of the Public Expenditure of Parliament I was one of those seeking the reform of government expenditure controls to emphasise outputs rather than inputs.

^{xxvii} Rt Hon Helen Clark.

LWQS committee^{xxviii} took the Prime Minister by the elbow and guided her out over the lake on a narrow jetty, barely wide enough for both to stand upon. The Prime Minister's security officers were appalled. The discussion between two feisty ladies did not take long, but the Prime Minister was persuaded that action was needed. This short walk down the jetty was eventually worth \$72.2m to the lakes in government subsidy. The local MP^{xxix} played a significant role in the detailed work to crystallise official support.

Remedial activities were planned in consultation with local communities through the formulation of *Action Plans* devised by *Action Plan Working Groups*. Draft action plans were prepared by EBOP for each lake with a scientific assessment of the lake and its catchment, and the sources of N and P enrichment identified. Possible interventions were described and evaluated, and the Working Groups expressed community preferences. Their role was consultative, educative and advisory.

The action plans got off to a shaky start at Lake Okareka: in part because the lakeside community was divided over the relative importance of better lake water quality as compared with pastoral vistas; and in part because of reluctance by officials to yield leadership to the community. Eventually a plan was produced²³ and has been successfully implemented.

Lessons were learnt, and Action Groups and Action Plans were effective for some lakes.^{xxx}

The most difficult issue was unsolved: a reduction of the outflow of nitrogen from farm land in the Rotorua catchment as diffuse discharge.^{xxxi,24} It was not enough that the authorities consulted and the parties met together. The farming leaders of the time were not committed to change and no skilled facilitator was used.^{xxxii}

Later, in 2009, EBOP froze action plans after a legal opinion²⁵ cast doubt on the validity of the basis for requiring nutrient reductions from farms. After a delay, Action Groups were reinvigorated for Lakes Rotoehu and Rotoma, and similar processes involving the community were recently initiated for Lakes Tikitapu and Okataina, and re-started for Lake Tarawera.^{xxxiii}

^{xxviii} Sally Brock.

^{xxix} Hon Steve Chadwick MP.

^{xxx} Initially for Lakes Okaro and Okareka and much later for Lakes Rotoehu and Rotoma.

^{xxxi} The failure of the Working Group for Lakes Rotorua and Rotoiti was in part due to the diversion of effort to another group called the Land Use Futures Board which despite good leadership never resolved the difficult issue of reducing nutrient flow from farms in the Lake Rotorua catchment

^{xxxii} When these two factors were remedied some seven years later, good progress was made under the WaiOra agreement

^{xxxiii} New EBOP staff were not always aware of what their predecessors had done.

With great reluctance, we in LWQS spent much time and effort on the processes required by the Resource Management Act (RMA).^{xxxiv}

We were involved with various consent applications under the RMA. We dealt with the Regional Water and Land Plan (RWLP) as it was being developed and especially *Rule 11* of that Plan.

Two issues arose.

- Farmers were concerned over restrictions on intensification of land-use.
- No action was proposed to protect the seven lakes not subject to Rule 11. All these lakes had water of higher quality but were at that time not considered to be threatened. We objected to this in the proposed RWLP, and eventually agreed to a compromise that required action plans should water quality fall below a threshold level. While this seemed far too soft at the time, it has proved valuable in getting action initiated automatically.

Under the RMA, the underlying statutory document setting limits and timeframes to reduce nutrient flows in the region is the Regional Policy Statement (RPS). Negotiations over the proposed RPS involved LWQS heavily for several years before the water quality provisions were agreed in 2013.

In 2006 I resigned as chair of LWQS,^{xxxv} John Green QSM was elected, and has led the Society since. His wife^{xxxvi} has played an important role as secretary.

LWQS work changed as the councils became active and we worked with them on implementing action plans to fix the lakes. For example we advocated low pressure sewerage systems with “grinder pumps” rather than gravity systems. We persuaded EBOP that 250 years was too long to wait to restore Lake Rotorua water quality. We continued to support science. We continued to organise symposia focusing on the most important issue at the time, but with broader scope. We continued to bring in world leaders such as Professor Robert Costanza (by video) and Mayor Bo Frank, of Växjö, Sweden.

Agreement between farmers and LWQS on reducing flows of nutrients from farm land reductions came as a result of fresh initiatives by our MP^{xxxvii} and a farming leader.^{xxxviii} This

^{xxxiv} The RMA is the major piece of environmental legislation in New Zealand for regulation of the use of land and water, land use planning, and control of pollution. To have a single piece of law dealing with most environmental issues is a great concept. In practice, working through its legal procedures is mind-numbing, tedious and frustrating for lay-people.

