Rejuvenating Lake Rotoiti

BOC findings and recommendations for the oxygenation of Lake Rotoiti

Prepared for Environment Bay of Plenty

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1. EXECUTIVE SUMMARY

Environment Bay of Plenty has asked BOC to propose on the costs, implementation and implications of installing a delivery system to oxygenate Lake Rotoiti as a short-term solution to halt the decay of the lake and improve its water quality. The oxygen delivery to the hypolimnion (the deeper part of the lake) must be in a form that is completely dissolved during summer stratification.

The main technical goals for oxygenation are:

- Supply of at least 77 mg O^2 $m^{-3}d^{-1}$ (Hamilton, 2003)
- Maintain a DO level of 5 to 6 mg/l (Dell, 2003)

There are also important community goals, which are reviewed in this report.

Most of our investigations into the delivery system are centred on a diffuser system into the deeper parts of the lake; however we also briefly investigated the feasibility of side stream super-saturation. This report covers two options:

1. **Option 1 – Submerged Membrane Diffusion** Diffusing oxygen into Lake Rotoiti from a land base and across the lake bed to achieve the required oxygen levels. There are two alternatives regarding the location of this solution (1a and 1b).
2. **Option 2 – Side-stream Super-saturation.** Saturating the lake with oxygen by removing lake water at Ohau Channel and dissolving large amounts of liquid oxygen into it before pumping it back into the lake

We recommend membrane diffusion for technical and cost reasons, but other options are equally as viable technically but may involve greater cost.

We believe both solutions presented are:
- Fast (implemented within 6 months of agreement to proceed)
- Natural (we would like to contend that oxygen is one of the most natural ingredients available)
- Workable (with few compromises required by the community)
- Relatively inexpensive (especially relative to the cost of the problem)
- Minimal in their impact on the life of the community
- Without additional environmental impacts
- Able to show improvement in water quality quickly.

The solution has been designed to achieve optimum dissolution of 10-20 tonnes per day of oxygen injected into Lake Rotoiti. Assuming the data and calculations provided to BOC are correct, we would expect to see the algal bloom and the lake odour to gradually diminish.

This report looks at both technical and non-technical aspects of the solution, including environmental, cultural, recreational and social impacts. We also take into account several alternative options and their implications for Environment Bay of Plenty, Rotorua District Council and other stakeholders.

This report outlines BOC's recommended solution for oxygenating Lake Rotoiti. It defines what we believe to be the most workable technical solution, costs, implications, and how this could be implemented.

PART ONE – CONTEXT

2. THE PROBLEM

The state of water quality on Lake Rotoiti/Rotorua is an extremely pressing environmental, cultural and community concern.

The bottom waters of Lake Rotoiti have been anoxic (ie devoid of dissolved oxygen) on a seasonal basis for a number of years. Oxygen depletion has led to the reduction of processes in the lake sediments that would normally cause nutrients like nitrogen and phosphorus to dissolve.

As a result, Lake Rotoiti's water quality has significantly declined. Algal blooms and further deoxygenation are symptomatic of high rates of nutrient release from bottom sediments and exacerbate the decline of water quality in the lake.

Because Lakes Rotoiti and Rotorua are linked through the Ohau Channel, management of Lake Rotoiti, in particular, is very complex. As a rough order of magnitude, 70% of the nitrogen and phosphorus that flows into Lake Rotoiti comes from Lake Rotorua.

In spite of work to reduce nutrient loads from the 1970s onwards, including the construction of a leading edge high-tech nutrient stripping plant in 1991 to treat effluent, monitoring has shown that nitrogen inputs from sewage have declined but there has been a marked increase (70 tonnes/year or more) in nitrogen flowing from groundwater.

During the 2002/03 summer, Lake Rotoiti was closed to the public because of a blue green algal bloom. This is the first time that this has occurred during a period of high public use, and has been a wake-up call for the lake's guardians (Source, Lake Rotorua/Rotoiti Catchment Management Action Plan Newsletter 01, September 2003).

3. BACKGROUND

This is a summary of a detailed report commissioned by BOC, conducted by José Béya and David Hamilton of the Centre for Biodiversity and Ecology Research, University of Waikato (see Appendix Two for full report), along with desk research of information relating to this issue.

3.1 The lake/s

Lake Rotoiti is located in part of the Haroharo Caldera. Water depths in the eastern portion occupying the caldera are deeper and limnologically distinct from the shallower eastern basin.

Inflow is from runoff from the moderately developed catchment through numerous tributaries with the greatest inflow from Lake Rotorua via the Ohau Channel. Rainfall and some subterranean inflow from lakes Rotoma and Rotoehu also contribute. Outflow is by way of the Kaituna River.

The lake is volcanic, with a lake area of 33.48km^2 and a maximum depth of 120m. There is a catchment area of 120.56km^2 and the catchment land cover area consists of 32% pasture, 28% lakes, 23% native forests, 10% lowland scrub, 5% exotic forest, and 1% each of sand dune and tussock.

3.2 How oxygen is normally mixed in Lake Rotoiti

Lake Rotoiti is a monomictic lake (one period of complete vertical mixing per year) with a stratification period of 6-9 months. This seasonal stratification results in two distinct layers of different density. The cooler, heavier water (hypolimnion) remains beneath warm buoyant water at the surface (epilimnion) (Fig. 1). In deeper temperate lakes, stratification occurs seasonally with increasing temperature and solar radiation during spring (around September in Lake Rotoiti). Mixing in stratified lakes is carried out by the addition of momentum by wind or reduction in water column stability as a result of convective cooling. Stratification usually persists until early- to mid-winter (around June in Lake Rotoiti), when convective cooling acts in conjunction with wind to 'turn over' the lake and mix the water column.

There are only low rates of transport and diffusion between the surface and bottom waters when a lake is stratified (see Fig. 1). Mixing is confined mostly to the lake boundaries and is accomplished predominantly by wind.

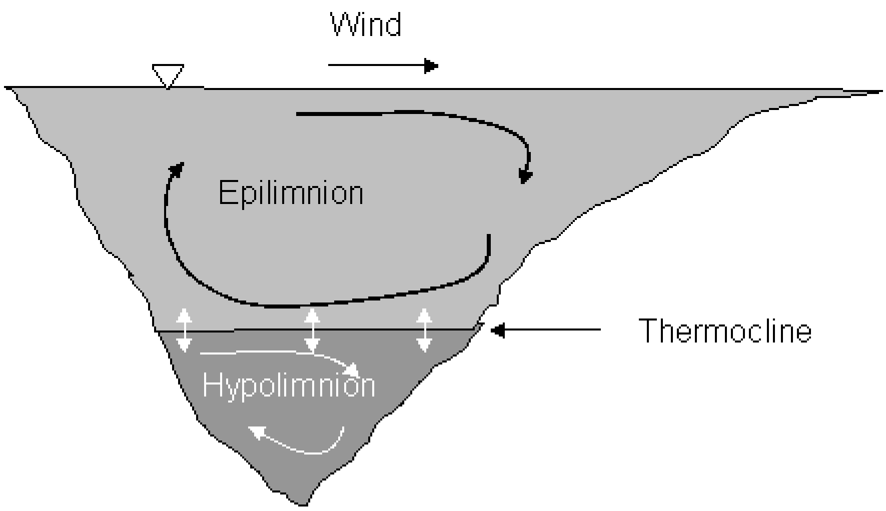

Figure 1: Conceptualisation of mixing in a stratified lake showing the different layers formed, the seasonal thermocline region of greatest temperature gradient and the relatively low rates of transport across this region.

3.3 The process and impact of oxygen depletion

During the stratified period, the decomposition of organic matter in the hypolimnion depletes oxygen. The organic matter can use the oxygen at a faster rate than it can be renewed. If there is a lot of organic matter, the level of dissolved oxygen (DO) may be exhausted before the organic matter decreases substantially, i.e. the waters become anoxic.

Anoxia is likely to persist if the rate of diffusion across the thermocline is low, and there are no major sources of DO to the hypolimnion (such as surface re-aeration or photosynthesis, which occurs in the epilimnion). This situation is likely to continue until winter mixing renews the dissolved oxygen levels.

Deoxygenation of the hypolimnion can occur for up to 7 months of the year, from September to June. The volumetric hypolimnion oxygen demand has increased from approximately 24 mg O^2 $m^{-3}d^{-1}$ to 77 mg O^2 $m^{-3}d^{-1}$, almost a three fold increase (Hamilton, 2003).

The greatest hypolimnetic volume is contained within the eastern end of the lake, which is the deepest end. Dissolved oxygen (DO) and temperature profiles exhibit an isothermal behaviour within the hypolimnion indicating a reasonable mixing is occurring.

The top of the hypolimnion is on average approximately 30 metres deep, varying at different depths and times. For a volume of water of 280,000,000m^3 measured from the lake bottom to the 30m contour, it is estimated that 13 to 16 tonnes of DO is required daily to counteract the oxygen depletion. Further oxygenation may be required if the depletion rate is found to increase with oxygen enrichment, and to facilitate the spread of oxygen through the hypolimnion.

The aim of hypolimnetic oxygenation would be to maintain a DO level of around 5 to 6 mg/l. Typically, DO levels tend to fall below this level around November-December and are not replenished until June when the lake moves towards being fully isothermal. Hence oxygenation would need to occur for approximately six months, consuming more than 2700 tonnes of oxygen over this period.