^{xxxv} I took up a position in Romania, returning in late 2007, and continuing as a member of LWQS committee with involvement especially with the Symposia.

^{xxxvi} Ann Green.

^{xxxvii} Hon Todd McClay MP

^{xxxviii} Farm trustee Dr Tanira Kingi, who also is a scientist.

was given legal effect in 2013 when the Environment Court approved it as part of the Regional Policy Statement (RPS).^{xxxix}

Many people other than those mentioned in the text have contributed to the success with the lakes Programme.^{xl}

Action commences

With all the authorities convinced, action started to save the lakes. The remediation is a story in itself, and the following is only a summary.

The developing science confirmed that enrichment by N and P compounds from human activities caused most of the lake problems.^{xli} By the early 2000s all the easier measures had already been implemented: fencing cattle away from streams and lake margins, planting erodible banks of streams, and dealing with effluent flows from dairy-farm milking premises. The further measures needed were substantial and expensive:

- reticulated sewerage for communities around the lakes,
- specific engineering works such as the “Lake Rotoiti wall”, and the precipitation of P from some lakes and streams,
- adoption of best practice in nutrient reduction by farmers,
- some change in land use from farming to forestry.

The solutions required bigger changes: much more than minor modifications in behaviour by people living in the catchments. Major investment and changes in public policy were required.

Interventions were discussed by Working Groups, and formally approved by the Strategy Group and by the two local authorities (RDC and EBOP) who carried out the programme.

The first of the new major measures put in place were the Okawa Bay sewerage reticulation in 2006²⁶ and the “Rotoiti Wall” in 2008.²⁷

The role of RDC was provision of sewerage reticulation^{xlii} and treatment, which comprised about half of the total programme costs. The city treatment plant was progressively upgraded to deal with increased inflows.^{xliii}

^{xxxix} The principles are set out in the RPS, and the detail is currently being negotiated in a positive atmosphere.

^{xl} Included amongst these are John McIntosh, Warwick Murray, Andy Bruere, Bill Cleghorn and Bill Bayfield of EBOP; Professor Warwick Silvester of University of Waikato; Dr Kit Rutherford of NIWA and several colleagues, Rick Vallance of Ngati Whakaue Tribal Lands Incorporation; Jim Howland, Marcel van Leeuwan, Mary Stanton and many others of LWQS.

^{xli} Most lakes also have nutrient inflows from geothermal or geological sources. While these inflows added to the nutrient load from human activities, in themselves none were sufficient to cause eutrophication of a lake.

^{xliii} When the last scheme now in late planning is completed, Lake Tarawera will be the only significant lake side community not sewered.

EBOP designed and implemented the other projects, including several engineering works. It is collaborating with farmers around lakes to reduce their nutrient outflows. EBOP has also tested weed harvesting and aeration as methods of reducing nutrient levels in lake water.²⁸

Funding was provided by central government, EBOP and RDC, by charging for sewerage services and through rates (local taxes). Public sector costs were borne about 50/50 by central government and by the two local councils. In addition farmers will bear much of the cost of improving management or changing land use.

EBOP has always been in a strong financial position, and has used its financial strength to support the programme.^{xliv}

RDC was in a very different financial position with projects like the airport extension requiring funding. Nevertheless it too, once convinced, gave priority to funding sewerage works to benefit the lakes.

Central Government funding came in two parts: \$7.2m committed in 2004 as a result of Barry Carbon's initiative, and then \$72.1m committed in 2007.^{xlv} The latter was negotiated with ministers by EBOP^{xlvi} and RDC with LWQS assistance.

Water quality in the lakes is generally improving.²⁹ In the 2012-2013 season TLIs for most lakes have fallen.³⁰ It is far too soon to claim victory since climatic fluctuations may be a factor, but the results and action taken are tangible. Across all the lakes:

- Sewerage is nearly complete.
- For all but three lakes (Tarawera, Rotomahana and Rotokakahi) the action taken, underway or planned should be sufficient to meet water quality targets.
- For the most difficult challenge of Lake Rotorua almost all sewage-derived nutrients are now removed, P is being precipitated in contributory streams, and a major step has been taken towards reduction in N outflows from farms.

Thus major progress has been made on the programme to restore the Rotorua lakes.