4. WHAT ENVIRONMENT BAY OF PLENTY HAS REQUESTED OF BOC

Environment Bay of Plenty is considering a range of management options that may quickly remediate the nutrient problems by re-establishing dissolved oxygen in the bottom waters of Lake Rotoiti through the period when oxygen would normally decline.

Environment Bay of Plenty has asked BOC to propose on the costs, implementation and implications of installing a delivery system to oxygenate Lake Rotoiti as a short-term solution to halt the decay of the lake and improve its water quality. The oxygen delivery to the hypolimnion must be in a form that is completely dissolved, during summer stratification.

Environment BOP has requested that the report take into account that:

- Flexibility is required to ensure the solution reaches the deepest parts of the eastern basin
- 10-20 tonnes of liquid O2 are likely to be needed each day for six months of the year
- The solution should include the ability to manage O2 usage/supply levels so that experimentation and setting of best practice guidelines can occur in year one.

It is expected that should an oxygenation project be given community and government support, it could run for up to 10 years. Environment BOP requires that:

- The system should deliver liquid oxygen to the deepest parts of the eastern basin just above the sediment bottom, where oxygen bubbles are dissolved before reaching the thermocline. This implies flexibility in the location of the solution.
- The system should be able to deliver 10 to 20 tonnes of liquid oxygen per day over a six-month period

Consideration must be given to maximising efficiency of oxygen usage – ie, shutting off oxygen delivery once a set DO concentration is reached; pulsing oxygen delivery as required to maintain DO concentration. Given the experimental nature of this operation, Environment Bay of Plenty expects there will need to be intensive monitoring and experimentation with the delivery volume in the first season to establish best management practices, and that Environment BOP would play a major role in this evaluation.

5. SOLUTION GOALS

5.1 Technical goals

Following a comprehensive consultation process, Environment Bay of Plenty has set water quality standards for both Lakes Rotorua and Rotoiti in its Regional Water and Land Plan. Each standard is expressed as an annual Trophic Level Index (TLI). The TLI is made up of four components; Total Nitrogen, Total Phosphorus, Chlorophyll and Secchi Depth (clarity).

The main technical goal for BOC is to optimally dissolve 10-20 tonnes per day of oxygen into Lake Rotoiti. This is based on the criteria provided to BOC by Environment BOP.

We understand Environment BOP's goals for oxygenation are:

- Supply of at least 77 mg O^2 $m^{-3}d^{-1}$ (Hamilton, 2003)
- Maintain a DO level of 5 to 6 mg/l (Dell, 2003)

5.2 Community goals

As well as fulfilling technical and environmental requirements, it is important that BOC's solution satisfies the needs of stakeholders such as the Te Arawa iwi, other community interests such as the Lakes Water Quality Society, recreational users such as fishing enthusiasts and tourism operators; central Government stakeholders and funding providers.

5.3 Likely solution criteria

The community requirement for the solution is likely to be along the lines of:

- Fit for purpose – able to achieve scientific and environmental targets
- Cost-effective and affordable for the community with benefits outweighing tangible and intangible costs
- Culturally appropriate in terms of land use and cultural implications for iwi
- A "natural solution" rather than an "engineered" or "man-made" solution
- Aesthetically acceptable visually
- Environmentally acceptable in terms of minimal noise and air pollution, traffic use etc
- Socially acceptable in terms of ability for local people to re-use the lake for recreational, tourism and food gathering purposes

We address these criteria in Part Three of this report relating to community impacts. Please note that we have not addressed any Resource Management Act implications in this report.

PART TWO – THE TECHNICAL SOLUTION

6. WHAT BOC PROPOSES – OVERVIEW OF KEY RECOMMENDATION

6.1 General approach and issues

This report covers two options:

- **Option One: Submerged Membrane Diffusion** Diffusing oxygen into Lake Rotoiti from a land base and across the lake bed to achieve the required oxygen levels. There are two alternatives regarding the location of this solution (1a and 1b).
- **Option Two: Side-stream Super-saturation** Super-saturating the lake with oxygen by dissolving oxygen into lake water before pumping it back into the lake. We were only able to briefly evaluate this option, but present our findings here as an alternative to the diffusion method.

Both options have positive and negative implications from technical, practical, community and economic perspectives and are discussed in detail below.

Methodology

We began our investigations by reviewing methodologies that would effectively distribute and dissolve oxygen at 3-5 locations throughout Lake Rotoiti. This requires membrane diffusers to be located at water depths of approximately 50m to ensure good dissolution efficiency. When calculating this solution, we used a network analysis model to optimise pipe diameters and distribution gas flows for 3-5 separate locations.

3. We believe both options provide workable solutions with minimal impact. We are confident either would provide a short-term alleviation of this critical issue, especially given the cost of taking no action, and compared with the costs of other types of solutions. BOC wants to engage with stakeholder groups regarding how your preferred solution could be adjusted to suit their requirements.

Delivery methods

We reviewed two supply scheme options:

- Delivering liquid oxygen to the lakeside where it would be diffused through a network of pipes into lake water from an onsite cryogenic vacuum insulated vessel
- Building a dedicated pressure swing absorption plant (PSA) – ie, manufacture the oxygen at the lake.

The oxygen demand is based on 10-20 tonnes per day supplied over a six-month period. Actual demand of flow patterns will need to be determined over the initial period. On-site plants are suited for constant demand all year round. As a part of the BOC offer, we will undertake to review the optimum supply method. **Liquid oxygen is the only form of supply that will provide the flexibility needed.**

General requirements and challenges

In the section below, we address some of the specific requirements and challenges facing each option. Unless otherwise stated, we have incorporated these issues into the design and costings presented to you in this report. Both solutions require basic infrastructure of a telephone line for our telemetry equipment, a three-phase power supply, a water supply such as a nearby tap and hose for de-icing of the valves etc.

In its current location, Option 1a does not require a power generator, but if another location is selected, and mains power is not available, a generator may be required, with estimated noise levels of around 90 dB. If this level was considered to be too high, we could easily attenuate it for little additional cost.

General operational issues

Both the diffuser and supersaturation systems involve ongoing maintenance. While both the basin diffuser and sidestream oxygenation systems would be designed as stand-alone or automated systems, daily site checks would be essential. The checks would include:

- Oxygen storage vessel pressure
- Gas flow pressure
- Check for leaks
- Oxygen flowrate
- Safety issues related to oxygen gas
- 24/7 access to oxygen facility for delivery and service.

Each of these parameters can be monitored remotely using various data retrieval and acquisition hardware and software via a telemetry system. BOC will address all issues with respect to safe installation and the gas supply scheme.

6.2 Implementation process – how it would roll out

The process of implementation will include:

- Heads of agreement/feedback from councils
- Stakeholder involvement/buyin
- Detailed design and costing
- Contractual agreement
- Installation – up to six months for deployment of project, including surveying, earthwork for delivery/supply access, laying of concrete pad, installation of equipment including oxygen vessel, vaporisers, telemetry, power supply, and laying of pipe, final testing (Option 1)
- Launch
- Operation, with delivery by tanker approximately once every two days
- Maintenance – at beginning and end of each season

6.3 Option 1 – Submerged Membrane Diffusion

BOC proposes that an oxygen pipeline be installed into the lake from a land based liquid oxygen vessel having a suitably sized ambient air vapouriser at the shore of the lake near State Highway 30 (as indicated in Figures 2 and 4 below). The oxygen pipeline would be run to the deepest part of the lake. BOC tankers would deliver liquid oxygen every second day to fill the liquid oxygen storage tank, which would be remotely monitored by the BOC Teltank 32™ System.

The oxygen gas flow into the lake would be at a rate of ~20tpd however, there is considerable scope within the BOC system to change this dosing rate to suit the specific conditions.

Ideally, installation of the BOC system would take place over a 6 – 8 month period during winter of 2004.

6.4 Site location options

A suitable site for the installation from a practical engineering perspective has been identified near Uenuku mai Rarotonga Marae (option 1a). Other sites are possible on private land (option 1b). The cost of Option 1b could be higher because additional infrastructure may be needed (such as roading, power and possibly water supply, geological engineering and more pipe).