Factors hindering or helping restoration

General political economic and social factors were not a significant influence in hindering or advancing restoration. Both major political parties assisted once convinced. The state of the

^{xliii} However the discharge of the treated effluent into the Whakarewarewa forest currently exceeds the consented limit for N and is a live issue.

^{xliv} Its funding for the Chair held by Professor David Hamilton was especially important.

^{xlv} As a 50% share of the major Rotorua Lakes Protection and Restoration Action Programme.

^{xlvi} Chair was John Cronin, and CEO was Bill Bayfield.

economy did not affect funding, with favourable decisions made at both high and low points of the economic cycle. Social factors were not significant except specifically as below.

The main factors hindering or helping restoration related to information, institutions and attitudes.

The information gap comprised a lack of good science and inconsistent monitoring. The misguided scientific consensus that the lakes would eventually recover without further action was wrong. A comprehensive monitoring programme of the early 1990s had been reduced and made sporadic.

The institutional reforms under the RMA were still working through to regional plans and regional policy statements. In the years to 2000 they had proved to be insufficient to trigger action. The Ministry for the Environment was still developing its role, as was the Commissioner for the Environment. In civil society, few national environmental organisations had impact on political decisions, apart from on specific issues. None had significantly taken up fresh water quality issues.^{xlvii}

Environmental awareness had been slow to develop in NZ. Few issues had attracted public attention. Major issues had been soil erosion,³¹ the preservation of indigenous forests and the treatment discharge of raw sewerage by Auckland city.³² Deteriorating water quality had been little recognised as a national issue.

The hardy freshwater scientists who survived the reforms of the 1990s were important in providing a scientific base on which to build. The University of the Waikato contributed substantially through one or two key scientists, but more especially after the establishment of the Chair in Lakes Management and Restoration.

Leaders in all three tiers of government contributed greatly once they were aware that problems needed to be solved. The Ministry for the Environment and the Commissioner for the Environment played a key role once engaged.^{33,34} The RMA codified environmental law and in particular required regional land and water plans to be produced and implemented. The Bay of Plenty Plan Land and Water Plan prevented further enrichment of some lakes, and has been a useful, if limited, assistance for other work. LWQS obtained advice and encouragement from environmental NGOs once its own efforts were underway.

Public attitudes to the lakes and the need for restoration changed and made it possible for political decisions to be made. Key to the change in public attitudes were the LWQS symposia.

^{xlvii} Major organisations were Forest and Bird Society (founded in 1929); and the Maruia Society (later Ecologic) and the Environmental Defence Society from the 1970s. Their greatest achievement was more preservation of indigenous forests.

The Lessons and Conclusion

In retrospect, the approach by LWQS was quite logical:

- develop the science,
- inform decision makers and opinion leaders about the science,
- change public policy,
- obtain funding,
- get physical works undertaken,
- improve land management and change some land use

We sought a scientific base for lake restoration, we publicised the science, and we strategized on changing public policy. We spent no time on a master plan for the lakes, or on vision statements or mission statements. Rather we followed the advice of Professor Willy Ripl in 2001 on the sequencing of remediation measures: *do whatever you can as soon as you can*.

In 2002 with severe algal blooms affecting the lakes and the authorities indifferent, our task looked hopeless. Even in 2006 the Commissioner for the Environment warned that: *Water quality will continue to get worse for some decades to come. In light of this bleak scenario, the challenge is enormous.....*³⁵ We found, however, that eutrophication can be reversed, and sometimes quickly. Waters that had annual blue-green algal blooms became free of blooms a season or two after nutrient inflows were greatly reduced. Restoration of some lakes was achieved much more quickly than we ever envisaged possible.

Effective action to restore the lakes required good science. The science was undertaken with some independence from the authorities responsible for the lakes. LWQS symposia built up interest in the science and transmitted scientific knowledge to decision makers and the community.

Complacent public authorities were prodded into action by community groups. It took time, patience, determination and commitment by dedicated people. Competent people in government authorities acted once the facts were clear.

Success was the result of hard work. We kept tight focus on better water quality and were not diverted by other issues. We were independent of the authorities.

Changes such as different land-use or reticulation of sewerage were neither easy nor cheap. They required persuasion and exhortation, some carrot, and some stick.

Agreement between stakeholders with conflicting interests required more than discussion around the table. Good leadership was needed from stakeholder groups and skilled mediators advanced agreement greatly.

Leading LWQS was a great journey shared with talented and interesting people. It was hard work, but has been richly satisfying as lakes improved far beyond our best hopes. Good water quality is the legacy LWQS and others leave behind - but we have the challenge of working on until all lakes are fully restored.

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