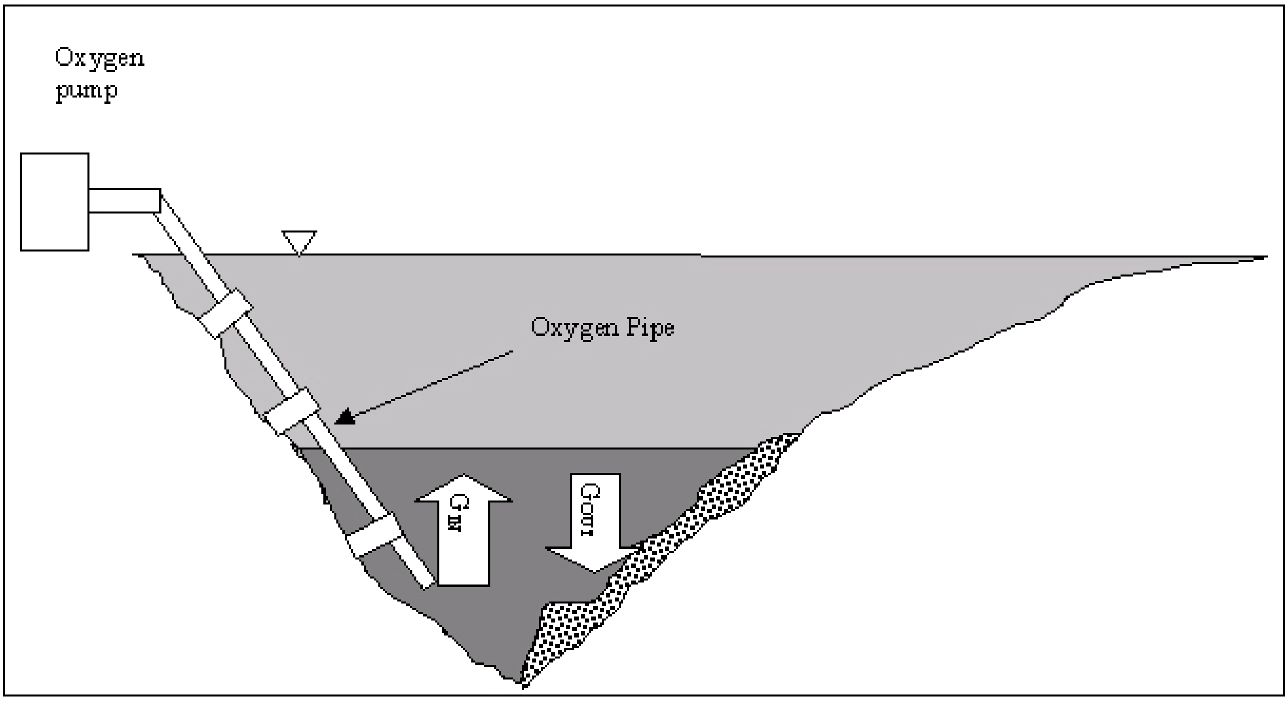

Figure 2: A simplistic view of how Option 1 would work.

6.5 Requirements and challenges

We used pipe network analysis modelling software to optimise gas distribution pipework for the basin. Although we calculated on a basic oxygen dissolution rate of 833kg/hr (20 tonnes per day), this pipework design will be capable of handling twice this capacity – approximately 1600kg/hr.

The application rate of oxygen at each diffuser station is assessed as follows:

- *Cs O_2 @ 50m:* 230mg/l (assumes water is saturated with nitrogen)
- *Dissolution rate:* 166.6kg/hr
- *Assume a 10m dia water column**: 3926m^3
- *Oxygen loading rate:* 42.4mg/l
- *Oxygen loading rate as % of Cs:* 18%

*A 10 m diameter water column is conservative since the impact of the array of diffusers will cover this area.

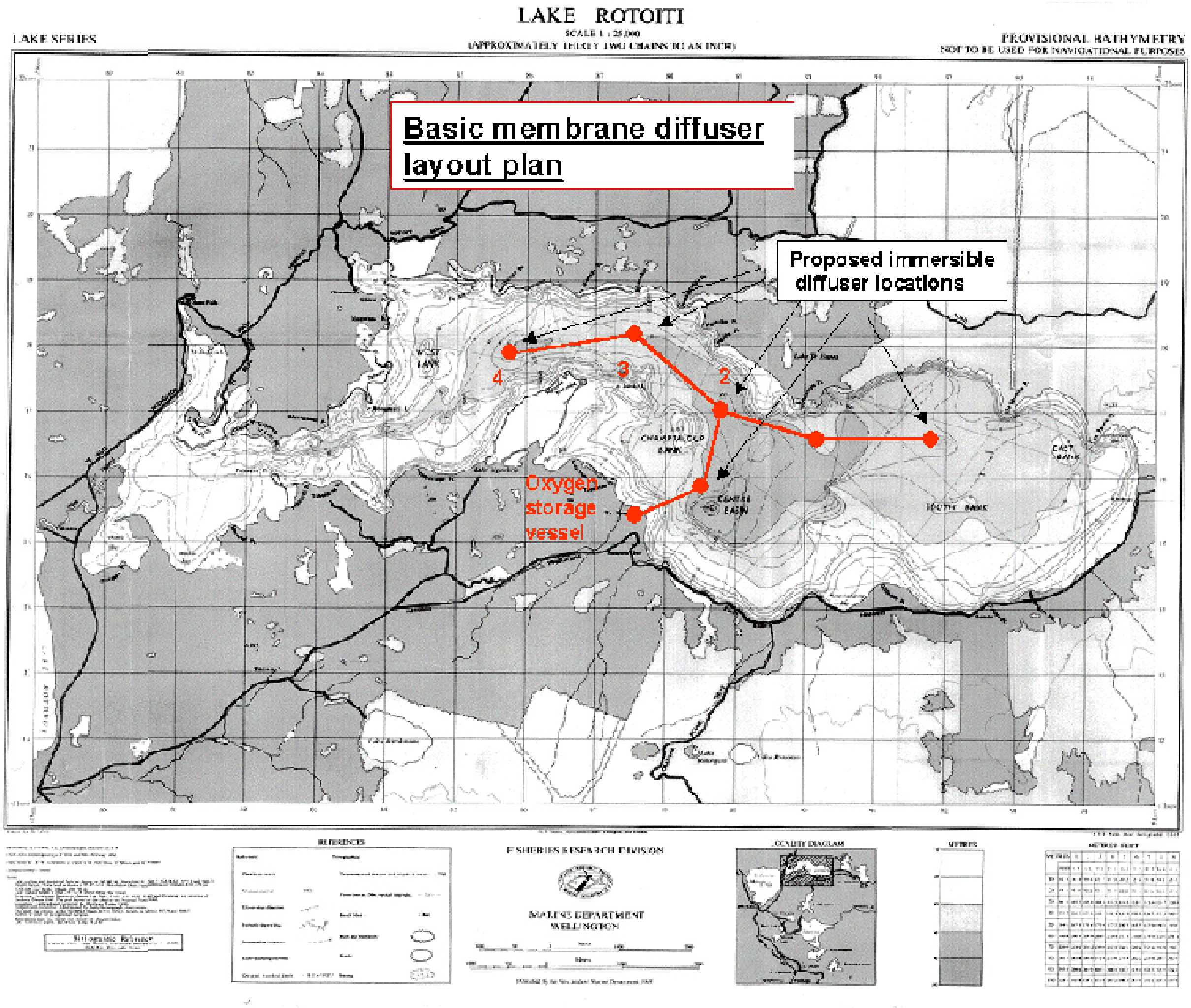

Figure 3 - the approximate locations of diffusers on the lakebed.

This simplistic approach does not take into account the gradient for mass transfer and also any oxygen demand of the water. Dissolution efficiency will also depend on the degree of mixing within the immediate water column zone.

Please note that we calculated each diffuser station at a standard 50m depth in the interests of simplicity and because of the early stages of our investigation. In practice it is likely that orifice plates will be needed to ensure equal distribution of the gas at each diffuser station based on the final/expected depth for each station.

Some of the challenges we envisage include:

- *Oxygen pipework and distribution:* This option presents some challenges for laying pipework, recreational safety and ongoing maintenance. We will need a substantial pipe distribution network to effectively diffuse oxygen throughout the lake using the membrane diffuser approach.
- *Measuring dissolved oxygen levels:* We have assumed that there will be minimal changes in DO throughout the basin and that automatic control would not be relevant in the initial startup. DO control effectiveness is directly related to the effectiveness of the DO transducers, and in low mixing environments it can be quite difficult to obtain DO measurements. We recommend that manual adjustments be carried out based on field DO measurements.
- *Immersible diffuser platforms:* Any gas diffusion system with a gas liquid interface requires regular maintenance. In addition, diffusion methodologies require that the individual diffusers be located in a horizontal position. These are issues in the Lake Rotoiti situation because much of the construction surface (the lakebed) is submerged in very deep water. In order to accommodate these two issues, we have evaluated an immersible platform concept that will enable regular maintenance and level correction on the floor of the basin at each of the designated diffuser locations.

6.6 Installation and maintenance

This approach will require laying approximately 8.5km of pipeline. The diameter of this primary pipework will be 75mm, 50mm and 40mm. The pipework would be laid out in a similar manner to cable.

The solution also includes prefabricated concrete weights and protective armour to secure the main supply pipework to the floor of the basin. In addition, the system will need to be protected from anchor damage or impact resistance – perhaps through warning signage for lake users.

We have built requirements regarding the removal, cleaning and replacement of each membrane diffuser into our solution design. For instance, we have incorporated an immersible pontoon over each diffuser station enabling it to be raised and lowered using specialised air and water pumping equipment. We anticipate that we will need a dedicated maintenance craft for this task, which we would like you to provide.

Although this solution will not hinder boating and recreational activity (except for anchors etc), we will need exclusive access to the area around diffuser stations in the two periods during the year (beginning of season and end of season) when maintenance and setup/shutdown will occur.

Since the planned operation of the oxygenation system(s) is for six months per year, the membrane diffusers will need to be removed and cleaned prior to start-up at the beginning of each subsequent operation period. Our floating pontoon design will enable us to carry this out easily and regularly.

Figure 4: A typical BOC onshore oxygen installation

6.7 Option 2 – Side-stream Super-saturation

Many sidestream technologies are available for supersaturating a sidestream by mixing the lake water with oxygen before reintroducing this into the Ohau Channel basin. The primary methodologies consist of either high shear of gas and water or a Turbolox cascade water contact method using a variety of water column contacting methods.

BOC high-shear method

We looked at several options regarding the size and number of dissolution units that would be needed. We recommend a Hydrodynamics Cavitation mixer for super-saturation because it achieves a high oxygen:water volume ratio of approximately 300%:

- *Sidestream water flowrate:* 225m^3/hr @ 20kPa
- *Oxygen dissolution rate:* 674m^3/hr ie 22tonnes per day
- *Input power:* approx 460kW
- Number of dissolution units: 2

Although the Hydrodynamics Cavitation mixer is considered to be relatively new technology, it has been rigourously tested and successfully applied to a wide range of gas/liquid applications.

BOC Turbolox

The alternative option, which achieves a maximum oxygen:water volume ratio of 5% is:

- *Sidestream water flowrate:* 4135m^3/hr @ 200kPa
- *Oxygen dissolution rate:* 615m^3 O_2/hr ie 20tonnes per day
- *Input power:* approx 440kW
- *Number of dissolution units:* 6 (operating at 3% volume ratio assuming a start DO at 60% saturation)

The key benefit of the sidestream option is its small footprint: it has a low visual impact on the local environment and is essentially non-intrusive to the lake environment. It also has the benefit of all the equipment being based on one location, ie, dissolution equipment and the oxygen facility.

However, it would require a substantial power demand to provide energy for dissolution. Option 2 is likely to require a generator with estimated noise levels of -90 dB. If this level was considered to be too high, we could easily attenuate it for little additional cost.

The installation of sidestream pumps, pipework, and intake screens is well-established civil engineering practice.

7. BENEFITS

We believe both solutions presented are:

- Fast (implemented within 6 months of agreement to proceed)
- Natural (we would like to contend that oxygen is one of the most natural ingredients available)
- Workable (with few compromises required by the community)
- Relatively inexpensive (especially relative to the cost of the problem)
- Minimal in their impact on the life of the community
- Without additional environmental impacts
- Able to show improvement in water quality quickly.

NOTE: On the basis that our calculations for dissolved oxygen demand in the lake are correct and the solutions deliver the amount of oxygen required, BOC would expect to see the algal bloom and the lake odour gradually improve. However this can not be guaranteed.

Appendix Two provides a report from José Béya and David Hamilton of the Centre for Biodiversity and Ecology Research, University of Waikato *Calculations to support BOC oxygenation report.*

8. COMMERCIAL CONSIDERATIONS

Outlined below is the **indicative capital and operating costs** associated with lake oxygenation. Costings for option 1 only have been provided because more detail would be needed to cost Option 2:

Option 1	Indicative capital investments required by Environment BOP	Operational investments, including supply and delivery of oxygen and vessel facility and system maintenance	Provisos and notes
1a - Membrane diffuser on marae/other eastern sector lakeside site, close to lake/good road and infrastructure access	$1.5 million	$1.2 million per year (approx 20 tonnes per day)	
1b - membrane diffuser on eastern sector lakeside site, distance from lake/poor road and infrastructure access	$1.5 million	$1.2 million per year (approx 20 tonnes per day)	Possible additional expense by BOP for road improvement, phone and power supply etc, and possible geological engineering requirements depending on land suitability and stability

9. BOC SCOPE OF WORK

9.1 Design

BOC has developed a basic concept and design for the required oxygen supply and dissolution. In principle the concept is simple and the risk is low.

The design concept includes:

- Oxygen Supply Schemes options
- Oxygen pipe work
- Distribution
- Diffuser stations
- Immersible diffuser platforms
- DO controls

Once a commitment to proceed has been received, BOC will carry out a more in-depth, detailed analysis of the design concept.

9.2 Investments

The investment associated with the recommended solution has two elements – initial capital investment and ongoing operating costs. In the first two years, there may need to be more frequent diffuser maintenance, tapering off in subsequent years.

Capital Investment (Option 1 only)

- Establishment cost
- Detailed design
- Supply of pipe work and installation
- Supply of diffusers and installation
- Immersible diffusers platforms
- Control panel
- On shore concrete foundation pad for the facility
- Installation of the facility

Operational Cost (Option 1 only)

- Oxygen gas supply and the on land oxygen facility. (The facility includes vacuum insulated vessel, vaporisers, telemetry system, control panel)
- Maintenance of the facility and the diffusers

9.3 Commercial process

- These findings contain BOC's recommendations to Environment BOP
- If Environment BOP accepts BOC's recommendations, we further recommend that Environment BOP requests a formal proposal from BOC for the design, installation and supply scheme for the dissolution of oxygen into Lake Rotoiti.
- Upon acceptance of the formal proposal from BOC, Environment BOP and BOC will enter into a formal supply agreement.

PART THREE – COMMUNITY IMPACTS

10. MINIMAL IMPACTS EXPECTED

We were instructed by Environment BOP to analyse the effects of installation on the community and lake recreational users.

Our initial analysis indicates there are minimal environmental, recreational or social impacts, and there is ample scope for community-based negotiation of the options we have presented.

As a prospective supplier of an environmental engineering solution, we are aware that Environment BOP, Rotorua District Council, and other stakeholders must reach consensus on the general acceptance of a solution. We envisage that during the consensus-building process, you may need to consult with us on the technical viability of various alternatives, and we are happy to do so.

We note the high level of community cooperation going into the development of a strategy for management of the lake, and are pleased to have the opportunity to provide a solution that enables Environment BOP and its stakeholders to buy some time for longer-term decision-making. We believe our solution could work indefinitely while this discussion and any related development goes on, and invite you to consider this as a long-term solution as well.

PART FOUR – WHY BOC

11. MAINTAINING EXCELLENCE

BOC is a leader in best-practice operational and accountability-based leadership.

On an operational level, we maintain the highest standards of quality, safety and accuracy. In terms of ethical, social and environmental responsibility, we appreciate that as a global organisation that conducts its business in some 50 countries, BOC touches the lives of many people – among them our shareholders, customers, employees, suppliers and the local communities in which we do our business. We take our responsibilities towards all these groups very seriously.

This section outlines some of the specific steps we have taken to ensure we maintain excellence in all our operations.

11.1 BOC in the South Pacific Region – Process Gas Solutions

BOC New Zealand is part of BOC's South Pacific region. Its Process Gas Solutions division serves the food, metals, minerals and other process industries. We service 400,000 customers through 40 production facilities, 90 retail outless, more than 800 agents and 2200 employees throughout Australia, New Zealand and the South Pacific. In adition to a wide range of gases and related products, BOC PGS division has an extensive portfolio of innovative solutions and services.

11.2 BOC Community participation

BOC devotes significant energy to initiatives that improve the well-being of the community in New Zealand. An example is its *Where There's Water* Community Environmental Grants programme. This programme, in which BOC funds community projects around the country, was given a New Zealand Ministry for the Environment Green Ribbon Award this year to honour its contribution to water quality in 2003 – the International Year of Fresh Water.

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12. BOC AROUND THE WORLD

12.1 Code Of Conduct

BOC staff follow the Code of Conduct principles of ACTS:

- **Accountability**, where each one of us knows what we are responsible for and what we are empowered to deliver
- **Collaboration**, enabling us to maximise our achievements as a group
- **Transparency** in our dealings, because visible problems can be solved and informed people make better decisions.
- **Stretch** our performance and continually push the boundaries of what is possible.

12.2 Corporate responsibility – safety, health, environment, quality (SHEQ)

The BOC Group takes its safety, health and environmental responsibilities seriously, and strives in all its business dealings to operate safe working practices, eliminate incidents and ensure it causes no harm to people or the environment.

The Group’s global Integrated Management Systems and Standards (IMSS) database disseminates the Group’s SHEQ policies through the BOC intranet, outlining the minimum standards and actions needed to align with or conform to ISO 9000 (quality assurance), ISO 14001 (environmental) and ISO 18001 (health and safety) management systems as well as the International Safety Rating Systems (ISRS). The management of safety and environmental performance is measured in the same way. As a result, BOC has improved efficiency with a reduced accident rate, fewer lost workdays, a greater recycling take-up, better energy conservation and less waste from the Group’s production and distribution processes.

13. SUMMARY

Environment Bay of Plenty has asked BOC to propose on the costs, implementation and implications of installing a delivery system to oxygenate Lake Rotoiti as a short-term solution to halt the decay of the lake and improve its water quality. The oxygen delivery to the hypolimnion (the deeper part of the lake) must be in a form that is completely dissolved during summer stratification.

This report covers two options:

- Membrane diffusion of oxygen into Lake Rotoiti from a land base and across the lake bed to achieve the required oxygen levels. There are two alternatives regarding the location of this solution (1a and 1b).
- Super-saturating the lake with oxygen by removing lake water at Ohau Channel and dissolving large amounts of liquid oxygen into it before pumping it back into the lake

We recommend option 1a, membrane diffusion, for technical and cost reasons, but acknowledge that there may be some community opposition to this option. Other options are equally as viable technically but may involve greater cost.

The solution has been designed to achieve optimum dissolution of 10-20 tonnes per day of oxygen injected into Lake Rotoiti. Assuming the data and calculations provided to BOC are correct, we would expect to see the algal bloom and the lake odour to gradually diminish.

In terms of recommended delivery method, liquid oxygen is the only form of supply that will provide the flexibility needed.

BOC looks forward to Environment BOP's feedback and the opportunity to participate in the process of beginning Lake Rotoiti's recovery.

PART FIVE – APPENDICES

APPENDIX ONE – UNIVERSITY OF WAIKATO REPORT

Commissioned by BOC from University of Waikato to support recommendations submitted by BOC to EBOP for oxygenation of Lake Rotoiti

APPENDIX TWO – BOC BACKGROUND INFORMATION

- Where There's Water programme and Ministry for the Environment Award
- Case study demonstrating experience with similar solutions – Oxygenating the Swan and Canning Rivers